Indigenous Nutrient Management Practices
- wisdom alive in India

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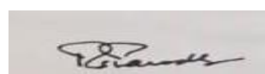
FOREWORD

In the past fifty years, the agricultural research system in India, has developed many scientific technologies for efficient management of natural resources but their implementation at the level leave much to be desired. Moreover, of late there is growing concern about long-term sustainability of agriculture and environmental safety with high input [chemical] based modem technologies.

In contrast, the traditional agricultural system apparently sustainable at low productivity and at low population pressure is breaking down under the continued onslaught of human and animal population pressure and cannot meet the ever-increasing and varied demands of the society. In the present scenario, among other measures a paradigm shift in soil resource management strategy is inevitable, This could be possible if we imbibed traditional knowledge and perceptions of farmers and weaved technologies around them.

Local farming communities are a treasure trove of knowledge gained through ages about the soils and various practices to maintain soil fertility. These practices are well adapted to the local conditions and resources. The time tested Indigenous Technical Knowledge (ITK) available with farmers provides much needed insight into the management of soil fertility for sustained agricultural production. In fact, most of the ITK passes through considerable up gradation and adaption over a period of time. These technologies are generally eco-friendly, inexpensive and socially acceptable, Therefore, it becomes imperative that we collected, analysed and documented these technologies to blend them with the modern scientific technologies.

The contributors and editors of the publication "**Indigenous Nutrient Management Practices-wisdom alive in India**" deserve all praise for their dedicated efforts in compiling the ITK on nutrient management for six agro-ecosystems of the country.

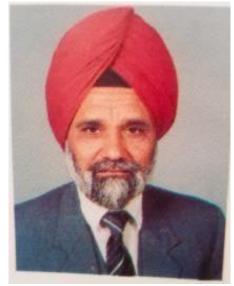


(R. S. PARODA)

March 22, 2001

Secretary, Department of Agricultural Rescarch & Education
& Director General, Indian Council of Agricultural Research
Krishi Bhawan, New Delhi

PROLOGUE

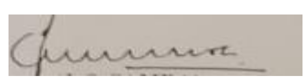


The spectacular performance of Indian agriculture witnessed during the second half of the 20" Century against the onslaught of rising demographic pressure is a vivid demonstration of the growing effectiveness of our agricultural research and development system with committed researchers and hard working farming community, While being proud of our past achievements, we should not lose sight of formidable challenges that we face in the 21* Century. The true issue of sustainability in agriculture still remains unaddressed, Management of natural resources - soil, water and vegetation - for sustainable agricultural production represents a most daunting task and is certainly going to receivemuch of our attention in the years to come.

Soil is the most basic and vital natural resource on which agricultural production depends. Maintenance of soil fertility and productivity is, therefore, a real key to achieve sustainability in agriculture, No doubt, we have developed wealth of frontier science based technologies appropriate for efficient management of soil fertility through optimizing nutrient supplies from different sources but many of these technologies could not find favor with farming community in general and resource poor small and marginal farmers in particular owing to several reasons. Against this there is growing realization that the present technologies need to be modified in the light of the indigenous technical knowledge (ITK) available with farmers so as to make them cost effective and acceptable to local farming communities.

Farmers possess a store-house of knowledge about their soils and various practices to restore and maintain soil fertility. Since the earliest stages of agriculture, farmers have been active in developing techniques for crop production and maintaining soil fertility, The indigenous technical knowledge (ITK) available with farmers provides much needed insight into the management of soil fertility and nutrient management for sustained agricultural production, because such knowledge has been time tested and carried on from one generation to another, Moreover, the indigenous technologies developed on the basis of experiences gained and lessons learnt by the farmers are generally eco-friendly and do not require off-farm inputs. In order to make use of these indigenous. techniques and give them much needed scientific touch, it is essential to collect, collate, analyse and understand the scientific basis of such technologies.

This publication **entitled "Indigenous Nutrient Management Practices - wisdom alive in India"** is a compilation of different indigenous techniques practiced by the farmers across the six broad agro-ecosystems (Fiz, Arid, Semi-arid, Sub-humid, Humid and per-humid, Coastal and Island) of the country. The contributors of individual chapters and the editors of the publication have done a commendable job in compiling indigenous knowledge possessed by the farmers and highlighting the possible scope of blending it with the modern techniques of nutrient management. They all deserve appreciation for the meticulous accomplishment of the task It is hoped that the information presented in the publication can be handy for the researchers involved in evolving location specific and cost effectivesoil fertility and nutrient management technologies for sustained agricultural production.



March 22, 2001

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PREFACE

In India, the "Green revolution" resulting from introduction of high yielding cultivars, intensive cropping, intensive use of fertilizers, improved management practices and expansion in cultivated and irrigated area, has increased crop production but at the cost of soil fertility, soil productivity and possible risk of soil degradation. The higher level of production is being attempted to through increased use of fertilizers and pesticides, but use of modern techniques alone have created ecological imbalance and affected stability and sustainability of crop production. It is now realized by the scientists and farmers that yields are declining year after year with the samelevel of input use. At the same time, the greatest challenge now being faced by the Indian agriculture is to produce more from shrinking natural resource base to meet food, fodder, fibre, fuel and raw materials. In global terms, India today has 16 per cent population, 15 per cent farm animal population but has only 2 per cent of the geographical area, 1 per cent of rainfall, 0.5 per cent of forests and 0.5 per cent of grazing land, Since landis a shrinking resource for crop production, there is no option but to produce more food and other agricultural commodities from the limited available land. In other words, the need for more food has to be met through higher yields per unit of land, water, nutrient, energy and time. The present pattern of development through exploitive agriculture cannot lead us to a better common future. Exploitive agriculture offers great possibilities if carried out in a scientific way but possess great dangers if practiced only with an immediate profit motive; that is what the effect of green revolution is being experienced in India. Intensive cultivation of land without conservation of soil fertility and soil structure ultimately led to the springing up of deserts.

We all agree on one point that the agriculture during "pre-green revolution" era followed less intensive traditional agricultural practices like crop rotation with legumes, intercropping/mixed cropping with legumes, use of legumes as green manure crop and the application of organics mainly farm yard manure (FYM) to soil. These are only few examples of indigenous nutrient management. The contribution of nitrogen from the leguminous green manure crop is well documented. Crop rotation with legumes ameliorates soil conditions and overcome problems such as accumulation of phototoxic in soils, multiplication of phytopathogenic soil micro flora, increased incidence of pests and destruction of soil physical properties. The farmers are traditionally in favour of application of FYM which maintains good physical and biological health of soil and improves micronutrients status of soil. These practices are the outcome of trial and error kind of attempts made over a period of time and passed on from generation to generation usually verbally or by practice. These are also environmental friendly. Under changed scenario of the new patent regimes, it will, thus, become imperative to look back to these traditional soil-nutrient management practices followed by our farmers to restore soil fertility and sustain productivity, many of which have been abandoned after green revolution and/or losing ground in the wake of new scientific methods of nutrient management.

Thus, in the present publication, compilation of various indigenous nutrient management practices alive in different parts/states of the country are thought of; some of which are common for all the states and some are specific to a particular state. Various traditional practices prevailing in 28 states of the country are discussed under 26 chapters and are categorized under six broad agro-ecosystems viz; Arid- ecosystem, Semi-arid ecosystem, Sub-humid ecosystem, Humid and per-humid ecosystem, Coastal ecosystem and Island ecosystem. Each chapter consists of brief background (about the crops, soil, socio-economic status, fertilizer use) of the state, various indigenous nutrient management practices, practical relevance of these indigenous practices to the farmers, existing problems of nutrient management in the state and possible scope of blending indigenous nutrient management practices with new scientific techniques of nutrient management.

Traditional indigenous nutrient management practices popularly followed in most regions include: application of FYM to the field, use of rice straw/husk and wheat bhusa as bedding materials to the cattleshed, penning of cattle, goat and sheep, use of weeds (Ipomoea, Lantana), water hyacinth, dhaincha and sunnhemp for green manuring/composting, application of pond sediments/tank silts to the fields, etc. However, practices specific to a particular state are: Khadin cultivation in western Rajasthan; permanent set-furrow system for groundnut cultivation in Gujarat; vermiculture through rishi-krishi method of Maharashtra; Haveli and bandh cultivation in Madhya Pradesh; collection of dropping of sheeps and goats by tying bags to cover anal part and earning more from ginger following organic farming in Himachal Pradesh; use of jute leaves as potential source of manure in West Bengal and Orissa; recycling of nutrient through pond excavation, animal-hay-bed compost technology in Punjab; application of sudumannu (burnt soil) in coastal Kamataka; vegetable cultivation with the use of fresh cowdung in the pits in Kerala; walking in rice field for minimizing iron toxicity in Assam; Zabo and panikheti farming system in NEH region; maintaining soil fertility in coconut plantation in Andaman through natural growing of Pueraria grass. These are appropriate technologies, innovated, tested, improved and implemented since long by the local peasant. These technologies are at the finger tips of the farmers and thus give results invariabily. These indigenous practices basically aim at adding organic matter to the soil, utilization of the locally available materials and rational use of natural resources. To be more specific, each indigenous nutrient management practice has much practical relevance to the farmers. For example, (i) penning of cattle/sheep/goat in the cultivated field add organic matter to the surface soil through urine and excreta, (ii) the animal urine directly absorbed by the crop residue prevent nitrate pollution of ground water. The losses of N and mineral elements are reduced by using absorbent bedding for cattle, (iii) tank silt is rich in nutrient and high in organic matter content. (vi) wood/coal ash acts as an alternate source of K which atleast partially fulfils the K requirement of crop, (v) growing of Pueraria grass in coconut plantation and its in-situ decomposition make the nutrient available to plants and enhance the earthworm activity in the plantation, and (vi) tying bags to cover anal parts of animals when taken for grazing has practicalrelevance to meet out the shortage of manure. Therefore, we feel that systematic documentation of these indigenous nutrient management practices in the form of a publication is inevitable to conserve the old farming traditions and knowledge of the farmers from being lost.

Our present scientific techniques aim at high productivity with costly inputs at the expense of soil health. But the indigenous practices make use of low inputs to attain sustainability. In a situation where land is limited and the population continues to grow, the traditional ways of farming may no longer be tenable. So, we have to compromise between the two and evolve new technologies by blending best elements of indigenous technical knowledge (ITK) and modem science based techniques. Indigenous nutrient management practices have strong scientific basis. However, not all the practices have been scientifically evaluated to ascertain their relevance in the present times. With little refinements and blending with the modern scientific techniques, all the indigenous techniques followed by farmers could be made more effective and adoptable.

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CONTENTS

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ARID ECOSYSTEM

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CHAPTER 1

INDIGENOUS KNOWLEDGE OF NUTRIENT MANAGEMENT IN WESTERN RAJASTHAN

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ABSTRACT

Low rainfall, high temperature and light textured soils are the major constraints for crop production in western Rajasthan. A majority of the soils in the region are deficient in nitrogen, low to medium in phosphorus and high in potassium. Due to uncertainty of rainfall and insecure returns the farmers are reluctant to apply fertilizers. However, based on the generations experience the farmers have devised criteria for judging the suitability of land for cultivation of a particular crop and cropping systems. Depending upon the land quality various management practices evolved by the farmers in the region help to regain the fertility of soil. 'Khadin ' cultivation is an ancient system and very useful in soil as well as water conservation. The other important management practices like crop rotation, fallowing, crop residue incorporation, addition of pond sediments, agroforestry etc. are followed to maintain the soil fertility. The practices improved over the existing one through scientific research viz. agroforestry, ley farming, use offarm yard manure and compost have been discussed.

The concept of indigenous knowledge in the present context is the traditional wisdom used for the conservation of land and water resources involving rainfed subsistence agriculture. These practices are the outcome of trial and error method and passed down from generation to generation, usually verbally or by practice. Traditional knowledge is the basis for agricultural development through resource conservation encompassing endogenous capacity building practices of regaining fertility of soil.

The indigenous knowledge has significance not only for the culture in which it has evolved, but also for the scientists and planners from outside. Until recently most of the success in maintaining the productivity of arid regions is due to these traditional techniques. These traditional practices are adapted to socio-economic and environmental conditions of the region and are often superior to modem technology brought from outside.

BACKGROUND INFORMATION

The arid zone has about 32 million ha area, of which 61% lies in 12 districts of western Rajasthan alone. The region is characterized by low annual precipitation (<100

to >400 mm), extremes of temperature (-2 to 48 °C), high wind speed (35 to 40 km/hr) and high evapotranspiration. A major portion of rainfall (95%) is received during the monsoon (June-September) and the coefficient of variation ranges between 40 to 60%. The rainfall pattern, frequency of drought and crop production in western Rajasthan are depicted in Fig. 1 and Fig.2. The western Rajasthan falls under north-west hot arid region of India based on the physiography, rainfall and water resources and are further divided into different zones and sub zones (Faroda *et al.* 1999). Salient features of zone and sub zones in western Rajasthan are described in the Table 1. The cropping intensity is about 100%. Pearlmillet *(Pennisetum glaucum)* is the major cereal crop of the region.
Clusterbean *(Cyarnopsis tetragonaloba)* ranks next to pearlmillet as an important rainfed crop. Mothbean *(Vigna aconotifolia)* and mungbean (*Vigna radiata)* are important leguminous crops grown in the area. In areas where irrigation is available wheat, mustard and cumin are grown during rabi season.

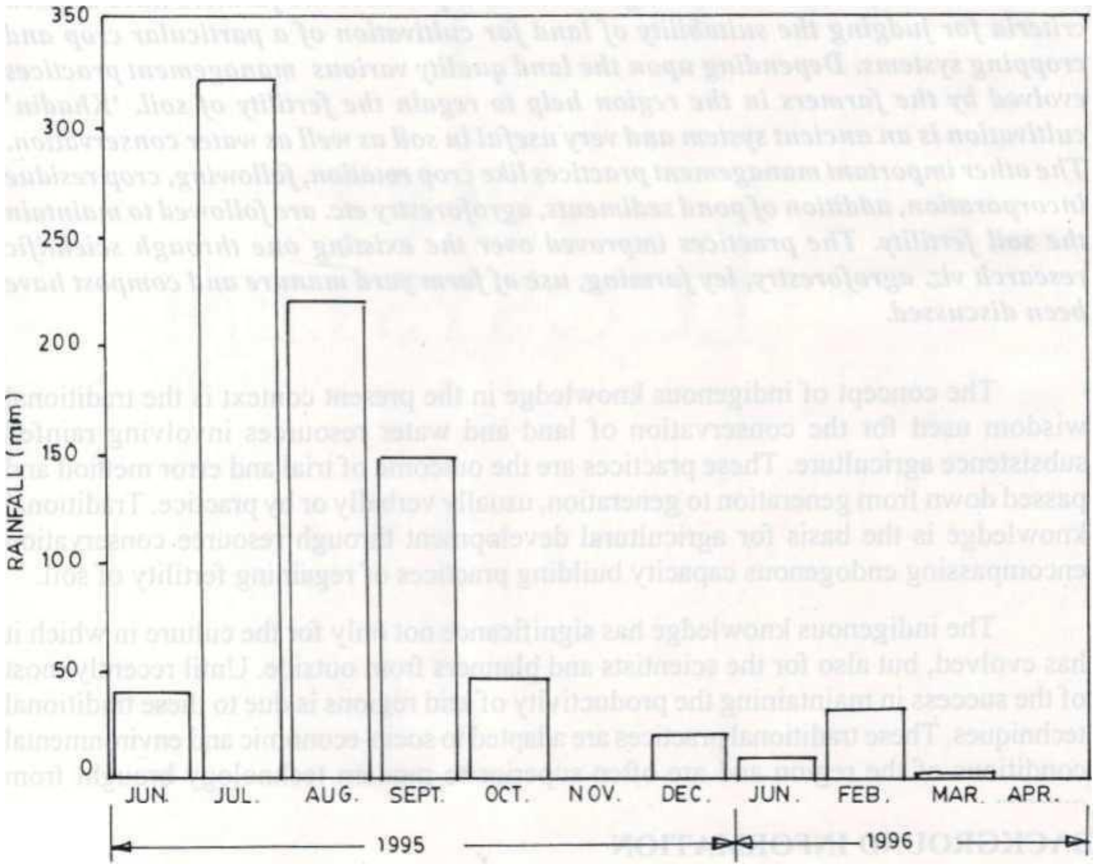
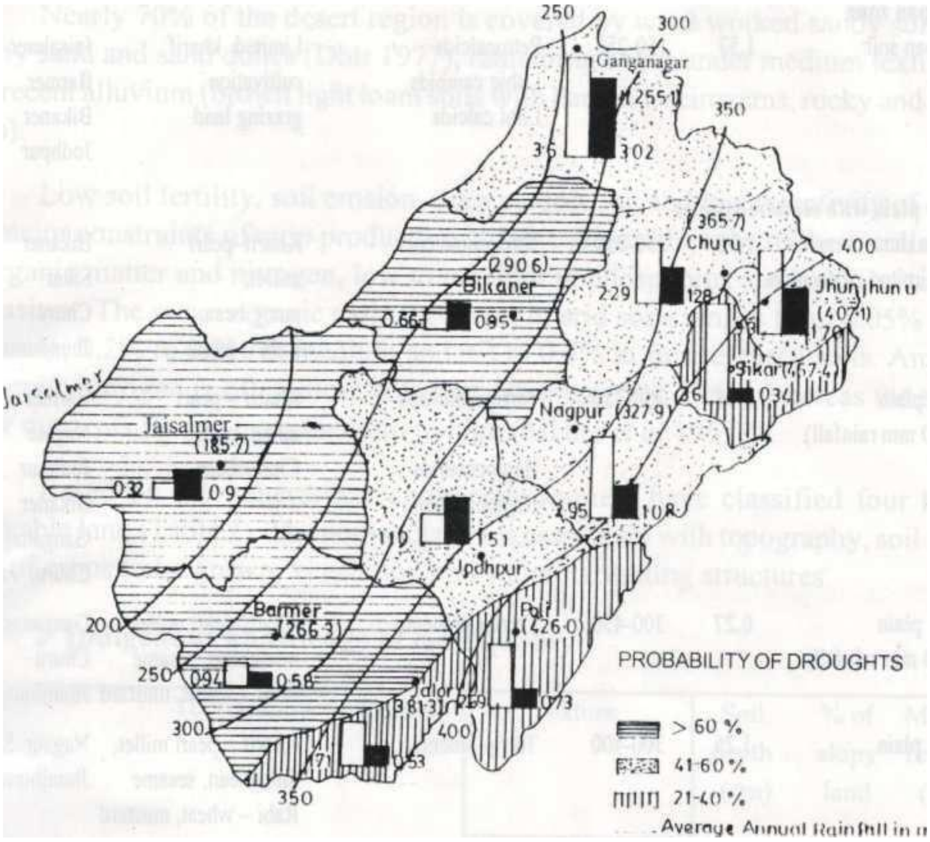


Fig. I Monthly rainfall from June 1995 to April 1996



( ) Pearl millet

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Fig. 2 Drought and crop production in Western Rajasthan

Table 1 Agroecological zones and sub-zones in western Rajasthan

Agroecological zones subzones	Area (million h	Rainfall ia)(mm)	Soils	Land use/major crops	Districts
1. Hyper arid zone					
Hyper arid	0.86	<100	Torripsamment	Sandy waste	Jaisalmer
2, **Dune complex with scrub and grasses**					
Western dune complex with *Lasiurus sindicus*	2.06	100-150	Torripsamments	Open grazing	Jaisalmer Barmer
Western dune complex with scrubs	0.26	100-150	Torripsamments	Open grazing	Bikaner Barmer

3, Hard pan zone					
Hard pan soil	1.57	150-250	Petrocalcids Lithic cambids Lithi calcids	Limited kharif cultivation grazing land	Jaisalmer Banner Bikaner Jodhpur
4.Sandy plain with scattered dunes					
Eastern dune complex with Limited cultivation	1.32	250-350	Torripsamments	Kharif-pearl millet, mung bean Rabi - gram	Bikaner Sikar Churu Jhunjhinu
.Sandy plain (< 300 mm rainfall)	3.68	250-350	Torripsamments Haplocambids Haplocalcids	Kharif - pearl millet, moth. Clusterbean	Barmer Nagaur Jodhpur Bikaner Ganganagar Churu. Jalor
Sandy plain (> 300 mm rainfall)	0.27	300-450	Torripsamments	Kharif-pearl millet, mungbean, sesame Rabi - wheat, mustard	Ganganagar Churu Jhunjhunu
Sandy plain	1.25	300-400	Torripsaments	Kharif-pearl millet. mungbean, sesame Rabi - wheat, mustard	Nagaur, Sikar Jhunjhunu
5.Luni-Banas basin					
Luni basin with coarse loamy soil	2.67	300-450	Haplocalcids Haplocambids	Kharif-pearl millet, clusterbean, sesame Rabi - cumin, wheat Mustard, isabgol	Nagaur, Pali Jodhpur Jalor Barmer
Luni basin with fine loamy soils	1.44	300-450	Haplocambids Haplocalcids Haplosalids	Kharif - pearl millet. sorghum, sesame Rabi - wheat	Pali. Jalo Nagaur Jodhpur
Mendha basin	0.17	400-450	Torripsamments Torrifluvents Haplocambids Haplosalids	Kharif - cotton Rabi - wheat. Mustard	Sikar Nagaur
Aravali foot hill	0.76	450-500	lithic cambids Haplocambids	Kharif-maize.cowpea. sorghum, sesame	Jhunjhunu. Sikar, Pali Jalore Nagaur

Nearly 70% of the desert region is covered by wind worked sandy soils, sand, loamy sand and sand dunes (Dhir 1977), remaining being under medium textured, old and recent alluvium (brown light loam soils with hardpan, seirozems, rocky and gravelly soils).

Low soil fertility, soil erosion, deep percolation and low retentivity of soils are the major constraints of crop production in these areas. Majority of these soils are low in organic matter and nitrogen, low to medium in phosphorus and medium to high in potassium. The mean organic carbon content in arid soils ranges from 0.05% to 0.2% in coarse, 0.2% to 0.3% in medium and 0.3 to 0.4% in fine textured soils. Among the nutrients, nitrogen is often most deficient (Sharma *et al.* 1966) whereas the status of other nutrients ranges from medium to high (Mehta *et* a/. 1967)

Based on the generations experience farmers have classified four types of cultivable land (Table 2). The nomenclature is associated with topography, soil fertility, type of crops to be grown, vegetation and water harvesting structures.

Table 2 Indigenous knowledge of land quality

Land quality	Topography	Colour	Texture		Soil depth (cm)	% of slopy land	Moisture retention (No. of days)
			Black soil (%)	Yellow soil (%)			
Excellent (Barani I)	Land depression	Black	50	50	135	20-30	10
Very good (Barani II)	Flat alluvial plain	Less black	40	60	105	-	-
Good (Barani III)	Related to type of natural vegetation	Yellow		80% sand	75	50	6
Fair (Barani IV)	Sandy, duny or sloppy	White 50% gravelly	10 40% sandy	-	45	>50	4

Selection of the crops and the amount of fertilizer/manure to be added depend upon the quality of land. Mothbean is generally grown in poor soil. Better soils are preferred for mungbean and pearlmillet while clusterbean is grown on relatively heavy soil. In sandy soils where pearlmillet and mungbean are grown cow dung manure and camel manure are used. In irrigated area sheep and goat manure is applied. The average fertilizer consumption in 12 districts of western Rajasthan is 13767, 4033 and 166 tonnes nitrogen, phosphorus and potassium, respectively (FAI 1996). But most of the fertilizer is applied to irrigated crops and very little is used under rainfed conditions.

EXISTING PROBLEMS OF NUTRIENT MANAGEMENT AND INDIGENOUS SOLUTIONS

1. Due to uncertainty of rainfall the farmers are adding little or no fertilizers. The practice of soil test based fertilizer application is not followed. Most of the farmers are using only nitrogen fertilizers.
2. There is scarcity of farmyard manure as cowdung is used for fuel purpose. Therefore application of organic manure is also low and there is little build up of organic matter and micro flora in the soil. Besides, because of high atmospheric temperature the decomposition of organic matter is at faster rate.
3. The volatilization losses of applied nitrogen is high and thus the nitrogen-use efficiency is low.
4. Though the phosphorus reserve in the soil is high, its availability is low.
5. Overgrazing results in bare soil and thus prone to wind erosion and loss of top fertile soil.

Due to uncertainty of rainfall in the region the farmers are reluctant to apply fertilizer because they are not sure of the return. Thus, in general, there is wide gap between the nutrients removed through harvest of the crop and that added through fertilizers or manures. Only few farmers add organic manure once in two or three years depending upon the availability. Farmers follow certain management practices, which help to maintain the soil fertility to some extent. Allowing herd of sheep in the field for one or two days and ‘khejri’ tree to grow in the field are the practices being followed by the farmers to maintain the soil fertility.

TRADITIONAL AGRICULTURAL PRACTICES FOR IMPROVING SOIL FERTILITY IN THE REGION AND PRESENT RELEVANCE OF THE TECHNOLOGY ADOPTED BY THE FARMERS

The field preparations for kharif crops are initiated in the month of May and June by clearing The shrubs and other weeds. The fields are ploughed with the onset ofm monsoon in July. Normally one ploughing is done in case of pearlmillet, mothbean, mungbean, sesame and clusterbean. However, if more than one ploughing is practiced the land has been kept fallow for a long time.

Rabi crops are grown in irrigated areas and in ‘ Khadins’. Wheat, mustard and chickpea and in some areas cumin crops are also grown. Farmyard manure @ 1-2 tonnes/ha is applied. Livestock grazing after the harvest of the crops is a common practice, which helps in regaining the fertility of the soils.

‘Khadin’ cultivation, annual crop residue incorporation, crop rotations, ley farming, fallowing etc. are some practices being followed for sustainable production in the dry regions.

‘Khadin ’ cultivation

This is an ancient system of cultivation. This system makes the use of shallow, gravelly and rocky uplands normally used for grazing as well as for the catchment for harvesting of runoff water. It is trapped in low lying valley plains that are converted into farm land where generally the rabi crops are raised depending upon the amount of rainfall. The water that accumulates and stands for long in ‘Khadin’ brings in regularly some fine and fertile sediment which settle down on farm land. The soils, therefore, are medium to fine textured and of alluvial nature. Being moist for longer period, microbial activities get accelerated and therefore, the soils are more fertile than rest of the desert soil. Although these soils fall in Tow’ category of soil test value, they significantly contain higher nutrients than desert soils. Available P,O_5 is medium to high while available K_2O is invariably high. The nutrient status of ’Khadin’ soil is given in Table 3.

Table 3 Nutrient status of ‘Khadin’ soils

‘Khadin’ site	**Available** **PA**	**nutrient (kg/ha) K_2O**	**Total N (%)**
I	38	340	0.0160
II	40	240	0.0182
III	64	720	0.0340
IV	200	1160	0.0350
V	56	410	0.0300

Source: (Singh and Kolarkar 1983)

Crop rotation

Farmers are cultivating pearlmillet since ages. However, continuous cultivation of pearlmillet in the same piece of land decreases yield potential. Farmers are aware that pearlmillet and cotton extract more nutrients and therefore exhaust the soil fertility while groundnut, chickpea, clusterhean etc. regain the soil nutrients. Therefore farmers traditionally prefer to grow pearlmillet-Iegume rotation as monoculture of pearlmillet causes reduction in yield which is attributed to depletion of nutrients and production of some allelochemicals (Saxena ***et al.*** 1995). The beneficial effect of legume is attributed to improvement in soil fertility. Therefore, depending upon the suitability of land and also farmer’s need crop rotations are followed. Usually culsterbean is grown in the first year followed by a mixed crop of pearlmillet, mothbean and sesame for about four years, with pearlmillet as predominating crop. Then the land is left fallow to regain the soil fertility. .

In tubewell irrigated areas two types of crop rotations are followed to maintain the soil productivity. In areas where water is saline, wheat and mustard are grown in rabi followed by fallow during kharifto leach down the accumulated salts during rains. In areas where groundwater is of good quality (non-saline) farming system followed is different. Chilli is grown during kharif and in the month of November, just before the last picking of chilli, wheat is broadcast as a relay crop and then stubbles of previous crops are uprooted. In these areas 5-6 t/ha goat manure is applied before transplanting of chilli whereas wheat and cotton receive DAP @ 100 kg/ha and urea @ 50 kg/ha.

Crop residue

Crop residues are important source of plant nutrients and also improve physical and biological properties of soil (Venketeswarlu and Hegde 1972). In arid region it has special significance because in addition to adding organic matter (which is low) protect the soil from erosion. Incorporation of clusterbean residue increased the organic carbon content of soil from 0.19 to 0.23% in four years. There was also an increase in status of available nitrogen and phosphorus content of soil added with crop residues. Clusterbean residue is more effective in increasing the crop yield and improving the soil fertility compared to pearlmillet and mungbean.

Application of pond sediment

The light textured soils suffer from deep percolation losses of water under the conditions of heavy rainfall. Alongwith water, the nutrients are also lost in the deep drainage. The surface incorporation of pond sediments available from dried up ponds have been found to improve the moisture and nitrogen status of sandy soil resulting in higher crop yield. The pond sediments are also applied in irrigation channels to check the seepage losses. Though in very small quantities, it reaches to cropped area and thus also helps in improving the nutrient status of soil.

Agroforestry

The farmers in the area allows to grow trees in the cultivated fields. It has been observed that 40 to 50 trees/ha is not uncommon in the area (Sharma and Gupta 1989). 'Khejri' *(Prosopis cineraria)* is the most common naturally growing trees in the fields and field boundaries. It does not compete with the under storey crops for natural resources. However, it is a slow growing area and thus availability of fuel and fodder from this tree takes a long time. The farmers are well aware that the crops under this tree give higher yields than that away from the tree. Gradual accumulation of mineral nutrients by the perennial trees and incorporation of these into an enlarged plant-litter- soil nutrient cycle is the mechanism responsible for soil enrichment. On an average 600 to 800 kg/ha of leaf litter is added by *P. cineraria* annually (Sharma and Gupta 1997). Although the stored litter is small, it is renewed annually depending on the climate. Leaf litter is related more closely with N-cycling as nitrogen is bound up in organic molecules. In arid zone, a major portion of the above ground biomass of vegetation is consumed and accumulation of litter and its contribution to nutrient cycle is meagre. An example for an increase in the nutrient content of soil under *Prosopis* spp. growing in an arid environment is presented in Table 4.

Table 4 Nutrient content of soil under two *Prosopis* species

Trees	Organic C (%)	Total N (%)	Total P (mg/100 g)	Total K
Prosopis juliflora				
Under tree	0.73	0.075	37	296
Open area	0.25	0.027	31	294
Prosopis cineraria				
Under tree	0.37	0.045	3.82	12.20
Open area	0.25	0.038	1.52	7.52

Tillage

The farmers resort to deep cultivation once in 3 to 4 years which help to restore the soil fertility. Also, the post planting cultivation followed by the farmers helps to reduce the crop-weed competition, better root growth and better utilization of water and nutrients. The uptake of nitrogen, phosphorus and potassium by the crop in uncultivated (weeds controlled by herbicides) and cultivated fields were significantly higher than where weeds competed with crops. As much as 20.6 kg N, 2 kg P and 21 kg K per hectare has been found to be removed by the weeds during the crop growth period.

Fallow System

Continuous cropping without addition of fertilizer or manure depletes nutrients from soil and thereby decreasing the crop yields. Therefore, farmers leave the land fallow for few seasons to restore its fertility. The farmers feels that pearlmillet-fallow is the most productive and remunerative cropping system. Clusterbean-fallow seems to be more promising in terms of productivity than mung bean-fallow.

THE SCIENTIFIC BASIS AND THE SCOPE OF BLENDING THE INDIGENOUS PRACTICES OF NUTRIENT MANAGEMENT

Integrated nutrient management

An integrated approach involving fertilizer N, crop residues, on farm waste, legume based cropping system and biofertilizer has been found to be useful for maintaining the soil fertility. Clusterbean, mungbean and mothbean are most common crops of the region. Among these clusterbean is most effective for improving soil environment and nitrogen use efficiency. The beneficial effect of clusterbean is due to heavy leaf shedding which add as much as 10 to 12 kg N/ha/per season.

Incorporation of 2 t/ha residue of clusterbean could improve the nitrogen use efficiency by about 50 to 60% in pearlmillet. Residues of clusterbean applied in conjunction with 40 kg N/ha through fertilizer is an optimum dose. Nitrogen @ 40 kg/ ha alongwith 8 t/ha FYM can give higher yield of pearlmillet even under dry conditions (Gupta *et al.* 1983). Mixing of urea with sulphur or its placement in the subsurface layer reduces the volatilization losses and increases the nitrogen use efficiency. Compost of mustard straw, which is otherwise waste material, adopting special decomposition technique contain 0.76% nitrogen, 0.32% phosphorus and 0.64% of potassium. Application of this compost @ 4 t/ha increases the yield of pearlmillet substantially (Tarafdar Personal Communication).

Agroforestry *systems*

Ziziphus rotundifolia is an important fruit tree of the arid areas. The leaves of this tree can be used as fodder. Studies conducted at CAZRI, Jodhpur have shown that the yields of clusterbean, mungbean, mothbean, horsegram, pearlmillet and forage grasses *{Cenchrus ciliaris* and *Lasiurus sindicus)* grown in association with this tree are at par with that under open field (without trees) (Sharma *et al.* 1993, Sharma *et cd.* 1994). It also significantly improved the organic carbon and available nutrients status of the soil when compared with other tree combinations (Table 5). Similarly, budded ‘ber’ (Z. *mauritiana)* has also been found useful for agroforestry systems, as it has no adverse affect on the yield of companion crop and gives higher returns.

Table 5 Organic matter, available P and K in soil under tree-grass combinations

Tree-grass Combination	Organic matter (%)	Phosphorus Potassium (ppm)	
Cenchrus ciliaris + Ziziphus rotundifolia	*0.378*	*5.16*	*3*
Cenchrus ciliaris + Acacia tortilis	0.278	4.22	72
Lasiurus sindicus + Ziziphus rotundifolia	0.359	5.24	94
Lasiurus sindicus + Acacia tortilis	0.322	4.69	91

Ley farming

Ley farming (grass-arable crop rotation) has been in practice since long for improving the fertility of soil. Systematic studies conducted by Rao *etal.* (1997) have shown that pearlmi llet grown after 6 to 8 years of grasses give 50 to 70% higher yield than the conventional cultivation. The increase in the crop yield is attributed to improvement in overall fertility status of soil, providing more balanced nutrition through continuous turnover oforganic matter within the soil, enhancement of biological activity and improvement in physical properties of soil.

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II

SEMI-ARID ECOSYSTEM

CHAPTER 2

Indigenous nutrient management practices - wisdom alive in India
Acharya C L, Ghosh P K and Subba Rao A. (Eds). 2001, pp 13-30.Indian
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TRADITIONAL SOIL-NUTRIENT MANAGEMENT TECHNIQUES PRACTISED IN PUNJAB

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ABSTRACT

Increasing cropping intensity, indiscriminate use of chemicals - insecticides, herbicides, fertilisers etc. and continuous use of rice-wheat crop rotation in Punjab is causing a serious concern of the maintenance of sustained productivity and arresting environmental pollution. At this stage it is very important to look back to the traditional soil-nutrient management techniques followed by our farmers but have been abandoned in the recent past. Some of these traditional practices commonly followed were recycling of nutrients through pond excavation, compost manure, animal-hay-bed technology, penning of cattle in the fallow fields, crop rotations including legume crops and their use as green fodder to the animals, relative uses of dung, fallow cultivation and straw mulch application. Possible ways for the revival of these practices are discussed.

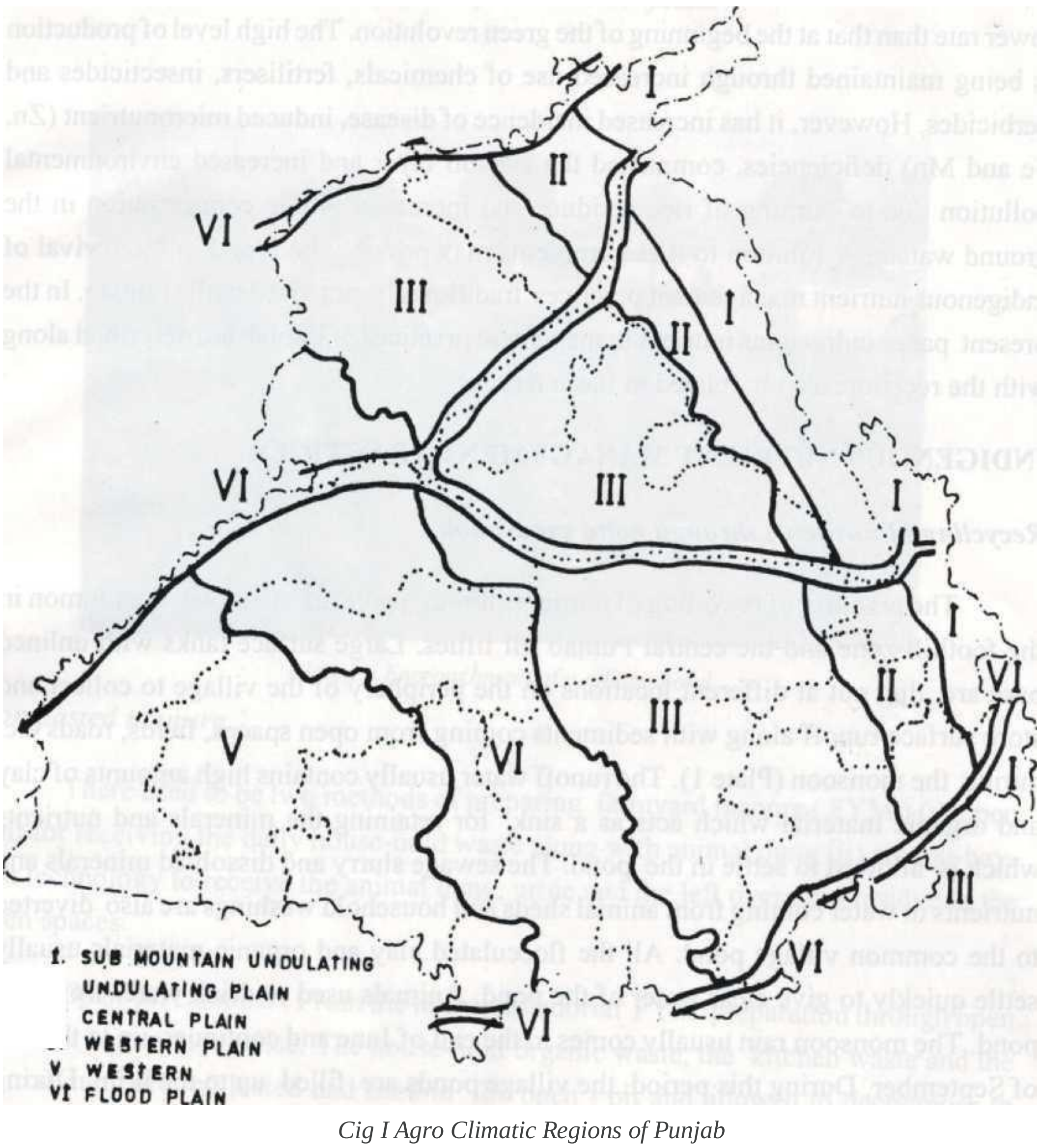
The Punjab state has 6 agro-climatic zones (Fig. 1) with total geographical area of 5.03 million ha, of which 4.26 million hais the cultivated area (97%). Only negligible area is kept as current fallow (Economic Advisor to Govt. of Punjab 1999). The net area sown has increased from3.88 million ha in 1966-67 to 4.26 million ha in 1997-98. The average cropping intensity, 185% and about 95% of the culitvated land is irrigated, of which 38% through canals and 57% through tubewells. There was drastic shift in cropping pattern in Punjab. The crop ro tations that were commonly followed invariably included legume crops. Soil fertility was maint ained by growing of legumes in crop rotations, intercropping of legumes with cereals or other crops. Major crop sequences followed in Punjab is given below:

Cropping system	Irrigated	Rainfed
Intercropping	Wheat + rapeseed or mustard	Wheat + gram Barley + gram
Crop rotation	Maize - wheat, Basmati rice - wheat/ senji/metha/berseem/ gram, Cotton-senji - sugarcane, Maize - potato	Maize, wheat+gram/gram/linseed/ barley/mustard, Sorghum-gram, (Bajra + moth + guar) - gram Guar (cluster bean) - (gram + wheat)/barley, (Cotton + moong/ mash/ moth) – barley/gram/(wheat + gram)/ (barley + gram), (Groundnut + guar) - barley/ (wheat + grant)/ (barley + gram), Fallow - taramira/toria/mustard, Moth - barley/ (gram +barley)

The important reasons for inclusion of legume crops in rotation was due to their low nutrient and irrigation requirements.

Chemical fertilisers used were meagre. Nitrogen was the only fertiliser used and its consumption was 5 thousand tonnes in 1960-61. During 1996-97, consumption of chemical fertilisers in Punjab was 962 thousand tonnes of N, 229 thousand tonnes of P and 17 thousand tonnes of K fertilisers. With assured irrigation facilities and introduction of high-yielding crop varieties the area under rice has increased from 0.2 to 2.2 million ha and under wheat from 1.4 to 3.2 million ha from 1960-61 to 1996-97 (Hira and Sidhu 1998). Consequently the area under other crops such as maize, cotton and legume crops have virtually reduced to the minimum such that rice-wheat is the major crop rotation being practised in the Punjab.

The per cent area under cereals has increased from 50.9 in 1966-67 to 73.5% in 1997-98 (rice from 0.227 to 2.278 million ha and wheat from 1.4 to 3.3 million ha). The area under pulses (gram and others) has declined from 13.47 to 1.1%, oilseeds from 6.2% to 1.8% and sugarcane from 3.0% to 1.6% (Rangi and Sidhu 2000). Rice was not the traditional crop of Punjab. The fact is that the state with 1.53% of the



Cig I Agro Climatic Regions of Punjab

geographical area of the country contributed 64% of wheat and 42% of rice to the centra] pool of food grains during the year 1997-98. The average yield of rice and wheat was 1.19t/hain 1960, 2.19 t/ha in 1970,2.73 t/ha in 1980, 3.53 t/ha in 1990 and 3.89 t/ha in 1997 indicating that production tempo is being maintained though at a lower rate than that at the beginning of the green revolution. The high level of production is being maintained through increased use of chemicals, fertilisers, insecticides and herbicides. However, it has increased incidence of disease, induced micronutrient (Zn, Fe and Mn) deficiencies, compacted the subsoil layer and increased environmental pollution due to burning of rice residue and increased nitrate concentration in the ground waters. A solution to these problems may possibly be found in the revival of indigenous nutrient management practices traditionally practised in the Punjab. In the present paper indigenous nutrient management practices of Punjab are described along with the recent research related to these issues.

INDIGENOUS NUTRIENT MANAGEMENT PRACTICES

Recycling of nutrients through pond excavation

The practice of recycling of nutrients through pond excavation was common in the foothill zone and the central Punjab till fifties. Large surface tanks with unlined base are dug out at different locations on the periphery of the village to collect and store surface runoff along with sediments coming from open spaces, fields, roads etc. during the monsoon (Plate 1). The runoff water usually contains high amounts of clay and organic material which acts as a sink for retaining the minerals and nutrients which is allowed to settle in the pond. The sewage slurry and dissolved minerals and nutrients in water coming from animal sheds and household washings are also diverted to the common village pond. All the flocculated clay and organic materials usually settle quickly to give clear water of the pond. Animals used to drink water from this pond. The monsoon rain usually comes in the end of June and continues up to the end of September. During this period, the village ponds are filled up to the brim. During the months of October to March, enough water remains in the ponds. In the month of April, the ponds start shrinking in size and the pond area recedes to a minimum and becomes almost dry during the months of May and June. As soon as the ponds dry up, the farmers dig the pond base by lifting the soil and transport it to the fields. The surface layer of pond base usually removed is about 30 cm depth. This is a rich source of plant nutrients. The pond sludge is spread in the field as a thin layer and is mixed in the soil after breaking the large size clods into smaller ones. The application of pond sludge to each field is done once in a span of 10-15 years.

Plate 1: Encroachment of a village pond

Composted manure

There used to be two methods of preparing farmyard manure (FYM) (i) open pit for receiving the daily house-hold waste along with animal dung (ii) animal-hay- bed technology to receive the animaldung, urine and the left over crop residue in the open spaces.

Open-pit compost: From the time immemorial FYM preparation through open- pit is a common practice. The house-hold organic waste, the kitchen waste and the animal dung arecollected and used in the open - pit and allowed to decompose to prepare the FYM compost. It was common to have two pits, one for summer excavation and the other for winter excavation. Two pit system helped in alternate removal of compost such that the organic residue or animal dung was composted completely within a period of one year.

In the early times, the composting pits were usually *kaccha* (unlined) but very deep i.e. about 2-2.5 metres. But slowly the practice of horizontal spreading in large area was taken up in the periphery of the village. With the result the depth of present day pits is not more than 0.5 metres. The sweepings from cattle sheds and some urine soaked by finely ground wheat *bhusa* or paddy husk from the cattle shed floor (Plate 2 and 3) are removed every day along with the cattle dung and are put into the compost -pit.

Plate 2 : fanner spreading wheat bhusa on the floor of the animal shed

The household sweepings, kitchen waste, ash from *chulas*, grass clippings, green/ succulent weeds and other leafy materials collected every day are also deposited into the compost-pit. In the early times the composting pits were prepared by digging soil upto 1-1.5 metre depth. The dug out soil from the pit used to be put on the sides so as to raise the total height to about 2.5 metre. Each day's collection of organic wastes are spread uniformly into the pit. The pit is filled till the raw material stands about 30 cm above its edges.

Animal hay-bed compost: The animals are usually kept on the farm in the open space where they are exposed to sunlight in winter and tree shade during the summer months. The common fodders fed to cattle are legume hays such as groundnut leaves and stems, guar, senji, metha, gram straw etc. along with straws of wheat, maize, sugarcane, sorghum, maize, guar and millet stalks. Animals consume the soft parts of the stalks and leave behind the hard stems. On the hay-bedding hard stems of crop residues are crushed by animal movements and cut by their hoofs (plate 4). The animal

Plate 3 : Paddy straw application on the floor of the animal shed

Plate 4 : Animal-hay-bed technology'

dung and urine are automatically mixed up with the left over crop residue. In these days paddy hay is used as bedding material as shown in Plate 3. The hay-bed compost becomes ready to use in five to six months. This partially decomposed farmyard manure rich in animal urine is applied to the soil before the onset of monsoon. The manure after spreading evenly in the field is worked into the soil by ploughing followed by planking. The quality of cattle dung and urine depends upon the concentrate feeds and type of fodder fed to the cattle. Earlier commonly used concentrates cotton cake, cotton-seed cake, linseed-meal, groundnut cake, gram etc. are rich source of N, P, K., Mg and S. It has been found that 80% of N and other minerals fed to cattle through concentrate feed are recovered in urine and faeces.

Penning of cattle in the field

The practice of penning cattle in the fallow fields is common. Wooden logs are usually used to tie the animals in the fields. Frequent shifting of these wooden logs along with the cattle is done so as to cover the whole field for uniform distribution of the animal dung and urine. One or two fields by rotation are kept fallow to receive the animal dung and urine during summer as well as winter months. Large herds of sheep, goat and cattle are kept in the fallow fields. The farmers used to feel obliged and usually come with a request to cattle herd owners for the night stays at their fann land.

Large number of farmers in the Punjab are now moving their residences to farm lands along with the cattle population. The farmers need to be educated to keep some land fallow for penning the cattle in the fields. This will not only save the labour cost for the removal of dung from the cattle kept area but will enrich the soil through addition of urine and dung directly into the field without any loss of nutrients. This practice will help in reducing the ground water pollution through nitrates, volatilisation losses of N, and leaching losses of other minerals nutrients from the cattle dung and urine. The left over crop residues fed to the cattle will be added directly into the field and its decomposition rate will be faster due to mixing of cattle urine and dung with the soil.

Direct incorporation of night soil in the field

Human excreta (night soil) is a potential source of nutrients. In earlier days the addition of night-soil directly into the field was a common practice in the lands adjoining the periphery of the village. Such lands are usually called locally as *nieanian* -a term referred to as a very fertile soil. The highest yields of crops are obtained from such lands. Because of higher inherent soil fertility, the land value of *nieanian is* usually the highest of all lands of the village. The human excrements of children, old people and patients are mixed up with the equal volume of dry ash and put into the compost pit for fermentation. If we could handle the human excrements carefully it would provide a potential quantity of manure ingredients into the soil to meet the plant nutrient requirements.

Green manure

Cowpea, sesbania and cluster been are generally used for green manuring in Punjab.

Legume crops as green fodder

The strategy of growing green manure i.e. burial of crops in the field to meet fertiliser requirements overlooks their use as fodder. In the earlier times most of green manure (legume) crops such as cluster bean (guar), cowpea, moth, moong, senji etc. were grown either singly or mixed in other fodder crops such as bajra, sorghum, maize etc. and were used as a fodder. Burial of green manure crops is rarely practised. In an exhaustive study to quantify the saving in the dose of N fertiliser with green manure in maize-wheat and rice-wheat crop rotations, it has been found that fertiliser savings due to green manure varied from 75 to 112 kg/ha (Aggarwal 1987).

Fallowing

With increasing crop intensity to 186% at present in Punjab, there is now no land left fallow. However, more recently it has been observed that some of the innovative farmers have just started experimenting with the revival of the old practice of fallowing before sowing the sugarcane crop after the harvest of paddy crop. These farmers leave the soil fallow after the harvest of paddy crop in the month of September-October. The standing paddy straw left in the field after combine harvested rice crop is ploughed into the soil. Frequent cultivation of land is done during the months of October to January to incorporate the paddy straw into the soil. Organic manure is applied to the field in the month of November-December and allowed to mix up in the soil and decompose properly to encourage nitrogen mineralization (Plate 5). The sugarcane crop is planted in the month of February. The farmers have observed that by this practice they can get yield of sugarcane as high as 100 t/ha. Whereas, the normal yields even of autumn sown sugarcane crop in the month of October along with gobhi sarson is about 70 t/ha (Plate 6). The additional income from the yield of gobhi sarson during rabi season is less than the additional income from the increasing of sugarcane yield from 70 to 100 t/ha.

Use of strayv mulches

The application of straw mulches is an age old practice that was usually followed for protecting the seedling of summer crops such as sugarcane end maize from scorching heat of sun. Sugarcane is usually sown in the month of February/March. The emerging seedling in the month of April has to face an acutely harsh climate of hot and dry due to high solar radiation, high temperature and no rainfall during the month of April, May and June. Monsoon rains come in the end of June or beginning of July. Irrigation facilities available are far less than the water requirement of crops. So it is a common practice to conserve the soil moisture by fine bed preparation through repeated ploughing followed by planking. Straw mulch of sugarcane trash available from the previous harvested sugarcane crop is collected and applied in the month of March immediately after sowing the crop. The surface applied trash is covered with soil at regular intervals so as to protect it from the wind erosion during the summer months. The whole soil surface of the cropped field is usually covered with the trash application.

Plate 5 : A fallow field ready for sugarcane sowing often ploughing paddy straw in soil

Plate 6 ; Mixed cropping of sugarcane with gobhi sarson

EXISTING PROBLEMS OF NUTRIENT MANAGEMENT AND INDIGENOUS SOLUTIONS

- The excavation of pond basin and its application to fields was abandoned with the introduction of chemical fertilisers. Long time disuse of these ponds have resulted in the encroachment of pond area as shown in Plate 1. The impact of relinquishing this practice is clearly visible on nitrate concentration in ground water of 57 wells in Ludhiana and Hoshiarpur districts (Singh and Sekhon 1977). Findings of these investigations pointed out four-fold high concentration of nitrate in the waters of wells located near the village than those near the cultivated fields. Nitrate content of well waters (mg NO_3-N/ litre) under cultivated and village areas of Ludhiana and Hoshiarpur districts of Punjab is given below:

Sampling area	Time of sampling	No. of samples	Range	Mean
Cultivated	June	46	0.1-27.2	4.4
	September	33	0.2-36.0	4.5
Village	June	11	0.3-59.6	16.8
	September	9	0.4-60.4	19.7

Source : (Singh and Sekhon 1977)

- The reason for the high nitrate content of well water in the vicinity of the village has been attributed to the disposal of animal wastes. The additional factor responsible for the high nitrate content in the well water of village might be that farmers have stopped the practice of excavation of clay soil from the pond base and its application to the fields. Continuous monitoring of such well waters and that of pond water for nitrate content can throw some more light on the role of ponds in the recharge of nitrate in the ground waters.

- The practice of spreading wheat *bhusa* on the floor of animal-shed has been abandoned possibly due to increased availability of water through mechanisation for cleaning animal-shed. The urine along with the dung residue normally passes into the sewage, thus resulting in nutrient loss on one hand and increasing nitrate concentration on the other.

- The practice of animal-hay-bed has practically disappeared from all areas of Punjab except by some farmers. The main reason for the disappearance of this practice can be due to increased awareness for keeping the animal floor clean and lesser availability of space with ever increasing population of human as well as cattle.

- With the ever increasing cropping intensity, the practice of keeping land fallow has vanished and so is the case with the practice of penning cattle in the field. There is a dire need to reintroduce such practices to reduce load of nutrients in sewage water and minimise the pollution of ground water in the rural areas.

- Now-a-days, most of the rural families have installed their own open ditch pucca latrines (toilet) in which basement is opened into deep *kachha* (unlined) pit. The human excrements are directly joining the ground water. This has become a major source of ground water pollution through addition of nitrate content as well as of dangerous pathogens.

- The residue of paddy are mainly burnt in rice surplus states like Punjab and Haryana. Large scale burning of rice residue is posing a serious threat to air pollution. Rice and wheat residue (million tonnes) available in Punjab (1991- 92) and nutrient lost in burning is presented below:

Crop	Residue (mt)	Residue burnt (mt)	Nutrient lost in burning (mt)		
			C	N	S
Rice	15.0	11.3	5.7	0.06	0.006
Wheat	18.5	3.7	1.9	0.02	0.002

Source: (Beri and Sidhu 1996)

- Additionally, 0.1 million tonnes ofN is lost due to burning. Earlier ten years study showed that *in- situ* incorporation of rice residue gave lower rice (4.5 t/ ha) and wheat (3.72 t/ha) yields compared to burning of rice in the field where yield of rice was 5.57 t/ha and wheat 4.12 t/ha (Beri and Sidhu 1996). However, their recent experiments on *in-situ* incorporation of rice residue have shown comparable or higher yields of wheat and rice as that with burning provided the rice residue is incorporated 20 days before sowing the wheat crop.

Farmers are not adopting the practice of incorporation of rice straw before sowing wheat crop as little time is available between harvesting of paddy and sowing of wheat. The optimum sowing time of wheat is last week of October to first week of November. The optimum sowing time for long duration sunflower hybrid is first fortnight of December. The rice straw could be incorporated before sowing of sunflower. The land may remain fallow during the months of October and November.

PRESENT RELEVANCE OF THE TECHNOLOGY ADOPTED BY THE FARMERS

- The excavation and removal of the sediments from the pond base helps in (i) enhancing the infiltration rate of water during the monsoon and the storage capacity for water, and (ii) minimising the chances of nitrate addition to ground water through pond base. The high infiltration rate of water in the pond helps in increasing the recharge of ground water. In such a process, the unit area becomes self sustainable with respect to the surface removal of nutrients coming from the run off water and sewage water and putting back all these nutrients into the field in the form of sludge. Such an approach also reduces the chances of ground water pollution. Recent studies have shown that nitrate contamination of ground water is mainly confined to the vicinity of the villages.

- Open-pit compost contains reasonable quantity of plant nutrients. The average nutrient content (%) of manure components is given below:

Manure component	N	P_2O_5	K_2O
Cattle dung fresh	0.3-0.4	0.1-0.2	0.1-0.3
Cattle urine	0.9-1.2	traces	0.5-1.0
Night-soil	1.0-1.6	0.8-1.2	0.2-0.6
Human urine	0.6-1.0	0.1-0.2	0.2-0.3
Household-ash	0.5-1.9	1.6-4.2	2.3-12.01
Wheat straw	0.5	0.10	1.28
Paddy straw	0.36	0.08	0.71
Maize straw	0.42	1.57	1.65
Bajra	0.65	0.75	2.50
Sugarcane trash	0.35	0.10	0.60
Jowar	0.40	0.23	2.17

- The animal urine directly absorbed by the crop residue has two main advantages. Firstly, it prevents nitrate pollution of ground water. The urine which is a rich source of N in the form of urea is not leached into the soil which otherwise percolates downward and causes nitrate pollution in the ground water. Most of the urine N could be bound in crop residue. Secondly, urea form of N of animal urine lowers the C:N ratio of the crop residue which hastens its decompositionrate and thus helps in the preparation of compost from crop residue. In addition, absorption of urine by the crop residue helps to minimise the chances of volatilisation of urinary N. Studies on the distribution of elements in the urine and faeces of cattle have shown that 95% of K, 63% of N and 50% of S are present in urine. The loss of N (in the form of ammonia) due to fermentation of exposed cattle urine and the washing away of soluble mineral elements by leaching reduces its manurial value. About half of this N and potash and one- sixth of P are readily soluble and therefore subject to losses. The losses ofN and mineral elements can be reduced greatly by using absorbent bedding for cattle through animal hay-bedding technique. The relative absorbing capacity of various crop residues is given below:

Material	Amount of water absorbed (kg) by one kg of the material after 24hours of soaking
Wheat straw	3.71
Paddy straw	3.80
Maize straw	4.60
Sorghum straw	2.51
Bajra straw	2.66

Nitrogen in the urine exists mainly in the form of urea which readily changes into ammonium carbonate and ammonia through bacterial action. Ammonia is rapidly lost into the atmosphere through evaporation and the wind action. This loss of N can be minimised if cattle urine is allowed to be soaked by absorptive crop residue applied as animal-hay-bedding.

Thus, through this animal-hay-bed technology, the loss of soluble nutrients from urine is prevented by minimising seepage and encouraging bacterial decomposition of crop residues.

- The practice of cattle penning has the practical value. The fresh dung left in the field rapidly dries up. The drying checks the ammonification and loss of N. The dung is usually worked into the soil and therefore, does not loose much of its fertiliser value. The urine is absorbed directly into the soil and reduces the chances of volatilisation.

- About 60 days green manure crops save about 75 kg N/ha in maize and 40 kg N/ha in succeeding wheat crop. The maximum saving is accomplished with cowpea green manure followed by sesbania, cluster bean and FYM application. These green manure crops have some indirect effect like (i) advancement in the tasselling, anthesis, silking, and maturity by about 5 days in maize and advancement in the emergence of 6"' and 8"‘ leaf of wheat by about 4 days, (ii) increase in the root density of maize by about 16% in 0-15 cm layer, 30% in 1530 cm layer and 40% in 30-60 cm layer, and (iii) increase in nitrate reductase activity by about 1.2 to 1.6 times (Sekhon and Aggarwal 1994).

- Return from marketing of legume crop as fodder are about four times greater than that from saving of N fertiliser by burial of the legume crop. The mean energy and economic returns from burial of legume crops (green manure) to improve yields are about the same as that from marketing of legume crop as fodder sale and dairy enterprise.

Comparative energy and economic returns from legume crop used as green manure or fodder is given below:

Use of crop	Economic returns (Rs/ha)	Energy returns (10^s kCal)
Fertiliser substitution	475	15.8
Yield improvement	2192	45.5
Fodder sale	2070	69.0
Dairy enterprise	382	16.5

Source: (Aggarwal 1987)

- The old practice of fallow cultivation if combined with the paddy straw incorporation will have many benefits (i) increase the return per unit land area, (ii) control of weeds without use of chemicals, (iii) incorporation of paddy straw to enhance the soil fertility and reduce the environmental pollution by not burning the paddy straw, and (iv) conservation of water resources by not growing the crop during rabi season. Effect of straw mulching (6t/ha) on reduction in maximum soil temperature at 10 cm depth, irrigation water saving and increase in yields of crops during summer period is given below:

Crop	Mulch induced reduction in maximum soil temp. (°C)	Saving irrigation water (cm)	Increase in crop yield (%)	Saving in fertiliser N (kg/ha)
Maize (forage)	1.1-7.9	15	26	50
Maize (grain)	1.4-6.8	-	20	-
Sugarcane	1.0-9.5	40	13	-
Sorghum (forage)	0.5-7.0	23	20	50
Japanese mint	0.6-9.4	32	9	25
Mung bean	0.8-9.1	7	17	-
Winter maize (grain)	2.O-5.5	23	20	-
Autumn potato	1.0-5.7	12	15	-

BLENDING WITH SCIENTIFIC TECHNIQUES

Various research investigations and analysis reveal that the old practice of growing legume crops in mixture with other forage crops and use of green material as fodder to animals is a better proposition than that of growing green manure and its burial in soil. Thus the old practice of growing green legumes as fodder crops should be revived.

If the old practice of fallow cultivation is coupled with the presently advocated practice of paddy straw incorporationinto soil, it would help in increasing the carbon content of the soil and help in maintaining the soil productivity. The benefits and role of short time fallow cultivation along with straw incorporation in different crop sequences had not so far been properly investigated by the soil scientists/agronomists.

The favourable effects of straw mulching in sugarcane were observed by Sandhu *et al.* (1980). Application of mulch on an average, increased cane yield by about 14%. For similar cane yield, mulch saved 18 to 34 cm irrigation water during pre-monsoon summer period. Similar favourable effects of straw mulching on crop yields and irrigation saving in maize (Khera *etal.* 1976), potato, mungbean (Ranjan 1982), Japanese mint (Khera *et al.* 1986), forage sorghum (Sandhu *et al.* 1987) and winter maize have been realized.

In a recent survey it has been estimated that quantities of rice-straw burnt annually in Punjab is about 12 million tonnes and through this significant amount of nutrients are being lost (Sidhu *et at.* 1997), Calculated in economic terms, through N alone the Punjab farmers are losing Rs 684 million annually. Moreover, burning of rice straw is posing a serious threat of air pollution and increasing respiratory problems to local population. Keeping these aspects in view, Sidhu *et al.* (1997) initiated research on composting rice straw using the procedure of Banger *et al.* (1989). Composting of rice straw is done in covered cement tanks/digestors (75 cm deep, 75 cm diameter with lined surface) buried in soil. In each digestor, 10 kg air dried rice straw moistened in 15 litre suspension *of Aspergillus awamori*, *Bacillus polymixa* and 0.38% N as urea (on straw dry weight basis) in water is placed in 10 cm thick layers. Mats of *Bacillomyces fusisporus* grown on potato dextrose agar plates, cut into one cm square pieces is also placed randomly at various depths in the digestor. Powdered Mussoori rock phosphate (2.5 kg) is spread between the layers. Surface is kept moist by sprinkling about 200 ml water at every 2-3 days interval. The contents in a digestor are mixed 15 to 20 days after starting the process when 500 ml broth of *Pseudomonas striata* is sprinkled. Eighty two gram of urea granules per digestor are also added. A second mixing is done between 25 to 30 days when 500 ml of *Azotobacter chroococum* is added.

The field experiments from rice straw mixed with rock phosphate as described above showed that application of 8 tonnes of rice straw compost to both rice and wheat increased the yield of rice and wheat by 51 % and 40%, respectively over control. The above procedure for preparing phospho-compost is very long and cumbersome, possibly no farmer will be able to adopt such a technology for preparing compost from rice straw. The alternative to this technology that the farmers can adopt easily is to combine the phospho-compost technology with the traditional practice of animal-hay- bed technology. The Mussoori rock phosphate could be applied on the animal bedding and covered it with a layer of paddy straw at frequent intervals of time. However, no research work has so far been conducted in this direction. The best alternative to burning rice straw could be its application on the animal bedding along with massive application of rock phosphate. Research as well as extension efforts should be attempted on the animal-hay-bed technology for its improvement and its adoption by the farmer.

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CHAPTER 3

INDIGENOUS NUTRIENT MANAGEMENT PRACTICES IN HARYANA

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ABSTRACT

Haryana has been divided into seven agro-ecological zones based on the precipitation and soil types. The average fertilizer consumption in Haryana is about 136 kg nutrients (N+P f) +K f))/ha. About 9.73 million tonnes of animal dung is produced annually from the available livestock of the state. Among the various organic manures, cattle dung is one of the major sources. Some of the indigenous nutrient management followed by the farmers are application offarmyard manure, slurry from gobar gas plant, incorporation of crop residues like cotton stocks, use of industrial and urban wastes, green manuring etc. The other indigenous practice of nutrient management being followed by the farmers of western part of Haryana is the maintenance of Jandi tree in the field.

The ancient agriculture relied entirely on natural resources like animal dung as a source of plant nutrients. A diagnostic survey of the rice-wheat area of Kamal, Kaithal, Panipat and Kurukshetra districts of Haryana was conducted by a team of scientists from State Agricultural University, Indian Council of Agricultural Research, International Rice Research Institute (1RRI) and International Centre for Improvement of Wheat and Maize (CIMMYT). The team suggested that the farmers had to increase the dose of fertilizers to maintain the productivity of rice and wheat crops. The results of long-term field experiments indicated that the organic matter content of the soils is decreasing due to imbalanced fertilizer use. Thus, it is high time to think again of indigenous nutrient management which is being lost to modem agriculture and use it properly either in toto or after suitably refining it scientifically as per the need of the farmers.

BACKGROUND INFORMATION

Haryana has been divided into seven agro-ecological zones based on the precipitation and soil types (Fig. 1). These zones vary from moist zone in the north, east to extremely dry zone in the west of Haryana, The total geographical area of Haryana is 4399000 ha out of which 3615000 ha are under cultivation. The average cropping intensity of the state is about 168 per cent. The total irrigated area is 2766000 ha, which is about 76.5 per cent of the total cultivated area of the state. Canals or ha, which is about 76.5 per cent of the total cultivated area of the state. Canals or borewells are the major source of irrigation.

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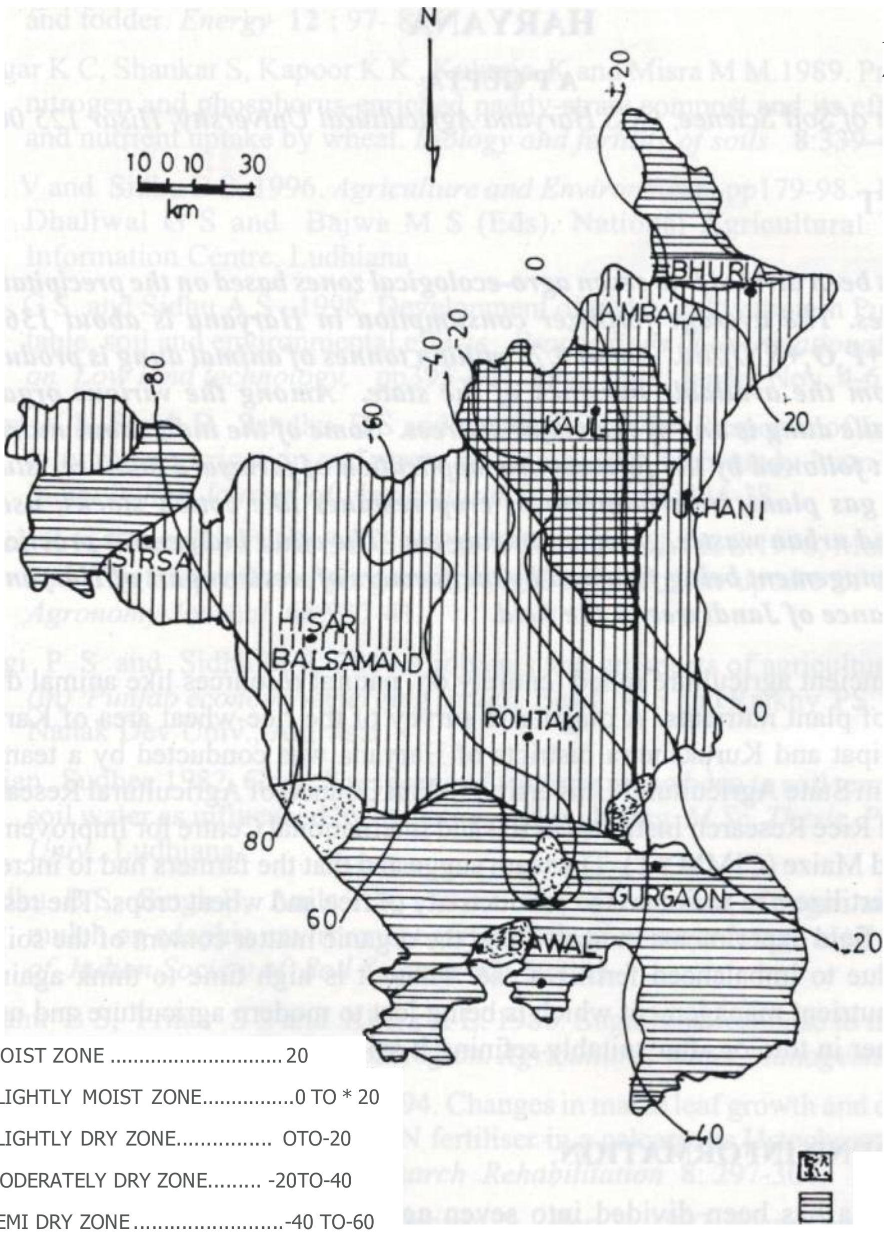

Fig. 1 Agro-ecological zone of Haryana

MOIST ZONE 20

SLIGHTLY MOIST ZONE...............0 TO * 20

SLIGHTLY DRY ZONE............... OTO-20

MODERATELY DRY ZONE......... -20TO-40

SEMI DRY ZONE ....-40 TO-60

DRY ZONE .... -60 TO-80

EXTREMELY DRY ZONE .... <-80

Haryana is divided into four broad agro-climatic zones, warm sub-humid (annual rainfa >1000 mm), hot sub-humid (annual rainfall 700-1000 mm), hot semi-arid (annual rainfall 350-700 mm) and hot arid (annual rainfall <350 mm). The major areas in the warm sub-humid zone are covered by forests; while rice, wheat and sugarcane dominate in the hot sub-humid and hot semi-arid zones and pearlmillet, cluster bean, wheat, mustard and gram in hot arid zone. The major crop sequences in the state are rice- wheat, cotton-wheat, fallow-mustard-sugarcane, pearlmillet-wheat and pearlmillet- gram. The average fertilizer consumption in Haryana is about 136 kg nutrients (N+P,0+K,O)/ha

In Haryana about 9.73 million tonnes of animal dung is produced annually from the available livestock of the state (Table 1).

Table 1 Livestock population, dung produced and nutrient potential in Haryana

Livestock	**Population ('000 Nos.)**	**Dung production (million t)**	**Nutrient p lotential ('000 t/ha/vear)**		
			N	**P_2O_5**	**K_2O**
Cattle	2133.6	2.35	2.24	0.85	1.43
Buffalo	4372.9	5.90	4.26	1.59	2.78
Sheep	1043.8	0.16	0.13	0.04	0.01
Goat	799.4	0.12	0.10	0.03	0.01
Poultry	8580.2	1.20	3.44	3.48	2.82
Total	16929.9	9.73	10.17	5.99	7.05

EXISTING PROBLEMS OF NUTRIENT MANAGEMENT

It has been diagnosed through various surveys that the organic matter content of the soil is declining with continuous cropping particularly under imbalanced fertilizer use. The decline in the organic matter content affect various chemical and physical properties of the soil and also the fertilizer response. Among the various organic manures, cattle dung is one of the major sources but about half of the total dung produced in the state is burnt as dung cakes. The waste generated from the agro-industries particularly from sugar mills and solvent extraction plants is also burnt in brick kilns. Organic manures application is labour intensive, which is also limiting its use in Haryana agriculture. Apart from the manures, almost all the crop residues, which have a limited use as fodder, are burnt by the farmers.

INDIGENOUS NUTRIENT MANAGEMENT AND PRESENT RELEVANCE TO THE FARMERS

Some of the indigenous nutrient management techniques followed by the farmers are described below:

Farmyard manure

The total dung available in the state has a potential to supply 24.21 thousand tonnes of N + P,O_5+ K_2O annually. About half of this is being converted into cakes and used as potential source of energy. Rest of the cattle dung is used for crop production. The cattle dung is stored in heaps on open area, exposed to rainwater and heat, which leads to losses of many essential plant nutrients. Such prepared farmyard manure (FYM) is applied to about 50,000 ha of cultivated land in Haryana constituting about 16 per cent of the total arable land. Farmers prioritize the application of FYM based on the fertility status of the soil judged by their experience and also based on the crops to be grown. The fields having low fertility gets the priority for FYM application. FYM is used mostly in potato, vegetables and sugarcane crops. If FYM is applied to a rice crop, nitrogen in the form of fertilizer can be reduced by about 60 kg N/ha. Apart from the cattle manure, farmers are also using poultry manure. Farmers believe that poultry manure has more nutrient supplying capacity compared to FYM but is not a good source of fertilizer for rice crop.

Slurry from gobar gas plant

Some of the farmers have installed *gobar* gas plants, which provide fuel for the domestic purpose and also manure for incorporation in the field. On the recommendations of the state agricultural universities, some of the farmers have opened two pits on both sides of outlet of a gas plant and the slurry produced is stored in the pits as shown in Fig. 2. The pit has enough capacity to store slurry for six months. The animal shed waste and the house-hold waste is also added to the pit. After six months the first pit is ready for use as manure and the slurry is stored in an another pit. Thus all the farm waste is composted and used as manure.

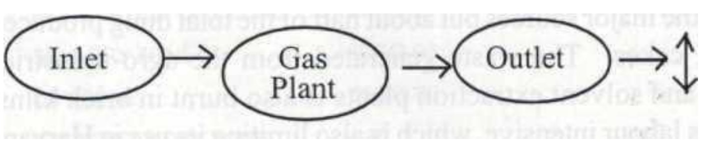

Fig. 2 Slurry management system of a biogas plant

Crop residues

About 25.3 million tonnes of residues are produced in the state which have potential of supplying about 4.79 million tonnes of nutrients (N+ P,O_5+ K,O) annually (Table 2). Most of the crop residues are being burnt by the farming community with the exception that some farmers incorporate sunflower stalks to the soil. Some of the farmers allow the animals to graze in the cotton field after picking the matured bolls. The unopened bolls of cotton contain fat. Once they are eaten by the animals, the fat content of milk increases and the dung is left in the field. After grazing is over, the cotton sticks are chopped into small pieces and incorporated into the soil. Incorporation of cotton sticks by farmers not only save fertilizer but also increase the yield of the succeeding wheat crop.

Table 2 Potential of crop residues and nutrients in Haryana

Crop Straw	Grain to straw ratio	Residue ('000 t)	Nutrient potential ('000 t)		
			N	P_2O_5	K_2O
Rice	1:1.5	3694.5	21.43	8.50	61.33
Pearl millet	1:2.0	1300.0	8.45	9.75	32.50
Maize	1:1.5	66.0	0.39	0.20	0.86
Cotton	1:6.0	256.2	3.84	1.17	5.12
Wheat	1:1.5	11739.0	57.22	29.35	150.26
Barley	1:1.5	135.0	0.58	0.28	1.62
Mustard	1:2.0	1788.0	5.54	2.86	13.41
Pulses	1:1.0	289.7	4.64	0.43	5.79
Sugarcane	1:0.2	6013.0	21.05	2.41	30.07
Total		25291.4	123.14	54.95	300.96

Industrial waste

In Haryana, there are 11 sugar mills, which are converting sugarcane into crystalline sugar. As on date 10 sugar mills are based on sulfitation process and one on carbonation process which will also be converted soon to the former process. Apart from sugar mills, there are four units of solvent extraction plants, which are extracting non-edible oil from castor cake. The production and the nutrient potentials from the pressmud and the castor cake are presented in Table 3. By using these wastes from the agro-based industries, about 6.65 thousand tonnes of $N+P_2O_5+K_2O$ can be recycled in agriculture, besides micronutrients.

Table 3 Pressmud and castor cake production and their nutrient potential in Haryana

Pressmud/Castor cake	No. of mills	Production ('000 t)	Nutrient potential ('000 t)		
			N	P_2O_5	K_2O
Pressmud (C)*	1	5.0	0.02	0.01	0.02
Pressmud (S)*	10	51.0	1.29	0.58	0.29
Castor cake	4	51.0	3.57	0.66	0.21
Total	15	107.0	4.88	1.25	0.52

*Pressmud (C) is of carbonation and pressmud (S) is of sulfitation process

Since inception of these sugar mills the farmers used to apply the pressmud to the agricultural fields, as it was available to the farmers at nominal charges. The pressmud is applied to wheat, potato, sugarcane and other vegetable crops. The present production of pressmud through sulfitation process can cover about 4500 to 5500 ha annually. From the last three years, the pressmud is being auctioned leading to the escalation of the price of the pressmud due to which its application to the agricultural field has been limited. Now the brick kilns, as a source of slow heat, are utilizing the pressmud. Similarly, the brick kilns in Haryana also use the castor cake. Farmers are also using the pressmud cake from the sugar mills based on carbonation process for crop production. The pressmud of the carbonation process contain about 60% CaCO,. Though the soils of Haryana are alkaline, crops respond well to pressmud of carbonation process.

Urban waste

There are two types of waste generated from the urbanization. The liquid portion is discharged through the sewer system and the municipalities auction the solid waste. However, both are used in the agriculture. In Haryana, about 163 million litres of the sewer water are produced daily which is irrigating about 326 ha of land around the cities. This water contains many essential plant nutrients as well as more of soluble salts and the toxic heavy metals. Farmers are using these waters for crop production, particularly for vegetable and fodder crops which gives higher productivity and more income to the farmers but without caring for the quality of produce as well as soils. The toxicants particularly heavy metals turn the soils unproductive by killing the soil micro flora. Under ***Yamuna Action Plan, the*** sewer treatment plants have been installed in Haryana and chances of pollution due to heavy metals will be minimized. Sewage sludge and the city solid waste are disposed off through agricultural fields around the cities.

Green manuring

Green manuring is being followed by a very small group of farmers in Haryana, particularly the progressive farmers. The crops like dhaincha, moong bean, cowpea, guar etc. are being used as green manuring crops. One of the innovations by such farmers is that they sell the beans of the pulse crops as vegetable and rest of the material is ploughed back to the soil. The green manuring is being followed only in rice-wheat area of Haryana. Growing pulse as green manure crop generate extra income as well as maintains the productivity of the soil which is otherwise declining due to continuous use of cereal-cereal cropping system. By adoption of green manuring practice, the farmers are also saving about 60-90 kg N/ha. Since this practice require water as well as machinery for incorporation, the area covered under green manuring is very small in Haryana.

The other indigenous practice of nutrient management being followed by the farmers of western part of Haryana is the maintenance ***ofJandi*** tree in the field. Farmers perception is that the tree provides multiple benefits. The wood is used as a source of fuel, leaves are used as fodder, fruit is used as a vegetable and the crop particularly gram grown under this tree gives more yield.

Crop rotation

When the crop yields are considered to be low in some fields, the farmers like to replace the main crop with a leguminous crop. This practice restores the productivity of the cropping systems in long run. When the weeds become a threat to wheat crop in various cropping systems, the farmers generally replace wheat with a fodder crop. This technology helps in reducing the weed population the next season.

SCOPE OF BLENDING INDIGENOUS TECHNIQUES WITH MODERN TECHNIQUES

It has been proved scientifically that the continuous application of 15 t FYM/ha could save 30 kg N and 20 kg P,O$_5$ in rice-wheat cropping systems. Apart from N and P,O$_5$ the application of K,0 and micronutrients can also be saved. Besides savings in the nutrients, the productivity of various cropping systems is enhanced and the fertility of the soil is improved. But its applicability is entirely dependent on the availability of the resources of organic manures. Green manuring also helps in savings of fertilizer N from 40 to 80 kg/ha in rice-wheat cropping system but the availability of water and the machinery to incorporate at the appropriate state is also very important to boost this technology with the farmers.

Indigenous nutrient management practices wisdom alive in India
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CHAPTER 4

INDIGENOUS TECHNOLOGY FOR NUTRIENT MANAGEMENT IN GUJARAT

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ABSTRACT

The state of Gujarat is endoyved with a variety of agro-climatic conditions (arid to sub-humid), soils (inceptisols, vertisols, aridisols), tribes and settlements. The fertilizer use varies accordingly. The inhabitants of this region practice numerous indigenous technologies for the nutrient management. It includes organic manuring, green manuring, use of local materials like tanch, pond silt, eolian sand, mulch, ash, spray of butter milk, permanent-furrow system etc. Some of these practices have been studied well. Their scientific base has been explored. However, these indigenous practices are location specific, cost-effective, have field validity and are a sort of appropriate technology for this region. It will be fruitful if we can direct our efforts for an in-depth study of this traditional wisdom.

The state of Gujarat is endowed with diverse pedo-edapho-meteorological conditions. Consequently a spectrum of socio-economically and culturally distinct people are engaged in agriculture. They owe time tested traditional wisdom for managing soil fertility.

Climate in conjunction with physiographic units reproduced array of soil types, which differ in its productivity, fertility, and adoption of crops and crop sequences. In this context the problems of nutrient disorders also vary. Inhabitants tackled it according to prevailing agro-ecological situations. It includes mulching in the hilly region, seasonal fallow in the intensively cropped area, green manuring in the assured water area, sheep penning in the arid region, organic manuring in the mixed farming area etc. In nutshell these traditional practices are location specific, cost-effective and bear high degree of field validity. To be more specific these are appropriate technologies, innovated, tested, improved and implemented since long by the local peasants. These are no any historical records of the same but these techniques are at the tip of tongue of the farmers and thus give results invariably. During the course of time the logic behind a traditional practice and the rationale of the same has been forgotten. Therefore, the main thrust should now be on the rapid documentation of the same followed by establishment of the rationale and refinement of it, if necessary. This is how traditional nutrient management practices provide good stuff for the research work. Therefore, a few glimpses of the traditional nutrient management practices followed in different agro-climatic zones of Gujarat are given in this paper.

BACKGROUND INFORMATION

The state of Gujarat, is located between 20°01' to 24°07' N latitude and 68°04' to 74°04' E longitude with an area of 19.6 m ha which accounts for six per cent of the total geographical area of the country. About 50 per cent of this area is under cultivation, of which only one fifth is irrigated. About 10 per cent area is under forest. The remaining 40 per cent is either left barren or unculturable waste. Of the total cropped area cereals and pulses account for 50 per cent, while the remaining area is under oilseeds, fibre and fodder.

The climate represents a wide variability, ranging from arid to sub-humid tropical monsoonic type. The mean annual rainfall varies between 300 to 2800 mm, covering 15 to 80 per cent of the mean annual potential evapotranspiration. The mean annual temperature ranges from 26° to 28 °C with the summer temperature ranging between 37° to 42 °C and winter temperature between 10^{n} and 18 °C. The state is divided into 7 agro-climatic regions (Fig. 1). Major traditional regions alongwith the details of climate, soil, cultivated area, major crops/crop sequences, fertilizer use and dominant traditional nutrient management practices are given in Table 1. It is evident from Table 1 that total rainfall and its distribution, irrigation facilities, irrigated area and soil types play a important role in deciding various crops to be grown and cropping system followed. In southern hill region with high rainfall, the important crops grown are paddy, pulses, vegetables, jowar, ragi, sugarcane etc. In case of comparatively low rainfall zone of south Gujarat the crops like cotton, wheat, banana etc are preferred in addition to pulses, sugarcane and jowar crops. Similarly though the rainfall is more or less the same, in middle and south Gujarat, tabacco is preferred in addition to crops like cotton, paddy, maize, groundnut as the soils are medium black to alluvial sandy loam to sandy clay loam. In kutch district with the lowest rainfall of the state, pulses, bajra, oilseeds and jowar crops are preferred and with irrigation facilities, cotton is grown. Major crop sequences followed in different agroclimatic zones of Gujarat state are as follows:

Agroclimatic zone	**Dry farming area**	**Irrigated area**
Southern hills	Paddy - maize	Sugarcane - paddy
South Gujarat	Cotton - groundnut	Paddy - wheat
Middle Gujarat	Cotton - sorghum	Green manuring - paddy
North Gujarat	Castor-pulses	Pulses - wheat - cumine
North-West zone	Pearlmillet - pulses	Pearlmillet - mustard
North Saurashtra	Pearlmillet - sorghum	Pearlmillet - groundnut
South Saurashtra	Groundnut- groundnut	Groundnut - wheat

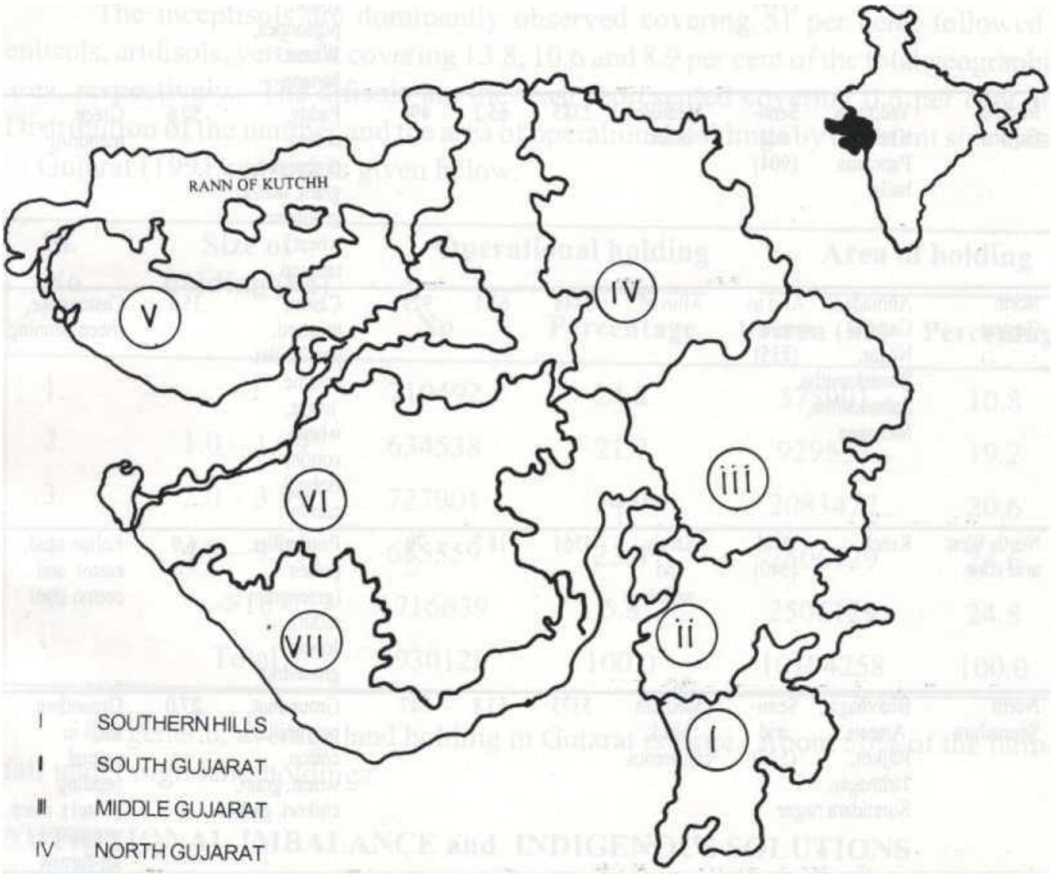

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Fig. 1 Agroclimatic zones of Gujarat state

Table 1 Details of the agro-climatic sub-regions of Gujarat following traditional nutrient management practices

SI. No.	Sub-region	Name of the districts	Climate/rain-fall (mm)	Soils	Geo graphical area ('000 ha)	Net area sown (%)	Irrigated area ('000 ha)	Major crops	▪ rtilizer use (kg/ha)	INMP*
1.	Southern hills	Dangs. Valsad	Semi arid (1793)	Deep black	701	43.2	62	Paddy (rainfed), pulses, jowar, ragi, sugarcane	50.9	Stubble mulch
2.	South Gujarat	Surat, Bharuch	Sub humid (974)	Coastal alluvial	1670	53.5	169	Paddy, sorghum, cotton, pigeonpea. Wheat, banana	61.9	Seasonal fallow
3.	Middle Gujarat	Vadodara, Kheda, Panchma halls	Semi-arid (904)	Medium black	2385	65.2	498	Paddy. cotton. pigeonpea, gram, maize, groundnut, wheat, tabacco	59.6	Green manuring
4.	North Gujarat	Ahmadad, Gandhi-Nagar, Banaskarntha, Sabarkantha, Mehsana	Arid to semi arid (735)	Alluvial	3848	63.1	929	Castor, mustard. pearlmillet, sesame, jowar, wheat. cotton, isabgul, cumin	35.7	Castor cake, sheep penning
5.	North-West arid zone	Kutch	Arid (340)	Sandy and saline	4561	18.7	79	Pearlmillet, pulses (greengram moth). Jowar, groundnut	6.9	Eolian sand, castor and cotton shell
6.	North Saurashtra	Bhavnagar, Amreii, Rajkot. Jamnagar, Surendara nagar	Semi-arid (537)	Medium black calcareous	5373	63.8	747	Groundnut, pearlmillet, cotton, wheat, gram, chikori, garlic	27.0	Groundnut. shell in animal bedding (Plate 1), *lanch*, permanent set-furrow
7.	South Saurashtra	Junagadh	Arid to Sub-humid (844)	Coastal alluvial medium black	1061	57.9	161	Groundnut, wheat, bajra, gram, banana, sugarcane	39.0	Organic manure. Wheat straw mulch

*** Indigenous Nutrient Management Practice**

Source: (Kute 1990)

Weather parameters like rainfall, temperature, soil including irrigated area are directly correlated with fertilizer use. In Gujarat the fertilizer use is the highest in south Gujarat (Zone II). It is due to optimum rainfall and its distribution, better soils and sufficient irrigation facilities. It is followed by middle Gujarat (Zone III) where the rainfall is slightly lower, irrigation facilities are optimum. In southern hill (Zone I), though the rainfall is the highest, the irrigation facilities are less and hence fertilizer consumption is comparatively less. The least fertilizer consumption is in North Western arid zone. Thus it is clear that the fertilizer consumption is consistent in high rainfall and irrigated areas. However, in low rainfall and dry farming areas with less irrigation facilities, particularly in Kutch area fertilizer consumption is less.

The inceptisols are dominantly observed covering 51 per cent, followed by entisols, aridisols, vertisols covering 13.8,10.6 and 8.9 per cent of the total geographical area, respectively. The alfisols are the least represented covering 0.6 per cent area. Distribution of the number and the area of operational holdings by different size classes in Gujarat (1991 census) is given below:

SI. No.	**Size of holding (ha)**	**Operational holding**		**Area of holding**	
		No	**Percentage**	**Area (ha)**	**Percentage**
1.	<1	710492	24.2	375991	10.8
2.	1.0-1.99	634538	21.7-	929557	19.2
3.	2.0-3.99	727901	24.9	2083477	20.6
4.	4.0-9.99	685559	23.4	2506129	24.6
5.	>10	1716639	5.8	2506129	24.8
	Total	2930129	100.0	10104258	100.0

In general, average land holding in Gujarat is large. About 50% of the fanners fall under high land holdings.

NUTRITIONAL IMBALANCE and INDIGENOUS SOLUTIONS

Continuous cultivation of soils has caused nutritional imbalance in the agro-climatic sub regions of the state. It varies with the soil type, climatic conditions, and crop sequences. Causes for different nutritional imbalance, and possible solutions are given in Table 2.

Table 2 Nutritional imbalances and indigenous solutions in agro-climatic sub-regions ofGujarat state

SI. No.	Sub-region	Nutritional constraints	Cause	Indigenous solution	Rationale
1.	Southern hills	N,K	Erosion	Stubble mulch	Controls erosion
2.	South Gujarat	Zn	Intensive cropping	Seasonal fallow	Gives rest to the soil
3.	Middle Gujarat	S, Zn	Water logging	Green manuring	Improves fertility and infiltration of water
4.	North Gujarat	N, P, Zn	Light texture hence leaching	Sheep and penning, castor cake	Improves water holding capacity and soil fertility
5.	North-west arid zone	Salinity	Wind erosion, sea-water intrusion	Cotton & castor shell, eolian sands	Reduces soil salinity, improves percolation of water
6.	North Saurashtra	P, Fe	Aridity „	Murrum, permanent furrow	Improves available water content and soil fertility into the permanent furrow
7.	South Saurashtra	P, K, Zn	Lime	Organic manure, wheat straw mulch	Improves soil fertility and conserve soil moisture

The southern hills are sloppy lands. A lower pediment embodies residual clays. Soil erosion is a major factor washing away the mobile nutrients especially nitrogen and potassium. Maize and paddy are the major crops exhibiting N and K deficiencyTribals of this region harvest maize and paddy leaving 6 to 10 inches of stubbles. Sometimes they pick up only cobs of com. The stubbles so left protect soil from erosion by the initial torrential rains.

South Gujarat is a heavy rainfall area and ample irrigation water is available. Farmers generally go for intensive cropping which exhausts the soils. Yields are gradually diminishing. Zinc is the deficient micro-nutrient in these soils. Fanners believe that soils have become cold. They also describe as a soil *fatigue*. It may be because of the phagocytic infertility of soil. To combate this problem farmers keep the soil fallow. They use the term *pasiu* to the fallow piece of land and they harvest good crop after the *pasiu*.

Middle Gujarat is a plain land. Water logging is a major production constraint. Deficiencies of N, S and Zn prevail in the major plain land. Farmers practice green manuring of *Dhaincha* as water is ample here. Green manuring improves soil fertility and infiltration of water.

North Gujarat is endowed with light textured aridisols. Deficiency of N, P and Zn are common. Nomadic tribes are engaged in animal husbandry. Sheep penning is a tradition to boost soil productivity. Enterprising farmers also use castor cake as a manure. This is how they have sustained the crop yields since decades.

North-western part encounters twin problem of salinity and aridity. Crop yields are quite low. Farmers spray the extract of *lakha luna-a* local hallophyte alongwith irrigation water. The extract, which is highly saline, boosts plant growth through improving the percolation rate of these marshy lands. Saline extract of hallophyte might be improving electrolyte concentration of soil solution and might be inducing high percolation of water, which may reduce salinity temporarily. But the first beneficiary is a crop plant standing on that field. Moreover, farmers also add castor and cotton shells, which they suppose, reduce soil salinity/alkalinity.

Saurashtra is a peninsular region of the state. Coastal part experiences aridity and salinity. Soils in other parts are calcareous in nature. Lime induced Fe chlorosis is a major nutritional disorder in groundnut besides other minor crops. Organic manuring, permanent-furrow system, addition of *murrum* has been considered by the farmer as a remedy to yellowing since the time immemorial. Mixed farming is a common practice. Hence farmers produce farmyard manure (FYM) every year. They manure their field in alternate years. The fields have permanent marking of furrowssince several decades. They manure, fertilize and sow the crop in the same set furrows since several decades. Soil, physico-chemical and nutritional properties of the soil in furrows were superior to the soils in between the two furrows. This is the major indigenous practice generally followed by the farmers in the Saurashtra region who have been harvesting sustained yield of groundnut since last 70 years. Crop rotation has also an impact in reducing the iron chlorosis. The fields where groundnut follow pearlmillet, the magnitude of iron chlorosis in groundnut is less.

Plate ; 1 A storage of groundnut shell on the farmers fields

Plate : 2 A storage of wheat straw on the farmers field

Besides some indigenous techniques like butter milk spray on groundnut, addition of paddy husk and sugarcane trash, inserting iron peg into stem, application of fish and poultry meal and manure, and table salt are in practice for different crops either to remove the nutrient disorder or to improve yield. The details of these techniques are given in Table 3.

Table 3 Scientific base and upgradation of the indigenous remedy to the nutrient imbalances inthe crops

Crop	Production constraint and visual symptoms	Scientific base	Indigenous remedy	Upgradation
Groundnut	Yellowing	Fe deficiency	Butter milk spray	Need of a compound 'which can keep iron in the reduced state before absorption by the plant
Paddy	Bronzing	Zn deficiency	Addition of paddy husk	Need for judging the paddy husk as a source of Zn
Wheat	White dots on the grains	N deficiency	Seasonal fallow	Need to check the effect of split applications of nitrogen
Sugarcane	Bunch top	B and Mo deficiency	Addition of sugarcane trash	Need to check whether sugarcane trash can maintain B/Mo ratio
Papaya	Impotent	Fe deficiency	Inserting Iron peg into the stem	To assess alternative sources of iron
Garlic & Onion	Mumification of bulbs	Multi nutrient deficiency	Ash	To test potassium and micronutrients as a solution to the mumification

Cotton appropriate and effect of the	Diminishing yield	Multi nutrient deficiency	Crop rotation, sheep penning	To evaluate crop rotation cycle to evaluate the sheep penning on soil and the crop
Mango status of during late	Late Flowing	Multi nutrient deficiency	Fish meal/ poultey manure	To establish micronutrient soil and role of bioenzymes flowering
Coconut to the improves Need to response of	Low Yields	K deficiency	Table salt application	Application of salt coconut tree Available K into Rhizosphere. Check the Coconut to K

PRESENT RELEVANCE OF THE INDIGENOUS PRACTICES ADOPTED BY THE FARMERS

Organic manure

Farmyard manure is a main source of organics in soils of Gujarat. The FYM is prepared in pits or heaps for 10 months. Traditionally, it is applied to the field in the month of May. Field testing of the indigenous practice under LTFE revealed that the average yield of groundnut is high under FYM as depicted in Fig. 2a (Malavia *et al.* 1999). High co-efficient of variation under NP (88%) and NPK (73%) compared to FYM (72%) treatment indicate that FYM is a major component technology in sustaining the groundnut yield during last 20 years of experimentation.

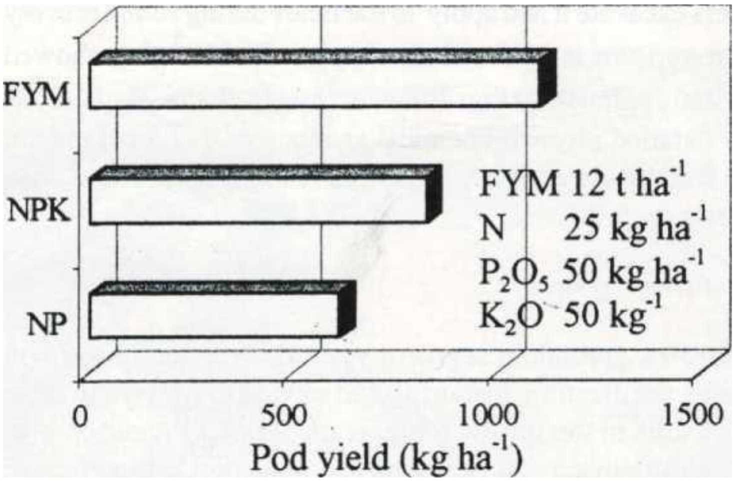


Fig. 2a Effect of FYM on groundnut (20years mean)

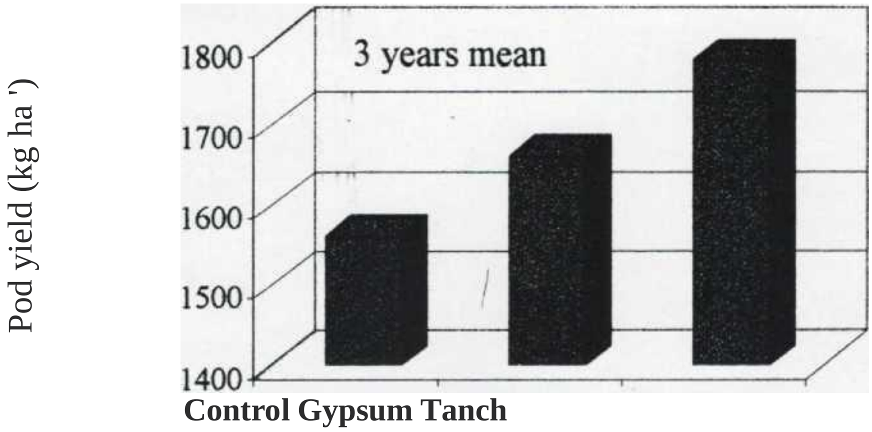


Fig. 2b Effect of soil amendments on groundnut

Mur rum

It's a uppermost weathered part of trap basalt termed as a *tanch* in the common parlance. Farmers excavate it and apply to the fields during summer every year. Farmers use *tanch* when gypsum is in the short supply. Field testing showed that *tanch* is superior to gypsum application (Fig. 2b) in increasing the yield of groundnut (Golakiya *et al*. 1998). A detailed physico-chemical analysis of this local material (Patel *et al*. 1989) revealed that the use of *tanch* has improved aggregation and water transmission properties of soils.

Permanent set-furrow system

In set furrows, groundnut is grown year after year in the same furrows (plate 2 and 3). Ploughing, fertilization, manuring and sowing every year in set-furrows change the properties of soils in the furrow (Patel *et al*. 1988). Organic carbon content, NPK. levels, water holding capacity and other physico-chemical properties of soil are turned up favourably due to the indigenous tradition of set-furrow system. This is perhaps the reason why Saurashtra fanners are harvesting sustainable yield of groundnut since last seven decades (Patel *et at*. 1983) (plate 3, 4, 5).

Plate : 3 A premonsoon sett of groundnut field with permanent furrow marking and heaps of FYM

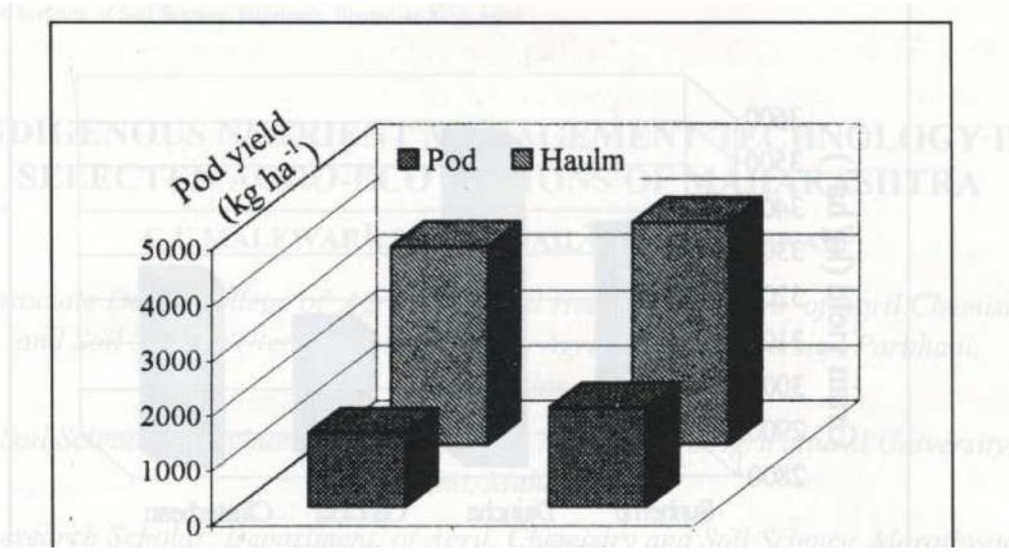
Plate : 4 The sowing of groundnut on the permanent furrow marking

Plate : 5 Groundnut in the permanent furrow

Mulch

Stubble mulching is common in the high rainfall areas. Rich farmers harvest the crop with combined harvester and use wheat straw as a mulch (plate 5). Some times they bum up the straw. It is their belief that ash boosts the growth of subsequent crop. Moreover, burning immunizes the soils too. Mulching effect on groundnut has been studied under field conditions (plate 6) for three-years (Ghosh *et al*. 1997, Golakiya 1999). Wheat straw mulch not only improved the pod and haulm yields (Fig. 2c), but also raised the organic matter and nutritional status of soil. Moisture and thermal regimes of the soil were also improved which sustained the groundnut yields.

*Plate : 6 Experimental field on wheat straw mulch*I



Control **Mulch**

Fig. 2c Ejfeci of mulch on groundnut (3 years mean

Green manuring

Green manuring with Dhaincha in the transplanted rice is practised in more than 88000 ha area in middle and south Gujarat during the period between onset of monsoon (in the second week of June) and transplanting of the paddy (in the first fortnight of August). Suitability of Dhaincha, Gliricidia and clusterbean as a green manure crop has been tested in the paddy fields for three years which showed that Dhaincha was superior to Gliricidia and clusterbean in increasing paddy yield (Fig. 2d). The benefits of these indigenous technologies are given in short in Table 2. ***Sheep penning***

Sheep penning is an age-old, cost-effective, practical and scientific indigenous nutrient management practice in the arid south Saurashtra agroclimatic zone. The litters of sheep get well mixed with soil during the period of penning. Light cultivation before the onset of monsoon makes it more effective. Sheep feed on the existing farm residue and drops litter in the same field during resting period. This is how sheep penning is an appropriate practice of nutrient recycling. The excreta of sheep is acidic in reaction. Hence, it is more effective in arid alkaline soils. Fanners follow rotation of sheep penning dividing entire field into yearly pockets. Farmers also increase the penning period in the patches with poor soil fertility under intensive cultivation. It increases the bulk of litter deposit in the desired patches of the field. Sheep penning practice requires an in-depth study for the efficient nutrient management.

SCIENTIFIC BASIS & SCOPE OF BLENDING THE INDIGENOUS TECHNIQUES

A few of the major indigenous practices have been studied as mentioned above. Scientific basis of many traditional practices followed to manage the nutritional

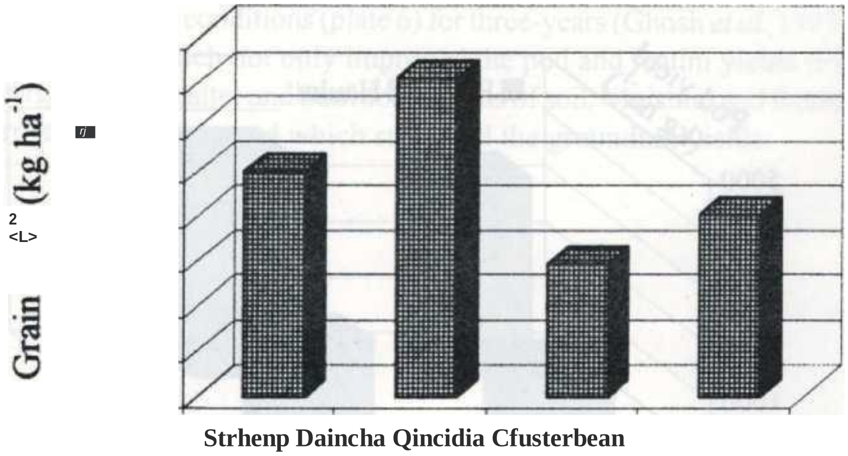


Fig. 2d Effect of green manure on paddy (3 years mean)

imbalances is yet to be established. Several such practices are listed in Table 3. But on the first place we should have a good documentation of these indigenous practices. Moreover, the description of such indigenous knowhow is also recorded in the old scriptures for example *Vrukshayarveda* - a text by Varahmihir. If we want to attend this aspect properly there should be a separate project with a specific mandate.

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CHAPTER 5

INDIGENOUS NUTRIENT MANAGEMENT TECHNOLOGY IN SELECTED AGRO-ECO REGIONS OF MAHARASHTRA

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ABSTRACT

On the basis of the long time practical experience of more than 35 years of the senior author including time to time discussions with teams of farmers and extension workers this compilation is made. In all 16 indigenous nutrient management practices have been described which are in vogue in nine agro-climatic zones of Maharashtra. The technologies refer to are use of dung-urine slurry, vermiculture through rislii- krishi method, use of soil of ant-hill + cowdung + urine + biofertilizer smearing to seed, use of Gadhies (Buruj) soil or tank and well silt, feeding of banana suckers/ pseudostem to sitting cattle in the field, practice of confining sheep/goats on uncropped land, practice of raising nursery on the place of sitting cattle/sheep/goat herd, burying of dead animals under fruit trees, robbing in rice fields, burning of sugarcane trash in the field, use of rice husk, sorghum stubble, use of fish waste direct and after composting, practice of utera crop after rice, use of residual fertile soil for growing legumes on rice bund and utilization of organic residue (biomass) of mung/urd in cropping system/intercropping. The practical utility of these technologies, present relevance and transformation of indigenous technology into new scientific technology with research backup in few cases are also suggested.

Traditional agriculture has an old origin which is based on religious Vedas, published and un-published experiences of farmers in the form of notes, compilations and books. It has perpetuated itself by allowing farming community to developIndigenous nutrient management practices - wisdom alive in India agriculture that understood how to conserve soils and their fertility. This agriculture was diversified, according to the type of environment, soil, climate and other ecological features. These indigenous packages of practices in the form of technologies were in vogue in our country till independence. Traditional agriculture has, however, slowly become modem with the introduction of chemical fertilizers, insecticides and pesticides including the use of high yielding varieties/hybrids of various crops. Swarup *et cd.* (1998), Goswami (1998) summarized the lessons learnt from long term fertilizer experiments under Indian conditions particularly the adverse effect of continuous use of N alone on crop yields and soil properties, comparative superiority of NPK + FYM over NPK on long term basis and overall superiority of proper blend of organic + inorganic fertilizers for optimum yields of crops without soil deterioration. These observations clearly emphasised the relevance and significance of traditional agricultural technologies for keeping the production system sustainable. Few indigenous nutrient management practices, though not supported by scientific reasoning, their usefulness can not be overlooked. On the other hand there is need to blend old and present nutrient management practices into new technologies for viable and effective agricultural development. Thus, an attempt is made to dig out old nutrient management practices, to evaluate their manurial value, scientific basis if any and further equate with present technology and formulate new blend on the basis of supporting evidences.

BACKGROUND INFORMATION

Maharashtra occupies an area of 307.7 lakh hectares, which is about 1/1 o"' of the geographical area of the country. It lies between 16.4° and 22.1°N' latitudes and 72.6" and 80.9 °E' longitudes. The western ghats (Sahyadri) run north to south separating the coastal districts of Thane, Raigad, Ratnagiri and Sindhudurg from rest of Maharashtra. The western slopes and the coastal districts get very heavy monsoon rains, w'hile to the east of the ghats rainfall drops to less than a tenth within a short distance from the ghats. Fortunately, all the important rivers, which originate from the watersheds of ghats, like the Godavari, the Bhima and the Krishna flow east across the drier regions and contribute to economic benefits. The east-west oriented ranges of Satpura and Ajanta are comparatively less important in modifying the climate. Though, Maharashtra experiences a tropical climate, it can further precisely be classified into (a) Hot and humid monsoonic climate, (b) Dry climate, and (c) Tropical rainy climate. According to the Agroclimatic planning unit, Maharashtra can be divided into 3 agroclimatic zones (Eastern plateau and Hills region), Western Plateau and Hills region and Western coast plains and Hills region). Western plateau and Hills region occupying a major part of the state covers 22 districts which are further agroclimatically subdivided into 4 sub-zones i.e. Hills, scarcity, plateau with relatively medium black soils and plateau with medium to deep black soils. As per NARP, the Maharashtra State is divided into 9 agroclimatic zone (Fig.1).

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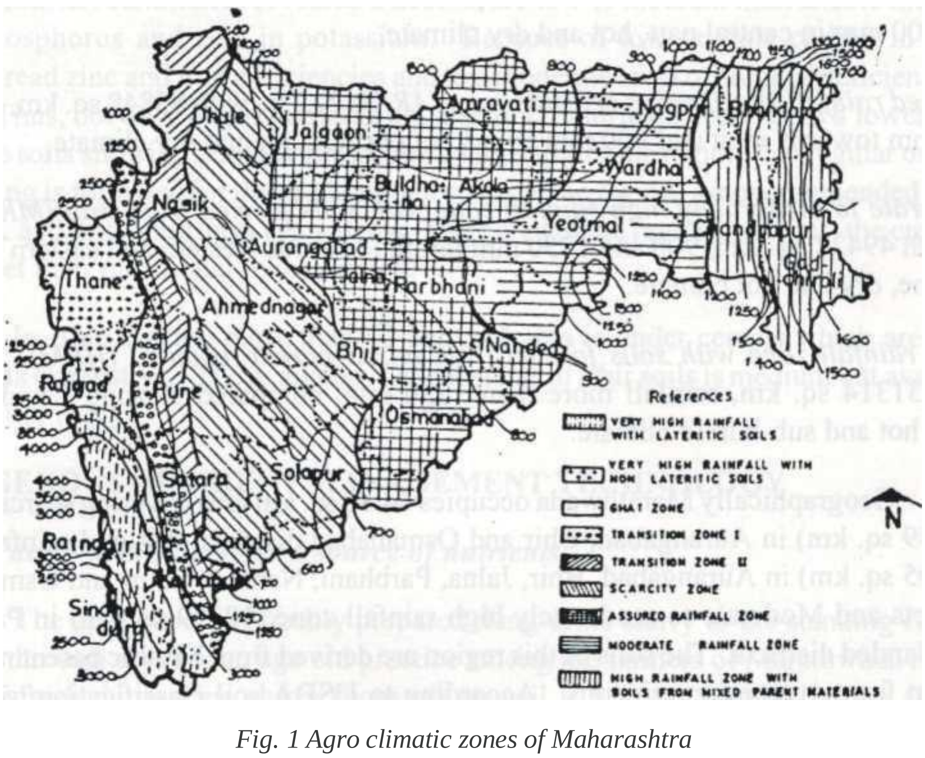

Fig. 1 Agro climatic zones of Maharashtra

Very high rainfall zone with lateritic soils (VRL): 5.1 % of the total geographical area of the state (16008 sq. km.), rainfall more than 2500 mm with hot and humid climate.

Very high rainfall zone with non-lateritic soils (VRN): 3.7 % with 11300 sq.km, rainfall morethan 2000mm with more hot and humid than zone 1.

Ghat zone (GH): 3.0 % with 9165 sq.km, rainfall more than 3500 mm, lowest maximum and minimum temperature as compared to all other zones.

*Transitional-1 zone with red to reddish brown soils (TRI):*3.7 % with 11289 sq. km, rainfall 2500 to 1750 mm.

Transitional-2 zone with greyish black soils (TR-2): 5 % with 15402 sq.km, rainfall 1750 to 700 mm, with hot summer and winter temperature than zone 3 and 4.

Scarcity zone (SC): 25 % with 77362 sq. km, rainfall 700 mm towards west and east and 500 mm in central part, hot and dry climate,

Assured rainfall kharif crops oriented zone (ARK): 27.7 % with 85848 sq. km, rainfall 700 mm towards west and 900 mm in eastern portion, hot and dry climate,

Moderate to moderately high rainfall zone with soils formed from trap (MR): 16.2 % with 49422 sq. km, 900 and 1250 mm rainfall towards western and eastern portion of zone, dry and hot climate.

High rainfall zone with soils formed from mixed parent material (HRM): 10.5 % with 31314 sq. km, rainfall more than 1250 mm, compared to zone 7 and 8, but more hot and sub-humid climate.

Geographically Marathwada occupies 64.80 sq. km area covering scarcity zone (11049 sq. km) in Aurangabad, Bhir and Osmanabad districts; Assured rainfall zone (41005 sq. km) in Aurangabad, Bhir, Jalna, Parbhani, Nanded, Latur and Osmanabad districts and Moderate to moderately high rainfall zone (12759 sq. km) in Parbhani and Nanded districts. The soils of this region are derived from basaltic parent material rich in ferro-magnesian minerals. According to USDA soil classification, soils are placed under the order Vertisols (13.0 per cent of total area), Inceptisols (64.8 per cent) and Entisols (22.2 per cent). Rainfed farming constitutes 88-89 % in Marathwada while 11-12 per cent area is under irrigation mostly concentrated in Parbhani, Nanded and Jalna Districts.

The average fertilizer use varied from 15 to 75 kg/ha, the highest being in Nanded district and the lowest in Osmanabad district. Kharif sorghum, cotton, summer groundnut, bajra, rabi sorghum, sunflower, safflower, wheat and soybean are the crops which are usually grown in Marathwada. In heavy black soils, cotton and kharif sorghum, are raised as a single crop in rainfed conditions and rabi sorghum on residual moisture. Mung (Kharif)-rabi sorghum (Rabi), paddy-gram, sorghum-wheat, soybean- sunflower and soybean-safflower cropping systems are also followed. Similarly,

sorghum + tur, bajra -t tur, tur + sunflower, cotton + tur, til + tur intercroppings are advocated. In irrigated agriculture cotton-summer groundnut, seasonal sugarcane, hybrid sorghum-sunflower-summer groundnut, hybrid sorghum-wheat-guar, paddy- potato-summer groundnut, chilli-wheat-ladies finger, sugarcane + potato and sugarcane + onion intercropping are the existing cropping systems in Marathwada.

EXISTING PROBLEM OF NUTRIENT MANAGEMENT

There are few constraints in nutrient management particularly in Vertisols and associated soils. Soil test summaries revealed that soils are low to medium in available nitrogen and phosphorus and rich inpotassium. Because of low organic carbon in soils, widespread zinc and iron deficiencies and to a moderate level of sulphur deficiency are seen. Thus, not only major nutrients but also micronutrients declined to a lower level in these soils showing nutrient stresses on a large area of the region. No regular organic manuring is followed for the predominant crops of the region. No recommended doses of NPK and micronutrients are added on large area of the region and, thus, the crop can not meet their nutritional requirements.

In Bhir district, more than 60 per cent area is under cereals which are more nutrients exhaustive. The available N and P status in Bhir soils is medium but available potassium is high.

INDIGENOUS NUTRIENT MANAGEMENT TECHNOLOGY

Use of dung-urine slurry as a source of nutrients

The application of freshly prepared dung-urine slurry to the standing crop on soil or through spray is an age old practice among the farmers of Marathwada region. Use of fresh dung-urine slurry (booster) on soil is a usual practice by the fanners irrespective of size of holdings in fruit crops at the time of flushes of mango, sweet orange, grapes, banana and in cash crops like cotton and chilli in Latur, Parbhani, Nanded, Jalna, Bhir, Osmanabad and Aurangabad areas. The dung-urine slurry is also used in fallow land and mixed with soil on small area of the region. In the remote cattle sheds, channels are dug and urine of cattle pass through these channels to the pit. In the morning dung is collected and thoroughly mixed with urine to prepare dung- urine slurry and is applied on soil or sprayed to the standing crop.

Use of rishi-krishi method for vermiculture

In this region, mostly the progressive cultivators have started traditional method *(Rishi-krishi)* of vermiculture. They collect 25 kg soil from the base of banian tree which is sufficient for sprinkling *Amrit pani* uniformly on an acre. The *Amrit pani* consists of 250 g ghee prepared from cow milk + 500 g honey + 200 litre water + 10 kg cowdung. Firstly, ghee is mixed with cowdung thoroughly followed by honey and then water is added to it. A mixture of soil (25 kg) and well-prepared *Amrit pani* is broadcast on an area of one acre uniformly. Normal earthworm count in one acre is 43560 but by the addition of this admixture *(Amrit pani),* the earthworm count in an acre get doubled (87120) due to enhanced energy and congenial soil environment. If the weight of one worm is 20 g which eats about the same quantity of soil, in 100 days, one worm can excrete 1 kg excreta. Then 87 thousand worms will excrete 87 tonnes of excreta rich in mineral nutrients, organic carbon, microbial population, organic acids, growth harmones and growth promoting substances. The experience of progressive farmers in case of sugarcane, banana and other fruit crops is most encouraging in respect of yield and quality of the produce.

Use of soil of ant-hill + cowdung + cow urine slurry for smearing the seedsalong with biofertilizers

Farmers from Nanded district, occurring in moderate to moderately high rainfall zone, use a slurry of 2 kg soil collected from ant-hill + 4 litre of cow urine + 2 kg cow dung mixed with 250 gm culture of *Azotobacter/Rhizobium* and 250 g phosphate solubilizing bacteria (PSB) culture to smear 20 kg seed of mono/dicotyledonous crops. After smearing the seeds, with the slurry they are dried and sown in the field. This technology helps in better growth and healthy crops and a significant increase in yields of wheat, soybean, cotton and groundnut.

Dung-urine slurry provides major and micronutrients in available forms which partly supplement the requirement of crops. The effects of added dung-urine slurry on the standing crops appear to be instant as it produces green dense leaves, increases height, biomass, and improves root volume and weight.

Scientific approach to improve indigenous technology': The manurial value of dung and urine has been improved through systematic research conducted at MAU. The blending of old and new technology i.e. dung-urine slurry enrichment with beneficial microorganisms and chemical fertilizers including micronutrients resulted in improvement of dung-urine slurry. Decomposition of dung-urine slurry for 96 hours i.e. 4 days is an ideal period for obtaining maximum availability of nutrients and microbial load of beneficial microorganisms and growth promoting substances. The balanced blend of chemical fertilizers and beneficial microorganisms formulated in the Department of Agricultural Chemistry and Soil Science, MAU, Parbhani is referred to as organic booster. The procedure for preparing organic booster is: 1 kg packet of organic booster is added to 4 kg dung in earthen mud pot and then 20 litres of water is added. The materials are throughly and completely mixed. The mouth of earthen pot is tightly closed with muslin cloth. The mixture is incubated for 4 days and stirred every day so as to intensify the microbial processes. Similarly, 300 and 600 g urea and single super phosphate, respectively are added to it to enhance the rate of decomposition and enrich the slurry. After 4 days the slurry (20 litres) is diluted by adding double the quantity of water (40 litres). It is recommended to use 1 litre slurry to a tree less than 2 years age and 2 litres to a tree of 5 years. Usually it is applied thrice at an interval of 15 days. The effect is seen after 1.5 to 2 months. The experience of organic booster users on fruit crops and field crops in entire Marathwada and other part of the state indicated that the root development increased by 12 to 46 per cent and yield increased by 29 to 48 per cent. Due to use of organic booster on oranges and sweet oranges of mother plants girth of stem and leaves of plants significantly increased. Further, the field experiment conducted during 1994-95 on banana using various organics/ inorganics indicated a significant variation in weight of bunch, total sugars of banana and nutrients availability in soil (Table 1). Among all the treatments, recommended dose of fertilizer (RDF) + organic booster @ 6 litre/plant was the best in increasing the weight of bunch, total sugars and availability of major and micronutrients in soil.

Table 1 Effect of different manurial treatments on yield, quality and soil available nutrients inbanana grown on Vertisol

Treatment	Weight of bunch (kg)	Total sugar (%)	Nutrients in soil ------- (kg/ha)-----		
			N	P2O5	K_2O
T] = RDF (200-150 - 200 g NPK/plant)	13.9	17.2	248	16.9	375
T, = 75% RDF + Organic booster @ 6 lit/plant	18.9	19.5	302	19.2	402
T = RDF + Vermicompost @ 5 t/ha (1.125 kg/plant)	16.1	18.8	281	17.1	394
T. = RDF + ZnSO 29 kg + $FeSO_q$40 kg/ha	17.5	19.2	286	18.1	398
CD (P=0.05)	1.18	0.80	9.4	1.61	10.2

RDF = Recommended dose of fertilizer

Use of gad hies soil, tank and well silts as source of nutrients

In old days mud was utilized for construction of *gadhi* or *buruj* in the villages. It is an age old practice to apply *gadhies (Buruj)* white soil to the cultivated lands which acts as a source of nutrients. As per cultivators' version, gadhies soil (white soil) is also named as *phu-phu* or *zaad* which not only improves the soil fertility but also improves the drainage if it is applied in ill drained soil. The practice of using *gadhies* soil is more concentrated in Bhir district but occasionally seen in other parts of the Marathwada region. Similarly, tank and well silts are applied to fields for raising crops in Marathwada, Vidarbha and western Maharashtra regions.

Thus, application of white soil and silt would enrich nutrients in cultivated soil and further act as an amendment particularly in heavy clay soils of the Marathwada region.

Scientific base: Though adequate scientific data base is not available, *gadhies (buruj)* soil (white soil) contains high amounts of mineral matter, having low water holding capacity as compared to clay. Thus, white soil can play a dual role i.e. as a source of nutrients and also as an amendment to improve physical properties of heavy clay and ill-drained soils. Usually, silt obtained from tank or well is a fertile fraction of soil. It contains 0.3 % each of nitrogen, phosphorus and potassium.

Use of waste suckers/pseudostem of banana as feed to animals allowed to stay in the harvested fields and return of cattle dung-urine to soils

In Jalgaon district 32000 ha area is under banana cultivation. Similarly, in Ardhapur area of Nanded district and in Malegaon-Basmat area, banana cultivation is done on 5000 and 4000 ha, respectively. A large number of banana growers allow the Kathiawadi tribal farmers to stay in banana harvested fields alongwith their cattle herds (cows/buffaloes). The tribal people chaff the green suckers/pseudostems and feed them to the cattle. Their staying period depends upon cash payment by the landlords and also availability of waste suckers/pseudostem in green condition. After completion of a period of 7-15 days, the added dung and urine is incorporated in the field by the farmers. On an average a buffalo/cow adds 10-16 kg dung and 6-8 kg urine/day. The dung contains 0.40,0.20 and 0.10 per cent NPK, respectively while fresh urine contains 1.0, traces and 1.35 per cent N, P and K, respectively. The added dung and urine enriches are preferred districts for sheep and goat rearing. Shepherd in Bhir and Osmanabad districts in particular and other districts in general travel along with their sheep and goat herds through out *talukas!A*\strict in search of feed/fodder/green twigs. The farmers request the shepherds to stay with their sheep and goat herds and offer the shepherds food/fodder and cash for 4-7 days. The added sheep/goat dung and urine is incorporated in soil by the farmers. Normally one sheep/goat gives 0.35 to 0.95 litre urine which contains 1.7, 0.2 and 0.25 per cent N, P^O. and K^O, respectively. On an average, a sheep/goat gives 382 kg dung and 188 kg urine per year.

The sitting of cattle herds, sheep and goats on the farm and incorporation of dung-urine in soil is practised on limited area. This practice has to be repeated on the other parts of the farm for creating uniform fertility and biological activity. Decomposition of added solid and liquid (dung+urine) depends on the soil moisture availability, native P and Ca levels in soils and temperature regime of the soil. Because of these factors, uniform decomposition of organic biomass may not be possible and gaseous and volatilization losses N are likely to be more.

Raising of rice nurseries in the field where cattle/sheep-goat herd were allowed to sit

In eastern Vidarbha, Bhandara, Chandrapur, Gadchiroli and Nagpur districts rice is grown as a main crop. The rice growers either keep their farm animals in the field during night hours or sheep-goat and bullocks-cow herd are kept on farm by inviting shepherds/cattle owner to sit their animals on payment for 4-5 days during summer. The farmers during ploughing, and harrowing demark the specific area of animal silting where significant amount of dung-urine is returned to the soil. After demarcation, they prepare the nursery bed by mixing and incorporating dung-urine added to the soil through animal sitting. The rice seeds are thickly sown in nursery and seedlings raised from this nursery never exhibit yellowing and iron chlorosis. Consequently, vigorous and fast growth of rice nurseries takes place.

Burying of dead animals (pet or domestic) under the fruit trees

Throughout the region, farmers' practice is to bury the dead domestic/pet animals under the fruit trees, specifically, under the mango tree. Their wisdom is that on decomposition, manure is added to the soil and they also love and express sentiments towards animals.

The dead animal contains large amount of biomass, mineral matter in the form of structure and bones specifically nitrogen in protein, phosphorus in bones etc. As a result of its decomposition, a large amount of organic matter is added to the soil in addition to release N, P, S and other nutrients which may improve the quality of mango. Raw and steamed bone meal is applied to mango trees at the time of flush in lateritic alfisols of Konkan area of Maharashtra.

Rubbing in rice fields

This is a traditional practice to collect stubbles, roots, rice straw from the field and spread over the small area of the field meant for raising rice nursery. Besides, the farmers add dry twigs collected from forest or bring twigs, branches and leaves of green forest trees, dry them and spread over rice waste. This biomass is burnt to ash and mixed with soil. On this land the farmers raise rice nursery. This practice is followed in two agroclimatic zones i.e. very high rainfall zone with lateritic soils (16008 sq, km) and very high rainfall zone with non-lateritic soils (11300 sq. km). The farmers believe that large amount of potassium and other nutrients are made available to rice crop. It also helps in controlling weeds, insect-pests and pathogens.

Alfisols/Oxisols are usually deficient in potassium particularly when these soils are derived from laterization process. The soils of rice growing area are also showing relatively more extent of K deficiency. Though, the farmers did not know about K deficiency in these soils, rabbing is a traditional practice followed by the farmers. The wood ash contains N 0.1-0.2%, P_2O_S 2.5-3.0%, and K2O 3.5-4.5 % in addition to traces of micronutrients. The nutrient composition may vary with forest trees species, used in this practice. Thus, this traditional practice has much relevance with the nutrient supply system.

Burning of sugarcane trash in the field

In western Maharashtra (Ahmednagar, Satara, Sangli, Pune, Kolhapur, Nasik districts etc.), the large amounts of cane trash available from sugarcane culture is burnt in the night hours. This is done to clean the field for growing the next crop. The fanners are of the opinion that mineral matter is added to the soil, A small amount of the cane trash after chopping is used in vermicomposting.

Scientific basis: By adopting this tradition, mineral elements particularly potassium essential for the growth of crops are added to the soil. On the basis of preliminary studies conducted on this aspect at Konkan Krishi Vidyapith (KKV), Dapoli, it has been shown that the rabbi ng practice in the rice field has little or no relevance because of some disadvantages like loss of beneficial microbial population.

(1985) compared the effect of burning wheat stubble on soil microflora over no burning. Total bacterial count was reduced in the range of 62 to 94 per cent in varied type of soils. Reduction in the Rhizobia and Azotobactor due to burning varied from 13 to 100 and from 56 to 100 per cent, respectively (Table 2). Probably, this is one of the reasons that KKV, Dapoli did not approve the practice of rabbing of stubble, roots and straw of rice and dried branches of forest trees.

Table 2 Effect of burning of wheat stubbles on soil microflora

Field No.	Treatment to stubbles	Total bacteria (XIO^4)	Reduction (%)	Actino-mycetes (XIO^4)	Reduction (%)	Fungi (XIO^4)	Reduction (%)	Rhizobia (XIO^4)	Reduction (%)	Azoto-bacter (XIO^3)	Reduc-tion (%)
I	Unbumt	140	84	41	63	22	32	33	64	28	72
	Burnt	22		15		15		6		8	
2	Unburnt	105	62	30	66	12	8	31	13	32	56
	Burnt	40		10		11		27		14	
3	Unburnt	165	85	102	75	16	50		32	38	95
	Burnt	25		25		8		3		2	
4	Unburnt	170	94	50	74	32	69	70	93	53	100
	Burnt	10		13		10		5		0	
5	Unburnt	190	90	58	78	22	50	90	95	30	90
	Burnt	21		12		11		4		3	
6	Unbumt	110	78	71	85	29	73	85	100	28	84
	Burnt	24		10		8		0		10	
7	Unbumt	205	91	65	80	26	77	105	90	25	76
	Burnt	18		13		6		10		6	

Use of rice husk as a source ofpotassium and organic carbon

Eastern Vidarbha region which comes under high rainfall zone is called a bowl of rice. After dehusking of paddy, large amount of waste husk is accumulated in the premises of rice mills. This husk is utilised for industrial and agricultural purposes. At household level, the fanners bring the husk from rice mills and use it as fuel. The powdery ash is composted with farmyard manure (FYM) and other farm wastes and used as manure. During winter the rice husk is burnt for making hot water and ash obtained is accumulated in the form of heap. After harvesting of rabi crop, powdery ash is transported to the fields and mixed with soil, while ploughing and harrowing. In some areas, direct application of rice husk in the field at the time of puddling is also a traditional practice. Due to puddling, decomposition of rice husk get enhanced and supplies potassium and other nutrients to rice crop. Some farmers transport the powdery ash to the field where they want to raise rice nursery in April-May and keep in the form of heaps. With the onset of monsoon, the powdery ash is uniformly spread on a small area, mixed and rice nurseries are raised. The rice nursery raised on ash amended soil grows vigorously and healthy seedlings are obtained.

Sorghum stubble used as a source of organic manure

Kharif sorghum is grown as main crop for grain and fodder in the Parbhani district. After kharif sorghum, wheat is taken under irrigated condition without removal of the stubbles and roots of kharif sorghum. The farmers irrigate the field and sorghum stubbles get decomposed and add organic matter to the soil alongwith available forms of nutrients which can be utilised by standing wheat crop.

Use offish waste as a source of nutrients

In coastal districts of Konkan region of Maharashtra, the farmers are traditionally using raw fish waste or fish waste compost for raising fruit crops and field crops. Fish is a daily food item in this coastal area. Nearly 50 per cent of fish remains as a waste which is rich in mineral and organic contents. The farmers daily collect the fish waste of their own house and also from other houses and deposit it in pit at the comer of their house. Further, they also collect the fish waste from the sea coast and fish market and add into the pit. They collect forest litter from the premises and use as fuel. The ash obtained is also added to the pit. The matured compost is applied to coconut, chikku, mango and cashewnut plantation and field crops at the start of monsoon or before the first flush of the fruit crops. The compost is well mixed with soil so as to increase its use efficiency. Another method is to apply raw fish waste directly to the field and incorporate it in the soil within the reach of active root zone of coconut, mango and other fruit crops.

The manurial value of fishmeal is known to the farmers since centuries and it is a traditional practice to apply fish meal to the fruit crops. The non-edible fish contains: 4 to 10 % N, 3 to 9 % $P_?O_5$ and 1 % $K_?O$ with C:N ratio of 4 to 5. Thus, on complete decomposition, it not only releases N, P and K in available form for the crops but also improves the soil physical condition. Thus, this technology has much scientific relevance for its adoption by the farmers. However, more work is necessary for blending this technology with the latest scientific techniques.

Growing of legumes (utera crop) for nutrient conservation

Now-a-days, farmers are fully aware of the importance of growing legumes for grain and nutrient conservation in soil through addition of biomass and biological N fixation. In the eastern Vidarbha region, rice culture in wet land condition is a prominent practice. When the rice panicles get tilted, towards the maturity time, the excess water is drained from the fields towards maturity and seeds of *lakh, lakholi,* horsegram are broadcast in the standing rice crop. The legume seeds easily germinate on residual soil moisture. When rice crop is harvested (about 2-3 weeks after sowing of legumes), the growing tip of legumes are also cut down along with harvest of rice crop. Within a week or so the plants show vigorous growth due to cutting of tips and proliferation of roots.

The practical relevance lies in taking the advantage of residual soil moisture, no tillage, no fertilizers and conservation of nutrients through residual fertility build up usable by the next kharifrice crop. This is also scientifically matched by introducing a legume crop in sequential cropping without any inputs except seed.

Growing kharif legumes on bunds

In Bhandara, Chandrapur, Gadchiroli and Ramtek *tehsil* ofNagpur district where *utera* crop is taken in the previous year for conservation of soil fertility, the residual fertile surface soil is collected before monsoon, and put on big bunds of rice fields spaced at 1.5 to 2'. About 100-150 g soil is heaped at every 15-20 cm distance within the bunds. At each heap, 2-3 seeds of tur are sown at a depth of 5 cm and covered with soil. With the onset of monsoon, the seeds germinate on residual fertile soil. About 2- 3 rows, depending upon width of bunds, tur crop is taken in addition to rice crop which gives additional yield of the tur crop.

Because of residual fertile soil collected from *utera* crop fields and with sufficien moisture available in the field, the seed germination is 100%. This crop is raised on bunds without any tillage operations and without any fertilizers. The scientific justification for successful technology lies in the use of residual fertile soil which supports primarily germination, emergence and initial growth. After root proliferation, it also utilizes native nutrients and also fixes atmospheric nitrogen in association with N fixers.

Utilization of residue of nioong and urd after their harvest in a cropping system approach

This practice is in vogue in assured rainfall zone and moderate to moderately high rainfall zones of Marathwada region. The farmers grow short duration legumes (moong/urd) in kharif season. After harvest of these legume crops, the remaining dry biomass is incorporated in the field by ploughing/harrowing and mixing completely in the soil, which adds organic matter to the fields. These legume crops, having narrow C:N ratio decomposes very fast and release other nutrients which can be utilised by the next rabi crops like sorghum or wheat. This technology has relevance in the present day condition because fertilizer input is becoming costly.

Scientific backup to the indigenous technology: Sufficient work has been carried out on soil-crop management systems for sustainable agriculture since two and halfdecades in India. In Marathwada Agricultural University, Parbhani, Lomte *et al.* (1999), conducted long term manurial trial since 1991 on sorghum based cropping system. They pointed out that growing sorghum + pigeonpea (3:3) intercropping in strip and changing strip arrangement every year significantly improved the chemical properties, fertility index and micronutrient availability of soil as compared to other cropping systems (Table 3). Reddy (1997) observed a significant variation in yield of cotton due to incorporation of blackgram residue in blackgram + cotton intercropping. These results confirmed the validity of the indigenous technology for nutrient management for sustainable agriculture.

Table 3 Nutrient availability in soil as influenced by cropping system

Treatment	**Available nutrient**				
	N	**P_2O_5 —(kg/ha)**	**K_2O**	**Organic carbon** (g/Rg)	**Zn (ppm)**
Cropping system (S)					
S] - Sorghum - cotton	235	11.9	370	4.30	0.98
S2 - Sorghum - pigeonpea	339	13.4	401	6.30	1.13
S3 - Sorghum + pigeonpea (3:3)	378	15.7	448	6.80	1.27
(with changing strip every year)					
S4 - Sunhemp - rabi sorghum	311	13.0	388	6.00	1.07
S5 - Greengram - rabi sorghum	292	12.3	379	5.40	1.04
S5 - Sole sorghum (monoculture)	189	10.1	344	3.20	0.81
CD (P=0.05)	4.52	1.04	10.70	0.200	0.135
Initial value (1991)	**223.0**	**11.4**	**369.0**	**4.80**	**0.92**

There is an immediate need to test, modify and convert traditional nutrient management practices into usable, viable technologies through intensive research efforts and scientific back up.

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CHAPTER 6

INDIGENOUS NUTRIENT MANAGEMENT TECHNIQUE IN NORTHERN TRANSITIONAL ZONE OF KARNATAKA

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ABSTRACT

Agriculture is the most important occupation of the people of Karnataka and it contributes 63 per cent to the state's income. The Northern transitional zone is the eighth agro-climatic zone of Karnataka. It has a total geographical area of 1.21 million ha with a cultivable area of 0.95 million ha of which 0.082 million ha of land is irrigated. Wells are the main source of irrigation. The soils of the zone are medium to deep black, red sandy loam and mixed red and black. The zone is blessed with south west and north east monsoons. The knowledge of agricultural systems accumulated by the farmers include seed selection of different crop varieties, cultivation paractices, terracing and land preparation. The indigenous knowledge have indeed been retained, adopted and implementedfor survival by the local farmers, often in an environmentally sustainable way. Unfortunately, much of the ancient lore associated with soil management has been lost and only a fraction remains and adopted by the farming community in the region. The indigenous nutrient management practices are still existing in the farming community which are worth mentioning. They include use of farmyard manure (FYM), compost, green manuring, addition of tank silt and to some extent crop rotations. With the advent of modern science and technology, indigenous practices and knowledge preserved in traditional cultural practices have been diminished considerably. There is now a growing concern to blend traditional wisdom with modern technologies maintaining harmony with the environment.

"Indigenous" indicates knowledge acquired by local people through their past experiences. However, this evolves over the time under the influence of traditional knowledge, external factors and agents and individual innovations (Simpson 1994). Indigenous knowledge systems reflect the knowledge, decision making and organising structures developed by particular communities to utilise, manage and conserve soil fertility and productivity resources. Karnataka is inhabited by a multiethnic community endowed with rich ndigenous knowledge of agriculture practices. The knowledge of agricultural systems iccumulated by the farmers include seed selection of different crop varieties, cultivation practices, terracing and land preparation. However, with the advent of modem science ind technology, indigenous practices and knowledge maintained by traditional cultural practices have considerably been diminished. Unfortunately, much of the ancient lore issociated to soil management has been lost and only a fraction remains and adopted *ry* the farming community in the region. Now-a-days, fertility and productivity have ieen reduced by many causes, generated by human activities those have impact on different fanning systems used by each ethnic group. Thus, there is now a growing :onem to blend modem with traditional technologies to maintain harmony with the environment.

BACKGROUND INFORMATION

Karnataka, has a geographical area of 19.1 million ha occupying eighth position in the country. Geographically it is situated between 11° 31' and 18° 45' N latitude and 74° 12' and 78° 40' E longitude. The state has 28 districts and 175 *talukas* which are divided into four revenue divisions *viz.*, Bangalore, Mysore, Belgaum and Gulbarga. About 71 per cent of the population lives in villages depending mainly on agriculture and allied activities (Rastogi 1991). Agriculture which is the most important occupation in the state, contributes nearly 63 per cent to the state's income.

Out of the 19.1 m ha, net area sown is 10.3 m ha which forms 54 per cent of the total geographical area in **the** state and 3.1 m ha are under forests. Only 20 per cent of the net area sown is irrigated, Of the remaining 80 per cent, as much as 70 per cent falls under dry zone, while only 10 per cent of the net sown has assured rainfall. Consequently, the croppng intensity is rather low at 110.50 per cent. In most of the area monocroppng is the rule because of uncertain and scanty rainfall. In the assured rainfall areas (only 10 per cent) covering hilly, coastal and tansitional areas, double cropping is practiced.

Based on rainfall pattern, topography, soil characteristics, cropping patterns etc. the following 10 agro-climatic zones are identified in Karnataka (Fig.l). For the delineation of a zone, a *taluka* has been taken as the smallest unit.

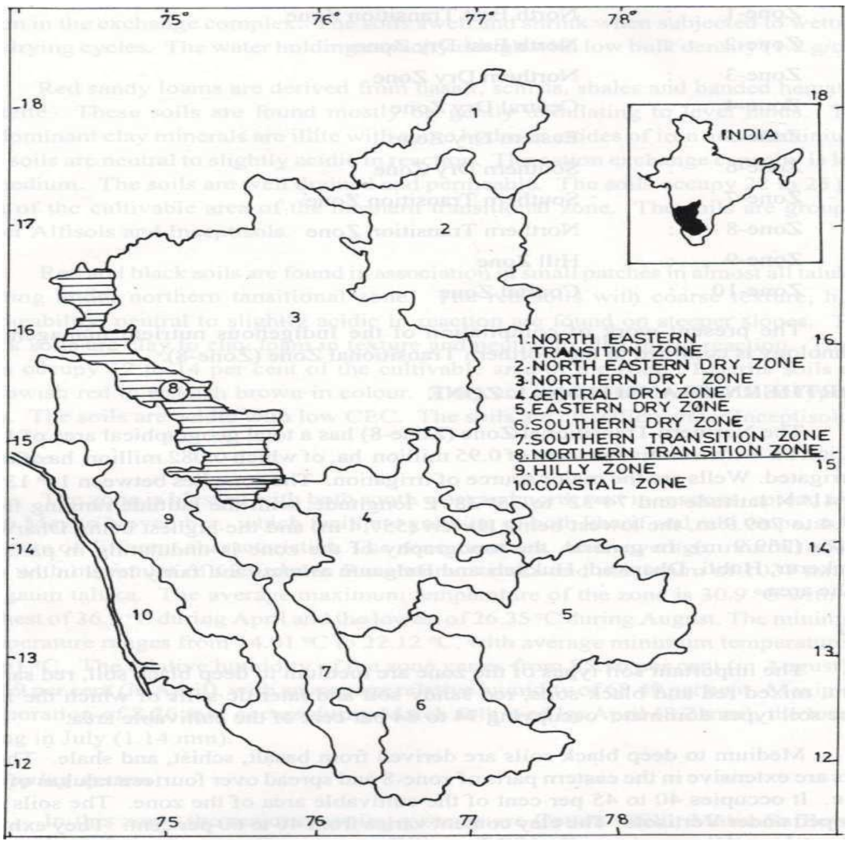

Fig. 1 Karnataka agro-climatic zones

Zone-1	:	North East Transition Zone
Zone-2	:	North East Dry Zone
Zone-3	:	Northern Dry Zone
Zone-4	:	Central Dry Zone
Zone-5	:	Eastern Dry Zone
Zone-6	:	Southern Dry Zone
Zone-7	:	Southern Transition Zone
Zone-8	:	Northern Transition Zone
Zone-9	:	Hill Zone
Zone-10	:	Coastal Zone

The present work of compilation of the Indigenous nutrient management technology is confined to theNorthern Transitional Zone (Zone-8).

NORTHERN TRANSITIONAL ZONE

The Northern Transitional Zone (Zone-8) has a total geographical area of 1.21 million ha with a cultivable area of 0.95 million ha, of which 0.082 million ha of land is irrigated. Wells are the major source of irrigation. The zone lies between 14° 13' to 16° 41' N latitude and 74°32' to 75° 38' E longitude, with the latitude ranging from 557.4 to 769.9 m, the lowest being Haveri (557.4 m) and the highest being Dharwad *taluka* (769.9 m). In general, the topography of the zone is undulating in parts of Hirekerur, Hubli, Dharwad, Hukkeri and Belgaum *talukas* and fairly level in the rest of the area.

Soil

The important soil types of the zone afe medium to deep black soil, red sandy loam, mixed red and black soils, red sandy soil and lateritic soils of which the first three soil types dominate occupying 74 to 84 per cent of the cultivable area.

Medium to deep black soils are derived from basalt, schist, and shale. These soils are extensive in the eastern parts of zone-8 and spread over fourteen talukas of the zone. It occupies 40 to 45 per cent of the cultivable area of the zone. The soils are grouped under Vertisols. The clay content varies from 40 to 60 per cent. They exhibit high cation exchange capacity (CEC) and base saturation. Calcium forms a major cation in the exchange complex. The soils swell and shrink when subjected to wetting and drying cycles. The water holding capacity is high with low bulk density (1.2 g/cc).

Red sandy loams are derived from basalt, schists, shales and banded hematite quatzite. These soils are found mostly on gently undulating to level lands. The predominant clay minerals are illite with some hydrous oxides of iron and aluminium. The soils are neutral to slightly acidic in reaction. The cation exchange capacity is low to medium. The soils are well drained and permeable. The soils occupy 22 to 25 per cent of the cultivable area of the northern transitional zone. The soils are grouped under Alfisols and Inceptisols.

Red and black soils are found in association in small patches in almost all talukas coming under northern tansitional zone. The red soils with coarse texture, high permeability, neutral to slightly acidic in reaction are found on steeper slopes. The black soils are clay to clay loam in texture and neutral to alkaline in reaction. These soils occupy 12 to 14 per cent of the cultivable area of the zone. Laterite soils are yellowish red to reddish brown in colour. They are dominated by kaolinite type of clay. The soils are acidic with low CEC. The soils are classified under Inceptisols.

Climate

The zone is blessed with both south west and north east monsoons, spread over from May to November, which facilitate growing of both kharif and rabi crops, as the soils are of different characteristics. The zone receives, on an average, rainfall of 749 mm with minimum of 623 mm in Ranebennur taluka and maximum of 1037 111m in Belgaum taluka. The average maximum temperature of the zone is 30.9 °C with the highest of 36.9 °C during April and the lowest of26.35 °C during August. The minimum temperature ranges from 14.01 °C to 22.12 °C, with average minimum temperature of 18.61 °C. The relative humidity of the zone varies from 85.36 per cent (in August) to 51.59 per cent (in April), with an average relative humidity of68.49 per cent. Maximum evaporation of 8.26 mm occurs dumg March followed by April (8.2 mm), the lowest being in July (1.14 mm).

Cropping system

In this zone, the major cropping systems are Cotton-Chilli, Maize-Safflower, Groundnut-Rabi Jowar, Greengram-Wheat, Maize-Bengalgram, Kharif Jowar- Safflower, Soybean-Greengram-Rabi Jowar, Paddy-Blackgram, Sugarcane-Soybean, Chilli-Onion-Garlic, Green manures-Tobacco- Hybrid Cotton/Sugarcane/Potato/Chilli. The area, production and productivity of the important crops in the zone is presented below':

Crop	Area ('000 ha)	Production ('000 t)	Yield (q/ha)
Paddy	153.6	244.3	16.9
Jowar	516.5	403.5	8.3
Maize	95.3	296.3	32.3
Wheat	124.4	88.8	7.9
Groundnut	244.7	190.5	8.1
Safflower	36.7	26.4	6.5
Sugarcane	101.7	8372.0	765.0
Cotton	275.1	392.2	14.1
Chilli	83.0	23.0	3.5

Socio economic aspects

The population in zone-8 is fairly high with a density of 295.6 persons per sq.km. Total population of the zone is 70.9 lakhs (1991 census). Proportion of male population (51.50%) is slightly more than the female population (48.50%). The rural population of the zone is 21.30 lakhs. Chikkodi taluk has the highest rural population (16.2% of the total) and the least is in Byadagi (3.5%). The population of SC andST's in the zone is 10.10 lakhs. Literacy level in the zone is 36.93 per cent of the total population.

The per capita income which indicates the standard of living of the population was hardly Rs 641 during 1970-71 increasing over the years to Rs 6,655 at the end of 1994-95.

Production factors

The share of agricultural sector in the state's net domestic product forms the major portion and was about 40 per cent. A perusal of the statistical data on some of the selected economic indicators showsa consistant increase of all selected indicators, except in respect of commercial and oilseed crop production, where the trend has not been consistent owing to dependence on the rainfall during different years.

Land holdings

Land ceiling laws of Karnataka allow an individual to possess 10 standard acres of irrigated and upto 54 acres of rainfed land. The distribution of land holdings in the zone-8 reveals that about 57.4 per cent of holdings are small and below 2 hectares. This distribution pattern emphasises the need for concentration of development efforts on small farmers as they constitute a sizeable majority.

Local knowledge and new technology interactions

A study was conducted in Northern transion zone (zone-8) of Karnataka state to determine the degree of scientific rationality of the indigenous nutrient management technologies and to test the identified nutrient management technologies with regard to their characteristics *viz.*, profitability, practicability and complexity etc.

The indigenous nutrient management techniques, commonly practiced by the farming community are: application of organic manures (farmyard manure/compost/ poultry manure/pig manure). Besides sheep penning, green manuring, use of oilcakes, use of fertilizers, crops, use of biofertilizer to a limited extent, crop rotation and to some extent use of industrial waste and tank silt are practised.

Rapid industrialization has led to the generation of huge amounts of some byproducts like pressmud, molasses, begasse, sewage sludge, fish meal and bone meal. Considering their manural value, the use of these by-products in crop production have been well established.

In absence of regular green manuring practice, farmers have adopted mixed/ intercropping with leguminous crops as one of the components to sustain crop productivity.To maintain soil fertility and to improve soil productivity tank silt application is considered low input technology which is commonly practiced by the farming community.

Tree species such as Banni *(Prosopis cineraria)* and Aari *(Hardwickia binata)* are not considered as green leaf manure crops but are found beneficial when they are sparcely distributed in the field. Such trees are now in decline due to utilization of the tree species aa source of fuel. The standard nutrient input recommendations for various crops grown in the region are given below:

Crop	**Soil**	**Recommendation**	
		Irrigated	**Rainfed**
Jowar	Black, mixed red & black	FYM - 6-7.5 t/ha Fert. - 100:75:40	FYM - 5t/ha Fert. - 100:75:7.5
Paddy	-do-	FYM - 5 t/ha or 10 t green manure Fert. - 100:75:50	FYM-5 t/ha or lOt green manure Fert. - 100:75:50
Wheat	-do-	FYM - 7.5 t/ha Fert. - 100:75:50	FYM -6 t/ha Fert. -50:25:0
Maize	-do-	FYM - 10 t/ha Fert. - 150:75:37.5 $ZnSO_4$ - 20 kg/ha	FYM - 7.5 t/ha Fert. -100:50:25 $ZnSO_4$ - 20 kg/ha
Groundnut	-do-	FYM - 10 t/ha Fert. -25:75:35 Gypsum 500 kg/ha Rhizobium culture	FYM -7.5 t/ha Fert. - 25:50:25, Gupsum 500 kg/ha Rhizobum culture
Cotton	-do-	FYM - 12 t/ha Fert.-80:40:40 (For Hy.) FYM-12.5 t/ha Fert. - 150:75:75	FYM -7.5 t/ha Fert. -40:25:25
Tobacco	-do-	FYM - 12.5t/ha Fert.- 100:37.5:25 (For chewing variety) Fert. - 50:25:25	FYM - 12.5 t/ha Fert. - 100:37.5:25 (For Bidi variety)
Chilli	-do-	FYM - 25 t/ha Fert. - 50:75:75	FYM - 25 t/ha Fert. 100:50:50
Onion	-do-	FYM - 30 t/ha Fert. - 125:50:125	FYM -30 t/ha Fert. 125:50:125
Safflower	-do-	FYM - 6.5 t/ha Fert. - 75:75:40	FYM - 5 t/ha Fert. -40:50:25
Sugarcane	-do-	FYM - 25 t/ha Fert. - 150:150:100 (Dharwad) Fert.-250:75:190 (Belgaum)	FYM - 25 t/ha Fert. - 150:150:100 (Dharwad) Fert.- 250:75:190 (Belgaum)

Fert. = N:P:K (kg/ha)

EXISTING PROBLEMS OF NUTRIENT MANAGEMENT AND INDIGENOUS SOLUTION

The major problems related to nutrent management and the solutions to those problems identified by the farmers are listed below. Some of the problems are soil related and others to climate. Farmers have their own methods to overcome such nurient management problems.

	Nutrient management constraints	Indigenous solution
1.	Imbalance in nutrient supply (N, P & K.)	-Nil-
2.	High fixation of phosphorus	-Nil-
3.	Low recovery of nitrogenous fertilizers	Split application/spot application in wide spaced crops
4.	Low availability of Fe/Zn in black soils	-Nil-
5.	Low organic carbon status of soils	FYM application
6.	Nutrient management in problematic soils	High rate of fertilizer application
7.	Inherent low fertility status	Use of organic manures
8.	Topography of land	Contour farming across the slope
9.	Crust formation in red soils	Trampling through sheep in the field/Iight harrowing
10.	Intensive cropping without replenishing of nutrient in soil	Use of more of FYM
11.	Prevailing moisture and temperature	Cultural practice
12,	Utilisation of vegetation as source of manure	Collection of litter material
13.	Problems in utilisation of urban solid waste due to presence of glass/plastic etc.	Separation of non-decomposable material in the urban solid waste manually

14.	Burning of farm waste/crop residues	*In-situ* incorporation
15.	Non-growing of green manure crops	Growing leguminous crops
16.	Non-use of bioferitilizers	Crop rotation with legumes
17.	Traditional varieties	-Nil-
18.	Irregular fertilizer application schedule	Split application

Fanners have ignored the importance of organic manures that should go with the fertilizers. Consequently, soil hardness and poor physical environment have resulted in. Farmers are aware of these changes in soils, however, now sufficient quantities of organic manures are not available. There is no balanced use of different fertilizers in respect of N, P and K. Importance of balanced use of nutrients is still not clear to farmers inspite of their experience of high vegetative growth of plants and more disease prevalance under high N input. It is suggested to use the available organic manures to all their fields equally at a fixed interval, when sufficient organic manures either not generated on the farm or procured/mobilised. Farmers are biased when are using organic manures as they prefer to use more organics for commercial crop; thus resulting in improper distribution of organic manures to their fields. In black soil area zinc and iron are becoming limiting factors for crop growth. Nutrient recovery in different soil groups under arable situations/flooded situation is need to be enhanced. One of the studies indicate that the nutrient recovery for N, P and K is 40, 30 and 40 per cent, respectively.

THE PRESENT RELEVANCE OF THE TECHNOLOGY ADOPTED BY THE FARMERS

The greatest challenge facing mankind in the 21st century is to produce the basic necessities of food, feed, fibre, fuel and raw materials. The green revolution witnessed by the country, esulting from expansion in cultivated area, introduction of high yielding cultivars, intensive cropping, and improved management technologies, has increased crop production but at the cost of soil fertility, soil productivity and possible risk of soil degradation. Use of modem alone have created ecological imbalance and affected stability sustainability of crop roduction. High cost energy crisis have forced adopton of some of the indigenous techniques which are safe and cost-effective. It is apparent that the agriculture during pre-green revolution era sustained soil health and the productivity through less intensive cropping, practice of crop rotations with legumes, intercropping/mixed cropping with legumes and legume as green manure crop. Growing forest species, permitting beneficial leguminous weed species and growing crops utilizing stimulatory effects of allelochemicals of different crops are other indigenous methods experienced by farmers which sustained fertility and productivity. Banni *(Prosopis cineraria)* and Aari *(Hardwickia binata)* the two tree species are increasingly important in the economy of the Indian arid zone. Both these species are drought resistant and well adopted to prevailing climatic conditions besides wide spread ecological adoptation. The soil profile underneath trees contained comparatively higher organic matter, total nitrogen, available phosphorus, soluble calcium, available sulphur, low pH, available micronutrients and better physical condition of the soil up to 120 cm depth. The greater depletion of moisture from deeper layers implies that these species would not compete with shallow rooted crop growing under their canopy. The regular annual crops under the canopy of these tree species are not affected in terms of growth, development and yield, instead are benefitted due to positive contribution by the trees.

Weed species do help in enriching nutrient status of soil. The leguminous weeds such as Touch me not *(Mimosa pudica),* Desmodium *(Desmodium diffusion)* produces nodules on plant roots and ensure adequate N, fixation and improves N status of soil. Whereas *Argemone mexicana*, a major rabi weed is rich in sulphur and used by the farmers for soil amendment in problematic soils.

Field crops generally add phytotoxins or allelochemicals to the soils mainly through crop residues and partially through root exudates. Allelochemicals generally have a suppressive effects on germination/establishment of crops, often with a stimulatory effect. The deleterious effects of allelochemical is more pronounced in monoculture due to accumulation in soil while the effect is very low in crop rotations (Narwal 1994).

THE SCIENTIFIC BASIS AND SCOPE OF BLENDING THE INDIGENOUS TECHNOLOGY WITH LATEST TECHNIQUES

Most of the rural communities now-a-days are more or less linked to national economics or have to compete with others for their products in the world market. In view of both the stagnation of such a non-linear top down development process and the increasing budgetary and environmental constraints of improved technical systems, planners, rural extension workers and agricultural scientists have begun to recognise indigenous nutrient management techniques of the country for upgradation of technology, representing sophisticated observations, experiences and knowledge on human interaction with the environment. Thus there is a scope to blend modem techniques with indigenous technologies for sustainable agriculture (Amara Pongsapich 1997).

The negative nutrient balance in soil is not uncommon in Indian soils. The facts like low nitrogen fixation without use of biofertilizers, low atmospheric nitrogen fixation due to erratic monsoon, high fixation of phosphorus in calcareious and acid soils, low levels of potassium in red soils, and imbalanced supply of secondary and micronutrients, justifies the need for blending indigenous nutrient management techniques with the latest scientific techniques to maintain soil health and agricultural productivity.

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CHAPTER 7

INDIGENOUS NUTRIENT MANAGEMENT TECHNOLOGY IN ANDHRA PRADESH

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ABSTRACT

Andhra Pradesh, primarily an agrarian state, is considered as one of the progressive states in agriculture development, sustaining a very high level of crop production. The state is endowed with vast potential of organic resources. The estimate of annual production of cattle dung in Andhra Pradesh is to an extent of 806 lakh tonnes. Farmyard manure (FYM) is the most readily-available and traditional organic manure. It is usually applied to vegetables, commercial crops etc. in good amounts. Penning is a common practice that ensures the use of sheep and goat droppings in the fields. The poultry litter generated in the state is estimated to be 13.70 lakh tonnes which is usually applied to commercial crops directly. Dhaincha, Pillipesara, sunnhemp, cowpea etc. are commonly used as green manuring crops in rice and sugarcane fields. Some green manure trees like Gliricidia, Pongamia and leguminous shrubs etc. are grown on field bunds and wastelands and their vegetative parts are utilized for green leaf manuring in rice fields. Weeds like Ipomoea, Lantana, Waterliyacinth are also utilised for green leaf manuring in some areas. Oil cakes obtained as by-products are used mostly as cattle feed and partly as manure. Non-edible cakes such as neeni, karanj, maltua, castor cake etc. are used as organic manures in upland crops, whereas the edible cake like groundnut cake is applied especially to vegetable crops. Groundnut hulls obtained during the shelling of groundnut pods are applied to paddy fields to improve the soil structure. The tamarind fruit residues are also applied to paddy fields. The stalks of cotton, castor and chillies are generally used for fuel purpose or burnt in the field. Ash collected from households is applied selectively to crops like onion, tobacco and chillies. Tank silt which consists of a large proportion of finer soil particles (silt and clay) and organic matter carried by run-off water from the surrounding land to the tanks during heavy rains is applied to upland soils. Mixing of clay in sandy soils to improve physical condition of the soil and transporting soil to cultivated fields from waste-land areas is a common practice to restore the soil fertility.

Andhra Pradesh is the fifth largest state in India and has a total geographical area of 27.44 million ha lying between 12°37' and 19°54' N latitude and 76°46' and 84°46' E longitude. The state with a population of 66.51 million (1991 census) has three distinct geographical regions, *viz.*, Coastal, Rayalaseema and Telangana. The climate of the state is mainly a semi- arid to arid, except for the coastal belt, which has humid to sub-humid climate. The mean monthly maximum and minimum temperatures vary from 34.2 to 44.8 °C and 12.5 to 21.3 °C, respectively. In northern-most Telangana districts, temperature goes down to 13 to 15 °C, the lowest temperature touching 10 °C during winter. The mean annual rainfall of the state is 925 mm. The average distribution of rainfall in a year is about 69 per cent during south-west monsoon, 22 per cent during North-East monsoon and remaining 9 per cent during winter and hot weather months.

Andhra Pradesh is called the'granary of south' and also 'the rice bowl of south'. Agriculture is the life line of economy of the state contributing to over a third of its GDP (39%) providing livelihood to about 70% of the population. The state has been witnessing tremendous changes in number of farm holdings. There is considerable reduction in size of the operational holdings during recent years. The average land holding of the state at present is 1.56 ha as against 2.51 ha in 1970-71. Out of 93 lakh agricultural land holdings in the state, about 77% of them belong to the categories of small and marginal farmers.

BACKGROUND INFORMATION

The state has abundant natural resources. It is divided into 7 agro-climatic zones based on the rainfall pattern, soil characteristics and cropping pattern (Table 1 and Fig. 1) (Subba Rao and Adinarayana 1991, Venkateswarlu 1995). About 38 to 40 per cent of the total geographical area is under cultivation. The major soil groups of Andhra Pradesh are (i) red soils, (ii) black soils, (iii) alluvial soils, (iv) coastal soils, (v) laterite and lateritic soils, and (vi) problem soils including saline, saline-alkali and non saline-alkali soils. Soils of the state are low to medium in organic carbon, low in available P and medium to high in available K. Deficiencies of P and Zn are widespread particularly in the soils ofNagarjuna Sagar Project and Sriramsagar Project areas. High responses to applied nutrients, particularly P and Zn in cereals, and S in groundnut are observed (Raman *et al.* 1985). The major food crops are rice, sorghum, pearlmillet, maize, fingermillet and pulses, while groundnut, cotton, sugarcane, castor gingelly, chillies and tobacco constitute the important non-food crops. Among thf individual crops, rice occupies the largest area of 35 lakh ha followed by groundnu (18.13 lakh ha) and sorghum (2.6 lakh ha). Among pulses, pigeon pea is grown in 3.T lakh ha out of the total area of 14.70 lakh ha under pulses. Sugarcane and cotton ar grown in 1.92 and 8.98 lakh ha, respectively.

Fig. 1 Agro-climatic zones of Andhra Pradesh with APAU research stations

Table 1 Description of agro-climatic zones of Andhra Pradesh

S-Nc	Zones	Rainfall (mm)	Land form (with elevation,	Soils	Major crops grown	Predominant cropping system
1	Krishna-Godavari (Delta) Zone	800-1100	Delta plains and river valley hinter lands	River valley and delta alluvial soils, mixed red and black and deep black soils in sub coastal valley	Rice, cotton. blackgram. greengram. groundnut, fodder, tobacco, sugarcane, chillies, coconut, sesame	Rice based
2	North-Coastal Zone	1000-1100	Coastal plain and isolated hill ranges, delta and several smaller rivers (0-300 m)	Coastal alluvium patches below lateritic and red sandy uplands	Rice, groundnut, pearl millet, mesta. finger millet, sugarcane, sesame, horsegram. greengram. blackgram	Rice, sugarcane, groundnut, pearlmillet and finger millet based
	Southern zone	750-1100	Coastal plain and southern part of central hill ranges, delta Pennar and catchment of smaller rivers (0-900 m)	Coastal alluvium patches below lateritic and red sandy hinterlands	Rice, groundnut, sorghum, pearl millet, redgram finger millet, horsegram	Rice and groundnut based
4	Northern Telangana zone	900-1200	Deccan plateau and valley low lands, Godavari catchment area (300-600 m)	Mixed red and black soils and medium black soils and plateau, deep black soils in valleys and red sandy soils in uplands	Sorghum, rice, maize, cotton, groundnut, redgram and bengalgram	Sorghum, rice and maize based
5	Southern Telangana zone	700-900	Deccan plateau and hill range catchment of Krishna river (300-600 m)	Red sandy soils and medium black and lateritic soils	Sorghum, rice. castor, groundnut, pearlmillet. redgram, horsegram, fingermillet, green gram, maize, safflower	Sorghum, rice and castor based

6 Scarce rainfall zone	500-700	Deccan plateau, hill ranges and valley low lands. catchment of Pennar river (150-600 m and ranges to >1000 m)	Red sandy soils in uplands and mixed red and black to deep black soils in lower areas	Groundnut, sorghum, setaria. rice cotton. coriander, pearlmillet	Groundnut, sorghum. setaria. rice and cotton based
7 High altitude tribal area zone	1000-1300	Mountains, isolated valleys and foot hills, catchment of several smaller rivers (150-1500 m)		Rice, pearlmillet. groundnut, finger millet, sesame, tuber crops. forest trees and horticultural crops	Rice and pearlmillet based

The fertiliser consumption in the state is rated higher compared to other states and it has surpassed the production. The N, P,Os and K,0 consumption which was 23,007 tonnes in 1956-57 has increased to 20,07,920 tonnes during 1998-99. The data on fertiliser consumption and use ratios in the state during the past 15 years are furnished in Table 2. At present, the quantities of N, P,0 and K,0 consumed per hectare of gross cropped area are 98.5, 43.0 and 12.5 kg, respectively with the total consumtion of NPK per ha being 154 kg in 1998-99 (FAI 1998-99). East Godavari, Krishna and Guntur districts consume the highest quantities of fertilisers while Adilabad consumes the lowest quantity in the state. Though there is no precise information on cropwise consumption, irrigated crops like rice, sugarcane, groundnut and commercial crops like chillies and cotton are found consuming higher quantities of fertilisers in the state. The dryland crops like millets, pulses and oilseeds consume lower quantum of fertilisers.

Table 2 Fertilizer consumption in Andhra Pradesh

	Fertilizer consumption (t)			**Use ratio**		
Year	**N**	P_2O_5	K_2O	**N**	P_2O_5	**K,O**
1985-86	568891	242792	76433	7.4	3.2	1
1986-87	583153	241450	76911	7.6	3.1	1
1987-88	619809	270277	76671	8.1	3.5	1
1988-89	903608	345686	106033	8.5	3.5	1
1989-90	1018792	401681	111949	9.1	3.6	1
1990-91	1068131	424138	127480	8.4	3.3	1
1991-92	997890	454960	129460	7.7	3.5	1
1992-93	1021660	410690	81750	12.5	5.0	1
1993-94	1085750	369500	88090	12.3	4.2	1
1994-95	1138090	385820	120280	9.5	3.2	1
1995-96	1187390	420790	142920	8.3	2.9	1
1996-97	1199580	436390	132820	9.0	3.3	1
1997-98	1074700	490100	129790	8.3	3.8	1
1998-99	1284260	560470	163190	7.9	3.4	1

Farmers of the state are using different chemical fertilisers for crop production purposes. These include straight fertilisers like urea, ammonium sulphate and calcium ammonium nitrate, single superphosphate and muriate of potash. Among the complexes, Di-Ammonium Phosphate (DAP), 20-20-0, 15-15-15, 17-17-17, 19-19-19, 14-35-14 and Urea-Ammonium Phosphate (UAP), 28-28-0 are used in agricultural and horticultural fields. Use of zinc sulphate and other micro nutrient fertilisers (ferrous ammonium sulphate, copper sulphate, manganese sulphate, borax/boric acid and ammonium molybdate) depending upon the necessity have been noticed in different parts of the state. Chelated fertilsers and certain mixtures of micro nutrients (approved by Government of Andhra Pradesh) are also available in the state for use by the farmers. Among organic manures, farmers apply farmyard manure (FYM), compost, cakes (castor, neem etc.), poultry manure, pressmud, pig manure, green manure and green leaf manures to crops in different parts of the state. Cattle and sheep penning (besides pig penning) are also in practice. Application of*patimannu* (old alluvium) and tank silt has also been observed. The trends in consumption of manures by farmers of the state are furnished in Table 3.

Table 3 Trends in use of manures by farmers of Andhra Pradesh

S. No	District	No. of farmers surveyed	FYM	Com post	SP	CP	No. of farmers using Castor cake	Neem cake	PM	GM	GLM	Pig manure	Not using
1	Kurnool	15	14	11	7	5	-		-	-	-	-	1
2	Chittoor	13	13	3	-	2	-	-	-	-	1	-	-
3	Cuddapah	21	19	-	2	-	4	3	1	5	1	-	1
4	Anantapur	20	20	3	I	-	1	1	1	-	1	-	-
5	Khammam-I	12	12	-	-	-	-	-	-	-	-	-	-
	Khammam-11	9	8	-	1	-	-	-	-	3	2	-	-
6	Medak	14	14	2	-	-	1	-	-	-	-	-	-
7	Nizamabad-I	11	11	-	3	1	-	-	-	3	-	-	-
	Nizamabad-Il	12	11	-	-	-	-	-	2	-	-	2 (PP)	-
8	Adilabad	12	12	-	1	-	-	-	-	-	-	-	-
9	Karimnagar	13	10	1	6	2	-	-	-	2	-	-	1(TS)
10	Warangal	12	12	-	2	4	-	-	-	1	-	-	-
II	Vizianagaram	14	14	-	1	11	-	-	-	-	-	-	-
12	Visakhapatnam	10	10	1	1	1	-	-	-	-	-	-	-
13	Srikakulam	10	10	-	2	-	-	-	1	-	-	-	-
14	Nellore	19	19	-	2	-	1	1	-	3	-	-	-
15	East Godavari	16	16	-	2	5	-	-	-	-	-	-	-
16	Guntur	10	10	2	-	-	-	-	-	3	-	-	-
17	Mahabubnagar	12	8	-	-	-	-	-	-	-	-	-	4
18	Ranga Reddy	12	9	-	3	-	1	-	-	2	1	-	I

SP: Sheep penning   TS: Tank silt   PM: Poultry manure   GLM: Green leaf manure.
CP: Cattle penning   PP: Pig penning   GM: Green manure   FYM: Farmyard manure

Farmers in different parts of the state are dependent upon the technologies developed by the State Agricultural University and ICAR Institutes located in the state. A recent survey has indicated that fanners of the state are collecting information through media *viz.* television, radio, magazines (specifically Annadata) and are adopting them. However, it is also klunderstood that certain farmers even to-date are dependent on the knowledge acquired from their forefathers while several of them have indicated that they are mostly guided by the progressive farmers of their areas. Surprisingly, a few of the farmers are found not applying any manures or fertilisers for crop production.

Andhra Pradesh has diversified and rich stock of animals. Currently the total cattle and buffalo population in the state can supply around 806 lakh tonnes of dung and 220 lakh tonnes of urine equivalent to 2.95 lakh tonnes of N, 1.02 lakh tonnes of P O_5 and 2.32 lakh tonnes of K,O. Sheep and goat together can supply about 1.3 lakh tonnes of N, P,O_S and K,O. The poultry manure can supply 1.02, 0.89 and 0.48 lakh tonnes of N, I\CL and K.,0, respectively. In addition, the poultry manure is a rich source of micronutrients.

Among the farm residues and crop wastes, stubbles of rice, sorghum, pearl millet, maize, cotton, and many other crops and sugarcane trash are available to an extent of 132 lakh tonnes with the nutrient potential of 3.48 lakh tonnes. Oilseed cakes constitute another nutrient resource with a potential of 0.93 lakh tonnes of major nutrients.

SOME INDIGENOUS NUTRIENT MANAGEMENT TECHNOLOGIES

Fanners in Andhra Pradesh are innovative. Over the ages, they tested, by trial and error, several techniques for collecting, processing and use of organic resources in crop production. Some ofthese are specific to Andhra Pradesh and others are similar to the ones adopted by farmers in other parts of the country. A brief account of these indigenous technologies is given below.

Farmyard manure (FYM)

Among the organic sources of nutrients, FYM represents most commonly and extensively used manure. Application of FYM straight away or after composting is common with several of the fanners. It is traditionally used in upland crops, high ' value vegetable and oilseed crops. In villages of rainfed areas dung is collected even from the cattle and buffalo trekking routes and the grazing areas. In some villages, the community lands where cattle graze, are auctioned annually for collecting the dung. The manure pits are usually dug near to cattle or buffalo sheds. Normally the manure pits are circular or rectangular in shape and 1 to 3' deep. A large number &f farmers are still adopting heap method for storing the cattleshed wastes. While a sizable number of farmers are found using pit method, very few farmers are following the covered pit method, which is the best way of storing this material before application to fields. In some areas the manure pits are provided on all sides, with a wall made up of cotton, sorghum or castor stalks. In order to protect the material piled up in the heap from getting disturbed by wind, fowls etc., farmers either keep stones around the heap, erect bamboo sticks *or /allies* prepared out of bamboo fibre. There are fanners who also use the flat stones (Cuddapah slabs) of irregular shapes at some intervals around the heap to protect the material. However, farmers are not aware of nutrient losses which are likely during heavy rainfall event. These farmers need to be educated on adopting the covered pit method to improve the quality of FYM being applied to fields.

Farmers of the state also maintain cattle depending upon need and their financial status. Rich farmers or those, who depend upon dairy as a business, maintain good number of cattle in their sheds. It has been observed that the urine of the animal is collected separately into pits near the sheds and used for sprinkling on the heap of FYM. An innovative method adopted by a farmer of Rangareddy district is furnished in Fig. 2. The fanner Sri V. Swami Reddy of Raikunta village near Samshabad {Ranga Reddy District) has innovatively designed a system to utilise the cattleshed wastes in different ways apart from growing crops and fodders. This can be emulatedby others.

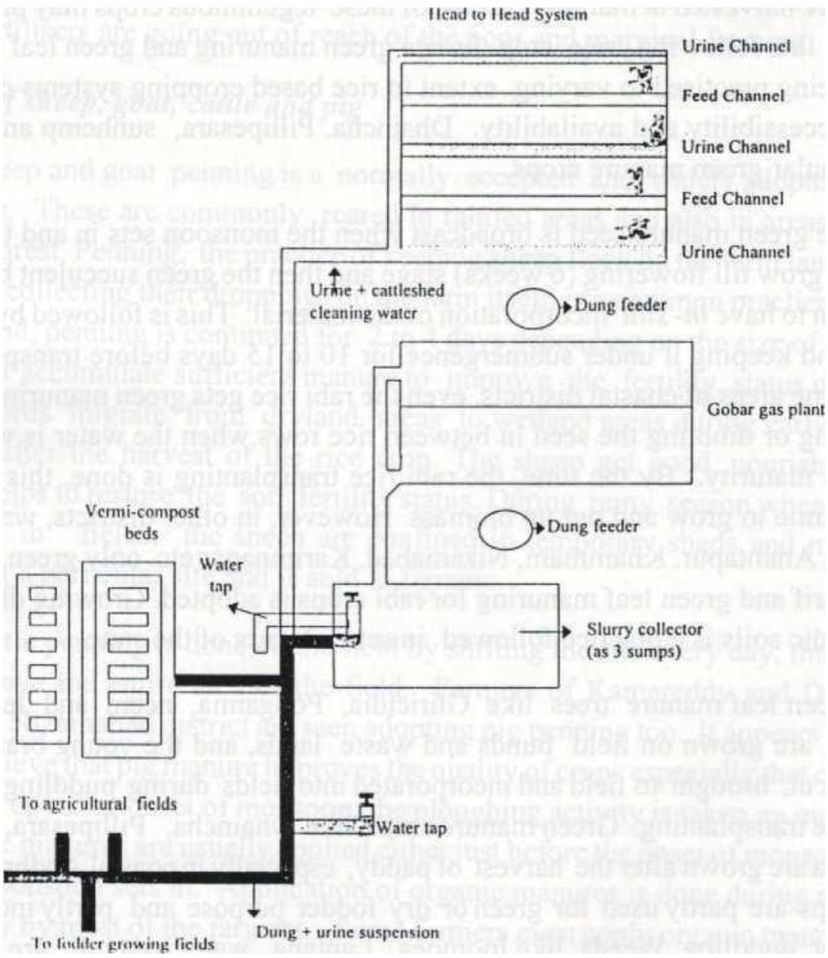

Fig. 2 Efficient use of cattleshed wastes

All sorts of household organic waste, remaining fodder, crop residues etc, are also returned to the manure pit. The manure accumulates in the pit during the whole year. Usually manure is removed in the summer and applied to the field. Farmyard manure is applied once in three to four years to a particular field. It implies that out of the total area or holdings with a particular farmer, only 30 to 40% area receives manure in a particular year and rest goes without any fertilisation or may receive fertilizer as per the financial resources of the farmer.

Green manuring

Growing blackgram and greengram after kharif rice is an age-old practice. The pods are harvested at maturity. Straw of these leguminous crops may provide 20- 25 kg N to the following rice crop. *In-situ* green manuring and green leaf manuring are also being practised to varying extent in rice based cropping systems depending on their accessibility and availability. Dhaincha, Pillipesara, sunhemp and cowpea are the popular green manure crops.

The green manure seed is broadcast when the monsoon sets in and the crop is allowed to grow till flowering (6 weeks) stage and then the green succulent biomass is ploughed in to have *in-situ* incorporation of the material. This is followed by flooding :he field and keeping it under submergence for 10 to 15 days before transplanting of rice. In some areas of coastal districts, even the rabi rice gets green manuring done by broadcasting or dibbling the seed in between rice rows when the water is withdrawn -st before maturity. By the time, the rabi rice transplanting is done, this crop gets sufficient time to grow and put up biomass. However, in other districts, *viz.*, Chittor, Cuddapah, Anantapur, Khammam, Nizamabad, Karimnagar etc. only green manuring during kharif and green leaf manuring for rabi crops is adopted. Growing dhaincha toreclaim sodic soils is a practice followed in several parts of the state.

Green leaf manure trees like Gliricidia, Pongamia, neem and leguminous shrubs etc. are grown on field bunds and waste lands, and the young branches and igs are cut, brought to field and incorporated into fields during puddling operation prior to rice transplanting. Green manure crops like Dhaincha, Pillipesara, sunhemp and cowpea are grown after the harvest of paddy, especially in coastal Andhra Pradesh. These crops are partly used for green or dry fodder purpose and partly incorporated nto field at puddling. Weeds like Ipomoea, Lantana, water hyacinth are spreading in waste lands. Biomass of these weeds is cut and incorporated into fields in someareas.

Dhaincha, besides being a high yielder r-’". withstand adverse seasonal conditions like drought and waterlogging. 1 *ftsBadabada* (wild indigo) was observed to be least susceptible to insect pests. This can also serve as good green manure crop in i ice fields.

Concerted Government action is needed to educate farmers more on use of ,adequate/recommended quantities of organic manure to help in sustaining the yields ofcrops besides maintaining the soil productivity. Making green manure seeds availableand growing species suitable for green leaf manuring throughout the state on wastelands and encouraging farmers to take up such activity on community basis would help in long way in crop production, specifically when the fertilizer costs are escalating and the fertilisers are going out of reach of the poor and marginal fanners.

Penning of sheep, goat, cattle and pig

Sheep and goat penning is a normally accepted and wudely adopted practice in the state. These are commonly reared in rainfed areas and also in areas nearer to hills and forest. Penning, the practice of keeping sheep flock on the farm lands during night and collecting their droppings on the farm itself, is a common practice. On each piece of land, penning is continued for 2 to 4 days depending on the size of the flocks to gather or accumulate sufficient manure to improve the fertility status of the soil. The shepherds migrate from dryland areas to wetland areas during early summer especially after the harvest of the rice crop. The sheep get good nourishment and penning helps to restore the soil fertility status. During rainy season when standing crops are in fields, the sheep are confined in temporary sheds and manure is collected at a particular site and is sold tofarmers.

Cattle penning is done on the field by shifting the site every day, thus making animals move the entire area of the field. Farmers of Kamareddy and Danakonda mandals of Nizamabad district are seen adopting pig penning too. It appears that these farmers believe that pig manure improves the quality of crops especially that of chillies.

|Depending upon the onset of monsoon, the ploughing activity is taken up on the field. The organic manures are usually applied either just before the onset of monsoon or just when the monsoon sets in. Application of organic manures is done during months of May to July by most of the farmers. Some farmers even apply organic manures at thetime of last ploughing during land preparation.

Poultry manure

Use of poultry manure, of late, is becoming popular owing to the expansion of poultry industry in the state especially in district like Hyderabad. Poultry litter is sold to the farmers from the poultry farms. The farmers apply poultry manure to remunerative or commercial crops like cotton and chillies.

In general, farmers have bitter experiences with this material when they applied it to the fields. They observed that the growing seedlings are damaged because of such application. It appears that the farmers using the material are not aware of the correct usage. The poultry manure has to be allowed to mature by heaping it separately for at least 15 days and then shift to Field for spreading. The high uric acid and N content of the material causes scorching of the young leaves and, hence, the crop shows bumt-up appearance. However, farmers who use poultry litter do not face this problem so seriously when compared with those who apply the pure droppings in the field. The farmers are also not fully aware that the poultry manure is a good source of some micro nutrients like Zn, Cu etc. which are added incidentally through feed mixtures.

Bio gas slurry

Use of biogas manure/slurry is also getting popularity with farmers due to increased installation of biogas plants. The biogas slurry contains 1.99% N, and 1.02% P compared to the raw dung composition of 1.55% N and 0.76% P. Similarly, C:N ratio of the slurry is much lower (23.20) compared to the raw dung (36.78). The ash content is also higher in the slurry (22.6%) than in the dung (17.7%) (Gaur *et al.*, 1984). In towns and cities, raw sewage water is generally used for cultivating grasses and vegetables, its heavy metal contents being ignored as a threat for animal arid human consumption, respectively.

Mixing of clay in sandy soils

Coastal sandy soils are poor in fertility, have high infiltration, low waterholding capacity and poor aggregation. To improve the physical properties and also to improve general fertility status, the farmers of this belt bring black soil and mix it with the sandy soils. During summer the dry black soil is carted to the field, kept in small heaps and ploughed down and mixed with sandy soil with the onset of monsoon season. Farmyard manure is also applied in abundant amounts. Clay mixing and farmyard manure additions bring about considerable improvement in the soil physical conditions and fertility status and thus help to raise thecrop productivity level.

Addition of organic materials and sand or soil to soils

Red soils are poorly aggregated, low in fertility especially low in organic matter, N and P status. Surface crusting is also a problem in these soils. Addition of organic materials may help in the aggregation and improve fertility status. Groundnut is traditionally an important crop on red soils. In Chittoorand Anantapur districts farmers collect and apply groundnut shells to paddy fields after decorting the pods and collecting the seeds. In red soils growing groundnut, sand is cartedand mixed with red soils to improve the physical properties of the soil especially the aeration. Sometimes to level the field or improve its physical properties, red soil is also brought and mixed with red soil. In dryland areas of Rayalaseema, tamarind trees are also in abundance. After separating the tamarind, the fruit residues (fruit coat, veins etc.) are collected and applied to paddy fields.

Transporting soil from waste lands/hilly areas to cultivated fields once in 5 to 6 years is a common practice in Rayalaseema region of Andhra Pradesh to avoid the loss of the productivity ofthe cultivated soils.

Tank silt application

In chalka soils (sandy loams) belt of Telangana, the general fertility status of the upland soils is poor. For irrigating the crops, several rainwater harvesting tanks have been constructed. Over the years, clay and silt carried through runoff gets deposited on the tank beds. At some regular periodicity, farmers dig out the tank silt and apply to uplands before the rainy season. Application of silt not only improves the physical properties of the soil but also enhances soil fertility and crop productivity.

Application of plant ashes, paddy straw and groundnut haulms

The stalks of pigeon pea (red gram) cotton, castor and chillies are usually burnt in the field, and the ashes are mixed in the soil. The stalk of pigeonpea, cotton, chillies etc. are also used as fuel in households. Ash is collected from domestic hearths and stacked separately. The household ash is applied especially to some selected crops like onion, tobacco and chillies. The potassium contained in the ash possibly improve the quality of onion, tobacco leaves and chillies. Similarly, common salt is applied to coconut trees.

In coastal districts, where paddy followed by groundnut is the predominant cropping system, farmers are seen adopting a method of storage of the paddy straw' and groundnut haulms. They stack the dry paddy straw upto a height of 1 to 1.5 m and then spread the leguminous fodder (groundnut haulms) as a layer. Later on they cover this with paddy straw to a greater height. This is locally called *'Vami'*. This method of feed storage is done to improve the quality of groundnut haulms so that the cattle relish them much. However, this practice has its other advantage too when the material is applied to field as a cattleshed waste. Unlike the paddy straw, this material mixed with groundnut haulms has relatively lower C:N ratio. This favours quick decomposition of material and release of nutrients would be faster under such conditions.

Miscellaneous nutrient and yvater conservation practices

To avoid seepage and curtail nutrient losses, it is a common practice to line the field bunds with clay in paddy. In red soil areas, termite mounds and ant are destroyed and the fine soil is spread in the field. During summer in rainfed areas, the dusty roads are swept and the fine earth is collected and applied to nursery beds especially of fingermillet and chillies. Cattle sheds are also scrapped and the urine soaked and dung plastered earth is carted to fields. Pig manure, a concentrated manure is purchased and applied to high value crops like chillies and cotton.

Groundnut cake, though serves as good cattle feed, is applied to highly remunerative vegetable crops. Neem, castor and mahua cakes are also used as organic manures, especially in upland crops.

Among the meal group of concentrated manures, bloodmeal and bonemeal are being used more for high value horticultural crops. Use of sewage and sludge, either in treated or untreated form is getting extended with incnjased urbanization, but accumulation of heavy metals like Cd, Co, Cr, Cu, Hg, Ni, Pb, Se and Zn in both soils and plants may pose a serious problem. Therefore, their use at present is largely restricted to the forage crops.

Industrial wastes like rice husk, bagasse, pressmud, sawdust, fruit and vegetable waste, cotton waste, etc are useful source of plant nutrients. However, their nutrient potential, actual use and other details are not available. Pressmud is a w'aste produet from sugar industry. It is initially stored for 2 months near factory and then the farmers in the nearby villages purchase and apply this material in their fields.

SCOPE OF BLENDING INDIGENOUS TECHNOLOGIES WITH MODERN SCIENTIFIC TECHNOLOGIES

Indigenous techniques have relevance to local conditions as they have withstood the test of time and helped the farmers to achieve good crop yields and also maintain soil health. In several Agricultural Research Stations located in different agro-climatic zones of Andhra Pradesh, some of the innovative techniques were tested alone or in combination with improved agronomic practices to understand the scientific basis of the technology and also to upgrade the old techniques.

Organic manures

The physical properties of semi-arid red sandy soils were greatly improved due to addition of cattle manure and compost when applied @ 20 kg N/ha for a period of 5 years (Mohd. Sahul Hameed 1979). Biogas manure and FYM were effective in increasing the availability of native micronutrients in soil (Sudhakar Rao 1986).

Green manuring

Leguminous crops like cowpea can be used as a green manure. Results showed that 10 kg N + cowpea green manuring (5 t/ha) was as good as 40 kg N/ha (Vijayalakshmi 1983). Green leaf manuring with *Sesbania rostrata @ 5* t/ha increased rice yields and was on par with *Sesbania aculeata,* Ipomoea and urea (87 kg N/ha) applied in three splits (Anonymous 1991-92).

Oil cakes

Based on nitrification studies, castor and groundnut cakes were found to be effective nitrification inhibitors and are recommended as good sources of N (Narasimha Rao 1961). Mahua cake can be used in place of groundnut cake in light textured soils even at low moisture levels (Veera Raju 1978). Neem and karanj cakes can be used for manuring in low land rice and for irrigated groundnut in light soils.

Groundnut shells and crop residues

Agronomic efficiency of applied N @ 40 kg/ha to sorghum in Alfisols as well as Vertisols was higher with urea + groundnut shells followed by urea + subabul compared to urea alone. The physical environment of the crust-prone soil was improved by the incorporation of crop residues like paddy husk, groundnut shells, composted coir pith, paddy straw, sorghum straw and green leaf manure. Incorporation of paddy husk @ 5 t/ha in crust-prone hardening red soils, one month before the onset of rainy season, increased the average grain yield of sorghum by 30 per cent (SPCIP 1967-94).

Incorporation of powdered groundnut shells @ 5 t/ha in the top 10 cm red msoil, 20-25 days before sowing of the crop, improved yields of sorghum and wheat by 34 and 24 per cent, respectively (SPCIP 1967-94) and that of groundnut by 34 per cent (Anjaiah 1983). Powdered groundnut shells reduced the crust strength from 2341 (control) to 1609 g/cm^2 at about 5 per cent soil moisture in red soils (Krishna Rao 1986).

Incorporation of paddy and sorghum straws and green leaf manure @ 5 t/ha in black soils modified the soil physical environment favourably for crop growth in terms of bulk density, soil strength and structure. The increase in yield of bajra was the highest with sorghum straw followed by paddy straw and green leaf manure over control (SPCIP 1967-94).

Weeds

Weeds, which are of universal occurrence and can grow in all seasons and in all types of soils including problem soils and waste lands, are rich in plant nutrients with more than 2 per cent N, K and Ca, 0.5 per cent P and Mg, 500 ppm Zn, 150 ppm Mn and 20 ppm Cu (Chandra Sekhara Rao *et al.* 1992). These weeds could be effectively recycled into soil by converting them into composts.

Mixing of clay and silt

Mixing locally available heavy textured soil/tank silt to an extent of increasing the soil clay by5 per cent in light textured red soils was observed to increase soil moisture content by 2 to 4 per centin upper 10 cm soil, significantly increased sorghum grain yields by 20 and 40 per cent compared to 2.26 q grain/ha and that of wheat by 16 and 28 per cent over 1.97 q/ha in the control plots, respectively (Gupta *et al.* 1984). Due to economic consideration and feasibility of operations, mixing of tank silt to increase clay by 2 per cent in alternate years was recommended. It can modify the soil physical properties favorably for crop growth leading to higher yield.

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CHAPTER 8

INDIGENOUS NUTRIENT MANAGEMENT TECHNOLOGY FOR TAMIL NADU

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ABSTRACT

The farmers of Tamil Nadu have a wide variety of traditional farming practices. Manuring the soil with farmyard manure (FYM), compost and green manures or green leaf manures is an age-old practice. Sheep penning and adding tank silt are common practices in some parts of the state. The main sources of organic manures are FYM and compost. For preparing compost, in addition to farm wastes, materials such as sugarcane trash, urban wastes like garbage, night soil, industrial yvastes like coir waste and pressmud are used. Enriched FYM with P and K and bio- inoculants are popularly used in crop production. The increasing number ofpoultry units supplies considerable quantities of poultry wastes, which are used as source of nutrients, wherever they are made available. Besides, non-edible oil/cakes, bio-gas slurry, sludges and effluents form minor sources of organic manures. The low N status of the soil, poor use efficiency offertilizer nutrients, non-adoption of soil test based nutrients doses, insufficient organic manures are major problems confronted with, in the nutrient management. Emphasis is given on use of coated fertilizers, blending of urea with neem cake, conjoint use of fertilizers, organic manures and bio-inoculants, use of rock phosphate along with green manure or compost, adoption of appropriate soil test based balanced nutrient doses tailored to match the crop needs, right method of applying right type of nutrient sources, crop rotation with legumes to overcome the problems in nutrient management. Blending of traditional ways with modern innovations will definitely help in emerging of a prosperous and progressive agriculture.

India lives in villages. Sir John Russel (1937) said that it is no mere form of words but a fact that wealth of India lies in the villages. For the purpose of our agriculture the most promising and least revolutionary method appears to be that of strengthening the living link between the past and present. The village is the living link. It has enough vitality to respond quickly to efforts at rehabilitation. It is in the village and in the fertile fields of the village that progress and prosperity are lying dormant. It is being realised that thereis a good deal of science in the traditional practices of our agriculturists and if understood will give confidence and initiative to scientific workers for generating new practices and enriching old ones. The wisdom of crop husbandry and associated farm enterprises gained by the farmers over centuries are in the form of the most appropriate traditional agricultural practices (Sankaram 1996). “A blend oftradition and frontier technology” would be the pathway to success of Indian Agriculture.

AGRICULTURE BACKGROUND OF TAMIL NADU

The dominant soils are deep red, black, lateritic red loam and coastal alluvial. The distribution of different types of soils is depicted in Fig. 1. Soils of Tamil Nadu belong to six orders according to USDA Soil Taxonomy (Anonymous 1992). They are Entisols, Alfisols, Ultisols, Mollisols and Vertisols. Soils in most of the districts are low in nitrogen, medium to high in phosphorous and potassium (Table 1).

Table 1 Fertility status of soils of Tamil Nadu

District	% of Soil Sample								
	Nitrogen			Phosphorus			Potassium		
	L	M	H	L	M	H	L	M	H
Kancheepuram	98	2		40	10	50	40	20	40
Cuddalore	100		..	20	30	50	25	60	15
Vellore	91	8	1	5	45	50	1	34	65
T.V. Malai	85	10	5	15	25	60	5	35	60
Salem	60	30	10	45	50	5	25	40	35
Dharmapuri	98	2		20	50	30	15	55	30
Coimbatore	90	10		10	50	40	5	40	55
Erode	92	8		15	80	5	20	50	30
Trichy	98	9,	2	25	35	40	5	35	60
Pudukottai	99	1		10	50	40	15	40	45
Thanjavur	80	12	8	25	55	20	15	20	65
Madurai	80	20	..	23	27	50		45	55
Ramnad	85	10	5	55	45		40	25	35
Virudunagar	95	5		18	70	12	5	55	40
Tirunelveli	80	10	10	40	50	10	15	45	40
Tuticorin	70	20	10	45	50	5	5	50	45
Kanyakumari	60	30	10	45	50	5	50	40	10

Source: (Anonymous 1997)(L = Low, M = Medium, H = High)

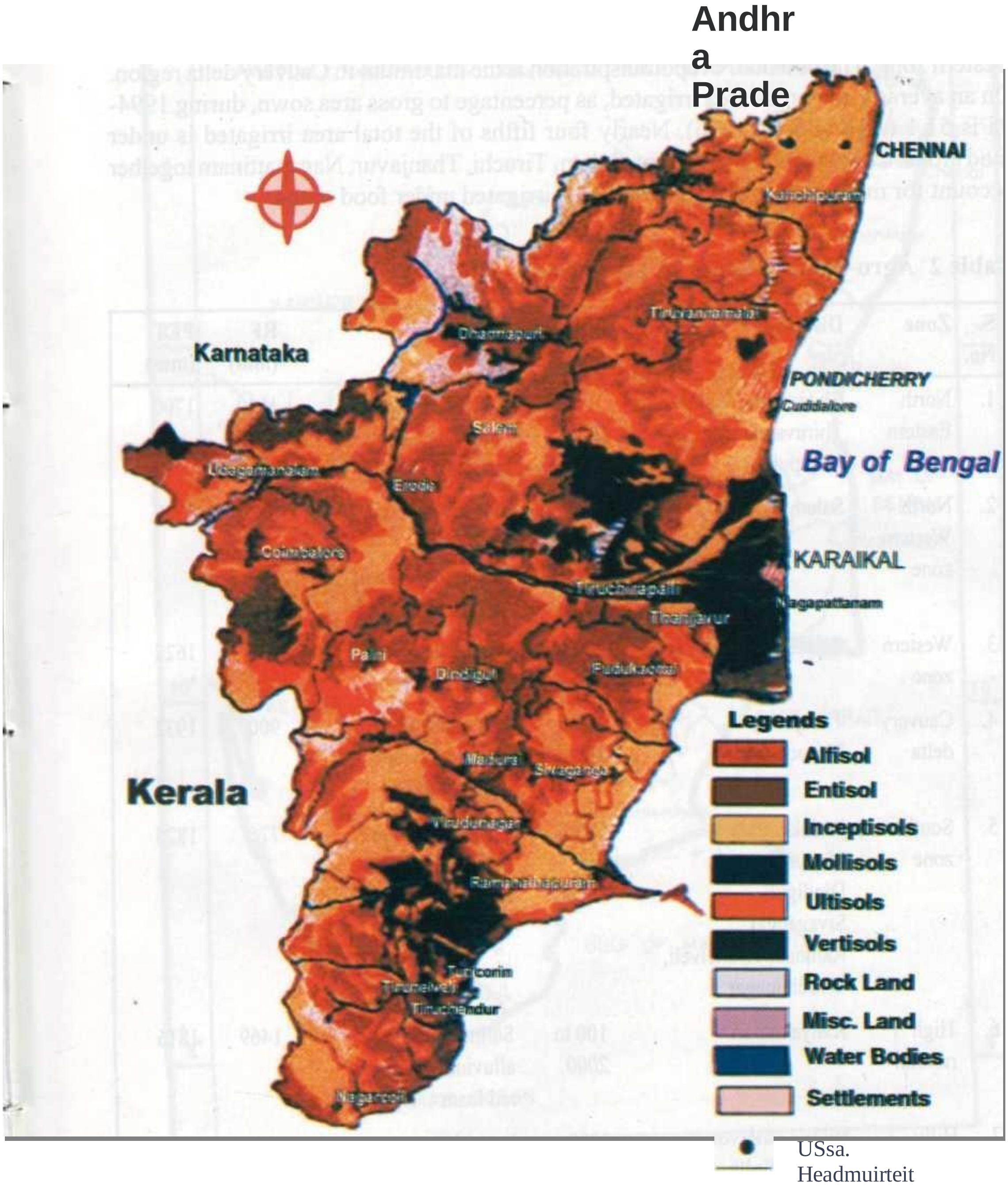

Fig. 1 Distribution of soils in Tamil Nadu

The characteristics of agro-climatic zones of Tamil Nadu are given in Table 2 and Fig. 2. Variation in rainfall is wide, the highest being in the hilly zone and the least in the western zone. The potential evapotranspiration is the maximutp in Cauvery delta region. On an average, the gross area irrigated, as percentage to gross area sown, during 1994- 95 is 51.1 (Anonymous 1996). Nearly four fifths of the total area irrigated is under food crops. Chengleput, South Arcot, Salem, Tiruchi, Thanjavur, Nagapattinam together account for more than half of the total area irrigated under food crops.

Table 2 Agro-climatic zones of Tamil Nadu

S. No.	Zone	Districts	Altitude (m)	Soil type	RF (mm)	PET (mm)
1.	North Eastern zone	Chengalpet, Vellore, Thiruvannamalai, Villupuram	100 to 200	Red sandy loam, clay loam, saline coastal - alluvium	1100	1700
2.	North Western zone	Salem	200 to 600	Non-calcareous red, non-calcareous brown, calcareous black	825	1727
3.	Western zone	Coimbatore, Erode	200 to 600	Red loams, black	720	1622
4.	Cauvery delta	Thanjavur, Thiruchrapalli.	100 to 200	Red loamy (new delta), alluvium (old delta)	900	1932
5.	Southern zone	Pudukkottai, Madurai, Dindigul, Sivagangai, Ramnad, Tirunelveli, Virudhunagar	100 to 600	Coastal alluvium, black, red sandy soil, deep red soil	776	1825
6.	High rainfall	Kanyakumari	100 to 2000	Saline coastal alluvium, deep red loam	1469	1816
7.	Hilly	Nilgris shervoroys, Elagri, Kolli, Anamalai, Palanis	2000	Lateritic	1000 to 5000	1213

Source: (Premsekhar 1999) (RF = Rainfall, PET = Potential evapotranspiration)

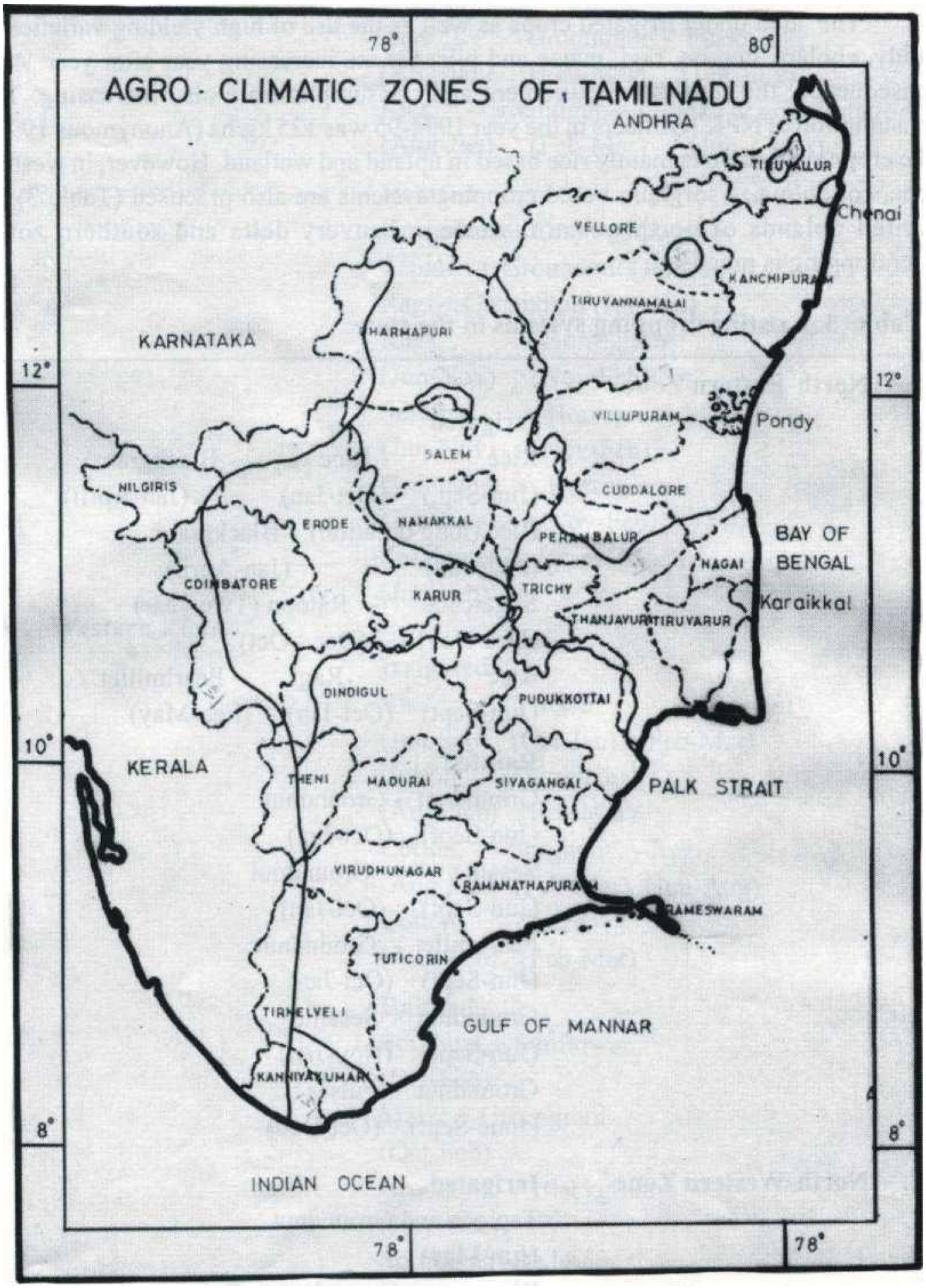

Fig. 2 Agro-ecological zones in Tamil Nadu

The area under irrigated crops as well as the use of high yielding varieties of paddy, cholam, cumbu, ragi, maize and oilseeds are increasing year after year. As a consequence, the fertiliser requirement and consumption are also increasing. The consumption of NPK fertilisers in the year 1994-95 was 125 kg/ha (Anonymous 1997). The cropping system is mainly rice based in upland and wetland. However, in western zone, cotton/maize/sorghum based cropping systems are also practised (Table 3). In rainfed uplands of north-western, western, cauvery delta and southern zones intercropping is practised.

Table 3 Existing cropping systems in the state

1. North-Eastern Zone

Irrigated

Rice - Rice - Blackgram (Jun-Sep.) (Oct-Jan) (Jan-April)

Rice (long duration) - Blackgram (Aug-Jan) (Jan-April)

Sugarcane - Ratoon (Two year)
(Dec-Nov) (Dec - Oct)

Rice - Ragi - Pearlmillet (Jun-Sept) (Oct-Jan) (Feb-May)

Rainfed

Groundnut - Groundnut (Jun-Sept) (Oct-Jan)

Sesame - Groundnut (Jun-Sept) (Oct-Jan)

Pearlmillet - Groundnut (Jun-Sept) (Oct-Jan)

Groundnut - Sesame (Jun-Sept) (Nov-Jan)

Groundnut - Pulses (June-Sept) (Oct-Dec)

2, North-Western Zone

Irrigated

Tapioca and Groundnut (Jun-May)

Rice - Groundnut - Pulse (Aug-Jan) (Feb-May) (Jun-July)

Rice - Groundnut - Pulse
(Aug-Jan) (Feb-Mar) (Jun-July)

Rice -Groundnut - Tapioca (2 years rotation)
(Aug-Jan) (Feb-Mar) (Jun - Mar)

Rainfed

Groundnut + Castor (Jun-Jan)

Tapioca + Groundnut (Jun-Jan)

Ragi + Groundnut (Jun-Jan)

Ragi - Horsegram
(Jun-Nov) (Nov-Feb)

Sesame - Horsegram
(Jun-Nov) (Nov-Feb)

Groundnut - Horsegram
(Jun-Nov) (Nov-Feb)
Sorghum+Redgram+Mochai
(Jun-Feb

3. Western Zone

Irrigated

Rice - Rice – Groundnut
(Jun-Sep) (Oct-Jan) (Feb-Mar)
Cotton – Sorghum
(Aug-Feb) (Feb-Mar)
Cotton - Sorghum – Ragi
(Aug-Feb) (Feb-Mar) (Jun-Aug)
Cotton - Maize
(Aug-Feb) (Feb-Mar)

Rainfed

Sorghum + Sunflower
(Oct-Feb)
Maize + Greengram
(Oct-Feb)
Groundnut + Blackgram
(July-Dec)
Sorghum + Redgram
(July-Dec)
Fodder Sorghum
(Sep-Jan)

4. Cauvery Delta Zone

Irrigated

Rice - Rice - Blackgram
(Jun-Sep) (Oct-Jan) (Jan-Mar)
Rice - Rice - Sesame
(Jun-Sep) (Oct-Jan) (Feb-April)
Rice - Blackgram/Soybean/Cotton/Sesame
(Aug-Sep) (Feb-May)
Groundnut - Rice – Maize
(Jun-Sep) (Oct-Jan) (Jan-Apr)
Groundnut - Rice – Sesame
(Jun-Sep) (Oct-Jan) (Jan-Apr)
Sugarcane - Ratoon cane (2 years rotation)
(Dec-Nov) (Dec-Oct)
Maize - Rice – Groundnut
(Jun-Sep) (Sep-Jan) (Jan-Mar)
Groundnut - Rice – Greengram
(Jun-Sep) (Sep-Jan) (Jan-Mar)

Rainfed (limited area)

Groundnut + Redgram
(Oct-Feb)
Groundnut + Pulses
(Jul-Oct)
Sorghum + Redgram (Oct-Feb)

5. South Zone

Irrigated

Rice - Rice - Sesame
(Jun-Sep) (Oct-Jan) (Feb-Apr)
Rice - Rice - Banana (Two years rotation) Cotton - Rice(Feb-Jun)
(Aug-Jan)
Sugarcane - Ratoon cane (Feb-Dec) (Dec-Oct)
Advance rice - Sesame
(May-Sep) (Oct-Dec) Special situation in

		Tirunelveli distric **Rainfed** Sorghum + Pulses (Oct-Jan) Cotton + Pulses (Oct-Jan) Sorghum - Groundnut (Apr-Jul) (Jul-Oct) Special situation in Tankasi *taluk*
6.	**High rainfall Zone**	
		Rice - Rice – Fallow (Jun-Sep) (Oct-Jan) Coconut + Arecanut + Tapioca (Perennial) Tapioca + intercrops (Planting throughout the year) Rice (Semi-dry) (Jun-Aug) **Rainfed** Tapioca (Jun-May)
7.	**Hilly Zone**	Potato - Wheat (irrigated) (Jan-Oct) (Nov-Feb) Mostly plantation crops **Rainfed** Potato – fallow (Aug-Jan)

Source : (Anonymous 1997)

Most of the farmers are resource poor. There are five categories of farm holdings. About 70 per cent of the total area comes under marginal category that is less than one hectare and about 16 per cent between one and two hectares (Table 4).

Table 4 Number, area and average size of operational holdings in Tamil Nadu in 1990-91

	Classification of Holdings	No. of operational holdings (lakhs)	Area operated (lakh ha)	Average size of holdings (ha)
1.	Marginal (Below 1.0 ha)	58.48 (73)	21.18 (28)	0.36
2.	Small! (1.0 to 2.0 ha)	12.75 (16)	17.94 (24)	1.41
3.	Semi-Medium (2.0 to 4.0 ha)	6.18 (8)	16.87 (23)	2.73
4.	Medium (4.0 to 10.0 ha)	2.27 (3)	13.01 (17)	5.72
5.	Large (10.0 ha and above)	0.31 (Neg.)	5.74 (8)	18.44
	Total	79.99 (100)	74.74 (100)	0.93

(Neg) - Negligible, (Figures in bracket indicate percentage to total)
Source:(Anonymous 1996)

Regarding literacy, the gap between male-female literacy rates and rural-urban literacy rates are getting narrowed down. The per cent literacy rate ranges from 46 (Dharmapuri) to 82 (Thanjavur and Chennai). The number and percentage of population below poverty line in Tamil Nadu was higher in rural areas (138.4 lakhs and 39.5 per cent), than in urban areas (38.5 lakhs and 20.5 per cent).

INDIGENOUS NUTRIENT MANAGEMENT PRACTICES

The FYM, the commonly found organic manure contributes about 1.9, 0.7 and 1.2 lakh tonnes of N, P,O_S and K,0 per annum in Tamil Nadu (Rani Perumal 1991). By adopting composting technology on many farms, the farm wastes are composted and applied to the crops. Of late, industrial wastes like coir pith and pressmud are also used for composting making. Sugarcane trash is mixed with rock phosphate andpressmud to prepare canetrash compost. Farmers generally use compost @ 12.5 t/ha. In municipal corporations, night soil composts are prepared. In the whole state, to improve the quality of FYM the technology of enriching the FYM with P (fortification of FYM) either as superphosphate or rock phosphate is practised by the farmers (Plate 1 and Plate 2). The slurry from biogas plants, the sludge and sewage effluent, the spentwash from sugar factories and the non-edible oil cakes like neem, mahua, karanj and castor are other minor organic sources of nutrients available in Tamil Nadu. Sludges are applied for forage crops @ 12.5 t/ha. There are more than 13,000 ha of lands under non-edible oil producing crops (Mercykutty *et al.* 1983) and thus this source is found to be very important one. The manurial values of FYM, composts and oil cakes are given in Table 5.

Plate 1 : Manure heap

Table 5 Nutrient content of organic manures

	Manures	Nutrient content (%)		
		N	P	K
	Rural and urban wastes			
a)	Farm yard manure	0.5 to 1	0.15 to 0.20	0.5 to 0.6
b)	Poultry manure	2.87	2.90	2.35
c)	Compost	0.5 to 1.0	0.20	0.50
d)	Sewage waste	1.08 to 2.34	0.84 to 2.14	0.53 to 1.73
e)	Goat manure	0.65	0.50	0.03
f)	Night soil	1.2 to 1.5	0.80	0.50
g)	Bio-gas slurry	1.40 to 1.84	1.10 to 1.72	1.34
	Industrial wastes			
a)	Press mud	1.12 to 1.19	2.12 to 2.43	1.98 to 2.03
b)	Coir waste	1.06	0.06	0.9 to 1.30

Source : (Anonymous 1997)

Sheep penning is another means of adding organic form of nutrients to the soil. Most of the small and marginal farmers rear these animals either in small numbers or as big herds. The nomadic shepherds living in Coimbatore, Ramanathapuram, Pudukottai districts possess the herds to earn their livelihoods. They move from village to village along with their herds. Three units consisting of 400 to 600 sheeps are necessary to cover one acre area. In some places of Southern zone, even ducks are used for their droppings.

For all upland and wetland crops FYM/composts of any kind/pressmud are applied @ 12.5 t/ha before ploughing. On ploughing they mix with soil thoroughly and sufficient time of about a week to 10 days is given for their mineralisation and release of nutrients to the crops sown or planted. This is done over and above sheep penning in some places

Another important and very old practice is green manuring. The details of the green manuring crops and green leaf manures are given in Table 6 and Table 7. The green manuring crops are grown in the fields and incorporated *in-situ* or they are brought from outside and applied to soil. Green manure or green leaves are added @ 6.25 t/ha for wet and upland rice, a week before transplanting. In double crop as well as single crop of wetlands of Cauvery delta and Periyar-Vaigai ayacut the green manures (Dhaincha and Pillipesara) are grown in summer and incorporated *in-situ*. These manures add about 10 to 15 t/ha of biomass which is equivalent to 30 to 45 kg of N/ha (Pataniappan 1991). Growing grain legumes as catch crop in summer rice fallows is practised in river command areas. These legumes when grown as catch crop or as a component in the crop sequences in upland or wetland or as mixed/inter crops in rainfed agriculture not only provide N_2 fixation but also increase the availability of P and other nutrients by solubilising them. The green leaves are also collected from hedges, "p^uram^bokku" lands (Lakshmikanthan 1952, Sivalogamudaliar 1944, Varadarajan and Sanyasi Raju 1956).

Table 6 Biomass production and N accumulation of major green manure crops grown in TamilNadu

Green manure	Age (days)	Biomass/dry matter (t/ha)	N accumulation (kg/ha)
Sesbania aculeata	60	23.2(F)	133
S. aculeata	50	24.4 (F)	165
S.rostrata	50	22.8 (F)	182
S. rostrata	45	11-18(F)	46-73
S.rostrata	60 .	17-24(F)	81-108
Sesbania spp.	50	18.4-21.9(F)	113-161
Sunhemp	28	2.4	63
S unhemp	42	4.4	99
Sunhemp	56	6.6	140
Sunhemp	45	3.9	117
Cowpea	49	2.1	49
Cowpea	4$	23-2.5	62-70
Cowpea	30-60	0.6-3.6	18-69
Mungbean	49	1.90	42
Mungbean	30-60	1.1-4.7	32-136
Clusterbean	60	3.8	87

F: Fresh Biomass

Table 7 Nutrient content and C/N ratio in the green leaf manures and weeds

Crop	Total N (%)	C/N ratio	Total P(%)	Total K (%)
Gliricidia sepium	2.76	31:1	0.28	4.60
Pongamia glabra	2.78	33:1	0.27	0.19
Azadiractha indica	2.83	70:1	0.28	0.35
Delonix data	3.51	27:1	0.31	0.13
Delonix regia	2.76	32:1	0.46	0.50
Peltophorum ferrugenum	2.63	34:1	0.37	0.50
Partheniam hysterophorus	2.68	30:1	0.68	1,45
Eichhornia crassipes	3.01	29:1	0.95	0.15
Ipomea cornea	2.01	43:1	0.33	0.40
Calotropis gigantean	2.06	64:1	0.54	0.31
Cassia fistula	1.60	120:1	0,24	1.20

Source : (Siddeswaran 1999)

In Coimbatore district farmers apply tank silt to crops like banana, turmeric and jasmine where as in Ramanathapuram farmers apply it to rice crop @ 25 t/ha. The increasing poultry units also generate enormous quantities of poultry waste. In the deep litter units, poultry droppings mixed with litter, are collected for use in agriculture.

Biofertilisers such as biological nitrogen fixers (Azospirillum, Blue Green Algae, Azolla, Rhizobia and Azotobacter), and phosphate solubilisers are other means through which the nutrients are made available to crops (Srinivasan 1994, Kannaiyan 1998). AzospiriIlium and phosphobacteria are applied @ 2 kg/ha.

The basal application of organic manures is followed by the application of fertiliser nutrients as per the recommendations. The recommended N dose is applied in three splits in clay soils and in four splits in light textured soils. Urea is blended with neem cake powder and applied basally to retard the nitrification process. The top dressing is done at active tillering, panicle initiation and heading stages of rice.

The full dose of recommended NPK are applied basally with sulphur sludge for irrigated groundnut. Gypsum is applied in two splits; ’/ as basal and '/$_2$ at 45 days after sowing. For other oilseed crops sludge is not added. Sugarcane receives N and K in three splits (30, 60 and 90 days after planting). Urea is blended with neem cake powder and applied to sugarcane.

In crop sequences, the residues of fertilisers are taken into account for prescribing nutrient doses for the succeeding crops. Inclusion of biofertilisers can substitute 25% of the recommended N and P. When STCR recommendations under Integrated Plant Nutrient Supply System is practised, 38, 13 and 33 kg/ha for green manures, 40, 22 and 40 kg/ha for farmyard manure/composts, 12 kg of N for *Azospirillum* and 10 kg of P,O_5 for phosphobacteria are reduced from the recommended doses of fertiliser nutrients

EXISTING PROBLEMS OF NUTRIENT MANAGEMENT AND INDIGENOUS SOLUTION

Till 1840, natural and organic materials applied to the soil supplied virtually all the nutrients required for profitable crop production. Later on, chemically manufactured fertilisers came into agriculture. Chemical fertlisers formed the major sources of nutrients for crop production. There is a dearth for organic manures and in most of the crop sequences green manures are not included since they do not fetch the farmers any monetary benefits. Thus the practice of applying organic manures has been reduced. This has led to biological improverishment, decline in organic matter status, and deterioration in soil health. There is no natural renewal of soil biological and physicochemical properties. The maintenance of “organic minimum” which is quite essential becomes impossible when crop nutrient need is fed through chemical fertilisers. In Tamil Nadu, as in the other parts of India the farmers are poor, with small holdings of less than one hectare. The area under dry land agriculture is more than that under irrigated agriculture.The soils contain very low content of available N.

The major nutrient management related problems encountered in Tamil Nadu are i) Low N status : the low mobility and high fixation affect P availability to a greater extent, ii) Losses of added nutrients, iii) Low efficiencies of added fertiliser nutrients, iv) Non-adoption of soil test based fertiliser recommendations, v) Gradually and steadilly dwindling cattle population and the consequent reduction in the availability of organic wastes, and vi) Absence of awareness among the farmers to adopt the proven technologies. The means and ways in which the problems are tackled are presented below.

Low N status

i. Application of biological nitrogen fixers.

ii. Application of green manuring/green leaf manuring (Siddeswaran 1999)/FYM/ different kinds of composts

iii. Adoption of crop rotations, intercropping (Purushothaman and Padmavathy 1994, Balasubramanian 1999) and mixed cropping preferably with green manures in paddy soils and with leguminous crops in all soils (Sankaran and Mudaliar 1991). There is symbiosis and synergistic interactions that improve the nutrient availability.

To alleviate the various losses of nutrients

i. Blending of urea with neemcake powder reduces the rate of nitrification thereby minimising the loss of N through leaching. A thin film of water maintained in the rice fields especially after applying urea reduces the loss of N through volatilisation.

ii. The organic sources of nutrients are applied well in advance (a week or 10 days before sowing) so as to avoid any microbial immobilisation of added nutrients.

iii. In Cauvery delta the stubbles of kuruvai rice is incorporated with rock phosphate to improve the P availability for the succeeding thaladi rice by overcoming the P immobilisation on account of wider C/P ratio when rice stubbles are ploughed in.

Enhancing the efficiencies of added nutrients

i. The combined application of organic manures and fertilisers improve the C/N and C/P ratios and organic carbon status, thereby, the soil exchange capacity is improved leading to better adsorption and reduced losses. The synergistic and complementary effects of conjoint application of fertilisers and manures increases the efficiencies of added nutrients (Sakthivel and Thiruvarasan 1994, James Martin 1994. Geethalakshmi *et al.* 1994).

ii. In case of P, whenever rockphosphate is applied it is accompanied with organic manures in neutral and alkali soils so that the organic acids released during decomposition of organics will dissolve the insoluble P (Karuppiah and Thangamuthu 1986). Application of phospho bacteria (PB) is also done for this purpose. The common practice of applying P basally produces more number of roots , which, in turn takes care of the foraging of P in root zone for the crop use throughout the growth.

iii. Combined application of P fertilisers and organic manures reduces the fixation of ortho-phosphate ions. The complexing action of organic acids will render the P fixing ions like Fe^{2}\ Al^{3+} and Mn^{2+} inactive. The improved anion exchange will also improve the P availability.

iv. Application of phosphobacteria solubilises the insoluble form of either native P or added P.

Adoption of blanket fertiliser recommendations

Soils of Tamil Nadu differ in fertility. Thus, crop responses to added fertlisers vary. In this context, blanket recommendation is good on account of its feasibility for adoption. But adoption of this practice will lead to deficiency or excess of nutrients in soil. Hence, the soil test based fertliser recommendations are always the best option. Soil test based fertiliser recommendations for targettcd yields results in balanced supply of nutrients, taking into account the residues of the fertiliser and other nutrients added to the previous crops and providing positive interactions. Wastages of costly inputs are avoided.

Availability of organic manures

Due to reduction in cattle population there is a dearth of animal manures. This situation can be circumvented by promotion of the rearing of cattle. By encouraging the establishment of dairy and poultry units in each and every block, rearing of sheep and goat by each farmer (big or small) and developing ways and means of mobilising the enormous quantities of industrial wastes (coirwaste, pressmud, flyash, spentwash effluents etc.), urban wastes (garbage, sludges, night soil etc.) the status of renewable sources of nutrients can be built up. The governmental organisations have started taking initiatives.

In the indigenous nutrient management system emphasis is given for reducing the rates of nitrification, controlled dissolution rate and use of slow release N carriers or coated materials, timely application of nutrients that synchronise with plant needs, appropriate doses that balance the nutrients supply in the presence of other nutrients, methods of application and right type of nutrient sources so as to make nutrient management proposition highly efficient and economical.

PRESENT RELEVANCE OF TECHNOLOGY ADOPTED BY THE FARMERS

Most of the small and marginal farmers have a rich reserve of traditional agricultural practices. Application of FYM, crop rotation with legumes, use of green manures and rural agricultural wastes and industrial wastes such as various kinds of composts, intercropping and mixed cropping, ash, tank silt and canal sediment application would enrich soil organic matter base. The bacterial fertilisers *Rhizobium*, *Azospirillum*and phosphobacteria are available. Under these circumstances, the efficiency of added fertilisers is enhanced. By practising proper crop sequences, there is reduction in the input costs, incidence of diseases and pests which ultimately minimize risk of farming. The adoption of traditional agricultural practices coupled with modem technologies facilitate effective nutrient interactions and beneficial integrations.

In the present technology packages, there is on-site resource generations, mobilisation of off-site nutrient resources, resource integration and sound resource management to a certain extent as emphasised by Paroda (1997).

FUTURE SCIENTIFIC BASE AND SCOPE FOR BLENDING THE INDIGENOUS TECHNOLOGY WITH MODERN TECHNIQUES

In India, still there is a wide gap between demand and supply of chemical fertilizers and there is little chance to narrow it down in the next ten years or so. Thus, future agricultural production must be more dependant on enhanced use efficiency of applied fertilizer. Towards this goal our traditional ways are to be combined with modem and innovative methods. A consolidated database at block/district level should be built up on the potentials of organics (nutrient stock), nutrient input, available water resources etc. The real dimensions of soil fertility and productivity studies are to be demonstrated right on the farmers' fields. The importance of soil testing in understanding the native fertility and other constraints of the soils in making the nutrients available for crop use should be realised by the famiing community. "Soil testing is to the art of crop production what the thermometer is to the medical profession". The nutrient doses tailored to suit a particular yield level based on crop need, soil fertility management practices, climatic conditions will be the best scientific way of nutrient application. In this process the farmers' resources, investment capacity and level of management, if considered for fixing the yield targets as indicated by Tandon (1994), then the soil test research will be able to provide the most balanced doses for a range of investment levels of farmers' fertliser budgets. The doses of nutrients for an yield goal if adjusted among the various sources *viz.*, organic, inorganic or native then, such systems will place IPNS on a sound footing. Moreover, such practices favour the blending of traditional ways with modernity. Crop yields, economics, nutritional quality and environmental safety will be taken care of. In the upgradation of indigenous technology with better scientific base, inter-disciplinary holistic approach to working of soil scientists with agronomists, ecologists and farmers will be a winning formula.

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III

SUB-HUMID ECOSYSTEM

Indigenous nutrient management practices - wisdom alive in India

CHAPTER 9

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INDIGENOUS NUTRIENT MANAGEMENT PRACTICES IN HIMACHAL PRADESH

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ABSTRACT

In Himachal Pradesh the agro-climatic conditions are diverse on account of wide variations in altitude and undulating topography. These range from sub-tropical at lower elevations to dry temperate at higher altitudes. Farmers having small and scattered land holdings (82%), follow subsistence agriculture under rainfed system owing to lack of assured irrigation. Soils are shallow in depth with poor water and nutrient retention capacity. Rice, maize, wheat, potato, oilseeds, pulses and vegetables are the important crops grown by the farmers. Almost all kinds offruits are grown in the state owing to great variability in agro-climatic conditions. The fertilizer nutrient consumption in the state is around 30 kg/ha, which is far below than the national average. Poor socio-economic conditions of the farmers and rainfed agriculture are the major reasons for low consumption of fertilizers. They have, however, developed over the years the location specific indigenous nutrient management technologies like the use of wastes from cattlesheds, application of farm yard manure, use of ash and human excreta, green manuring with leaves and twigs, biofencing, use offorest soil, transportation of soil from river beds, growing pulse crops on bunds, use of kitchen ash, sheep, goat, and poultry manure etc. Some of these technologies and others like collection of droppings of sheep and goats by tying bags to cover anal parts is an indicative of indigenous wisdom of the farmers. Although through these technologies there is less replenishment of nutrients removed by the continuous cultivation of crops yet blending of these indigenous technologies with the modern technologies is the only solution to meet the demand of higher production and productivity with long term sustainability. This will also help in restoring the much needed organic matter content of soils and to reverse the declining soil fertility. Some of these indigenous technologies for nutrient management followed by the **farmers of Himachal Pradesh are discussed in this paper.**

Himachal Pradesh lies in the lap of western Himalaya, presenting a scenic view of undulating topography. It is the land of rolling hills, rocky snow clad mountains, interspersed with tinkling streams and mighty rivers flowing at the bottom of valleys. The elevation of the state ranges widely from 350 m to 6975 m above mean sea level with a latitudinal change of less than three degrees (30°22'44" to 33°12'40"N). Altitude and latitude figures suggest that the state is located on a highly sloping terrain of the Himalayas. Consequently, the agro-climatic conditions change abruptly from place to place and, thus, the flora and fauna, and life style and outlook of the people are conspicuously different.

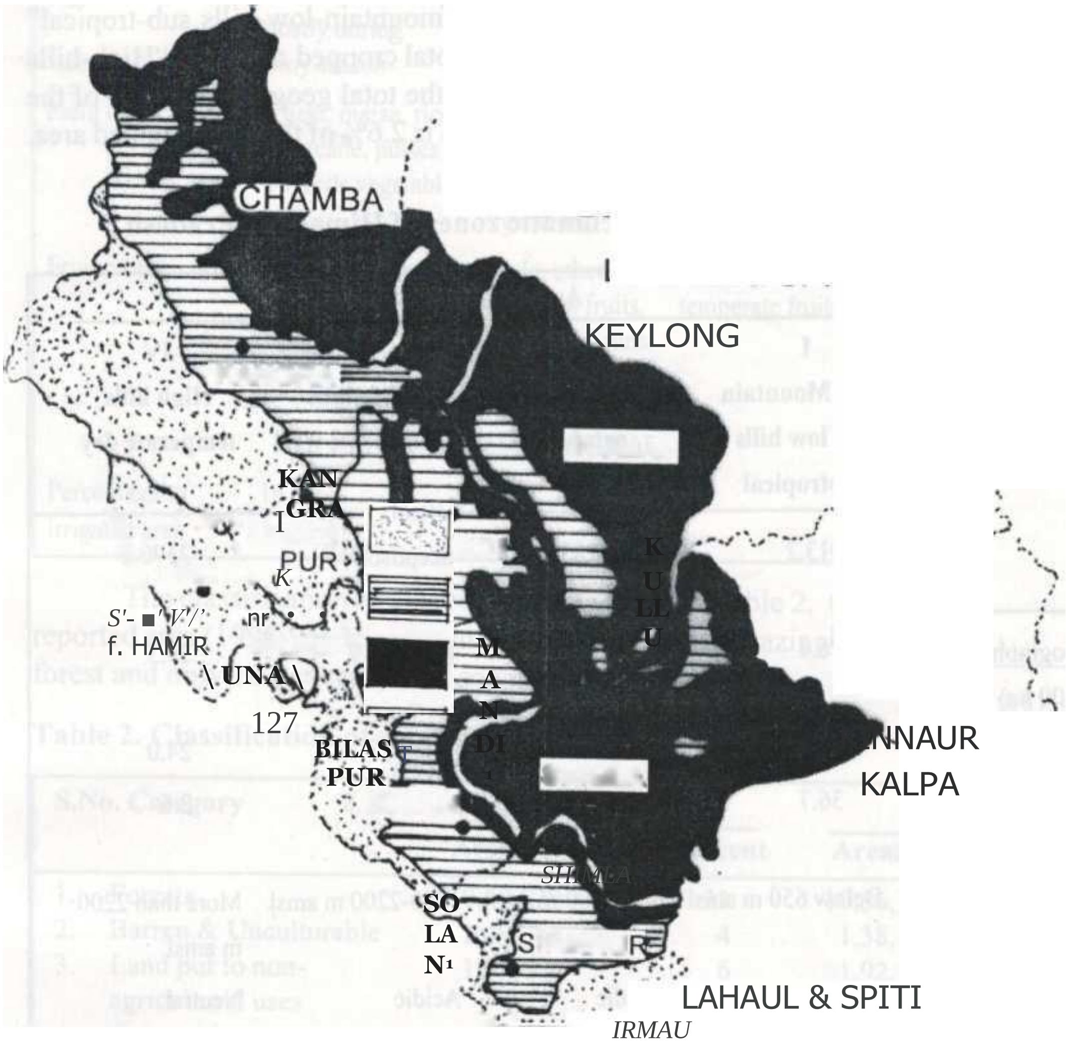
On account of wide variations in altitude and valley type of topography, the agro-climatic conditions of the state are diverse. These range from sub-tropical at the lower elevations to dry temperate at higher altitudes. Depending upon the altitude and climatological parameters, the state has been broadly divided into following four zones (Fig.l).

I Sub-mountain and low hills subtropical

II Mid-hills sub-humid

III High-hills temperate wet, and

IV High-hills temperate dry



ZONE

SUB MONTANEOUS LOW HILLS SUB TROPICAL

MID HILLS SUB HUMID

HIGH HILLS TEMPERATE WET

HIGH HILLS TEMPERATE DRY

Fig. 1 Agro-climatic zones of Himachal Pradesh

The salient features of these zones are given in Table 1. About 80% of the total cropped area falls in the first two zones viz., “Sub mountain-low-hills sub-tropical” and “Mid-hills sub-humid”. Another 18.8% of the total cropped area is in “High-hills temperate-wet zone”. The zone IV, having 39% of the total geographical area of the state, has only 1 % of its area under cultivation, which is 2.6% of the total cropped area.

Table 1 Salient features of the agroclimatic zones of Himachal Pradesh

Particulars	**Agro-climatic zones**			
	I sub-Mountainand low hills subtropical	**II Mid-hills sub-humid**	**III High-hills temperate wet**	**IV High hills temperate dry**
Geographical Areas ('000 ha)	913.2	1183.2	1280.9	2190.0
% of total area	16.4	21.3	23.0	39.3
Total cropped area ('000 ha)	335.1	383.4	171.8	24.0
% of total cropped area	36.7	41.9	18.8	2.6
Elevation	Below 650 m amsl	650-1800 m amsl	1800-2200 m amsl	More than 2200 m amsl
Soil Reaction	Neutral	Acidic	Acidic	Neutral
Texture	Loamy sand to sandy loam	Sandy loam to clay loam	Sandy loam	Loamy sand to sandy loam
Soil Group	Entisols, Inceptisols	Inceptisols Alfisols, Spodosols	Alfisols Inceptisols Mollisols	Entisols Inceptisols
O.C (%)	Less than 0.5	0.5-1.5	0.5-1.5	0.5 - 2.5
Fertility Status	LowN, medium P&K	Low to medium NPK	Medium to High NPK	Medium to High NPK

Rainfall	About 1000 mm mostly during rainy season	1500-3000 mm 80% during rainy season	About 1000 mm with erratic behaviour	250 mm mostly in the form of snow
Field crops	Wheat, maize, rice, sugarcane, pulses, oilseeds vegetables	Rice, wheat,maize, barley, pulses, oilseeds, vegetables	Wheat, maize, potato, vegetables	Barley, potato, wheat, vegetables
Fruit crops	Sub-tropical fruits	Apple, other temperate fruits, stone fruits, nuts and sub-tropical fruits particularly mango and litchi	Apple, other temperate fruits	Nuts, dry fruits and apple
Percentage of irrigated area	16.6	17.3	7.8	40.6

The classification of different areas is given in Table 2. Out of 33,96,200 ha of reported area (1995- 96) 35 percent is under pasture and grazing land; 31 percent under forest and only 16 per cent is net sown area.

Table 2. Classification of reporting area 1994-95 and 1995-96

S.No. Category	1994-95		1995-96	
	Area(ha)	Per cent	Area(ha)	Per cent
1. Forests	10,49,039	31	10,56,143	31
2. Barren & Unculturable	1,493,88	4	1,38,853	4
3. Land put to non-agricultural uses	1,98,669	6	1,92,088	6
4. Culturable waste land	1,18,126	4	1,23,500	4
5. Permanent pastures and others grazing lands	11,93.602	35	12,03,531	35
6. Misc.tree crops and groves not included in net area sown	48,634	1	45,908	1
7. Other fallow	20,695	1	25,816	1
8. Current fallows	55,938	1	55,622	2
9. Net area sown	5,68,338	17	5,57,742	16
10. Total reporting area by village pap,er (Ito 9) *	34,02,429	100	33,96,203	100

Source: (Anonymous 1995-96)

The human and total livestock population are 5.17and 5.85 million, respectively (1991 census). The population of cattle, buffaloes, sheep, goats and poultry birds is 2.17,0.7, 1.08, 1.18 and 0.72 million, respectively (Anonymous 1997). The fanners with land holdings of less than 0.5 ha are 39%; with 0.5 to 1 ha are 22%; with 1 to 2 ha are 21%. Thus, 82% of the fanners fall in the category of small to marginal. Nature has left very small portion of the land at the disposal of the people. Most of the areas are under naked mountains that can not be put to cultivation.

Starting from scratch after independence from subsistence fanning, the Himachal Pradesh agriculture has taken rapid strides and has become leading producer of fruits, particularly, apples, off-season vegetables, potatoes, ginger etc. The state is producing about 14.33 lakh tonnes of food grains, 4.25 lakh tonnes of vegetables, 1.40 lakh tonnes of potatoes and about 20,000 tonnes of ginger. About 10% of total geographical area is under cultivation (6 lakh hectares net cultivated) and 82% of this area is rainfed.

BACKGROUND INFORMATION

Soils

Soils, in general, are shallow in depth with adverse soil physical conditions. The soil texture varies from loamy sand to sandy loam in zones I and IV, sandy loam to clay loam in zone II and sandy loam in zone III. The soils fall under the major soil groups of Entisols, Inceptisols in zones I and IV; Inceptisols, Alfisols, and Spodosols in zone II. and Alfisols, Inceptisols and Moliisols in zone III. The soils of Shimla, Solan, Mandi, Sirmaur and Kullu regions are developed from shales with intrusion of quartzites and carbonaceous materials. The soils of Kinnaur are gravelly and are formed from granite and complex minerals of mica-gneisses, while soils of Lahaul and Spiti are formed from glaciers. The soils are neutral in reaction in zones I and IV, whereas in zones II and III they are acidic. Soils contain low to medium available N and P and medium to high available K. The organic carbon content varies from low to high (less than 0.5% in zone I, 0.5 to 1.5% in zones II and III and 0.5 to 2.5% in zone IV).

The retentivity of soils for water and nutrients is poor in different parts of the state (Gupta *et al.* 1983, Acharva and Bhagat 1984, Bhagat and Acharya, 1987, Sharma and Acharya 1987, Chenkual and Acharya 1990). The soils are fragile and more prone to erosion in zones 1, III and IV (Sambyal and Sharma 1986, Sharma and Acharya 1993). In zones II and III, the soils, particularly in rice growing areas, tend to form large clods after cultivation that become hard upon drying. The soils under rice-wheat exhibit adverse soil-water relations compared to maize-wheat rotation (Chenkual and Acharya 1990, Chaudhary and Acharya 1993). There is tremendous response to FYM applications in moderating soil-water behaviour (Acharya *et al.* 1988).

Crops

Due to' great variation in climatic conditions and physiography of the state, great variability exists in the crops and cropping systems. In some districts of zone IV like Lahaul and Spiti, Kinnaur, parts of Chamba and Kullu only monoculture is practised due to constraints related to temperature. However, in zone I and foothills of zone II, with the availability of irrigation water, taking three crops in a year is not uncommon. Mid hills of zone II and III enjoy a mixed climate and follow a variety of crops and cropping systems.

Maize-wheat is the most important crop sequence in zones I to III whereas potato (especially seed potato) is the main cash crop of zone IV. In zones I and II direct seeded rice is grown in areas where there is an assured supply of water either from monsoon rains or natural gravity streams. Gram is the dominant pulse crop whereas linseed, sesame, rapeseed and mustard are the principal oilseed crops. The extent of area under principal crops of wheat, maize and rice in the state is 0.357, 0.309 and 0.083m ha, respectively. While pulses and oilseeds cover an area of0.036 and 0.018m ha, respectively (Anonymous 1997). The potato is grown in about 0.013 m ha whereas other vegetables occupy 0.0146m ha in the state. In districts of Lahaul and Spiti, Solan, Kinnaur, Shimla and Kullu farmers have taken up growing of off-season vegetables on a large scale. Seed production of high-value-low-volume crops is picking up as there exists a great production potential for these crops in these districts.

On account of great variability in agro-cliamtic conditions, almost all kinds of fruits are grown. The state is referred to as "Apple State" of India. The total area under fruit crops is about 0.142m ha and the area under the apple is the maximum (56% of the total area under fruits}.

Irrigation

Crop production in more than 80% of the cropped area is entirely dependent on amount and distribution of rain. The gross irrigated area in the state is 0.171 m ha. About 55% of rice, 17% of wheat, 15% of barley and 8% of maize is grown under irrigated conditions. The higher percentage of irrigated area under barley is due to 100% irrigated area under barley in zone IV. Most important source of irrigation water supply is *Kuhl* (natural gravity stream). About 85% (0.99 m ha) of the net irrigated area is shared by this source, only 6.8% by canals and 0.6% by tanks. Wells and tubewells constitute only 6.7% of the net irrigated area. Outflow from natural water springs is also diverted in some areas to grow vegetables. The springs are quite commonly occurring in zones I to III of the state but most of them have either dried up or are showing diminished outflow due to ecological human interventions (Acharya *et al.*1989).

Fertilizer Application

The nutrient consumption through fertilizers in Himachal Pradesh is 31.8 kg/ha (27.0 N, 2.9 P,O_5, 1.9 K,O). Fertilizers use is the highest among the fanners of Lahaul and Spiti. However, the existing nutrient use through fertilizers for various crops is far below the recommended dose. This is due to poor socio-economic conditions of the fanners, erratic weather coupled with uneven distribution of rains, rainfed fanning system leading to low fertilizer-use efficiency, lack of technical knowhow with the farmers etc. Farmers are applying more nitrogenous fertilizers compared to phosphatic and potassic fertilizers because of the conspicuous visual effect of nitrogenous fertilizers on the crop growth, thereby an imbalance in fertilizer use is being created. Fertilizer availability at a right time is also a constraint due to remoteness of the area as well as poor transport facilities. Poor marketing infrastructure facilities for their produce also hinder the use of fertilizers in optimum amount

INDIGENOUS NUTRIENT MANAGEMENT PRACTICES

The application of organic manures, particularly of FYM, is kept at a very high esteem by the hill farmers. This is because of their role in furnishing humus forming materials to bring about improvement in soil structure, water holding capacity, microbial population and its activity, base exchange capacity and resistance to soil erosion. Farmers in different parts of the state have developed various technologies depending upon the availability of the organic resources to enrich soils, restore the plant food removed by the crops and to conserve moisture. Some of these technologies are discussed below:

Use of wastes from cattle-sheds

In zones I and II fanners spread wastes from cattle-sheds in standing maize. Lot of leafy materials like Basooti *(Adhatoda vasica),* Bhang *(Canavis sativa)* and other locally available wild shrubs, having no fodder value, are spread underneath animals to provide bedding^ particularly during monsoon season (Plate 1). Every morning instead of dumping this voluminous material at one place, it is collected along with dung and urine and spread in standing maize. This makes a good mulching material to conserve and carry-over the moisture from the time monsoon start receding. The material is incorporated into the soil at the time of field preparation for sowing of wheat. The practice not only conserves moisture but also enriches soil to provide nutrition to wheat crop as some of the materials like Basooti contains 3.4% N, 0.4% P and 3.8% K.

Plate I: Green pine leaves and other wastes as bedding material in the cattleshed

In upper reaches of districts of Shimla, Mandi, Kullu, Chamba, Sirmaur, Kinnaur, Lahaul & Spiti cattle-sheds are attached to the farmers house. The green leaves of pine tree *(Pinus sativus)* or other bushes are put in the cattle-shed as cattle bed and dung/ urine is collected on these beds for 2-3 days and then stored in a heap to prepare the FYM (Plate 2). Apart from this, dry pine leaves and other dry grasses are used as cattle bed during winter season which is usually removed after 4-5 days for preparing the FYM

Plate 2 : Heap method of FYM collection

In very low temperature regions of the state, cattle dung is collected in heaps within the cattlesheds during winter months, so that it decomposes under relatively high temperature conditions. It is then placed out in the open during summer in the form of heaps for further decomposition. The cattle dung normally contains about 0.2% nitrogen, 0.1% phosphorus and 0.15% potassium whereas cattle urine contains 0.6% nitrogen, 0.1% of phosphorus and 0.5% potassium. Use of this manure is very much popular among farmers because of its immense manurial potentialities.

Application of farm yard manure

In the absence of chemical fertilizers, organic manuring is the chief mode of soil fertilization. All efforts are made to collect and use animal droppings and for their subsequent decomposition along with the leaves and grasses, which are used in manuring the crops. This is the traditional organic manure called Farmyard Manure (FYM) and is most readily available to the farmers. It is the product of decomposition of the liquid and solid excreta of livestock, stored in the sheds, pens and camps of livestock along with varying amounts of straws or other litter used as bedding. This farmyard manure/ compost prepared from farm litter, liquid and solid excreta of livestock contains 0.5% nitrogen, 0.2% phosphorus and 0.5% potassium.

Farmers invariably apply 10-15 t/ha of farmyard manure to maize crop in maize - wheat crop sequence and to wheat crop in rice-wheat crop sequence. After rice harvest fields are ploughed immediately to avoid desication of the seed-zone and the partially decomposed FYM is placed in small heaps near the fields. Clods produced upon ploughing become brittle after first winter shower and FYM is broadcast from the heaps in the field. Some amount of fertilizer (mixture of NPK) is uniformly spread. Leftover clods are then manually pulverized using wooden clod breaker to prepare a good seed bed and wheat seed is broadcast. This strenous task of clod breaking is invariably performed by women.

In potato cultivation FYM is applied in furrows @ 20-30 t/ha before the tubers are placed in it. Almost similar rate of FYM application is followed in growing of vegetable crops.

To enhance the productivity of crops, people in Kinnaur still use the farmyard manure. It is worth mentioning that here animals are kept primarily to meet the need of manure.

Donkeys, cows, goats and sheeps are the main source of manure in the state. The manure is collected either from the cowsheds inside the house or outside the house. Generally, the ground floor in each house is used as a cowshed so that animals can be looked after in a better way during winter months. The dung is put outside the house in a heap form in lower area, whereas, in upper areas, it is directly put in small heaps in the fields. These heaps are covered with a thin layer of soil to avoid the dispersion of manure by wind. The manure is directly mixed with the soil while ploughing.

FYM is transported to the fields in Kilta (bamboo container) by people's participation and also with the help of horses. In west Himalayan cold deserts, FYM with a thin coverage of soil is kept in a small heaps in the field from October to March, With the onset of summer months it is spread in the open field. The practice of keeping small heaps of manure in an open field with soil coverage in high altitude zones helps in decomposition due to the maintenance and regulation of proper temperature conditions.

Amongst the manures, the cowdung is preferred the most. According to most of the farmers the sheep and goat dung may lead to burning of crops if applied in excess. The burning of crops due to the toxic effects of high levels of nitrogen (3%), phosphorus (1%) and potassium (2%) present in goat and sheep manure compels farmers to use less quantity of these manures. Ass dung though used is not preferred much. On an average 125 to 250 q of manure is used per acre by the farmers throughout the Kinnaur region. It is a farmers perception that the attack of termites is minimized with application of FYM.

Spreading of farm yard manure

In high hills of zones 111 and IV, instead of incorporation, FYM is spread over the fields after sowing of wheat (Plate 3). This is primarily done with an objective to moderate the thermal regime as the minimum soil temperature during winter goes very low. Depending upon the quantity applied, the coverage provided by FYM also helps in moisture conservation of seed-zone depth besides enriching soil fertility.

Plale 3 : Spreading of FYM in the field

Collection and management of organic manure

Flock of sheep or goats, contribute towards tribal economy by way of milk, meat, wool and manure. The flock when taken for grazing are tied with small bags, which cover their anal parts so that the excreta falls into the bag. The collection of droppings of sheep and goats by tying bags is an indicative of indigenous wisdom of the farmers to meet out the shortage of manure.

The method of manuring through feeding of sheep and goats is very much in vogue in those places which are visited by the Gaddi graziers, whether enroute to their campus or on move with their herbs. The Gaddis are paid for this benefit. Similar type of practice is followed for other animals as well when these are taken in a group for sale in traditional fairs *(melas)*. These traditional practices continue unchanged.

In Spiti valley, organic manuring is done once a year in the months of September- October because of the practice of monocropping. The manure is broadcast in the entire field, which is followed by ploughing for thorough mixing. The richest manure called Chaksa, comprises human excreta and is collected in separate dry latrine pit. Even the bones of animals which has nutritional value are thrown in the excreta, which adds phosphorus and calcium to the manure.

Use of ash

The inhabitants of cold desert areas of Kinnaur and Lahaul and Spiti use cattle dung, shrubs and bushes as the main source of fuel. Ashes available, there upon, are mixed either with household waste or human excreta. Sometimes ashes are also broadcast in the fields.

Mixing of ash with household waste and human excreta aids in nutrient availability and recycling. Ash primarily meets the deficiency of potash. Availability of phosphorus is also ensured. In addition to this, human excreta and household waste contain good amounts of nitrogen, phosphorus and potassium.

Mixture of ash and manure

A mixture of kitchen ash and goat manure is used in kitchen gardens for growing potatoes. The spreading of this mixture as organic manure increases the size of tubers on account of optimum supply of niJtrients. Also, organic manure improves the soil structure, porosity and water holding capacity of the soils. In this way there is an overall improvement in physical, chemical and biological properties like microbial population etc., which increase the size of tubers.

Specific technologies are used only in case of tomato, brinjal, capsicum and cauliflower. Kitchen ash and poultry manure mixture enhances vegetable production levels. Goat manure is considered to be more nutritious. According to farmers vegetables grown in goat manure have longer keeping quality. It is easy to plough fields manured with goat excreta. In fact, with the addition of goat excreta, there is an improvement in the physical properties like soil structure, water holding capacity and porosity. There is also an improvement in soil fertility as it contains 3% nitrogen, 1% phosphorus and 2% potassium.

Sprawling of ash dust in cucurbits and other vegetables crops

In the cold deserts, ash dust is a product obtained after the combustion of fuelwood. It has been observed that dusting of material in the fields bring early maturity and high yield of vegetable crops. The reason for the early maturity of cucurbits and vegetable crops is due to the fact that ash dust contains sufficient quantity of phosphorus in available form. Secondly, in cucurbits the ash dust has been used to repel the insect pest of the crops. Thirdly, amendments of ash dust in the soil improves soil structure and fertility. Ash dust also hastens the maturity of bulb crops, which normally takes 6-7 months for obtaining economic yields.

Green manuring

In Bharmour area of Chamba district and in some paddy growing areas of Kangra, Una, Kullu and Mandi districts green manuring with leaves and twigs of wild bushes such as bastooti, subabool, eupatorium, kaimal etc is done. The green material is applied to the paddy field before transplanting. In direct seeded rice, it is a practice to do wet puddling with animal drawn plough, locally called ‘halod’ in which weeds are uprooted and burried underneath while rice seedlings are uniformly spaced.

In some parts of the Kangra district the potato growers burry tender twigs of *Eupatorium adenephorum* in furrows alongwith application of FYM. The green matter of this material contains about 2% N and 1.5% K.

Biofencing with seabuckthorn (Hippophae rhamnoides)

There is a common practice to provide biofencing with seabuckthorn in cold deserts in general and Spiti in particular. Seabuckthorn being thomy in nature protects crop from stray animals. Its multipurpose utility as a nitrogen fixer, check against soil erosion, conservation of soil and moisture, source of fuelwood and indigenous drug (rich source of vitamin C) makes it a promising plant for eco-economic rehabilitation of the region.

Use of forest soil in vegetables production

In some parts of the state farmers transport forest soil containing humus and mix it in the surface layer for growing vegetables. This helps to enrich the soil and improve its fertility as it not only contains high amount of organic matter but also the earthworms which accelerate the decomposition of undecomposed material.

Transportation of soil front river beds

In some parts of the state soil from riverbeds is transported for vegetable growing, as it is rich in nutrients. Even the termite heaps/maunds are levelled, transported and mixed up with soil for vegetable production. In Una district, fanners near the riverbanks grow cucurbits in trenches filled with mixture of soil and FYM. The vegetables, musk melons, water melons etc. grown in these trenches fetch good price in the market as the produce is of good quality.

Growing of pulse crops on bunds of paddy fields

In paddy growing areas of Kangra, Chamba, Mandi and Kullu districts farmers grow pulse crops on the raised bunds of paddy fields. After harvest of paddy and pulse crops the soil from the bunds is scrapped and mixed in the fields for sowing of wheat crop.

In the valley areas, farmers adopting rainfed maize-wheat sequence grow raj mash and black gram alongwith maize to improve the fertility of soil. Maize crop receive good amount of FYM also.

Use of organics in ginger cultivation

Himachal Pradesh is considered to be the second home of ginger, the predominant districts for growing ginger being Sirmaur, Solan and Mandi. Maize/ginger intercropping system with balanced NPK and FYM application is a popular practice in mid-hills of Himachal Pradesh (Plate 4). About 50-60 t/ha FYM is applied with good amount of mulch maaterials .

The undecomposed material from the cattle-shed, used for bedding of animals, is applied as mulch (Plate 5). All efforts are made to collect and apply dry leaves, farm waste, leftover crop residues etc in the ginger fields. Farmers feel that keeping quality of ginger is more when it is produced with adequate organic manureand less of fertilizers.

Plate 4 : Ginger crop raised with FYM in mid-hills of Himachal Pradesh

Plate 5 : Intercropping of maize with ginger with balanced NPK and FYM *application in mid-hills of Himachal Prad*

RELEVANCE OF INDIGENOUS TECHNOLOGY ADOPTED BY THE FARMERS

The indigenous technologies developed over the years by the farmers are need based and location specific. As we are now confronted with the twin challenge of high production and maintenance of high productivity without causing any damage to the natural resources and the environment, the indigenous technologies as the "Wisdom Alive" can come to our rescue.

Farmers are applying organic manures since ages not only to replenish the essential nutrients removed by the crops but also to maintain good physical and biological health of the soil. The long term fertilizer experiments in the country continuing for the last 30 years proved this point beyond any doubt that the application of FYM atleast to one crop in a sequence not only produces high yield of crops but also the yields are sustained over the years. In this practice there is also build-up of soil organic carbon which is essential for maintaining high production levels. The application of FYM also takes care of supplying micronutrients, which are required in a very small amount. Hill farmers give high premium to the application of FYM and apply it in rotation to different fields. The maintenance of good soil tilth after harvest of paddy is well related to the application of organic manures. The problem of clod formation is associated with the degradation of soil structure which is improved with the application of organic manures.

The application of bulky cattle bed collected from the cattleshed in standing maize, although labour intensive, is much more relevant for maintaining optimum seedzone moisture and improving soil fertility besides supplying material for organic carbon build-up. Similarly, the application of large quantity of FYM to potato and ginger crops is to maintain a favourable environment for the development of tubers and rhizomes besides maintenance of appropriate conditions to regulate water and air flow in addition to the supply of nutrients.

The collection of droppings of sheep and goats, when taken for grazing, by tying bags to cover anal pails is an indicative of indigenous wisdom of the farmers to meet out the shortage of manure.

The application of ash dust mixed either with household waste or with human excreta in the cold desert areas of the state is to ensure availability of potash and phosphorus. Sprawling of ash dust in cucurbits to repel the insect pests of the crops is quite relevant from the view point of devising new integrated pest management practices.

The concept of biofencing, with multipurpose utility thorny seabuckthom tree being adopted by fanners of Spiti valley of the state is ''till relevant, as the concept has attracted attention of the scientists aiming at sustainable management of natural resources.

SCOPE OF BLENDING INDIGENOUS TECHNOLOGY WITH SCIENTIFIC TECHNIQUES FOR ITS UPGRADATION AND GREATER EFFECTIVENESS

Some indigenous technologies developed over years by the farmers are losing ground in the wake of new scientific methods ofnutrient management. This is primarily due to the labour intensive nature of the indigenous technologies and growing demand to produce more food owing to demographic pressure. The new methods of nutrient management which are primarily based on chemical fertilizers have helped in producing more yield of crops. However, it is being gradually realised by the researchers and farmers that the yields are falling year after year with the same level of input management. In other words the yield levels achieved are not sustainable and in some intensively cultivated areas more and more of nutrients are required to be added to obtain the yield levels achieved in the initial years. That means soil, the productivity base, is gradually losing its capacity to produce more because it is being ‘overworked’ without caring for the total replenishment of the nutrients removed by continuous crop production. The deficiency of some new nutrient elements is emerging out and the micro-nutrients which are required to be added in very small amounts are becoming the yield limiting factor. The soil organic carbon content which is one of the most important indicators of soil health has been lost rapidly, compared to the initial values, from the intensively cultivated areas. However, wherever there is continuous application of organics alongwith inorganic fertilizers in any of the cropping systems, the soil organic carbon in those cases has either been built-up or it is being maintained at a higher level. No deficiency of secondary or micro-nutrient has been observed with the combined use of organic and inorganics. The application of organics like farmyard manure to the soil practiced by farmers since ages is one of the examples of indigenous nutrient management, as 'Wisdom Alive' in India. Similarly, there are many other location specific technologies which if blended with new methods of nutrient management can help in mitigating the problem of maintenance of high production levels without much loss in soil productivity. We have either to reappropriate the old technologies as per the demand of the situation or blend these technologies with the modem methods of nutrient management so as to produce more at a level whichcan be sustained over the years without much damage to the soils' ability to produce more and ill- effect on the environment. Integrated nutrient management is more important especially in the hills where the fertilizer use is much lower than the plains. Moreover the soils of the hills are continuously subjected to water erosion,leading to shallow depth and poor productivity. Improved method of FYM production and its utilization alongwith biofertilizers, plant residues and mulches with supplemental irrigation could increase the fertilizer use efficiency and crop production. Nitrogen may be added through fertilizer while P and K and micro- nutrients can be supplied by FYM, green manure, biofertilizers and vermicompost etc. The studies conducted in this respect are discussed below.

The maize-wheat system is quite common in the foot and mid hills under upland conditions. Grewal *et* rz/.(1985) while working in the foot hill of Shiwalik region observed 33% increase in both soil moisture and grain yield of maize and wheat due to FYM application. Tandon(1989) worked out the contribution of different fertilizer inputs towards the crop productivity in a long term experiment on acid soil ofPalampur (1971-72 to 1984-85). The contribution of N, P, K, NPK and FYM was 19, 37, 13, 69 and 31% in case of maize and 82, 0, 1, 83 and 17% in wheat, respectively (Table 3). Minhas and Singh(1998) have evaluated the utilization of weed plant *(Eupatorium adenoporum)* available in the forests of H.P. under maize-wheat crop sequence. They observed that incorporation of *Eupatorium* @ 20 t/ha on fresh weight basis was as effective as FYM (20 t/ha), however, their combined application was better (Table 4). The incorporation of this weed could substitute 60 and 40 kg N/ha in maize and wheat, respectively. Gupta and Sharma (1987) found a positive response of wheat up to 52 kg P/ha and the incorporation of lime and FYM further improved the wheat productivity and P use as well. Badiyala and Verma (1990) reported that application of FYM and biofertilizer through seed treatment *(Azotobacter* CTOCOCZWZ) increased the NH_4-N and NO_3-N status of soil. The performance of FYM and biogas slurry @ 20 t/ha were found almost equal in terms of direct effect on wheat crop but both were less effective than single superphosphate (SSP) @ 100 kg P,07ha (Table 5). The residual effect of rock phosphate applied to wheat on succeeding maize crop was more than SSP but less than that of FYM and biogas slurry (Sharma *et al.* 1995)

Table 3 Contribution of different inputs to the total yield increase from NPK+FYM application in long-term fertilizer experiments on acid soils at Palampur(average over 1971-72 to 1984-85)

Crop	Total response FYM+NPK(kg/ha)	Percent contribution of				
		FYM	N	P	K	NPK
Maize	4545	31	19	37	13	69
Wheat	2544	17	82	0	1	83

Source: (Tandon 1989)

Table 4. Effect of manures on the grain yield of wheat and maize(q/ha) at Palampur

Treatment	Wheat		Maize	
	1991-92	1992-93	1992	1993
Co ntrol	28.5	17.1	39.2	43.7
FYM	31.7	22.9	51.3	58i9
Eupatorium	29.0	22.2	47.0	59.8
FYM+Eupatorium	*34.6*	*26.7*	*54.3*	*63.8*
CD(P=0.05)	1.9	1.0	2.2	2.7

Source: (Minhas and Singh 1998)

Table 5 Effect of Udaipur rockphosphate and organics on wheat-maize sequence at Palampur

Treatment	Direct effect in terms of Wheat (q/ha) grain yield	Residual effect interms of maize(q/ha) grain yield	Available P in soil(kg/ha)
Control	17	21	13
40kg P/ha as SSP	34	31	17
40kg P/ha as URP	19	35	16
FYM (20 t/ha)	25	42	15
BGS(20 t/ha)	27	37	17
CD(P=0.05)	5	NS	5

BGS = Biogas slurry Source: (Sharma *et al.* 1995)

Acharya and Kapur (1993) reappropriated the cumbersome practice of carrying and spreading of bulky wastes from cattle shed to the field situated at a distant place. Direct spreading of wildly growing wastes like wild sage *(Lantana camara}* and eupatorium *(Eupatorium adenophorum)* in the standing maize at the recession of monsoon rains is a better option suggested by them. The practice not only conserved and carried over moisture for timely sowing of wheat without any presowing irrigation of 8cm but also produced the highest grain yield and water use efficiencies at each N level (Table 6). In another study Acharya *et al.* (1998) reported that the soil structu underneath wild sage and eupatorium was mellow and sowing of wheat with conservation tillage (minimum tillage and retention of dried twigs on the surface) and recommended P and K almost doubled the grain yield of rainfed wheat compared to the fanners practice (Table 7). Conservation tillage here holds promise because it does not require elaborate tillage and ultimately reduces animal draught in the hilly regions. Acharya *etal* (1998) further reported that spreading of wild sage or eupatorium twigs on the soil surface also favoured conditions for the growth of earthworms just before sowing of wheat as it moderated the hydro-thermal regimes and provided organic food to the worms. The earthworms populations increased by about 5 times with the application of these materials over the farmers practice (Table 8). Thus recycling of these readily available materials, having no fodder value, will encourage their use to enrich soils and promote the adoption of conservation practices rather than their wasteful eradication.

Table 6 Grain yield (kg/ha) of rainfed wheat under different treatments

N (kg/ha)	W,	w2	w,	w4	Mean
N,,	1183	893	911	780	942
N_{40}	1713	1486	1628	1356	1546
N	2285	1923	2050	1802	2015 '
N_{120}	2635	2166	2442	2239	2371
Mean	1954	1617	1147	1544	

W_p*In -situ* moisture conservation through application of lantana mulch to previous standing maize crop; W_2, pre-sowing irrigation of 8 cm; W_3, pre-sowing irrigation of 4 cm + 4 cm at early post-sowing stage, W_4, early post-sowing irrigation of 8 cm.
Source: Acharya and Kapur (1993)

Table 7 Grain yield (kg/ha) of rainfed wheat using organic wastes and conservation tillage

N (kg/ha)	Mulch-tillage (T)				
	T,	L	T>	T<	T_5
N_{60}	2858	3252	2660	3048	1664
Nuo	3424	3532	3131	3353	1794

T,- Mulching previous standing maize with wild sage followed by its incorporation with conventional tillage immediately prior to sowing of wheat; T - as T, but wheat sown following conservation tillage and retaining the residues of wild sage as a mulch; T_3- as T, but with eupatorium instead of wild sage; T_4- as T_2 but with eupatorium instead of wild sage; T_s- conventional farmer practice of soil tillage after harvest of maize; $N_{f>0}$ and N,,o- nitrogen @ 60 and 120 kg/ha.

Table 8 Earthworm population (number/m) in surface (0-0.15 m) layer at sowing and flowering stagesof wheat(1991-92)

Treatment	Number of earthworms	
Mulch-tillage (T)	Sowing	Flowering
T,	20	8
T_2	21	10
L	21	8
T_4	20	10
T_5	4	1
CD(P=0.05)		
Nitrogen (N)	1.7	1.4
N60	17	8
N120	17	7
CD(P=0.05)		
Interaction (TXN)	NS	0.9
CD(P=0.05)	NS	NS

Tp Mulching previous standing maize with wild sage followed by its incorporation with conventional tillage immediately prior to sowing of wheat; T_2- as but wheat sown following conservation tillage and retaining the residues of wild sage as a mulch; T_a- as T, but with eupatorium instead of wild sage; T_4- as T, but with eupatorium instead of wild sage; T_s- conventional farmer practice of soil tillage after harvest of maize; $N_{60}$and$N_{|20}$- nitrogen @ 60 and 120 kg/ha; NS - not significant.

Source: (Acharya *et al.1998*.

Potato is an important cash crop of the hills. The work done at Shimla has shown that the application of FYM @ 30 t/ha was equivalent to 28 kg N/ha (Sharma and Grewal 1986) and could fully meet PK needs of the potato crop. Sud *et* a/.(1990) reported that FYM had positive effect on tuber yield and its application @ 20 t/ha not only reduced the optimum dose of N from 181 to 163 kg N/ha but also increased the yield level from 23.5 t to 31.2 t/ha. FYM @ 10 and 20 t/ha also improved the fertilizer use efficiency by 10 and 35%, respectively (Table 9). FYM could also be used as mulch to conserve soil moisture in the hills where crops are usually rainfed. Besides FYM the use of plant waste materials, namely, green peas plants, robinia leaves, pine leaves etc. has also been found to economise on the fertilizer input by 50 percent (Table 10). Among the organic manures, poultry manure was found much better than FYM because the plants grown with poultry manure were characterised by large leaf area (Sharma *et al.* 1997). The use of pine needle mulch could economise substantially on fertilizer input (Table 11). It also improved the soil moisture status substantially and raised the minimum soil temperature and thus improved the PK availability from soil source and that of N from the fertilizer source. Beside, mulch decreased the soil water losses by 50% (Table 12), hence improved water and nutrient use efficiency. The use of vermicompost at 5-10 t/ha has also been found useful to improve the productivity of potato.

Table 9 Effect of FYM on N needs of potato at Shimla

FYM (t/ha)	Optimum N dose (kg/ha)	Yield at optimum dose (t/ha)	Response(t/ha)
0	181	23.5	16.1
10	177	26.7	17.7
20	163	31.2	20.9

Source: (Sude/u/. 1990)

Table 10. Effect of organic materials on potato yield (q/ha) and organic carbon (Shimla hills)

Organic materials	Yield (q/ha)				
	NPK dose(%)	1995	1996	Average	soil organic carbon (%)
Robinia leaves	50	257	298	278	2.14
Oak leaves	50	265	290	277	2.04
Wild Bushes	50	296	291	294	2.48
Pine needles	50	291	282	287	2.10
Pea leaves	50	322	296	310	2.55
FYM	50	301	298	300	263
Poultry manure	50	340	334	337	2.44
Goat manure	50	285	288	286	2.21
Fertilizer NPK	50	270	280	275	2.40
Fertilizser NPK	100	311	300	305	2.38
CD (P=0.05)	-	41	39	-	0.20

Source :(Sharma *et al.* 1997)

Table 11 Effect of pine needle mulch on tuber yield and fertilizer economy in Shimla hills

Treatment	Fertilizer Dose	Response at optimum dose (q/kg nutrient)	Tuber yield (q/ha)
N-experiment			
Bare	180	0.47	168
Mulch	150	0.87	216
P- experiment			
Bare	76	0.84	229
Mulch	50	0.80	248
K- experiment			
Bare	150	0.55	195
Mulch	106	0.30	206

Source : (Sood and Sharma 1985

Acharya and Kapur (2001) suggested that the problem of growing scarcity of FYM for potato cultivation for shallow depth soils of hilly areas can be mitigated through additions of compost prepared from abundantly growing organic wastes like *Eupatorium adenophorum*. The compost so prepared contained 1.8% N, 0.05% P and 0.45% K compared with FYM (1.62% N, 0.08% P and 0.32% K). The tuber yields in treatment with lOt/ha FYM + 10 t/ha eupatorium compost were nearly similar to the treatment where FYM @ 20 t/ha was applied (Table 12).

Table 12 Tuber yield, water use and water use efficiency of spring potato under differenttreatments

Treatment*	4 years pooled average (yield t/ ha)	Water use efficiency (kg/ha/cm)
T,	13.30	341
T_2	15.15	404
T_3	13.51	367
L	15.19	393
T_s	16.33	479
T_6	18.34	520
CD(P=0.05)	1.46	

T_p conventional cultivation + 20 t/ha FYM + 60 kg N/ha; T,, T, but with 120 kg N/ba; T,, T, but with 10 t/ha FYM + 10 t/ha eupatorium compost: T,, T, but with 120 kg N/ha; T_s, T, + pine needle mulch @ 10 t/ha at sowing; T_6, T,
+ pine needle mulch @10 t/ha at sowing.

Source: (Acharya and Kapur 2001)

The preceding results have underlined the need for blending the organic manure/ farm wastes/leaves of weeds or trees and biofertilizer with fertilizer alongwith water management practices in the rainfed conditions of the hills. FYM is the conventional source but inadequate to meet the nutrient needs. It needs supplementing with nitrogenous fertilizer

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CHAPTER 10

INDIGENOUS TECHNOLOGY FOR NUTRIENT MANAGEMENT IN JAMMU AND KASHMIR

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ABSTRACT

Agriculture is the mainstay of the people of Jammu and Kashmir. The farmers of Jammu and Kashmir produce crops, rear livestock and majority of the farmers use organic manure prepared from dung and urine of the livestock. A number of farmers practice green manuring wherein dhaincha and sunnhemp are mainly used. The Indigenous nutrient management technology blended with latest techniques for its upgradation followed by the farmers of Jammu and Kashmir has been presented. On-farm testings indicated that half of the recommended dose of N, P(f and KJ) through chemical fertilizers and half through FYM gave better yield in maize. Use of green manuring with Crotolaria juncea or Sesbania aculeata has been proved useful in increasing the yield of wheat. A long term experiment in rice- wheat crop sequence on different organic and inorganic sources of nutrients in the irrigated belt of R.S.Pura, indicated that combined use of organics and inorganic fertilizers can sustain soil fertility and grain yields in rice-wheat cropping system. Under irrigated conditions, application of recommended dose offertilizers to rice or maize crop during kharif and recommended NPK to wheat during rabi season can increase the yield by 18 and 21 per cent of these crops over farmer's practice.

The soil is sacred to the Indian fanners. From the time immemorial they have followed a number of practices for sustainable agriculture. Indeed, the fertility of the soil is the strength of the farmer. Traditionally the farmers have been using organic manures including green manuring and recycling of plant nutrients as in case of forest, wherein the trees grow in harmony with the nature without any cultural practices, maintaining micro-organisms in the soil and recycling the plant leaves and tree species residues. The stress is, therefore, more and more on having a system known as "Indigenous Technology for Nutrient Management" developed by the farmers with some modifications.

In the present paper, the indigenous technology for nutrient management followed by the farmers in various regions of Jammu and Kashmir State has been presented with some suitable refinements.

BACKGROUND INFORMATION

Geographical Situation

Jammu and Kashmir is located between 32° 17' to 37° 58' N latitude and 72° 40' to 80° 30' E longitude. It is bounded by Pakistan in the West, Afghanistan in the NorthWest and China and Tibet in the North and East. The state has three geographical regions viz. Ladakh, Kashmir and Jammu

Physiography

On the whole, the altitude varies from about 300 to 7000m above mean sea level with some peaks of more than 8400m high. Based on physiography, Jammu and Kashmir state has been divided into four parts viz. the outer plains, outer hills, middle mountains and inner mountains.

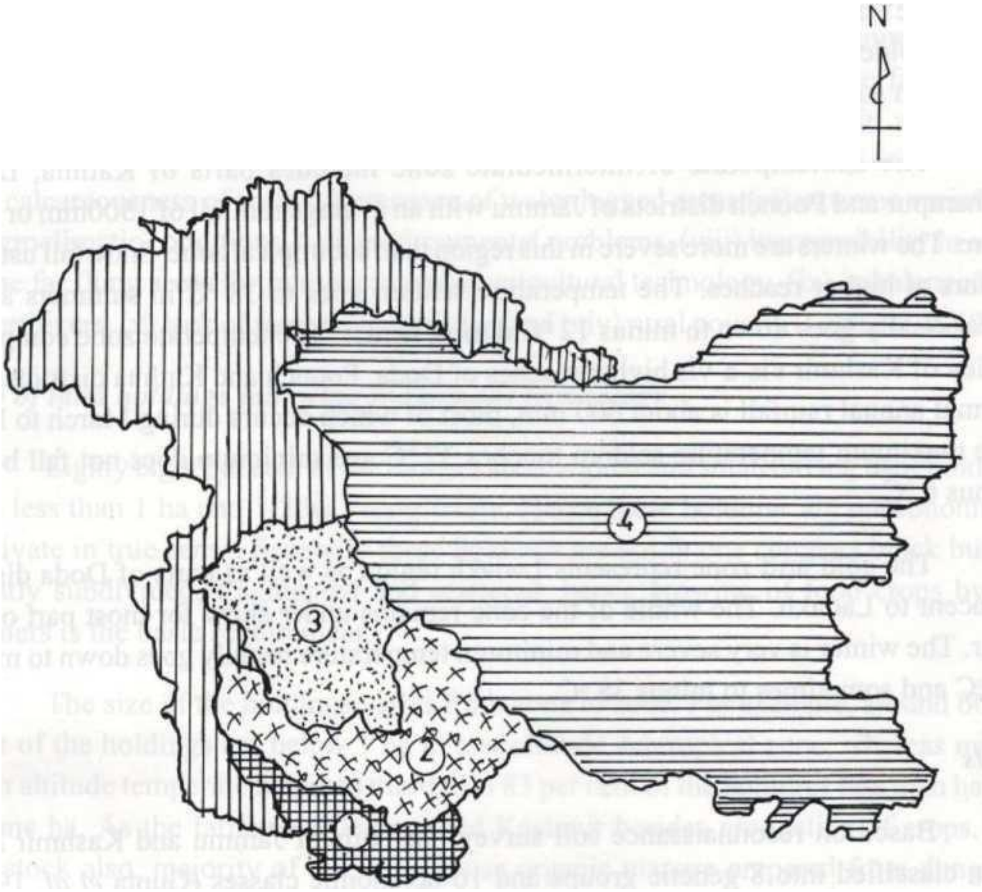
The outer plains (300 nt elevation) comprise plain portions of Jammu and Kathua districts with an area of 240 km^3, and are almost well levelled in topography. The outer hills are represented by the ranges situated more inwards and formed of older tertiary rocks with altitude from 800 to 2400m. The average height of outer hills is about 1000m above mean sea level. It comprises some parts of Kathua, Udhampur, Rajouri and Poonch. The area is lying between the rivers Chenab and Ravi, arising from gentle slope of 3°. It is undulating and rugged topography characterized by a number of Duns. Dansal, Udhampur and Jhajjar Kotli are some such Duns.

The Middle Mountains (3500 to 5000m, elevation) comprising parts of Doda, Srinagar, Poonch, Anantnag and Baramula are characterized by deep cut valley and precipitous gorges. Numerous ridges extending in irregular directions branch off again and again till the Pir Panjal is reached which encloses the valley of Kashmir. A number of other valleys such as Bhaderwah, Kishtwar, Paddar and Warwan are located in this region.

The inner mountains, which are located in the north of middle mountains with an average elevation of 5200m, encompass Ladakh valley. Other valleys such as Hunza, Nagare, Change Henmo and Gilgit are also present.

Climate

Agrociimatically, the Jammu and Kashmir state has been divided into 4 zones viz. Subtropical, sub temperate or intermediate, temperate and cold arid (Fig. 1) owing to variability of physiographic features.



1 LOW ALTITUDE SUBTROPICAL ZONE (LASTZ)

2. **MIDTO HIGH ALTITUDE INTERMEDIATE ZONE**

3. **MIDTO HIGH ALTITUDE TEMPERATE ZONE**

4 COLD ARID ZONE

Fig. 1 Agro-climatic zones of J & K

The outer plains and parts of outer hills are characterized by subtropical climate with an average rainfall of about 1000mm. May and June are the hottest months during which the temperature rises to 38 °C or sometimes upto 46 °C. December and January are the coldest months. The mean maximum and minimum temperatures are 39.9° and 23.4 °C in summer and 26.3 and 6.5 °C in winter.

The subtemperate or intermediate zone includes parts of Kathua, Doda, Udhampur and Poonch districts of Jammu with an average rainfall of 1500mm or even more. The winters are more severe in this region than subtropical zone. Snowfall usually, occurs at higher reaches. The temperature seldom goes to 38 °C in summers and it occasionally goes down to minus 12 °C during winter. The temperate zone comprises valley of Kashmir vis-a-vis higher reaches of Doda, Poonch and Kathua districts. The normal annual rainfall is about 600 mm, most of which occurs during March to May. The maximum temperature seldom touches 37 °C and minimum does not fall below minus 6 °C.

The cold arid zone represents Ladakh region as well as parts of Doda district adjacent to Ladakh. The whole of the zone remains under snow for most part of the year. The winter is very severe and minimum temperature usually goes down to minus 15 °C and sometimes to minus 38 °C.

Soils

Based on reconnaissance soil survey, the soils of Jammu and Kashmir have been classified into 8 genetic groups and 16 taxonomic classes (Gupta ***et al.*** 1985). There is wide variability in soil colour, structure, texture, pH, organic carbon and total N-status, calcium carbonate content, bulk density and water holding capacity. The soils are also variable in available nutrients. Low content of clay accompanied with poor status of organic carbon (Gupta 1994) are found to be responsible for low amount of available plant nutrients in Lithosol soil group, occurring in Siwalik hills of Jammu.
Similar is the situation in soils of Karewas in Kashmir (Bhat 1994). Owing to coarse texture, uncultivated soils of Leh and Kargil districts of Ladakh region are also deficient in available nutrients viz. N, P, K and organic matter.

Socio economic aspects

Agriculture is the mainstay of the people of Jammu and Kashmir. The soil related problems are low fertility status in soils of Siwalik hills of Jammu, Karewas of Kashmir and uncultivated areas of Ladakh, undulating topography in the major part of the state and lack of irrigation facilities. Similarly though the environment of some areas especially of Kandi belt of Jammu is not favourable for domestication of animals owing to non-availability of green fodder and water throughout the year, the farmers are rearing livestock and poultry. Other problems faced by the farmers in agriculture production are (i) soil and water losses, (ii) soil acidity (iii) soil salinity and sodicity, (iv) calcareousness of soils (v) presence of water logged areas (vi) extreme variations in agroclimatic conditions, (vii) environmental problems, (viii) inaccessibility in some of the far flung areas for introducing new agricultural technology, (ix) imbalanced use of fertilizers, (x) lack of marketing facilities, and (xiv) rural poverty (Gupta ***et al.*** 1992).

Size of land holdings following indigenous technology

Eighty eight per cent of the farmers are marginal and small having their holdings size less than 1 ha and 1-2 ha, respectively. Hence these holdings are uneconomic to cultivate in true sense. Secondly these holdings are not in one compact block but are mostly subdivided, fragmented and scattered; hence growing of food crops by the farmers is the basic requirement.

The size of the holdings varies from zone to zone. For example, around 60 per cent of the holdings are below 1 ha in low altitude subtropical zone, whereas mid to high altitude temperate zone has more than 83 per cent of the holdings less than half ha to one ha. As the farmers of Jammu and Kashmir besides production of crops, rear livestock also, majority of the fanners use organic manure prepared from dung and urine of the livestock in their fields for crop production.

Cropping System

Cropping systems of Jammu and Kashmir differ widely due to wide variability in climate, physiography, soils, lithology and vegetation (Gupta ***et al.*** 1985). Generally, three cropping systems are followed viz. (i) rice based, (ii) maize based, and (iii) wheat based. The main crop rotations followed in various agroclimate zones are presented in Table 1.

Table 1 Cropping patterns in relation to different agroclimatic and soil conditions of Jammuand Kashmir

Geographical Division	Agroclimatic zone	Characteristics of soils	Cropping patterns
Jammu	Subtropical plains (irrigated)	Variable in texture i.e. sandy loam, loam or silty loam on the surface and loam to clay loam in sub surface, pH varies from 7.0-8.6 or even more and organic carbon from 0.15 to 0.75% or greater with dominance of Ca^{2+} and Mg^{2}' followed by K^{+}, sometimes dominated by Na'	Rice-wheat, Rice-wheat-moong fodder, Rice- mustard-mash/fodder Rice-toria/potato/wheat, Rice-potato-potato
Jammu	Subtropical submontaneous or foot-hills i.e. kandi belt of Jammu (unirrigated)	Characterized by coarse texture often intermixed with gravels/stones, low water holding capacity and plant nutrients, pH lies between 7.4-8.2 and organic carbon from 0.07-0.06%	Maize-wheat, Maize - wheat + mustard, Maize+cowpeas/maize-wheat, Maize/bajra- mustard/ taramira, Mash? kulth-wheat + peas, Groundnut- wheat? mustard, Mash / kulth-barley + peas /mustard/ baj ra-wheat-mas h- mustard (2 years)
Jammu	Subtemperate or Intermediate (Irrigated)	Silty clay loam or loam, clay to clay loam or clay in texture with pH from 5.9-7.4 and organic carbon from 0.53 to 1.25%	Rice-wheat, Rice- berseem (possible only in valleys or other areas where assured irrigation water is available)
Jammu	Subtemperate (Rainfed)	Silty loam to clay loam with presence of rock bits, pH varies from slightly	Maize-wheat / mustard / gram / peas/ lentil /barley +peas, Upland rice-

		acidic to neutral (6.3-8.8) depending upon $CaCO_3$ content rich in organic carbon (0.53-1.52%)	wheat/mustard/peas, Mash-wheat
Jammu	Temperate	Characterized by variable texture, pH generally varies form 6.3 to 8.2 but in few areas it is less than 6. i.e. 5.1-5.9, organic carbon ranges from 0.62 to 1.86%	Rice-fallow, Rice- mustard, Rice-berseem, Oat/gram (fodder)
Jammu	Cold arid zone	Light textured i.e. loamy sand to sandy loam, pH ranges from 6.1 to 6.7, organic carbon from 1.1 to 2.9 (on the basis of Marwah and Warbun areas)	Salan/cheena/kangni- fallow, Buckwheat- maize, Maize-wheat/ barley/mustard, Saffron (kistwar, area) Perennial crop, Lesser millet/mash orrajmash-wheat barley/ mustard
Kashmir	Temperate (Irrigated)	Silty loam or silty clay loam, pH lies between 6.3 to 8.1, organic carbon from 1.1 to 2.7%	Rice-fallow, Rice- mustard, Rice-berseem/ oat/gram (fodder)
Kashmir	Temperate (Irrigated)	Variable in texture ranging from loam, clay loam or clayey, organic carbon content form 0.25%	Maize-fallow, Maize+moong/mash/ raj mash-wheat/barley/ lentil, Saffron (Pampore) a perennial crop
Ladakh	Cold arid	Sandy siliceous, sandy skeletal, siliceous, coarse loamy, siliceous, none to slightly alkaline and slight to moderately alkaline, sandy loam to clay with pH from 9.0 to 9.4 in Changthaang area	Wheat/barley/mustard, pea/lesser millet/pulses/ lucerne (fodder), Monocropped area (April to October)

Source: (Gupta *el al.* 1980, Gupta *et al.* 1992)

Cropping intensity

Cropping intensity in the state is varying from 138 to 300 per cent depending upon agroclimatic situation. In low altitude irrigated areas of the subtropical zone, where rice-wheat-moong/mash and rice-potato-potato are grown, the cropping intensity is 300 per cent. Where rice and berseem is followed every year, the cropping intensity is 200 per cent. In the dryland areas of the low altitude subtropical zone, where maize- wheat/barley or moong-wheat or pearmillet-wheat, is grown cropping intensity is 200 per cent. Where wheat + gram intercropping is practised dumg rabi season, the cropping intensity is 150 per cent. In this case farmers still keep portion of the land fallow during kharif season to get good crop in rabi season. In rainfed area of mid to high altitude intermediate zone, maize-wheat is the main crop rotation where the cropping intensity is 200 per cent.

Irrigated area

In Kashmir region about 40 per cent of the gross area of the state is under irrigation. However, only 20 per cent of the net area sown in Jammu region is irrigated. Owing to lack of irrigation facilities in Jammu region, more than 70 per cent of agriculture is dependent upon monsoon rains which are uneven, irregular, uncertain and show considerable variation. Rice is the major crop grown in irrigated area, followed by wheat, rape seed and mustard. In Ladakh region crops are grown with irrigation. ***Fertilizer inputs***

There is limited use of chemical fertilizers in soils of Shiwalik hills of Jammu locally knowrn as Kandi belt. The consumption of chemical fertilizers in terms of N, $P_{,}O_{5}$, K,0 varies from 10 to 32 kg/ha with an average of 20kg/ha. Use of chemical fertilizers in Karewa lands (Kandi belt of Kashmir) is also very less (lOkg/ha in maize and no fertilizers in beans and pulses). In irrigated area of Jammu and Kathua districts of Jammu region, the average consumption of chemical fertilizer is 46.9kg/ha, against all India average consumption of 90kg/ha. In irrigated areas of Kashmir, the consumption of chemical fertilizers works out to be 50.9/kg ha. In Ladakh region, the use of chemical fertilizers is almost negligible.

The most disturbing feature in fertilizer consumption is an apparent imbalance in use ofN, $P_{,}O_{\$}$, K,0 (nutrient consumption ratio). Most of the rainfed and irrigated farmers do not use phosphatic and potassic fertilizers as a basal dose. In Kandi belt of Jammu, the farmers apply onlyurea after sowing the crops as top dressing.

INDIGENOUS NUTRIENT MANAGEMENT PRACTICES

Floating gardens of Kashmir formed from the weeds of Dal Lake viz. Typha *angustata, Phragmites communis, Trapa sp.* and *Euryate ferox* are of much economic importance for vegetable production. In these gardens, most versatile manure added by the boatmen is *hydrilla* muck and no chemical fertilizer is required for crop production. In these floating gardens the use of chemical fertilizers was tried for more production of vegetables but it reduced yields of tomato, pumpkins, cucumbers, melons and watermelons. Presence of high content of organic matter (3.5 to 5.7%) and available N (272 to 420 ppm), P (3.1 to 48 ppm) and K (322 to 390 ppm) status in these lands provide favourable microbial activities for the growth of the plants (Gupta *et al.*1982).

The common practice adopted by majority of the farmers of all the three regions of jammu & Kashmir state is to apply farmyard manure whichever quantity available with them. Some of the farmers particularly of Doda district use coniferous needles as cattle beds for soaking urine and dung. The soaked material is thrown in open heaps daily and after a few months, this is used as manure in the fields, A number of farmers especially of Jammu and Kathua districts practice green manuring. *Sesbania aculeata* and *Crotolaria juncea* are the main crops used for the purpose. In irrigated areas of R.S.Pura and Bishnah, *Sesbania aculeata* is sown in the middle of May. After 40-50 days of sowing, the crop is buried into the soil and then rice is transplanted after 2-3 days. In dryland area, *Crotolaria juncea* is sown after 1st showers of monsoon and before 45 days after sowing it is buried into soil. Then wheat is sown in October.

In some cases, the nomadic gujjars and bakerwals are allowed to keep their cattle in the field when these are fallow. During the penned period, the cattle dung and urine is incorporated in the field, thereby enriching the soil fertility. This is a practice in R.S.Pura and Bishnah tehsils of Jammu district as well as rainfed areas of Kathua, Udhampur and Rajouri districts.

The recycling of human and animal excreta in soils of Ladakh is a time immemorial practice borne out by necessity and suitability which is quite consistent with agroclimatic conditions of the region. This nutrient rich night soil is the prime source of organic matter nourishing the coarse textured soils of Ladakh. This practice is, in fact, prevalent in whole of the cold arid desert of Ladakh, extending to Tibet and China as well.

EXISTING PROBLEMS OF NUTRIENT MANAGEMENT AND INDIGENOUS SOLUTION

Problems

As already stated, the farmers of Kandi belt of Jammu and Karewa lands of Kashmir use only nitrogenous fertilizer i.e. urea. This imbalanced use of fertilizers not only declines the yield of crops but also renders the soil acidic as imbalanced application of acidifying N fertilizers decreases the soil pH (Gupta *et al.* 1992). With the decrease in soil pH, the availability of P to plants gets declined. Even continuous use of N, P_2O_5 and K.O fertilizers has led to depletion of micronutrients especially Zn in irrigated areas of Jammu. The deficiency ofZn and Mn has also been observed in soils growing maize and citrus. In soils of Kandi belt, deficiency of organic matter vis-a-vis available N, $P_2O_5$and K,0 has been observed (Gupta *et al.* 1994) due to non-application of the required quantity of FYM.

In view of great variation in the steepness of the slope ranging from slightly gentle (1-2%) to steep slope (30% or even more) in Jammu and Kashmir, soil erosion is one of the main problems which has assumed an alarming proportion in the state. Steep slope causes runoffofwater resulting in decreased moisture content in the soil. The swift running streams of water carry away the superficial layers of the soil. Thus, loss of plant nutrient viz. organic matter or humus, nitrate, potassium, calcium and magnesium occurs. This renders the soils not only acidic, due to loss of basic cations Ca^{2+}, Mg^{2+} and K^+, but also deficit in nitrogen. The plants cannot establish themselves under such situations. Soil erosion is causing great damage in the Siwalik belt and the adjoining middle and inner Himalayas. Even in a slope of about 2-3 per cent there was loss of about 106.5t/ha annually. In the districts of Jammu, Kathua, Udhampur, Rajouri and Poonch, the damage to soil due to erosion is considerable particularly in the tracts falling under outer hills.

The Karewa lands of Kashmir, having highly undulating topography are bare without vegetation and as such suffer from excessive soil erosion ranging between 16 to 250 t/ha. The cold arid zone of Ladakh and Warban tract of Doda district have also a serious soil erosion problem. Glacial erosion is quite marked in Ladakh. During hot season the glaciers on melting create flash floods. The main causes of soil erosion are deforestation, overgrazing of the grasslands and denudation of the slopes. The reckless felling of trees and shrubs for timber, fuel wood and loppings for fodder have led to deforestation.

Calcareousness of the soils is another soil problem for iron in some of the pockets of the state. Excess of calcium carbonate may cause a lime induced iron chlorosis in many plants resulting in the depression of crop yields. When there is an excess of calcium the availability of phosphorus and zinc to plants is decreased because of the formation of complex compounds like calcium phosphate and calcium zincate.

Acid soils have an adverse effect on plant growth which is chiefly related to the presence of Al, Mn, and Fe in toxic concentrations, low availability of basic cations like Ca, Mg and K, imbalance of nutrients and poor microbial activities (Gupta *et al.* 1992).

Indigenous Solution

Fertility status of the soils is replenished by using organic manures such as FYM, green manuring, compost and use of night soil. The practice of organic manuring not only improves soil productivity but also ameliorates soil condition and enhances the microbial activity and fertilizer use efficiency. Composting of organic residues and their application to soil reduces problem of methane emission from submerged soils compared to direct application of organic residues. However, the practice of preparing residues and storing manure/compost on cultivators' fields is very defective. Dung and litter are usually collected each morning and put in heaps in open spaces in the fields. The manure heaps, remain exposed to rains and sunshine, and create considerable loss of nutrients. Approximately half of the manurial value is lost. During decomposition, there is a loss of ammonia by volatilization. Nitrates produced in soil manure contribute to ground water pollution due to leaching of nitrate. Ammonia that emanates from volatilization contributes to acid rains. Hence, the manure/compost must be prepared in the pits to avoid the heavy loss of nutrients through leaching, drainage and in gaseous forms. Increase in the concentration of soluble salts adversely affects the soil productivity and degrades the quality of land. Dissolved salts accumulate on the soil surface with an adverse effect on the plant growth. In sodic soils, excess amount of exchangeable Na* affects the uptake of other nutrients like $Ca^{2'}$ and Mg' .

High salinity in soils of Kandi belt of Jammu is quite prevalent (Gupta *et al.* 1992) and also in soils of cold arid zone of Ladakh vis-a-vis valley of Kashmir (Gupta *et al.*1980). In Jammu district alone, about 10,000 hectares land has been found to be affected by salts.

Salinity and sodicity can be prevented by providing the irrigated lands with proper drainage. The management of salt affected soils can also be done by growing crops tolerant to salinity and sodicity like barley and oats, tree species *Acacia nilotica.*

A. modesta and adopting better water management practices. However, continuous application of organic manures including green manuring has been found very effective in reclamation of such soils.

The state of Jammu and Kashmir is most fragile as far as its topography and geography is concerned. Thus, the land resources of the state have been spoiled due to soil erosion of various kinds. About 8.92 lakh hectares of large chunks of eroded riverbeds have become degraded land. The indigenous technology followed by the farmers of the area to conserve soil and moisture of the land is through the use of vegetative barriers. The terraced bunds are utilized for growing of suitable grasses, bushes like *Vitex negundo, Ipomoea crassicaulis, Dodonaea viscosa and Carissa spinarum* to control soil erosion and run off losses. *Grewia optiva, Bauhinia variegate, Butea monosperma, Albizia lebbek. Acacia nilotica, A. modesta* are some of the fodder trees. These trees serve the dual purpose of meeting the fodder needs of the villagers and helping in soil/water conservation.

PRESENT RELEVANCE OF THE INDIGENOUS TECHNOLOGY ADOPTED BY THE FARMERS

The technology adopted by the farmers of Jammu and Kashmir, worked effectively to the continuity and stability of their cropping system due to (i) beneficial effects on soil physical, chemical and biological properties, (ii) crop productivity, and (iii) to stabilize buffering action. However, farmyard manure and compost are limited in supply. Similarly, green manuring is not possible in some situations. So, the alternate source is integrating chemical fertilizers with farmyard manure, compost, green manure, compost, and other organic sources. Hence the indigenous technology adopted by the fanners needs to be modified in light of the facts stated above.

THE SCOPE OF BLENDING THE INDIGENOUS TECHNOLOGY WITH LATEST TECHNIQUES FOR UPGRADATION OF THE INDIGENOUS TECHNOLOGY

The key challenge confronting agriculture sector is to produce more food for growing population. Sonone of the agricultural systems will be sustainable unless the soil, which constitutes the most important natural resource, is managed scientifically for meeting the present and future needs. There is growing realization that intensification of cropping system is producing great strain on the natural resource base that supports agriculture. The use of organic manures is useful in sustaining agriculturalproduction and saving the environment from being further deteriorated. Organic manures, however, are available in limited quantity and having low amount of nutrients, can not fully meet the requirements of various crops. So these must be blended with chemical fertilizers. Accordingly, a number of models for integrated nutrient supply system to keep the soil resources more productive were developed in maize-wheat and rice-wheat cropping systems:

Maize-Wheat Cropping System

The results of the experiments conducted at Dryland Agricultural Research Substation, Rakh Dhiansar under Sher-e-Kashmir University of Agricultural Sciences and Technology (SKUAST), showed that application of FYM @ 10 t/ha alone gave lower yield but when it was supplemented with 30 or 40 kg N/ha, the yield of maize and wheat increased substantially over control vis-a-vis farmer’s practice (Table 2).

Table 2 Yield of maize and wheat as influenced by various combinations of organic and inorganic fertilizers

Treatment	**Kharif (Maize)**		**Rabi (wheat)**	
	1985	**1986**	**1985**	**1986**
1. Control	12.95	11.94	14.38	16.31
2. FYM @ 10 t/ha	16.37	21.13	20.50	20.13
3. FYM @ 10 t/ha+30 kg N	18.31	24.81	22.38	24.98
4. Farmer’s method (4 t FYM+20 kg N)	20.18	20.99	24.11	21.17
5. Recommended (NPK) (60:40:20)	26.56	29.39	26.61	25.33
6. 50 per cent recommended NPK	20.32	22.66	22.83	20.18
7. FYM @ 10 t/ha+60 kg N	22.75	25.47	28.16	27.41
CD (P=0.05)	1.83	3.93	3.96	4.20

Source: (Singh and Bali 1998)

"On Farm Testings" (OFT) in 4 different locations in Kandi belt of Jammu from 1993-1995 on maize also showed that when FYM was applied with N, P,O. and K,0 fertilizers there was improvement in the yield of maize (Table 3). The highest yield was obtained with recommended dose of N, P,O$_5$ and K,0 followed by half through N, P,O$_5$ and K,0 + half through FYM, the lowest being in case of farmer's practice. Therefore, keeping in views the financial constraints and to maintain sustainability of production, half of the recommended N, P,O. and K.,0 through fertilizers and half through FYM be followed.

Table 3 Nutrient management in maize

Treatment	Average yield (q/ha) of four location									
	1993			1994			1995			
	Highest	Lowest	Mean	Highest	Lowest	Mean	Highest	Lowest	Mean	Overall
Full recommended Dose of NPK (60:40:20 kg/ha)	36.80	22.40	30.00	28.00	24.00	26.50	30.00	25.00	27.00	27.83
Haif of the recomm ended dose of NPK+half through FYM (30:20:10 kg+10 Tonners FYM/ha)	30.50	18.80	25.00	26.00	20.00	22.00	27.00	22.80	24.50	23.83
Farmers practice (4 tonners FYM+20 kg N/ha)	22.00	16.00	18.70	22.00	14.00	16.00	20.00	12.00	14.40	16.37

In Kandi soils green manuring with *Crotolaria juncea* or *Sesbania aculeata* has -iso been proved useful In this practice, the green manure crop is grown with 70 kg AP . Sowing is done with the onset of monsoon and green manure is incorporated at -5 days after sowing by about middle of August. It helps in increasing about 30 per tent wheat yield without supplying any additional fertilizers to wheat crop. Green muring in a particular area can be adopted for 3 years and farmers can earmark the area in every kharif season accordingly.

Rice-Wheat Cropping System

In the irrigated belt of Jammu, farmers use organic manures during kharif eason. A long term exper - . . on different organics and inorganics in the irrigated -elt of R.S. Pura showee n - n n;chest grain yield was obtained with 100 per cent N,A and K$_2$O applications :r. nee as well as wheat during the initial years. However, with the advancement of time, higher yield was recorded in treatment where 75 per cent N, P,O$_5$ and K^O were applied through FYM, green manuring or wheat straw (Gupta and Gupta 1997). Besides, an increase in grain yield of both the crops, there was an appreciable increase in available N and also phosphorus status of soil (Table 4).

Table 4 Grain yield (t/ha) as influenced by different treatments in rice-wheat cropping system

Treatment		19985-87			1988-90			1991-93		
		Rice	Wheat	Total	Rice	Wheat	Total	Rice	Wheat	Total
Kharif	Rabi									
T_1 = Control	Control	3.2	1.5	4.7	2.6	1.2	3.8	2.7	1.2	3.9
T_2 =50% F	50%F	3.6	2.4	6.0	3.7	2.5	6.1	3.5	2.4	5.9
T_3 =50% F	100%F	4.2	3.1	7.3	3.8	3.5	7.3	3.7	2.9	6.5
T_4 =75% F	75%F	4.5	2.8	7.3	4.0	•3.0	7.0	4.0	2.6	6.6
T_5=100%F	100%F	4.9	3.2	8.1	4.4	3.6	8.0	44.6	3.1	7.7
T_6 =50 %F+50%FYM	100% F	4.4	3.4	7.8	4.2	3.8	7.6	4.9	3.3	8.1
T_7=75%F+25%FYM	75% F	4.8	2.8	7.5	4.4	3.2	7.6	4.7	2.9	7.6
T_8=50%F +50% rice straw	100% F	4.1	3.0	7.1	4.1	3.5	7.7	4.1	3.1	7.1
T_9=75%F +25% rice straw	75%F	4.7	2.9	7.5	4.4	3.3	7.8	4.3	2.8	7.1
T_{10}=50%F+50% GM	100% F	4.5	3.3	7.8	4.2	3.7	7.6	4.7	3.1	7.8
T_{11} =75%F+25GM	75%F	4.7	3.0	7.7	4.4	3.3	4.9	4.7	2.9	7.6
T12 = Conventional	Conventional	3.6	2.0	5.6	3.1	1.8		3.5	1.8	5.3
CD (P=0.05)		0.2	0.3	-	0.1	0.1	-	0.1	0.1	-

F= inorganic fertilizer, FYM = farmyard manure; GM = green manure (dhaincha),
100% F= rice (100 kg N, 26.4 kg P and 24.9 kg k/ha); Wheat (100 kg N, 22.0 kg P and 20.7 kg K/ha): Conventional = farmer's practice of applying 60 kg DAP/ha (basal) and 60 kg urea/ha (top dressed)

On Farm testings, on rice, IET-1410 variety in the farmers fields during Kharif, 1998 at four locations showed that 50 and 60 per cent of the recommended doses of N, P,O_S and K,0 can be saved through FYM and green manuring (Table 5).

Table 5 Effect of organic manures on the yield of rice

Treatment	**Yield of rice (q/ha)**	
	Grain	**Straw**
T_1 (Recommended dose of NPK) (100:50:30)	38.60	42.70
T_2 (50 per cent through NPK and 50 per cent thorugh FYM)	29.80	36.72
T (40 per cent through NPK and 60 per cent through green manuring)	31.00	38.80

Rice-Wheat and Rice-Maize Cropping Systems

Some of the farmers of irrigated belt of Jammu and Kathua districts usually use about 100 kg urea and 5t FYM/ha to rice and maize crops besides adding recommended dose ofN, P,O_5 and K.,0 (100.50.50) to high yielding varieties of wheat during rabi season. The results of experiments conducted under All India Coordinated Agronomic Research, Project, wheat at R.S.Pura, Jammu on farmers fields during 1998-99 on rice-wheat and maize-wheat cropping systems have shown an increase in yield by 7.0 and 18.6 per cent over farmer's practice by adding recommended N, P,O_5 and K.,0 to rice and wheat crops, 125 per cent of recommended N, P,O_S and K,0 to rice and 100 per cent recommended to wheat and 100 per cent recommended with 5t FYM/ha to rice and 100 per cent recommended N, P,O, and K,0 to wheat respectively (Table 6). Similarly in case of maize-wheat system an increase of 10.6 per cent with recommended N, P,O_S and K,0 to both the crops, and 21 per cent with recommended NPK to maize with 5t FYM /ha and only recommended dose of N, P,O_5 and K,0 to wheat over fanner's practice has been observed (Table 7).

Table 6 Grain yield of rice and wheat as influenced by different treatment

Treatment	Grain yield (q/ha)		
	Rice	Wheat	Per cent increase over farmers practice
Tj 100% recommended NPK to both the crops	49.43	29.88	7.00
T, 125% recommended NPK to rice +100% NPK to wheat	51.47	31.96	12.71
T_3 100% NPK+5t/ha FYM to rice+100% NPK to wheat	52.73	34.85	18.68
T_4 Farmer's practice fertilizers application in kharif + 100% NPK to wheat	45.37	28.60	
CD (P=0.05)	1,55	1.95	-

Table 7 Nutrient management in maize-wheat sequence

Treatment	Grain yield (q/ha)		
	Maize	Wheat	Per cent increase over T3
T, 100% recommended dose of NPK to both the crops	27.68	44.03	10.56
T, Recommended dose of NPK+5t FYM/ha to maize and 100% NPK to wheat	31.35	46.85	21.02
T_3 Farmer's practice of fertilizer application to kharif crop and 100% recommended NPK to wheat	24.13	40.97	
CD (P=0.05)	1.90	0.88	-

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CHAPTER 11

Indigenous nutrient management practices - wisdom alive in India
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INDIGENOUS NUTRIENT MANAGEMENT TECHNOLOGY IN CENTRAL HIMALAYA

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ABSTRACT

Traditional societies managed the natural resource capital available with them to provide food, fodder, manure and other requirements. But the balance between utilization and availability/natural regeneration was disrupted due to increased demands. This altered balance of availability and demand made most traditional systems of natural resource management strategies unviable. But conserving the natural systems could be possible only with reduction of demands either through alternatives or through reduced consumption. While meeting the demands through alternate means was not possible in marginal areas such as Himalaya, reducing consumption through revitalizing the old systems of production, which demand lesser inputs and increasing the capacity of the technology to reduce such inputs have potential. Indigenious technology of traditional societies indicates, organic resource incorporation into the farming systems and composting of available resources (crop residue, by-product) as major nutrient management strategies in central Himalaya. This paper attempts to document, analyze such traditional knowledge systems of plant nutrient management in central Himalaya and suggests scientific refinements.

Soil fertility management, in a broad sense, embraces actions or interventions for meeting the ever-increasing crop-based demands of fast multiplying human population. Removal of substantial quantities of mineral nutrients by harvesting the crops from the production site is the major factor that differentiates the managed ecosystems from the natural ecosystems. In young mountain regions, like Himalayas, where both deforestation and upliftment processes are still active, in such ecologically fragile environments soil management becomes more difficult. Change in natural resource management is a continued evolutionary process set in from the beginning of advancement of human civilization. Unfortunately, human dimensions of land use changes linked to soil fertility or productive capacity of land remain poorly understood (Fischer 1990).

Local or indigenous technical knowledge is now increasingly receiving the attention in conventional scientific investigations. Indigenous knowledge primarily responds over long term and over areas beyond the one concerned by intensive production systems (Scott and Walter 1993). In Central Himalayas, traditional farming community considers croplands not as a discrete independent system but as a subsystem of a complex ecosystem consisting of croplands, animal husbandry, forests and human beings. Under changed scenario of new patent regimes, there is an urgent need for documenting, validating and recognizing traditional knowledge in view of its paramount importance to developing country like India (Singh 1999). This paper attempts to review the available indigenous nutrient management techniques in this region, validate the concepts behind them, wherever possible, and suggests improvements based on scientific knowledge.

BACKGROUND

Study area

The Indian Central Himalayas consists of 12 districts of Kumaon and Garhwal divisions (Anonymous 1982) of hill region in Uttar Pradesh State (Fig. 1). It lies between 29°44'-31°25' N and 77°45'-81° T E and encompasses an area of 5.1 million ha supporting 5.8 million inhabitants (Anonymous 1991). The area has three major physiographic regions, *viz.*, mountains, hills and tarai/bhabar. The area, in general, is characterized by highly dissected terrain, steep slopes, sparse and unevenly distributed population/ habitations, fragmented or widely spread small landholdings, gravelly soils on poorly weathered parent material and highly active tectonic movements. The region is divided into three different agroclimatic zones along the elevation gradient (vertical zonation). The zone between 500 to 1000 m elevation is considered as the lower altitude area, between 1000 to 1800 m elevation as middle altitude area and above 1800 m elevation as higher altitude area (Maikhuri *et al.* 1996).

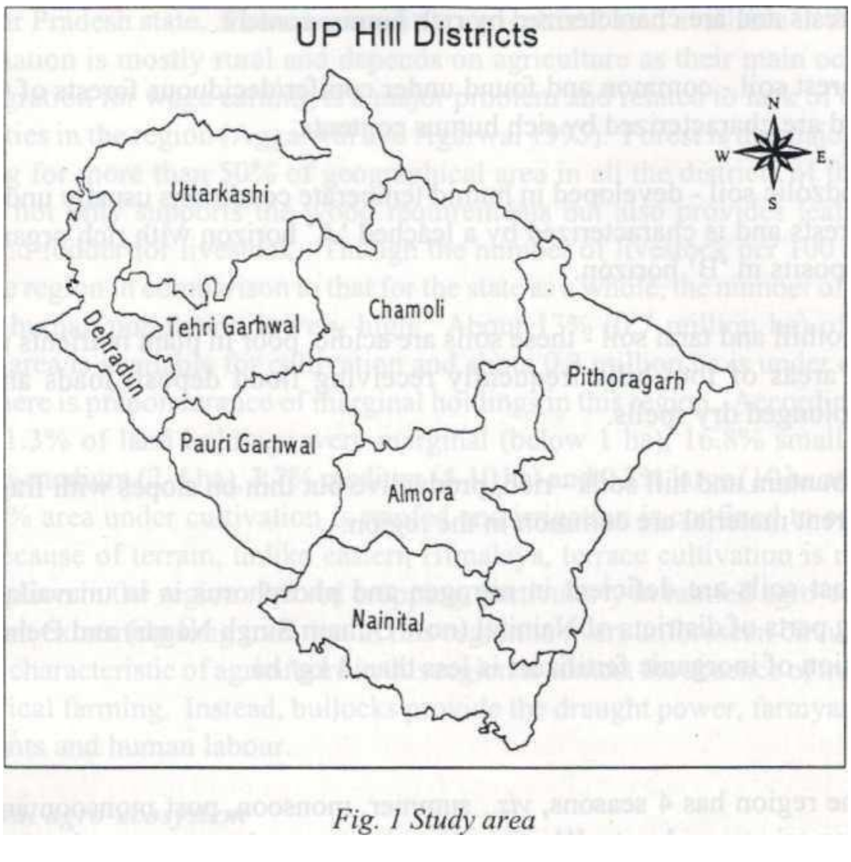

Fig. 1 Study area

Soils

The principal soil types found in the region are as follows (Roy Chaudhri *et al.* 1963, Alexander 1972, Negi 1990).

(a) Himalayan Alluvial soil (Group A) - fairly old in origin but limited in extent to longitudinal dun valleys, tarai/bhabar and river valleys in mid hills.

(b) Himalayan Alluvial soil (Group B) - recent in origin and extensively found in tarai/bhabar, dun valleys, river terraces/valleys. They are highly deficient in nitrogen, humus and phosphoric acid.

(c) Red and black soils - limited in extent of distribution of acid igneous rocky parent material regions and highly deficient in soil fertility.

(d) Ferrugenous red soils - common and are characterized by friable, porous, nutrient poor soils.

(e) Brown soils - mainly found under dense broad-leaved temperate and sub-alpine forests and are characterized by rich humus content.

(f) Forest soil - common and found under conifer/deciduous forests of the region and are characterized by rich humus contents.

(g) Podzolic soil - developed in humid temperate conditions usually under conifer forests and is characterized by a leached 'A' horizon with rich organic matter deposits in 'B' horizon.

(h) Foothill and tarai soil - these soils are acidic, poor in plant nutrients and found in areas of foot hills frequently receiving flood deposit loads and having prolonged dry spells.

(i) Mountain and hill soils - rich, productive but thin on slopes with fragments of parent material are common in the region.

Most soils are deficient in nitrogen and phosphorus is in unavailable form. Excluding parts of districts of Nainital (now Udham Singh Nagar) and Dehradun, the consumption of inorganic fertilizers is less than 4 kg/ ha.

Climate

The region has 4 seasons, *viz.*, summer, monsoon, post monsoon and winter. The winter rains are due to Western disturbances and summers rains by summer monsoon winds. Generally the winters are severe and summers are pleasant. The highest maximum temperature observed is up to 36° C during summer (May-June) in valleys and the lowest minimum falls below 0°C during winter (Jan-Feb) in many parts of the region. The prolonged spells of winter rain usually results in snowfall between 1500- 3000 meter elevations. However, it is generally snow or hailstorm with hardly any rainfall between 3000 - 5000 meters. Beyond 5000 meters, lies the line of permanent snow. Potential evaporation is about 51% to 57% of the annual total during South- West monsoon season, 5 to 10% during cold weather season. During summer and post-monsoon season, potential evaporation varies from 24% to 30% and from 9% to 13%, respectively.

Socio-economic aspects of the region

Like most of the societies of the world the initial societies in central Himalaya too were hunter-gatherers. In due course of time they changed to nomad-pastoral, pastoral-agrarian, pastoral-trader and finally to agrarian-pastoral or agrarian societies. The region has low physiological, arithmetic, rural and agricultural densities compared to the Uttar Pradesh state. There is very little agricultural land available in the region. The population is mostly rural and depends on agriculture as their main occupation. Male emigration for wage earning is a major problem and related to lack of economic opportunities in the region (Aggarwal and Agarwal 1995). Forest is the major land use accounting for more than 50% of geographical area in all the districts of the region. This area not only supports the wood requirements but also provides leaf litter for manure and fodder for livestock. Though the number of livestock per 100 ha area is low for the region in comparison to that for the state as a whole, the number of livestock per 1000 human population is very high. About 13% (0.7 million ha) of the total reporting area is available for cultivation and about 0.3 million ha is under culturable w_aste. There is preponderance of marginal holdings in this region. According to 1991 census, 71.3% of land holdings were marginal (below 1 ha), 16.8% small (1-2 ha), 9.0% semi-medium (2-4 ha), 3.7% medium (4-10ha) and 0.2% large (10 ha and above). About 90% area under cultivation is rainfed and irrigation is confined to only valley areas. Because of terrain, unlike eastern Himalaya, terrace cultivation is rather rule than exception in the region. Mixed cropping, particularly in rainfed agro-ecosystem, has been an extremely long tradition in this region to avert unforeseen circumstances. The main characteristic of agriculture in this region is almost the absence of mechanized and chemical farming. Instead, bullocks provide the draught power, farmyard manure the nutrients and human labour.

Traditional agro-ecosystem

Central Himalayas has a long heritage of subsistence economy, with agriculture being the core component, in which over 80% of the people are involved. Vast variation in altitude, topography, climate, forest resources, availability of water for irrigation and socio-economic and cultural factors exist producing a variety of land use patterns in the region.

The traditional hill agro-ecosystem of the central Himalayas exhibits a great deal of variability in crop diversity, crop composition, crop rotation, *etc.*, along with an altitudinal transect due to corresponding variations in a number of factors which influence agricultural practices. The cropping patterns, generally up to 1800 m elevation, and some times up to 2000 m elevation are built around two major cropping seasons *viz.*, Summer (kharif - April to October) and Winter (Rabi - October to April). Traditional farmers of this region generally cultivate ten to twelve and sometimes more crop species in rainfed agroecosystem to meet all their food requirements throughout the year. The majority of the crops cultivated by them are traditional or under-utilized and include wheat, rice and *Amaranthus* spp., *Hordeum* spp., *Eleusine coracana, Fagopyrum* spp., *Setaria italica, Echinochloa frumentacea, Macrotyloma uniflorum, Vigna umbellata, Parilla frutescense, etc.* From rainfed agriculture generally three crops are taken every two years while from irrigated land two crops are taken each year.

At higher elevations, particularly above 2000 m, the cropping patterns do not follow the above description, as the growing seasons are short. Most of the crops are cultivated between March to October (summer season). Only in some places a unique variety of wheat (winter wheat)/barley is cultivated which takes as much as 11 months (September to August) to give harvests. The fallowing period at these elevations is generally long and could be up to 10 months where the intensity of cultivation is limited.

INDIGENOUS NUTRIENT MANAGEMENT

In hills the root slips of millets cause problems of decomposition. Thus, mostly the land is kept fallow after millet harvesting. However, in places where millet is the first crop in a crop sequence, the root slips are collected in the farm during tilling and burnt to release the nutrients. In the central Himalaya the farmers use about 10 t/ha of compost generally containing 60-79% of pine needles, 26-30% of dung and other organic materials.

Applying FYM is the most common technique encountered in U.P. hills. However, in higher reaches of Pithoragarh the farmers spread the FYM in a thick layer of mulch after wheat sowing in the month of October. During the winters when the temperatures drop the seed/seedlings are protected by the FYM and the moisture retained by it provides conducive environment for germination when the temperature rises. Similarly in Saya method of cultivation prevailing in irrigated valleys, the soaked seed are broadcast in the submerged fields and FYM is applied as a protective cover. This ensures quick release of nutrients to be available for the plant growth. The farmers believe that this will help in reducing the acidity of the fields too.

Organic residue incorporation is a common feature in traditional agriculture. These residues are derived from two major sources *i.e.,* litter of trees present on field and crop by-products left back unharvested. Earlier studies indicated that the contribution of such resources are negligible in monetary terms but contribute about 12-14% of total energy inputs of millet-wheat rotation (Gopinath 1999). The tree litters are not removed from the-fields and allowed to decompose *in-situ,* thus allowing the nutrient input to the systems. The crop residues left unharvested are incorporated into the system through tilling the land. In some instances it has been observed that the hard root slips of millets were collected during the second/third tilling operation and were burnt.

EXISTING PROBLEMS OF NUTRIENT MANAGEMENT AND THE INDIGENOUS SOLUTIONS

Nutrient deficiencies and their imbalances are main constraints to crop production. If the farm system is to remain productive and healthy, it must be ensured that the amount of nutrients leaving the soil does not exceed the amount returned to the soil. Organic matter serves as a nutrient store from which the nutrients are slowly released into the soil solution and made available to plants. Organic matter in or on the soil also protects it and helps to regulate soil temperature and humidity. Five basic ways of handling organic matter are: applying it directly to the soil, either as a surface mulch layer or incorporated into the soil; burning it (causing mineralisation); composting it; feeding it to livestock; or fermenting it in biogas installations. In the U.P. hills applying it directly, composting and feeding to livestock are prominent organic matter management mechanisms followed in the traditional systems.

Some rough estimates of the level of organic matter inputs required under different agroecological conditions as derived from Young (1990) are about 8.5 t/ha above ground residues in humid areas, 4 t/ha in subhumid areas and 2 t/ha in semiarid areas, in order to maintain target soil carbon levels of 2.0, 1.0 and 0.5 per cent, respectively. As above ground residues of a single crop are usually less than 3 t/ha, it is clear that, in the humid tropics, extra sources of biomass (e.g., trees, cover crops) are needed to meet this target.

PRESENT RELEVANCE OF THE TECHNOLOGY ADOPTED BY THE FARMERS

Availability of sufficient organic matter is a critical point. If nutrients are replaced primarily by chemicals and farmers no longer attach high value to manuring, the soil will become poor in organic matter and buffered nutrients, and more susceptible to drought and pests. In other words, the productivity and stability of the farm system will decrease. In such cases, an initial investment in nutrients and labour will be necessary to increase biomass production to use subsequently as fertiliser, so as to build up the farmer's working capital constituted by soil organic matter (Rao *et al.* 1999).

Role of FYM in rice-wheat rotations in improving soil fertility has been tested in the research station of the'central Himalaya. It has been found that organic carbon, total N, available P and K. increased consistently with increasing levels of FYM whereas no such consistency was observed with increasing N levels. Wheat crop recorded higher yields in FYM treated plots (Anonymous 1998) compared with N treated plots (Tables 1A and IB).

Table 1 A Soil properties after seventh cycle of rice - wheat rotation

FYM (t/ha)	PH	O.C (%)	Total N (%)	Available P (kg/ha)	Available K (kg/ha)
0	6.2	0.95	0.07	21.8	107
5	6.1	1.11	0.08	24.6	130
10	6.2	1.12	0.08	28.0	142
15	6.2	1.18	0.10	31.3	181

O.C = Organic carbon

Table 1 B Soil properties after seventh cycle of rice-wheat rotation

N (kg/ha)	PH	O.C (%)	Total N (%)	Available P (kg/ha)	Available K (kg/ha)
0	6.3	0.98	0.06	22.4	161
20	6.4	1.12	0.07	25.4	156
40	6.1	1.21	0.08	29.1	118
60	6.0	1.33	0.10	26.4	147
80	5.9	1.25	0.10	28.8	118

THE SCIENTIFIC BASIS OF THE INDIGENOUS TECHNOLOGY AND SCOPE OF UPGRADATION

The farmers use heap method of composting and process is aerobic. The ratio of organic matter and dung varies with the seasons and thus the quality. As the temperatures during the summer/rainy seasons are more conducive to the decomposition, the time taken at this period is less than at other times. Availability of local resources influences the quality of resources going into the manure pit. The results of chemical analyses of dung, dried pine needles and oak leaves *vis-a-vis* local compost (Singh *et al*. 1997) are presented in Table 2. High C:N ratio of 28.2 in local compost, compared with the desirable value of less than 20 (Golneke 1981), shows that at the time of field application the compost is partially decomposed and that the application of 10 t/ha of local compost supplies 21.77 kg N, 8.7 kg $P,0_5$ and 18.9 kg K,0 per hectare. While several studies indicated the prevalence of pine litter and oak litter in the compost the actual quantity and composition of such litters are not clearly assessed. The annual litter fall and consequent addition of plant nutrients are presented in Table 3 (Singh and Bhatnagar 1997) and may be useful to include these litter in manurial scheduling and crop sustainability.

Table 2 Chemical composition of local compost and its composition

Bedding materials	Nutrient (%)			C:N ratio
	N	PA	K_2O	
Dung	1.03	0.21	0.39	33.0
Pine needles	0.59	0.11	0.32	76.3
Oak leaves	0.94	0.43	0.56	41.8
Local compost	0.72	0.29	0.63	28.2

Table 3 Litter yield and nutrient status of pine, deodar and oak

Species	Litter yield (t/ha/yr)	Litter nutrients (kg/ha)		
		N	P	K
Pine	6.07	42.53	3.04	7.89
Deodar	3.22	33.84	2.90	26.11
Oak	4.93	46.38	6.41	35.53

Organic matter resources harvested from common lands not in use could be a source for incorporation in the fields either directly or through composting. Though at present only grasses harvested from the common lands is fed to cattle and thus the nutrients are put to agricultural fields through compost, the harvesting of herbage is a possible upgradation of the technique. Other biological materials, readily available in the region, which can be very good source of manure are kudzu *(Pueraria thunbergiana)*, wild sedge *(Lantana camara)* and eupatorium *(Eupatorium odoratum* and *E. adenoforum)*. These plants can be harvested from the places unsuitable for crops. Our results indicated that the harvestable biomass production of kudzu could provide 5.62 t (dry weight)/ha of organic matter, 130.3 kg N, 12.5 kg P and 93.4 kg K per hectare (Singh *et al.* 1992). The performance of local compost may be improved by enriching with the chemical fertilizers. In a trial on farmers' field the local compost is enriched with 3% of Urea and SSP each on dry weight basis and is compared with local one. The mixed heaps were allowed to decompose for 30 days and this compost @ 5 t/ha and non- treated (enriched) compost @ 10 t/ha was applied to fields before sowing of spring rice and wheat. Four years' mean values of yield data indicate significant increase in yield of spring rice and wheat (17.3 and 20.8%, respectively) under the enriched compost treatment (Singh *et al.* 1997).

The possibility of *in-situ* production of green manure crop also provides an alternative strategy for sustainable agriculture. The results of an experiment conducted at Hawalbagh showed that sunhemp *(Crotalaria juncea)* grown in the inter-row spaces of maize and its' *in-situ* incorporation as green manure, without any extra fertilizer input, not only gives maize yield equivalent to sole maize but also improves soil fertility (Table 4).

Table 4 Wheat yield and soil properties after wheat harvest

Treatment during kharif	Yield (q/ha)	O.C. (%)	Total N (%)	Available P (kg/ha)	Available K (kg/ha)
Fallow	22.5	0.53	0.07	28.9	106
Sunhemp 45 days(S)	36.4	0.57	0.09	32.1	135
Sunhemp 65 days(S)	45.9	0.74	0.12	32.1	138
Sunhemp 45 days(I)	21.1	0.57	0.11	25.8	111
Sunhemp 65 days(I)	25.8	0.62	0.13	28.0	144
Maize sole	17.8	0.55	0.06	33.7	108

S = Surface application; I = Incorporation

Crop residue incorporation is common feature in traditional agriculture. A comparison of compost made of organic resources collected from common lands (Kudzu vine) and crop residues (maize stalk) to inorganic fertilizer NPK was conducted on farm at Hawalbagh for wheat-ragi *(Eleusine coracana)* cropping system (Table 5). Organic composts were applied to wheat crop and ragi was taken on residual fertility. The application of NPK provided highest yield in wheat, but organic compost treatment provided better yields for ragi crop. This indicated the organic sources of fertilizer are manifested in the succeeding ragi crop only. Similar results were also observed for wheat-rice cropping systems (Anonymous 1998).

Table 5 Comparison of equivalent N application through inorganic and organic sources

Source	Yield		O.C.	Soil properties		
	Wheat (t/ha)	Ragi (t/ha)	(%)	Availability (kg/ha) N	P	K
No nitrogen	1.03	0.83	0.31	140	19.9	54.0
Urea	1.90	1.35	0.33	162	22.7	59.3'
FYM	1.78	1.60	0.38	249	24.2	96,4
Kudzu compost	1.86	1.61	0.34	165	26.0	80.2
Initial soil status			0.32	142	19.6	51.1

CONCLUSIONS

Indigenous knowledge is not uniformly spread throughout a community, and individual aptitudes for storing traditional knowledge and generating new knowledge differ. Each individual possesses only a part of the communitys' IK. In most cases peasants do not document their knowledge so that it can be made available to Stranges. Their knowledge may be implicit within their practices, actions and reactions, rather than conscious resource. Farmers' knowledge is limited to what they can sense directly, usually through observation, and what they can comprehend with their own concepts. These concepts grow out of their past experiences. It may therefore be difficult for them to process, which are new or affect them only very gradually or indirectly. In situations where land is limited and the population continues to grow, the traditional ways of farming may no longer be tenable. However, changes due to land use alteration could be reduced if proper integration of traditional knowledge with scientific knowledge is applied. Soil fertility management is one such area in the central Himalaya where indigenous knowledge systems are still active and have potential for scientific validation and upgradation of the technology.

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CHAPTER 12

INDIGENOUS NUTRIENT MANAGEMENT TECHNOLOGY OFTHE PLATEAU REGION OF BIHAR

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ABSTRACT

The paper provides information on indigenous nutrient management technologies prevalent in the rainfed areas of Bihar plateau. The information is based on a survey of villages in three blocks namely Tamar, Arki and Bero of Ranchi district. These indigenous technologies pertain to different agricultural operations especially in rainfed uplands and lowlands. Farmer's practice in these areas have been compared with scientist's perceptions with a view to blend the existing practice with improved one in rainfed agriculture. Possible interventions in the farmer's practice under different farming situations have been outlined. '

The plateau region of Chotanagpur and Santhal Paraganas accounting for 45 per cent of the geographical area of Bihar is predominently inhabited by tribal people and other weaker sections of the society. Agriculture is the primary occupation of the rural mass but it is dependent on rainfall. The fanners are unaware of the benefits of improved scientific technologies and bulk of them are practising the traditional rainfed agriculture. The region is also facing tremendous pressure of environmental degradation which is posing serious threats to agricultural sustainability due to a variety of reasons such as degradation of forests, over-grazing of grasslands, erosion of soil and water and imbalanced use of plant nutrients.

With this background knowledge, it is important to know the indigenous technological knowledge (ITK) of the farmers of the plateau region. This will serve as a valuable resource material for the development of sustainable agricultural technology.

BACKGROUND INFORMATION

The plateau region of Bihar comprises 45 per cent of the total geographical area of the state and forms part of agroclimatic Zone 7. The region is characterised by hot climate, undulating plateau, hills and mountains, non-existence of perennial rivers, initially high forest cover which is fast depleting due to mineral and industrial exploitation and encroachment, concentration of tribal population in many areas with a life style geared to forest ecology, pockets with chronic drought conditions, low ground water table and high soil erosion. The region is primarily monocropped with rice being the predominant crop. Soils are acidic in uplands with low water and nutrient retention capacities.

Two agriculturally less progressive blocks of Ranchi district namely Tamar and Arki were randomly selected for collection of detailed information about indigenous agricultrua! practices with special emphasis on nutrient management. Information was also collected from Bero block (Nehalu village) where work on integrated nutrient management on a participatory mode has recently been initiated by the authors. Survey of 3960 households from KRIBHCO adopted villages of Bihar depict the 'socio-agroeconomic' profile of the plateau region (Table 1).

Table 1 Farming systems of Bihar plateau at a glance

Household statistics	**Bihar**
Simple population	24,241
Household number	3,960
District number	4
Cluster number	11
Village number	41
Population number (%)	
* Male	12,632 (52.1)
* Female	11,609 (48.9)
Household size (Number persons/House hold(HH)	6.1
Social category (%)	
* Schedule Tribes (ST)	49.7
* Scheduled Castes (SC)	20.5
* Others	29.8
Wealth Rank Categories (%)	
* Deficit (D)	75.9
* Self Sufficient (SS)	17.7
* Surplus (S)	6.4
Literacy (%)	

* Male	27.9
* Female	13.1
* Mean	23.4
Household Migrating (%)	
* Male	11.4
* Female	4.1
* Mean	7.9
* OfHH's	22.6
Total Area Cultivable Land (Acre/village)	305.9
Land Holding - acre/HH (%)	
* Total	3.17
* Upland (all categories)	1.47(46.4)
* Upland (homestead)	0.27(8.5)
* Medium land	1.01 (31.9)
* Lowland	0.69 (21.8)
Mean Land Holding Cultivated (acre/HH)	0.67
Irrigated area (acre/HH)	0.25
Landless Households (%)	9.0
Crop statistics	
Area Cultivated by Season - acre/HH (% total area)	
* Kharif	2.67(84.3)
* Rabi	0.39(12.4)
* Summer	0.02(0.6)
Cropping intensity (Cl %)	97
Vegetable cultivation - homestead (% HH)	52.5
Vegetable cultivation - field (% HH)	12.8
Household Using HYV Paddy (%)	18.9
Household Using Chemical Fertiliser on paddy (%)	• 21.2
Household with irrigation (%)	29.8
Households Share-cropping in (%) "	12.8 3.4
Households Share cropping out (%)	

Livestock Statistics

Number of Livestock (No/HH)

* Total All Species	7.53
* Cattle	2.41
* Buffalo	0.41
* Goats	1.58
* Sheep	0.01
* Poultry	2.91
* Pig	0.19
* Others	0.03
Households Keeping Livestock (% HH)	
* Total All Species	89.5
* Cattle	69.4
* Buffalo	14.8
* Goats	49.1
* Sheep	0.2
* Poultry	52.5
* Pigs	7.0
* Others	0.6

INDIGENOUS NUTRIENT MANAGEMENT TECHNOLOGIES AND PRESENT RELEVANCE OF TECHNOLOGY ADOPTED BY FARMERS

Tamar & Arki Blocks

Agricultural operation	Indigenous practice	Rationale
Land preparation, pre-sowing, manuring and soil treatment	1. Primary tillage in the form of 3-4 ploughings is done from January to May at long intervals.	Farmers feel that ploughing in summer helps in conserving moisture because it checks the loss of soil moisture through dustmulching. They believe that ploughing exposes soil to heat and cold which enhances the fertility status of soil.
	2. For direct seeded rice, cowdung is powdered	Farmers believe that dried cowdung after

And mixed properly with the soil After broadcasting of rice seeds and then planking is done.	coming in contact with water provide sufficient nutrition to rice plants and keep the insects aways from the field and the crop.
3. Pre- sowing manuring for transp--lanted rice is done by keeping Dried cowdung mixed with ashes in the field at different place in basketful of heaps. At the time of final ploughing the heaps are prop--erly spread in the filed.	Cultivators perceive that this practice enchances soil fertility and protect the soil aganits harmful microorganisms.
4. Dung cake is burnt in nursery plots Of fingermillet (Eleusune coracana) Prior to the first tillage operation for Seed-bed preparation.	Farmer's perception of this practice is that it provides nutrition to plants as well as prevents certain diseases and pests.
5. Fresh cattle dung is mixed with wat--er in standing rice field.	This practice enchances the soil fertility and increases water holding capacity.
6. Deep summer ploughing,stirring, Stirring, planking and leveling is done after every rain.	Farmers feel that such practices impove soil fertility.
7. Legume-based mixed and intercopp--ing practices likes Pigeonpea+rice, Pigeonpea + blackgram, Pigeonpea + fingermillet, Pigeonpea + maize, Cowpea + rice),Cowpea + rice,Gram + wheat, Gram+linsed,Gram + mustard are common among framers.	Farmer's perception of these practices is to maintain soil fertility.

Bero block

Agricultural operation	Indigenous practice	Rationale
Organic manures/ composting/ fertilizer use	Nearly all villagers produce manure. Wastage from house is kept in a pit near home. A few farmers use cake and flowers as manure. Chemical fertilizer mainly DAP/ urea is applied only by some surplus and self sufficient house holds. Rate of fertilizer use is 50 kg/acre for wheat and 25 kg/acre for paddy. There is no biogas plant in the village.	Farmers are aware of the role of FYM/compost in maintenance of soil fertility.
Soil testing & nutrient use for crops	Farmers have the knowledge that uplands are very sandy and are of poor fertility and need more attention than lowlands.	Farmers have knowledge about the soil and their fertility. »

MICRO-FARMING SITUATIONS & FARMER'S NUTRIENT MANAGEMENT PRACTICES

In the five adopted villages, viz., Karge, Rege, Hatma chatwal and Keshkani- kumbatoli of Mandar Block in Ranchi district under the Project on Technology Assessment and Refinement through Institution - Village Linkage Programme (IVLP) of ICAR, farmer participatory approach is being followed. Altogether twelve microfarming situations were identified with farmers' practices of nutrient management. These are as follows :

S. N.	Micro-farming situations	Edaphic features	Farmers' nutrient management practices
1.	Rainfed gravelly and Eroded uplands	Land is situated from high to medium slope, light textured red soils, highly acidic in rea--ction, very low water holding Capacity, sandy and stony soils, very low in available N, P and K	Generally no crop is grown. However, some farmers grow niger through seeding after 1-2 ploughing. No nutrient manage--ment is done. Leguminous plant tree are being tried for block plantation
2.	Rainfed gravelly Uneroded uplands	Land is situated from high to medium slope, light textured red soils, highly acidic in reaction, low water holding capacity, sandy and stony soils, low in N, P and K	Farmer grow Gora rice, fingermi--llet, gundli, maize, niger and pigeonpea. Pigeonpea is grown for improving the soil fertility. Legumebased cropping system is prevalent in such land situations
3.	Partially irrigated uplands	Land is situated in a medium slope, light textured sandy and semi-gravelly soil, acidic in reaction, low water holding Capacity, low to medium in available N and P and medium in K	Such lands are locally called as Barilands as these are situated nearby homesteads equipped with small diameter wells. Vegetables are grow. Due application of FYM in suffici--ent quantity soil fertility is maintained

4. Irrigated uplands	Lands is situated in a medium slope, sandy loam texture, acidic in reaction, low water holding capacity, low inavailable N and P and medium in K	Almost the condition is similar to the above. Vegetable cultivation is done throughout the year through big diameter Pucca wells. Each plant is cared through application of well decomposed compost and N : P : K:: 50 : 30 : 15
5.Rainfed slightly eroded midlands	Lands is situated in medium slope having slight erosion, sandy-clay-loam texture, medium water holding capacity, low in available N and P and medium in K. Sufficient water is received through rains from June to September	Generally rice is grown during kharif. Compost is applied at 2-3 years interval. Pulses/ oilseeds are grown by a few farmers during winter. Legume-based intercropping is also done
6.Rainfed mediumlands	Land is situated in a relatively lower slope without erosion, sandy-clay-loam texture, medium water holding capacity, low in available N and P and medium to high in K. Sufficient water is received through rains which is retained upto September	Rice and vegetables are grown during kharif season in rainfed condition. No nutrient is applied in rice excepting application of FYM at 2-3 years interval and nitrogen application during plant growth period in vegetable cultivation compost is applied during plantation alongwith DAP (N : P : K :: 25 : 25 : 0)

7.Partially irrigated medium lands	Land is situated in a relatively lower slope, heavy textured soils low in available N and P and medium to high in K. Medium water holding capacity	After harvesting of rice, vegetable cultivation is done. Each plant is given adequate quantity of well decomposed FYM/ compost with N : P : K :: 25:25: 0. Only urea is provided to rice crop during the growth period
8.Irrigated mediumlands	Land is situated in a relatively lower slope, heavy textured soils, less acidic in reaction, low in available N, medium in P and K	Some farmers cultivate vegetables throughout the year and some farmers grow vegetables/ wheat after harvest of rice. FYM/compost is applied during land preparation. Imbalanced nutrition N : P : K.:: 25 : 25 : 0 is given. Fishmeal is given in vegetable cultivation. Use of borax is becoming popular in cultivation ofcauliflower
9.Rainfed lowlands	Land is situated in a lower slope, heavy soils with better water holding capacity and better fertility status. Medium in available N and P and high in K. Almost neutral in reaction	Monocrop of rice is commonly followed. Farmers apply DAP (N : P::24:20) in the cultivation of HYV of rice like IR 36, Sita, etc. In standing rice crop raw cattle dung is applied in bunded fields

10.Partially irrigated Lowlands	Land situated in lower slope, heavy soils with good water holding capacity and good fertility status. Medium in available N and P and high in K. Partial irrigation through rivules/channels during winter season. Soil is neutral in reaction.	In such situation after harvest of rice, vegetables are grown with the use of compost/ FYM. Paira cropping of linseed/ peas is also becoming popular
11. Irrigated Lowlands	Lands is situated in a lower slope, heavy soils with good fertility status. Medium in available N and P and high in K. Irrigation through small diameter Kutcha wells/rivulets during winter and summer seasons. Almost neutral in reaction	Vegetables cultivation with the use of chemical fertilizers (N : P : K : 25 : 25: 10) is done. Some farmers cultivate wheat after rice harvest. Small quantity of N and P is applied through DAP
12. Rainfed deep Lowlands	Land is situated in a relatively lower slope, heavy clay-loam Soils with good fertility status. Waterlogged condition upto Jan.-Feb. Medium in available N and P and high in K. Almost neutral in reaction. Problem of drainage after kharif crops	In such situations no fertilizer or manure is applied to rice crop. After recession of waterlogging during Feb.-March cultivaton of summer vegetables is done through use of FYM and small quantity of chemical ical fertilizers

SCOPE OF SCIENTIFIC BLENDING OF THE INDIGENOUS TECHNOLOGY

Informal discussion with the respondents reveal that most of the indigenous technologies were low cost, locally available, eco-friendly and simple in operation compared to the scientific technologies. However, they were aware that the existing indigenous technologies were less effective than the scientific technologies. Thus, there is a scope of a scientific blending of the indigenous technologies to bring about improvements in rainfed agriculture practised in the region. Some of these are :

Indigenous nutrient management technology of the plateau region of Bihar

S.N.	Indigenous Technology	Possible scientific blending of the indigenous technology
1.	Primary tillage in the form of 3-4 ploughings is done from January to May at long intervals.	Summer ploughing should be done.
2.	Pre-sowing manuring for transplanted rice is done by keeping dried cowdung mixed with ash in the field at different places in basketful heaps. At the time of final ploughing the heaps are properly spread in the field.	FYM should be used at least one month before transplanting and field should be ploughed so that FYM could mix with soil properly for transplanted rice.
3.	To prevent soil erosion desi babool ***(Acasia nilotica)*** and siris ***(Albegia lebbeck}*** are planted on the ridges of rice fields.	For controlling soil erosion field should be ploughed and cover crops should be grown on the ridges.
4.	Plot to plot bunding and terracing of slopy land is done.	Bunding and terracing should be done for controlling soil erosion and maintaining soil fertility.
5.	Summer ploughing and mulching is doneto conserve the soil moisture.	Summer ploughing and mulching should be done to conserve the soil moisture.
6.	Water is harvested and stored in rainy season to use for irrigating the rabi crops during scarce period.	Water storage practices during rainy season and its utilization in scarce periods during late rabi summer season should be done.

7. In pulses, crops like pigeonpea, black gram etc. are grown without use of fertilizers.	In pulses, treatment of seeds with Rhizobium culture and use of lime in furrows and phosphorus in acidic uplands is necessary for realising higher yields.
8. Traditional way of composting involves use of FYM and householdwastes in pits/heaps.	Use of FYM/Lantana/Ipomoea/ straw etc. as raw materials for composting. Use of rockphosphate, cellulose decomposer *(Trichurus* ***spiralis)*** followed by 3-4 turnings and coveringthe pit by cowdung- soil paste.
9. Soil testing is not done to assess the soil fertility & use of plant nutrients based on soil test ratings.	Soil testing needs to be popularised bya participatory approach. A 3-5 years monitoring will help assessing build up or decline in soil fertility.

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CHAPTER 13

INDIGENOUS NUTRIENT MANAGEMENT TECHNOLOGY IN BIHAR

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ABSTRACT

The indigenous nutrient management technology generated by the farmers of Bihar has been compiled. The nutrient management technology is very site specific, time tested, efficient and profitable and is a great wealth with farmers in different agro- eco-regions of Bihar. Soils of Bihar are of different types and land holding is fragmented. Majority offarmers are poor and practice rainfed agriculture with low fertilizer consumption. Major constraints in crop production and nutrient management are imbalanced use offertilizer, less use offertilizers and low fertilizer- use-efficiency, less use of organic manure and lack of crop residue recycling, emergence of multiple nutrient deficiencies, lack of soil testing facilities and nutrient deficiencies in problem soils. Unfortunately, the traditional practice of applying organic manures has been changed in favour of inorganic chemicals fertilizers during last three or four decades mainly due to relative cheapness and hence high shot-run economic profitability of chemical fertilizers and scarcity of organic manure. Integrated plant nutrient supply system (IPNS) is a step in the direction of sustainable agricultural development through necessary modification of conventional nutrient management technology. The blending of the indigenous technology with latest scientific techniques is of prime importance not only in sustaining soil fertility and crop productivity hut also to protect soil health from deterioration.

Adoption of the diverse indigenous nutrient management technologies depend on a large number of soil-water-psychological variables. It was observed that age, source of income, social participation, source of irrigation/quality of water, size of holding, education level, capital, socioeconomic status of farmers are important factors for adopting nutrient management technology. Farmers of Bihar have a great wealth of indigenous materials for agricultural use like Singhbhum rock phosphate, basic slag of steel factory, pyrite, pressmud of sugar factory, farm, city and industrial wastes for generating scientific techniques for nutrient management using these sources of locally available non-renewable conventional organic materials. Organic farming still exists in the real sense in remote areas of hilly regions of otanagpur and tribal areas of Bihar where no fertilizer and plant protection chemicals have yet reached. The productivity of these areas is too low. The farmers who are engaged in real indigenous organic farming are very poor and are deprived of the benefits of high prices for their produce. The relevance of organics is more so in areas of Bihar with poorly-developed infrastructure for marketing of mineral fertilizer and surplus crop residues resulting from this area such as hill regions or sparsely populated areas.

The objectives of this paper are to compile indigenous nutrient management technology practised by the Bihar farmers over the years for generating scientific techniques for nutrient management in Bihar for sustainable crop production.

BACKGROUND INFORMATION AND INDIGENOUS NUTREINT MANAGEMENT TECHNOLOGY

A brief information pertaining to area, soil type, socio-economic aspects, size of holdings, cropping system, rainfed/irrigated agriculture and fertilizer inputs are presented zone wise in Tables 1 and 2. Taxonomically 4 orders viz. Alfisols, Inceptisols, Entisols, and Vertisols were identified.

Total geographical area, soil type, socio-economics conditions and cropping system of different agro-system of Bihar

SI. No.	Regions	Area in sq. km	Soil type (order)	Socio economic condition	Cropping systems	Irrigated/ Rainfed	Fertilizer inputs (tonnes)
1.	I-Hot sub-humid (North Bihar Plain) (Moist)	55911 (32)	Entisols Inceptisols	Marginal to medium	Rice-wheat, Rice-winter Maize, Rice-sugarcane	Irrigated - 26% Rainfed - 74%	N-241533 PA-59574 KO-25788
2.	II Hot Sub-humid (South Bihar Plain) (Dry)	32544 (19)	Vertisols	Medium to large	Rice-wheat, Rice-Potato, Maize-Potato, Khesari/ Lentil as pairacrop with rice	Irrigated-56% Rainfed-43.4%	N-221583 PA-36489 K_2O-10701
3.	Ill Sub-Humid (South West high land) (Dry)	30456 (17)	Alfisols	Poor farmers Marginal	Monocropped rice,lentil, niger, potato	Irrigated - 89.7% Rainfed - 10.3%	N-12320 PA -2777 K,O-1002
4.	IV Sub-Humid (Eastern Chotonagpur plateau) (Dry)	51457 (30)	Alfisols	Poor farmers marginal	Monocropped rice, lentil, niger, potato, ragi	Irrigated-18.2% Rainfed - 81.8%	N-3549 12030 KO-1666
5.	V Hot-Humid (Mahanand (Moist)	3500 (2)	Entisol	Small to medium	Jute-Wheat Jute-rabi, maize Khesari, Lentil as paira crop with rice	Irrigated/ Rainfed	N-11983 PA- Plain) 2081 K> 3483

Table 2 Average size of holding, number of holding area in Bihar

Category of holdings	Size of holdings	No. of holdings	Area (000' ha)
Marginal (Less than 1 ha)	0.35	23196	13632
Small (1 to 2 ha)	1.36	11631	5545
Semi-medium (2 to 4 ha)	2.73	2469	6738
Medium (4 to 10 ha)	5.65	783	4401
Large (10 and above)	16.41	95	2111

Agro-ecozone I

In North-western part, the soils are under the influence of the rivers Gandak, Burhi Gandak and Ghaghara and the soils are highly calcareous. Patches of saline soils are also present where rainfall is limited with prolonged dry season. In the zone, nearly one third of the total cultivated land remains flooded. One fourth of the total cultivated area in the districts of Chapra, Siwan, Vaishali, Gopalganj, Champaran, Muzaffarpur and Samastipur is salt affected. Rising water table in the area has gradually led to partial shift of maize from kharif to rabi. The dominant cropping systems are rice-wheat, rice-rabi maize, rice-sugarcane and sugarcane is one of the major crops in this zone occupying nearly more than 77% of the total area in the state. The land is fragmented and size of land holding mostly is small. Most of the farmers are poor and marginal. The fertilizer consumption is low due to floods.

Indigenous Practice: Biofertilisers such as Rhizobium for pulse, blue green algae for rice and organic manures such as compost, FYM and pressmud are extensively used by the farmers. Indigenous materials like pyrites of Amjhore, Bihar is used as a source of Fe and S for oilseed crops. Pyrites and pressmud are used as amendment for reclamation of alkali soil. Sewage-sludge is used for growing vegetables in the vicinity of town.

Constraints: The main constraints for crop production and nutrient management are fixation of nutrients such as phosphate and zinc in calcareous and alkali soils and high volatilization losses of nitrogenous fertilizers applied in such soils, limit nutrient availability and need proper soil resource management, water stagnation, soil salinity- alkalinity, calcareousness, soil erosion, low moisture status and coarse texture soil.

Agro-ecozone II

The soils of this zone are of alluvial origin. Diara soils are found on narrow belt of high land along with river Ganga. They are very deep, well to moderately well drained and neutral to slightly alkaline with high base saturation. Adjacent to Diara land is the back water belt of ricer Ganga. Treeless low-lying land locally known as “Tai land’ occurs. Tai soils are dark coloured, very deep, very fine textured, slightly alkaline with deep wide cracks. The dominant cropping systems are rice-wheat, rice- potato, maize-potato and rice-lentil. The size of land holding is small. Most of the fanners are rich to marginal.

*Indigenous Practices:*Fanners are using indigenous materials such as pyrites, phosphogypsum and gypsum as sources of sulphur for its deficiency correction.

*Constraints:*Green manuring with sunhemp is done. Fann wastes like FYM, compost and house hold wastes are used for maintaining organic matter in soil and for correction of zinc deficiency. In this zone, zinc and sulphur deficiencies limit the realisation of optimum yield. The main constraints for crop production and nutrient management are poor drainage, flood hazard, droughti and erosion**.**

Agro-ecozone III

This zone occupies an area of 30456 sq. km and is at the highest altitude in Bihar state. It comprises well known kaimur plateau and undulating hilly and sloping lands. Soils of kaimur plateau are derived from sandstone and are coarse textured shallow to moderately deep or deep, somewhat excessively drained and very susceptible to erosion hazard. Soils of undulating high land are usually shallow to moderately deep, reddish in colour, coarse to fine loamy in texture, gravelly, acidic with low base saturation and poor fertility status and low in organic matter. Rice, maize, gram, arhar, kulthi, niger and til are most important crops. Fertilizer use is very low. The NPK consumption is 88.8 kg/ha.

*Indigenous Practices***:** Farmers are mostly depending on organic farming. Indigenous calcite, dolomite and basic slag are used as amendments for reclamation of acid soil. Indigenous rock phosphate is used as a source of phosphorus in such soil. Forest litter, shrubs, crop residues, cow dung, and green manure are used to maintain organic matter in soils.

Constraints: Soils erosion, acidity and moisture deficiency and low availability of nutrients especially phosphate and molybdenum are most important production constraints of uplands. The key constraints of crop production and nutrient management are severe soil erosion, droughti, low soil depth, gravelly and coarse textured soils and low fertility status.

Agro-ecozone IV

This zone occupies an area of 51457 sq. km. representing 30 per cent of the total geographical area. There are hills alternating with escarpment valley and river basin. Soils have developed on parent materials which are sedentary in nature. They are moderately to strongly acid, low to medium cation exchange capacity and medium in base saturation. Tropical dry deciduous forest and rainfed mono cropped rice, pulse and ragi are generally grown.

Indigenous Practices: In this zone, calcite and dolomite are used for reclamation of acid soils. Organic manures such as cow dung, compost, forest litter and crop residues are used as source of nutrients. The organic farming is done generally in hilly areas.

Constraints: The main constraint of nutrient management and crop production is the poor economic condition of farmers. The main constraints for crop production are soil erosion, droughti, shallow soil depth, coarse textured soils, surface encrustation and low soil fertility status.

Agro-ecozone V

This zone comprises alluvial plains below the foothills of eastern Himalayas and a form of Indo-Gangetic alluvial plains. This zone occupies an area of 3500 sq. km b representing 2 per cent of the total geographical area. They are in general deep to very deep, coarse to fine loamy in texture, well to imperfectly drained, slightly acidic to neutral in reaction and subject to moderate to severe flooding. The fertilizer use is very low. The dominant cropping systems are jute-wheat, jute-rabi maize, khesari and lentil are taken as paira crops. Majority ofthe farmers are poor and land holdings are small.

Indigenous Practices: Farmers are practicing green manuring with short duration pulse crops like green gram and cowpea. Crop residues and compost are also incorporated in the soils.

Constraints: Heavy leaching of the soil has created soil acidity and nutritional problems resulting perhaps in non-setting of grains in gram and wheat. The soils are very low in nitrogen and very low to medium in available phosphorus and potash. Deficiencies of zinc and boron and toxicities of manganese have been recognized in these areas. The key constraints of crop production are flood hazards and poor drainage in this zone.

EXISTING PROBLEM OF NUTRIENT MANAGEMENT AND THE INDIGENOUS SOLUTION

A discussion was held with a group of farmers in IPNS Village Harpur, Samastipur, Bihar and different zones of Bihar. The existing problems of nutrient management were identified. With the change over of the cropping system and rapid adoption of modem intensive farming with emerging new techniques, the nutrient requirements have gone up many folds. This has resulted in rapid turnover of plant nutrients in soil-plant system and causing multiple nutrient deficiencies in. Some of the problems of nutrient management are as follows:

- Imbalanced use of fertilizer
- Less use of fertilizers and low fertilizer use-efficiency
- Less use of organic manures, biofertilisers and lack of crop residues for recycling
- Multiple nutrient deficiencies
- Lack of soil testing facilities
- Nutrient deficiencies in problem soils

*Imbalanced use of fertilizers***:** In Bihar, the farmers tend to apply only nitrogen in the form of urea in a bid to achieve short time gain. Application of P and K. fertilizers has almost been ignored. During the period of subsistence agriculture, the nitrogen in soil maintained the productivity at a level that permitted only marginal response. A wide N: P: K ratio is a matter of great concern. It is amazing that NPK ratio in Bihar during 1998-99 was 13.6 : 3.5:1 as against 8.5 : 3.1 : 1 in the whole country. Bringing this ratio closer to the desirable ratio of 4: 2 : 1 for cereals is essential for maximizing the efficiency of fertilizers and to increase application of P and K through indigenous material. Indigenous Singhbhumi rock phosphate is poor quality material. Partial acidulation of rock phosphate is a possible means of utilizing indigenous rock phosphate not only in acid soils but also in neutral or slightly alkaline and calcareous soils. A mixture of SSP and indigenous rock phosphate in a ratio of 1:3 or 1:1 developed a satisfactory phosphate supplying potential. Indigenous rock phosphate alongwith organic manure and/or phosphate solubilising organisms has been extensively used as a source of phosphorus for rice based cropping systems and its residual effect on legumes. This would provide a research based cost-effective means of meeting phosphate needs of a vast area under acid, neutral, alkaline and calcareous soils and will also improve N: P ratio. It may be possible to use 1/3 rd of total P,O_S through rock phosphate whose efficiency can further be increased by using it in conjunction with indigenous pyrites, organic manure, compost, green manure and phosphate solublising organisms.

Of the total K removed, about 78-87% is retained in the straw. About 80% K in rice straw is water-soluble. The utilization rate of K in straw could be as high as 50 to 60%. In general 5 tonnes rice straw contains on average 30.5 kg N, 9 kg P,O_S and 69 kg K,O. Thus straw incorporation will improve N:P:K ratio. Different sources of nutrient viz. organic manure, crop residue and biological input should be included in balanced fertilizer scheme (Prasad 1994 b).

*Less use offertilizer and low fertilizer-use-efficiency :*Fertilizer use for crop production in Bihar is not adequate. Balanced use of fertilizers needs to be increased for boosting grain production. The total NPK consumption in Bihar is 88.8 kg/ha (1998- 99) whereas the total removal of NPK by major crops from soils is being 100.2 kg/ha. This leads to a negative balance of applied nutrient. Also soils are becoming deficient in nutrient elements with continuous cropping. Consumption of plant nutrients is of the order of 7.86 lakh tonnes as against removal of 20.74 lakh tonnes from Bihar soils in the year 1996-97 leaving a gap of 12.88 lakh tonnes annually resulting in depletion of total nutrients reserves of Bihar soils (Table 3). This deficit has to be met from the renewable sources of nutrient i.e. organic and biological sources of plant nutrients. Nitrogen would be gained from both the sources whereas P and K source would mainly be obtained from recycling of organic matter and crop residues. A simple computation of potential of renewable organic resources and nutrient contents in them indicates that total potential sources of nutrients from these sources are about 12.8 lakh tonnes (Table 4). Anticipating the associated difficulties encountered to exploit these resources, we may hope to exploit about 60 per cent of the total potential sources. This is roughly the estimated deficit that we want to compensate from these indigenous materials. There is need to improve the consumption of nutrients through cheap and indigenous resources like rock phosphate, crop residue, green manuring and biofertilisers.

Table 3 Nutrients addition, removal and gaps in Bihar soils (in lakh)

Nutrients parameter	N	P_2O_5	K_2O	Total
Nutrients addition in soil	6.39	1.01	0.46	7.86
Nutrients removal from soil	8.23	3.14	9.37	20.74
Nutrients gap	-1.84	-2.13	-8.91	-12.88

Less use of organic manures, biofertilisers and lack of crop residuefor recycling : Crop stalks are burnt as fuel. The bulk of crop residues are used as cattle feed or used as fuel. Straw is used as packing materials for making paper and building boards. Rice straw and sugarcane trash are used as thatching materials for huts and temporary dwelling in villages. Considerable amount of forest litter and oilseed stalks are burnt as fuel. Sugarcane bagasse produced is also entirely used as fuel in boilers of sugar factories. In north Bihar, sugarcane trash is burnt in the field. Maize stalks are used as cattle feed or fuel.

In hills of Bihar, especially in Chotanagpur plateau, forest leaf is traditionally utilized as a component of compost. The use of mineral fertilizers in hills of Chotanagpur is practically negligible and farmyard manure or compost is used as major source of plant nutrients to support crop production. Prasad (1999) estimated that 716 lakh tonnes of farm wastes would be available for composting. Taking this into consideration and other surplus wastes such as sugarcane in predominantly wheat growing area, the potential of crop residues can be estimated to about 209 lakh tonnes annually for recycling on agricultural land (Table 4).

Table 4 Potential of organic and biological resources in Bihar and plant nutrients

Name of Resources	Annual potential (in lakhtonnes)			Plant nutrients (in lakhtonnes)			
	Dung	**Urine**	**Biomass**	**N**	**P_2O_5**	**K_2O**	**Total**
Rural compost	-	-	155	0.775	0.465	0.775	2.015
Urban compost	-	-	0.45	0.007	0.005	0.007	0.019
Crop residue	-	-	209	1.045	1.254	3.135	5.434
Cattle	493.55	304.40		1.349	0.524	1.349	3.222
Buffalo	192.02	130.01	—	0.548	0.205	0.548	1.301
Goats and Sheeps	12.12	8.08	-	0.216	0.063	0.024	0.303
Pigs	0.80	0.80	-	0.008	0.005	0.006	0.019
Poultry	0.10	-	-	0.001	0.001	0.001	0.003
Other live stock	17.34	11.44	-	0.224	0.052	0.116	0.442
Human being	48.56	438.00	-	5.157	1.240	1.143	7.54
Water hyacinth Compost	-	-	1.2	0.024	0.012	0.028	0.064
Forest litter	-	-	7.2	0.040	0.015	0.040	0.095
Sewage sludge	-	-	0.20	0.002	0.001	0.001	0.004
Pressmud	-	-	0.12	0.001	0.003	0.001	0.005
City refuse		-	0.56	0.004	0.004	0.005	0.013
Rhizobium, nonlegume and blue green algae		-	-	0.005	-	-	0.500
Total				9.901	3.849	7.229	20.979

In rural area, biogas plants are being installed. The biogas plant will supply biogas slurry for nutrient supply and biogas for fuel. Surplus organic manures and crop residues can be incorporated in soil as a source of nutrients. Crop residue incorporation in soil is suggested but it has problem of antagonistic interactions with fertilizer due to immobilization of plant nutrients. Wheat and rice straws before incorporation are treated with 2 per cent urea solution to narrow down C/N ratio (Prasad and Sinha 1995). In rice-wheat system acceptance of use of ***Sesbania or Crotolaria*** for green manuring during summer season is poor. To overcome this, a short duration crop like summer green gram after plucking of pods and turning the biomass into the soil when still green gives dual profit by providing grain for consumption and straw for green manuring.

Non-availability of appropriate and efficient strain of rihzobium has been found to be one of the major problems in widespread adoption of bio-fertiliser technology. Lack of suitable carrier due to which self life is short is another constraint. Peat is an ideal carrier material but it is not abundantly available in the state and lignite and pressmud are the only options left with the manufacturers. The demand and production of biofertiliser is seasonal and as a result no established sale net work exists except in a few cases. In general, there has been a lack of strong extension/education backup, insufficient publicity programme.

Multiple nutrient deficiencies :With the introduction of high yielding varieties and high analysis fertilizers, multiple nutrient deficiencies are emerging fastly. In rice- wheat rotation deficiency of Zn, Fe, B and secondary nutrients like S are common. Use of indigenous organic manure, biofertiliser, crop residue recycling and green manuring are necessary for balancing the nutrients**.**

*Lack of soil testing facilities :*There are no proper soil testing facilities in each district of Bihar.

Nutrient deficiencies in problem soils :Acid and alkali soils are found in Bihar occupying about 20 lakh ha. Nutrient imbalance is one of the main reasons of low productivity in acid soils. Phosphate fixation is high in acid soils. There are deficiencies of calcium and magnesium. Liming in acid soils of Bihar is the probable solution (Mandal 1996). Liming through limestone and calcite are accepted as a practice for raising productivity of acid soils. Several industrial wastes such as steel mill slug and blast furnace slug, ferrochrome slug, phosphogypsum and precipitated CaCO, from fertilizer industries have also been successfully used as amendment for acid soils. Economics of lime at a time is questionable particularly in the humid tropics since lime requirement of acid soil in Bihar are very high and effect of liming does not last long due to leaching losses and its use become cost-prohibitive. The other alternative is to grow acid tolerant plant species and varieties. Rice has certain amount of tolerance forsoil acidity since flooding of rice fields raises soil pH to almost neutrality. The placement of liming materials in row where seeding is done, has also been found as a possible answer to reduce the cost of liming.

In Bihar, alkali and saline soils occupy about 4 lakh ha. Nutrient management is difficult in such soils without reclamation. Nutrients fixation and losses in such soils are quite acute. The Gandak command area of Bihar which constitutes the north-eastern part of Bihar has about 2.24 lakh ha of alkali land. In 1990, the European union and Government of India signed an aid agreement to reclaim alkali land in UP and Bihar through monetization fund. In pilot phase, 500 ha alkali land has been reclaimed. In expansion phase I and II, 567 and 828 ha lands, respectively were reclaimed in Muzaffarpur and Siwan districts. The mpact of indigenous pyrite use on crop production indicated that as the yield increases of paddy and wheat were 174% and 114%, respectively. Indigenous pyrite is good amendment for reclamation of alkali soils of Bihar (Prasad and Prasad 1998).

PRESENT RELEVANCE OF THE TECHNOLOGY ADOPTED BY THE FARMERS

Ancient wisdom and traditional farmers practice, however assert the supremacy of organic manures as a source of plant nutrients especially in respect of maintenance of soil health in particular and long term sustainability of the production system in general.

The use of organic manure alone suffers from the drawbacks of low content of plant nutrients and its slow release characteristics. High transportation cost and limited availability in agricultural region have prevented their widespread use.

In recent years, growth in yield has slowed down and attained stagnation in many areas where intensified agriculture with the new technology have been adopted since its inception in mid sixties. A part from the stagnating or even declining productivity, there are observations on soil and water degradation and threat to human and animal health due to poor nutrient management practices adopted by the farmers. A decrease in response of crop to fertilizer over the years suggests that more and more fertilizers are required to produce the same quantity of output.

A large number of demonstration trials and integrated plant nutrient supply system have been conducted on farmer’s field. Economics and yield anlaysis of rice, wheat and winter maize showed that main product, by product, net return, benefit/cost ratio, grain/kg nutrients were greater in Integrated Plant Nutrient Supply System (IPNS) than that of Farmer’s practice (Fp) (Table 5 and Table 6). On an average, the return was higher in IPNS by Rs 12275 in rice and Rs 13720 in wheat with an additional cost of Rs 1733 in rice and Rs 1184 in wheat compared to farmer’s practice. A yield advantage of 26% in maize grain was obtained in the IPNS plot with lower quantities of plant nutrients in comparison with farmers practice (FP). The qunatity of the product of the biomass/kg nutrients was more in the IPNS plot than Fp plot (Table 6). Nutrient balances are positive in IPNS plot compared to farmer’s practice inspite of more nutrient removal and less nutrient addition in winter maize in IPNS plot than that of farmer’s practice (Prasad 1999).

Table 5 Comparative economics and efficiency of farmer practice (FP) and IPNS in rice andwheat under rice-wheat system in calcareous soil

Indicators	Rice			Wheat		
	Fp	IPNS	Difference	Fp	IPNS	Difference
Nutrient cost (Rs)	1932	3665	1733	26629	3823	1184
Main product (q/ha)	22.00	38.50	16.50	26.50	42.10	15.60
By product (q/ha)	43.00	75.00	32.00	50.50	78.50	28.00
Return (Rs)	16400	28675	12275	23600	37320	13720
Add retum-Add cost (Rs)	7718	18260	10542	11861	24397	12536
Add return/Add cost	4.99	5.98	0.99	5.50	7.38	1.88
Main product/nutrient	13.25	13.23	-0.92	12.33	12.72	0.39
Biomass product/nutrient	25.90	25.77	-0.13	23.49	27.72	4.23

Cost of N, P O and K O are Rs 9.25, Rs. 19.00 and Rs 6.50/kg
Cost of Wheat grain (n>Rs 7.00/kg, Straw @ Re 1/kg
Cost of Paddy grain @ Rs 5.50/kg, Straw @ Re 1/kg

Table 6 Comparative economics and efficiency of Fp and IPNS in winter Maize in calcareoussoil

Indicators	Winter maize		
	Fp	IPNS	Difference
Nutrients (Rs)	3527	3413	-114
Main product (q/ha)	57.00	72.00	15.00
By product (q/ha)	25.75	33.75	8.00
Return (Rs)	31075	39375	8300
Add retum-Add cost (Rs)	17348	25762	814
Add return/Add cost	5.92	8.55	2.63
Main product/nutrient	18.63	27.17	8.54
Biomass product/nutrient	33.66	50.94	15.36
Total nutrients added (kg/ha)	306	265	-41
Total nutrients removed (kg/ha)	242	348	106
Agronomic efficiency (kg grain/kg nutrient)	12.58	20.19	7.61
Nutrients removed (kg/q. grain)	4.25	4.83	0.58
Initial soil test value (kg/ha)	426	426	-
Post harvest soil test value (kg/ha)	462	465	3
Nutrients balance (N+P2O5 + K2O) (kg/ha)	36	39	3

Cost of maize grain Rs 5.00/kg, Straw @ Rs 0.25 kg

The result revealed the relevance of indigenous technology adopted by farmers over years in the present system of crop production. The relevance of organic manuring is more in the areas with poorly developed infrastructure and surplus crop residues such as hill regions or sparsely populated areas.

THE SCIENTIFIC BASIS AND SCOPE OF BELNDING THE INDIGENOUS TECHNOLOGY WITH LATEST SCIENTIFIC TECHNIQUES ETC. FOR UPGRADATION OF TECHNOLOGY

Integrated plant nutrient supply system (IPNS) is a step in the direction of sustainable agricultural development through necessary modification of the conventional nutrient management technology. Improvement or conservation of soil health is only a part of the beginning of human efforts to make agricultural development more sustainable through technological interventions. Traditionally organic sources of nutrients like FYM, compost, biogas slurry, and crop residue have been important inputs in crop production for maintaining soil fertility and to ensure yield stability.

In terms of nutrient economy, the results of field experiment conducted at Pusa, Bihar indicated that 10 t/ha FYM + blue green algae (BGA) @ 15 kg algal crust could substitute 25 kg N, 15 kg P_2O_5 and 10 kg K_2O/ha in rice. Further it was observed that there was residual effect equivalent to 20 kg N, 12 kg P,O. and 8 kg K,O/ha on the succeeding wheat and winter maize in calcareous soil (Prasad 1994a, 1994b, 1994c). Integrated use of blue green algae compost with chemical fertilizer augments nutrient- use-efficiency by about 10% for N, and 5% for P in calcareous soil (Prasad 1994a). Biogas slurry, water hyacinth, compost and FYM @ 10 t/ha in combination with 30 kg P_2O_5/ha gave higher yield compared to 60 kg P_2O_5/ha as chemical fertilizer. In this way, use of these organic manures can substitute 30 kg P_2O_5/ha in rice production and there was residual effect equivalent to 30 kg P_2O_5/ha in rice-wheat system. The use of these organic manures not only helps in supplementing a part of fertilizer needs but also improves the cereal productivity by increasing organic carbon and available nutrients in soil (Prasad 1994a). Integrated use of banana wastes compost @ 5 t/ha with 30 kg K,O gave similar yield of rice to that 60 kg K_2O/ha. The results of follow-up trial on farmer's fields reveal that soil test calibrated fertilizer dose and organic manure always ensured economy and efficient use of fertilizers. High yield of wheat has been obtained without overdepleting the soil fertility when fertilizer were applied along with organic manure based on soil test values in Alfisol (Prasad and Prasad 1998). Mechanical harvesting of wheat and rice is a common practice in rice-wheat belt. Rice-wheat cropping system results in depletion of nutrients and organic matter content, which can be arrested by regular incorporation of crop residues. For managing residues of rice-wheat crop rotation, the residues and stubbles of both the crops are not ploughed in but left undisturbed (crop residues as mulch) to hold soil and to conserve moisture. Rice seedlings are transplanted in between stubbles of wheat and wheat is sown in between rice stubbles by chiseling. Crop residues as mulch and its incorporation in soil is superior (24.8 q/ha wheat yield) to no crop residue mulch (20.8 q/ha) under minimum tilage. Similarly, the performance of crop residue mulch (30.6 q/ha) is greater than no crop residue mulch (26.8 q/ha) under conventional tillage (Prasad 1999).

Integrated effect of chemical fertilizers with crop residues (rice and wheat straw) after soaking in 2% urea solution or 25% extra N application to wheat and rice and inoculated with cellulolytic culture ***(Aspargillus*** spp.) to hasten the decomposition of crop residues improved the yield of rice and wheat. These results further suggested that FYM + crop residues could substitute 50% NPK (50 kg N, 30 kg P_2O_5 and 20 K,O/ ha) for rice and their residual effect was equivalent to 50% recommended dose of NPK on succeeding wheat crop. An early application of FYM @ 10 t/ha mixed with recommended dose of NPK was able to sustain crop productivity. In contrast, in the absence of FYM application, even 50% higher rate of NPK could not maintain initial productivity. It is surmised that FYM played an additional role apart from its capacity to contribute NPK (Sinha 1993). The research work conducted at RAU, Pusa indicated that green manuring by growing short duration summer green gram up to 25% flowering stage (3.8 t dry matter/ha) and crop residue (straw) incorporation after taking 6.8 q/ha grain could substitute 25% recommended dose of NPK for rice and its residual effect was equivalent to 25% NPK substitution to succeeding wheat crop under rice-wheat system in upland and lowland situations of calcareous soil.

Green manuring with summer green gram is superior to its straw incorporation after taking grain under both upland and lowland situations but farmers have to sacrifice the yield of summer green gram. The benefit accruing due to green manure includes increase in organic matter content, available plant nutrients and improvement in physical, chemical and biological properties of soils. The green manure crops of sesbania, sunhemp and black gram added 1001, 1076 and 225 g Zn/ha in soil. The integrated effect of green manuring with mineral fertilizer on rice yield was in the order of sesbania = sunhemp > blackgram. The residual effect of these organic manures was significant on the grain yield of wheat. These results also suggested that green manures could substitute 25 kg ZnSO /lta that is sufficient for correction of Zn deficiency in calcareous soil. Green manuring builds up available Zn in soil (Prasad ***et al.*** 1995). In calcareous soil, effectiveness of organic carriers of Zn vis-a-vis zinc sulphate was in the order of poultry manure >pressmud >biogas slurry >sewage-sludge >ZnSO . Zinc use-efficiency was also higher (2.0 to 8.1%) with organic - Zn compared with ZnSO (0.3 to 1.5%). Organic sources also maintained relatively highlevel of DTPA- Zn in soil (Prasad ***et al.*** 1989). The relative efficiency of different Fe-enriched organic materials in augmenting rice yield varied in the order of sewage-sludge >poultry manure > municipal wastes > pressmud > FYM > FeSO (Prasad ***et al.*** 1989).

The blending of the indigenous technology with latest scientific techniques holds a great promise not only in sustaining and maintaining soil fertility and crop productivity but also acts against emergence of multiple nutrient deficiencies and also protects soil health from deterioration.

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CHAPTER 14

INDIGENOUS NUTRIENT MANAGEMENT PRACTICES IN MADHYA PRADESH

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ABSTRACT

Madhya Pradesh is the largest state of our country and has diversified soil, climatic and agro-ecological conditions. The state has a rich heritage of traditional knowledge and wisdom in agriculture. Since resource intensive modern scientific agricultural technology is beyond the reach of majority of the farmers, they still rely on many indigenous practices which are based on the traditional wisdom and vast experience in all aspects of agricultural production systems including crops. Use of inputs such as nutrients and water, however, figures prominently for obvious regions. The indigenous practices relating to nutrient management in field crops still alive in various parts of the state have been compiled and discussed. These are use offarm refuses and residues, organic manures, bio-fertilizers, green manuring, mixed cropping, agro-forestry', Vermiculture and night-soiling as source of plant nutrients; use of Mahua (Madhuca latifolia), karanj (Pongameapinnata), neem (Azadirachtaindica), sal (Shorea robasta) cakes for coating of urea, and conservation practices such as Haveli and Bandh cultivation, bunding, mulching etc. for conservation of nutrients and increased nutrient use efficiency. The traditional practices adopted by farmers evolved through experiences have scientific rationale and great deal of relevance to available resources and soil and climatic conditions of a particular region. Suitable refinement of these indigenous techniques of nutrient management has been suggested with a view to makethem more effective.

Agricultural research and development is currently facing unprecendented challanges in terms of availability of and accessability to food as the country’s populationcrosses 1000 million mark. Although the pace of generation of improved practices throughICAR Institutes and SAUs has accelerated in the recent past yet the transfer of technology andits adoption particularly by the small farmers has remained low. Agriculture in India has a longhistory dating back to neolithic age of 750-6500 B.C. There has been a common belief amongIndian farmers that they would enjoy better health, socio-economic status, living standard iftheir diet and food habits contained a greater proportion of indigenous foods produced/collectedby adopting indigenous techniques. Indigenous food or crop producing techniques weregenerally associated to some religious functions which later-on became social-cum-religioustraditions. Any deviation from these traditions was viewed very seriously by the society. Therehas been existing a great diversity in and wealth of traditional agro-techniques in different partsof India. These practices have been evolved to match local requirement and resources. Some of the practices as they relate to nutrient management in crops in Madhya Pradesh have been discussed.

BACKGROUND INFORMATION

There is a common saying in Western Madhya Pradesh **"Malav Dharti Gahar Gambhir, Pag-Pag Roti Dag-Dag-Neer".** This means that the soils of Malwa region are so deep and productive that at every step there is ample food and water. History reveals that there has not been any famine in Malwa region so far. Similarly the saying in northern parts of the state is **"Ghati Dhasain Matti"** meaning that the productive soils lie in valleys not on hills. These sayings suggest that there existed knowledge with regard to relationship of soil depth, soil fertility and soil water retentivity as they relate to general prosperity of the region in general and agrarion society in particular.

Madhya Pradesh is the largest state of our country which possess varying ecology, land forms, soil types, land use, socio-economic and cultural heritage and food habits etc. The economy **of** Madhya Pradesh is largely dependent on agriculture sector. The entire state is divided into 12 agro-climatic zones (Fig.l). The basic characteristics of different agro-climatic zones of Madhya Pradesh are given in Table 1.

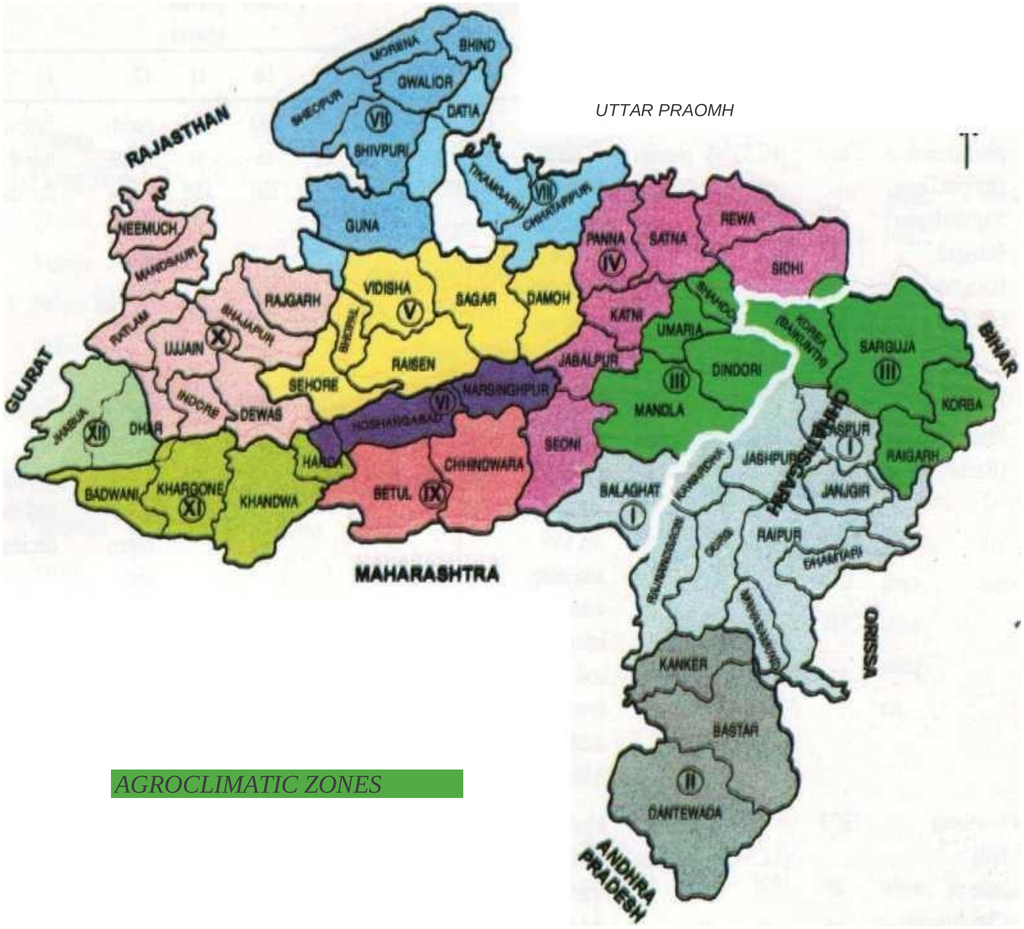
The total area of 443 lakhs ha is distributed in 11385100 holdings with an average holding size of 2.57 ha (Anonymous 1997). The average holding size (3.27) of Vindhyan Plateau is the largest among all the 12 agro-climatic regions, whereas the lowest average holding size (1.66 ha) is in Chhattisgarh plains.

Alluvial soils, primarily, exist in Gird (2.65 m ha) and Bundelkhand zones (0.7 m ha). These soils are also found in patches along the river banks, such as Sone, Narmada and Mahi.

I, **CHHATTISQARH PLAINS**

II, **BASTER PLATEAU**

- **IH, NORTHERN HILLS ZONE OF CHHATTISQARH**



IV. **KYMORE PLATEAU ANO SATPURA HILLS**

V. **VINDHYAN PLATEAU**

- **VI. CENTRAL NARMADA VALLEY VII. GIRO ZONE**

VIR. SUNDELKHANO ZONE

IX. **SATPURA PLATEAU**

X. **MALWA PLATEAU**

XI. **NIMAR VALLEY**

XII. **JHABUA HILLS**

Fig. 1 Agroclimatic zones of Madhya Pradesh

Table 1 Basic characteristics of different agrclimatic zones of Madhya Pradesh

	Zone with Districts	Agro-ecological region	Area (m ha)	Physio-graphy	Soils	Climate	Rainfall (mm)	PET (mm)	Water deficit (mm)	Grow-ing period (days)	Major Crops	Forest type
1	2	3	4	5	6	7	8	9	10	11	12	13
I	Chhattisgarh plains (Raipur,Durg, Rajnandgaon Bilaspur, Balaghat and (1/2S) Raigarh	J3C3	7.77 (17.55%)	Eastern Plateau	Medium & deep, Loamy Red and Yellow Soils with Medium AWC	Hot, Sub-humid	1200 To 1600	1400 To 1500	500 To 700	150 To 180	Paddy teora Kodo-kutki, gram, linseed etc.	Tropical Moist deciduou
II	Bastar Plateau (Bastar)	J2C3/4	3.91 (8.82%)	Eastern Plateau	Shallow & medium loamy red soil and deep, loamy lateritic soil with low and medium AWC	Hot, Sub-humid	1000 To 1600	1400 To 1700	500 To 700	150 To 180 (210)	Paddy Kodo-kutki, kulthi niger, urd etc.	Tropical dry deciduous and moist deciduous
III	Northern hills zone of Chhattisgarh (Shahdol, Surg uja, Mandla & (1/2N) Raigarh)	J3C3	5.56 (12.54%)	Eastern Plateau	Medium & deep, loamy red and yellow soils with medium AWC	Hot, Sub-humid	1200 To 1660	1400 To 1500	500 To 700	150 To 180	Paddy teora Kodo-kutki, wheat maize, niger etc.	Tropical Moist deciduou
IV	Kymore Plateau and Satpura hills (Jabalpur, Satna, Panna, Seoni,Rewa & Sidhi)	16C3/4 and 15C3	4.99 (11.27%)	Central high lands	Medium & deep, clayey, black soils with medium and high	Hot, Sub-humid	1000 To 1500	1300 To 1500	500 To 700	150 To 180 (210)	Wheat, paddy, gram, koda-kutki, soybean etc.	Tropical dry deciduous

(Sagar.Damoh, Bhopal, Sehore, Raisen and Vidisha)			lands	clayey, black soils with medium and high AWC	humid	1250	1500	700	180 (210)	gram. lentil. jowar etc.	deciduous
VI Cenral Narmada Valley (Narstngpur and Hoshangabad)	15C3	1.51 (3.40%)	Central high lands	deep. clayey, black soils with medium and high AWC	Hot, sub-humid	1000 to 1250	1300 to 1500	500 to 700	150 to 180 (210)	soybean. wheat. gram, arhar. paddy etc.	Tropical dry deciduous
VI[Grid (Morena. Bhind. Gwalior. (1/2W) Shivpuri and Guna)	N8D2	3.74 (8.46%)	Northern plains and Central high lands	Deep, loamy, alluvium derived soils with medium AWC& shallow to medium sandy to loamy, grey brown soils	Hot, semi-arid	500 to 800	1400 to 1900	700 to 1000	90 to 50	wheat, mustard, gram, jowar. bajra etc.	Tropical dry deciduous

				with low to medium AWC							
VIIIBundelkhand (Datia, Tikamgarh, Chhatarpur & (1/2 E) Shivpuri)	I6C3/4 and N8D2	2.08 (4.94%)	Central high lands	Mixed red and black soils, soils with low and medium	Hot, sub-humid	800 to 1000	1300 to 1500	500 to 700	150 to 180 (210)	wheat, gram, jowar, urd sesame etc.	Tropical dry deciduous &thorn
IX Satpura Plateau (Betul & Chhindwara)	14C3	2.19 (4.94%)	Central high lands	Shallow & medium, clayey black soil with low &medium AWC	Hot, sub-humid	1000 to 1200	1300 to 1500	500 to 700	150 to 180 (210)	soybean. jowar, wheat, kodo-kulthi, maize etc.	Tropical dry deciduous
X Malwa plateau (Ujjain, Mandsaur, Ratlam, Shajapur Indore, Rajgarh, Dewas &	I5D2 and I5C3	5.18 (11.68%)	Central high lands	Medium & deep, fine loamy & clayey black soils with medium &high	Hot. semi-arid	600 to 1000	1600 to 2000	800 to 1200	90 to 150	soybean. gram. jowar wheat, maize etc.	Tropical dry deciduous and thorn
XI Nimar valley (Khargone, & Khandwa)	15D2	2.47 (5.56%)	Central high lands	Medium & deep, fine loamy & clayey black soils with medium & high	Hot, semi-arid	600 to 1000	1600 to 2000	800 to 1200	90 to 150	cotton, jowar, wheat, urd, groundnut etc.	Tropical dry deciduous
XII Jhabua hills (Jhabua)	I5D2	0.68 (1.51%)	Central high lands	Medium &deep, fine loamy & clayey black soils with medium &	Hot, semi-arid	600 to 800	1600 to 2000	800 to 1200	90 to 150	maize, urd, gram. wheat, jowar etc.	Tropical dry deciduous

Note:Figures in parentheses are per cent of the total geographical area of Madhya Pradesh state

Medium and deep black soils occupy the maximum area (36.3%) in the state. These soils widely occur in Kymore plateau and Satpura hills (1.01 nt ha), Vindhyan plateau (4.26 m ha), Central Narmada valley (1.51 m ha), Gird zone (1.10 m ha), Malwa plateau (5.18 m ha), Nimar valley (2.47 m ha) and Jhabua hills (0.68 m ha). Shallow and medium black soils are mostly found in Kymore plateau and Satpura hills (0.87 m ha) and Satpura plateau (2.19 m ha). Mixed red and black soils are found in Chhattisgarh plains, Northern hills zone of Chhattisgarh, Kymore plateau and Satpura hills and Bundelkhand zone representing 18.30 per cent of geographical area of the state. Red and lateritic soils occur mainly in Bastar plateau (3.91 m ha) with some patches in Chhattisgarh plains and in Northern hills zone of Chhattisgarh. The red and yellow soils are primarily spread over the Chhattisgarh plains (6.85 m ha) and Northern hills zone of Chhattisgarh (2.85 m ha). To some extent, such combinations, are also found in Jhabua hills.

Except Bastar plateau and Northern hills of Chhattisgarh, soils of all the zones are low in nitrogen. Similarly, phosphorus content is low to medium except in Nimar valley and Jhabua hills. Potassium content in soil is generally high except in zones 1, 2 and 4. Soils of all the zones are deficient in zinc.

The state receives about 700-1600 mm annual rainfall and has limited irrigation facilities. Hence, major area is under rainfed farming with cropping intensity ranging from 112 to 165%. Under irrigated conditions rice-wheat, rice-wheat-vegetables, soybean-wheat/gram are the major crop rotations being followed. The area under horticultural crops is increasing in Malwa plateau, Nimar valley, Chhattisgarh plains and Satpura plateau. Among plantation crops cashew is gaining significance in Bastar plateau.

The nutrient consumption alongwith productivity of cereals, pulses and oilseeds in different agro-climatic zones of Madhya Pradesh during 1997-98 are presented in Table 2. The overall consumption of nutrients in the state is low (47.6 kg NPK/ha).

Although there are wide variations in fertilizer consumption across agro-climatic zones, they are not necessarily reflected in crop productivity. For example, Nimar valley attained the distinction of highest consumption of NPK (98.1 kg/ha) but the productivity of crops was lower than in Malwa where NPK use was only 75.6 kg/ha during 1997-98.

Table 2 Average nutrient consumption and productivity of field crops in different agroclimaticregions (1997-98)

S. No	Agroclimatic zone	Nutrient consumption (kg/ha)				Productivity (kg/ha)		
		N	P	K	Total	Cereals	Pulses	Oilseeds
1	Chhattisgarh plains	28.9	11.6	5.25	43.9	906	165	384
2	Bastar plateau	8.3	2.5	1.0	11.8	675	381	297
3	Northern hills zone of Chhattisgarh	10.57	4.7	1.55	16.8	680	287	297
4	Kymore plateau andSatpura hills	15.96	12.05	0.6	28.61	*111*	535	529
5	Vindhyan plateau	22.38	19.9	1.18	43.46	1251	806	1014
6	Central Narmada valley	32.95	28.2	1.4	62.55	1402	927	1278
7	Gird zone	43.86	18.52	0.7	63.08	1710	1127	722
8	Bundelkhand zone	24.52	14.7	0.6	39.82	1615	738	779
9	Satpura plateau	19.8	8.8	1.7	30.3	865	507	822
10	Malwa plateau	43:3	27.2	5.1	75.6	1879	902	1139
11	Nimar valley	59.1	27.5	11.5	98.1	1299	472	746
12	Jhabua hills	30.3	7.7	0.8	38.8	1209	475	775
	Average							

The traditional practices like application of FYM, compost, cakes of rnahua *(Madhuca indica)* and neem *(Azadirachta indica)*, poultry and pig manure, kitchen waste, growing of legumes such as green gram, urd, pigeonpea either as mixed crop or intercrop with cereals and green manuring of sunhemp and cowpea are few to name which have been followed by the farmers in different agro-climatic zones of Madhya Pradesh. Green manuring is usually practised in Chhattisgarh plains, Bastar plateau and Northern hills zone of Chhattisgarh, in fields brought under transplanted rice. In Kymore plateau and Satpura hills zone, Haveli system is followed where water is impounded during rainy season in bunded fields and subsequently drained by middle of October. Kharif fallow is practised under rainfed area of Vindhyan plateau to conserve moisture and to achieve enhanced nutrient -use efficiency.

Many farmers of Central Narmada Valley grow sunhemp as a green manure crop once in 7 years. They believe that the practice results in progressive improvement in soil fertility for 3 years and it takes another 3 years for its effect to diminish. Intercropping of pigeonpea/cluster beans with pearl millet and or sorghum is practised in Gird zone. Pressmud is applied by some farmers as an amendment for reclamation of the salt affected soils. Application of paddy straw in rabi season as a mulch is practised in Bhind district specially in the salt affected areas. Application of cowdung as manure and mixed cropping of sorghum with pigeonpea/urd beanAnoong bean is practised in interior parts of the Satpura plateau.

Application of FYM, use of hay and cow urine as insecticide, bio-fertilizers for improving nitrogen, summer ploughing, vegetative mulch etc. are being practised by scores of fanners of Malwa region and Nimar valley.

Some farmers mix cakes of mahua, neem and karanj with urea before its application to the paddy field in Chhattisgarh region and Kymore plateau zones. Some farmer grow rice as an intercrop with ***Acacia*** species.

A large section of farming community in Madhya Pradesh is neither adopting recommended practices nor following traditional practices of nutrient management. Low risk bearing capacity and rainfed nature of agriculture are detering factors for adoption of the recommended package of nutrient management practices. Thus, the only option for the over all development of agriculture in different agro-climatic zones is to blend recently developed techniques with traditional wisdom existing with the fanners of the state.

NUTRIENT MANAGEMENT PROBLEMS

The major problems of nutrient management that exist in the state are:

Inadequate nutrient addition to crop or cropping system

Increase in intensity of cropping and even increasing use of high analysis fertilizer contributed immensely to nutrient mining from the soil which has an adverse effect on soil health. Biswas ***et*** cr/.fl996) indicated wide variations in nutrient removal and nutrient use patterns across agro-climatic regions. However, nutrient removal by crops generally exceeds its addition to soils. This imbalance poses a serious threat to long term sustainability in food production in the state.

Nutrient supply not based on soil test values

The nutrient use under different agroclimatic regions of Madhya Pradesh is inadequate and imbalanced (Table 2) as it is not based on soil test values resulting in low productivity and poor nutrient use efficiency.

Limited use of organic sources

The low organic matter content in soils is associated with reduced microbial population and diminished soil productivity. The use of available organic resources (FYM, compost, crop residues and farm refuses) in the state is very limited (Anonymous 1994) which leads to further depletion of organic matter from already deficient soils. ***Losses of applied nutrients***

The losses of applied nutrients through leaching are common in Gird region, Bundelkhand. Kymore plateau and entire Chhattisgarh region and runoff in black soil regions of Malwa plateau, Nimar valley, Jhabua hills, Central Narmada valley and Northern hills of Chhattisgarh are significant. They lead to poor recovery of applied nutrients.

Fixation of applied P and Zn in black soil region

The response of crops to and recovery of applied P are generally poor primarily due to high P fixation capacity of black soils and inadequate water availability to the growing crops during rabi in black soil regions of Malwa, Vindhyan, Central Narmada valley and Satpura plateau. Black soils of these regions are also deficient in Zn. ***Nutritional imbalances in parts of Gird, Malwa & Nimar valley regions***

Soil pH and exchangeable sodium content of soils in parts of Gird, Malwa and Nimar valley regions are above critical levels. This renders P, Fe, Mn and Zn less available. Also the calcareous nature of vertisols promotes ammonia volatilization following surface application of ammonium and ammonium forming fertilizers (Goswami and Sahrawat 1982).

Low nutrient use efficiency

The black soils of Central Madhya Pradesh because of its poor internal drainage encounter oxygen stress during kharif impeding root growth of upland crops and root proliferation and nodulation in pulses. As a consequence water and nutrient uptake by

crops is retarded. In Alfisols the argillic and in Entisols, calcic or gypsic horizons severely restrict root development in part of Vindhyan and Satpura plateau.

Use of local varieties and low seed replacement rates

The Farmers continue to grow local, less responsive cultivars of crops throughout the state. The seed replacement rates are also very low (< 5 per cent). This acts as an impediment for efficient nutrient use.

Low soil organic matter

Biological activity in soils is low devoid of irrigation.

Wide spread deficiency of N_tP,S and Zn

Deficiency of S and Zn is now wide spread whereas soils is low in N and low to medium in P. Many soils now require K application as crops exhibit significant response to K application.

TRADITIONAL WISDOM/PRACTICES OF NUTRIENT MANAGEMENT

The nutrient management problems outlined above have been addressed by farmers through many traditional practices that still exist in various parts of the state. These practices relate to sources of plant nutrients, application methods and conservation of plant nutrients.

A. Sources of plant nutrients

(i) Farm refuses and crop residues

(ii) Organic manures

(iii) Biofertilizers

(iv) Mixed cropping

(v) Vermiculture

(vi) Green manuring

(vii) Agro-forestry (babool trees inbetween rice field in Chhattisgarh region)

(viii) Use of silt collected from water reservoirs/tanks in cultivated field

(ix) Use of sewage sludge

B. Application Methods

Farmers have been practising traditional methods of application and conservation of plant nutrients. Most commonly followed practices are given below:

(i) Storage of cow/buffalo dung on ground surface for 6 to 8 months (Plate 1) and its subsequent broadcast in the fields during summer.

Plate I : Traditional method of compost making

(ii) Coating of urea with neem *(Azadirachta indica),* mahua *(Madhitca latifolia),* Karanj *(Pongamea pinnata),* sal *(Shorea robasta)* cakes by physically mixing before application to rice fields.

(iii) Browsing of residues of harvested crops during summer by herds of goals and/ or sheep. The practice still followed in Jhabua, Satpura plateau. Central Narmada valley, Vindhyan plateau, Bundelkhand and Gird zones of the state results in enrichment of soils with droppings and urine.

(iv) Green manuring with dhaincha *(Sesbania acideata),* Sunhemp *(Crotolaria juncea)* in Central, Northern and Eastern part of Madhya Pradesh is practised, to supplement soil nitrogen and organic matter.

(v) Burying weeds and wild rice *(Karga)* in rice field in Chhatisgarh region which eventually decompose and augment plant available nutrient supply.

C Practices that encourage conservation and use efficiency of nutrients

Haveli cultivation in black soil region: This practice has been in use for conservation of water and nutrients in soil. The practice has been widely followed in Central Narmada valley and part of Kymore plateau and Satpura hills zone. Bunded Helds are kept submerged during rainy season. They are drained off and planted to a non-irrigated rabi crop usually wheat.

Bunding of fields : Field bunding is practised in alluvial tracts of Madhya Pradesh for erosion control. This results in nutrient conservation also.

Summer ploughing : Summer ploughing is practised in many regions of the state to conserve moisture and to reduce soil and nutrient loss during intense rains.

Mulching : Crop residues which are of low economic value such as sorghum straw, soybean trash, dried weeds are used for this purpose. Mulching reduces runoff- induced losses of soil and plant nutrients from cultivated lands. Mulching is practised in Kymore plateau and Satpura hills zone. Central Narmada valley, Malwa plateau and Nimar valley zones.

Palas *(Butea monosperma)* leaves are commonly used as mulch in vegetables by farmers of Vindhyan plateau for controlling weeds and conserving soil moisture during kbarif season. Subsequently dried leaves are incorporated into the soil with a view to enrich soil which results in higher yield and nutrient use efficiency.

Soil mulching is quite popular in Western and Central Madhya Pradesh as it conserves soil moisture, controls weeds and improves soil aeration thereby improving water and nutrient use efficiency.

RELEVANCE AND REFINEMENT OF TRADITIONAL WISDOM/ PRACTICES OF NUTRIENT MANAGEMENT

Many traditional practices adopted by farmers though evolved through experiences have scientific basis and great deal of relevance to available resources, soil and climatic conditions of the region concerned. There is a considerable scope of blending traditional practices with latest scientific techniques, to make them more effective and popular.

The relevance of traditional practices of nutrient management and their refinement is discussed as under:

The application of farm refuse and crop residues

Utility and importance: Use of organic residues on the soil surface decreases rain drop impact on soil resulting in reduced dispersion of soil aggregates and enhances infiltration rate. The runoff and sediment losses are considerably reduced.

Refinement: Direct mixing of farm refuses and crop residue leads to temporary immobilization of plant nutrients and the possible release of phytotoxic compounds (Burgos 1993). Hence, the crop residues should be used either as mulch or modified as, organic manure by Narayan Rao Pandari Pande (NADEP) method prior to their restitution to the soil.

Organic Manure

Utility and importance: The soils of the state are generally low in organic matter content. Addition of organic matter as FYM, compost, poultry manure, pig manure, night soiling, droppings of goats, sheeps etc. besides supplying macro and micro nutrients, provides the basic ingredients for humus formation which, in turn, improve the physical, chemical and biological environments of soils.

Refinement: Mixed arable-live stock farming systems are characteristics of large areas in Madhya Pradesh. In these systems manure from livestock and farm wastes is commonly used as a source of nutrients in fields. The FYM produced by indigenous methods takes long time and is of poor quality in terms of nutrient and humus content. Indore, Bangalore or NADEP method of composting (Plate 2) are improved versions of traditional methods still in vogue. NADEP compost contains 0.6 to 1.2% N, 0.5% P and more than 1.0% K. The quantity of N and P can be enriched by addition of rock phosphate or single super phosphate at the time of tank filling. Addition of bio-fertilizers to the NADEP compost further improves its nutritional quality.

Traditionally, the practice followed for use of FYM by fanners involves shifting of FYM to fields and its storage in small piles on the surface during summer months. The practice leads to losses of nutrients due to volatilization during hot period. To derive maximum benefit from FYM, it is essential that it should be spread evenly and incorporated into a wet soil after pre-monsoon rains.

Plate 2 : NADEP method of compost making

As there is large number of cattle population in Madhya Pradesh, the fanners may be encouraged for installation of Gobar gas (bio-gas) plants (Plate 3) for which subsidy is already available. Gobar gas slurry can be utilized for compost making. These plants can also meet the domestic energy requirement.

Plate 3 : Gobar gas plant in operation at farmers home

Venni-comp o sting

Utility and importance: Vermi-composting has proven to be an efficient and inexpensive method of composting (Plate 4). The castings excreted by the earth worms are rich source of readily available minerals and humus. The vermi-compost is 5 times richer in N, 7 times richer in P, 11 times richer in K, 2 times richer in Mg & Ca and 7 times richer in Actinomycetes , than the ordinary soil. Besides it contains valuable vitamins, enzymes and hamiones like gibberellin. It can be used for raising crops 2 t/ha and 100-200 g/tree for horticultural crops. Vermiculture offers immense opportunities for augmenting nutrient supply by recycling biomass.

Refinement: Conjunctive use of organics (FYM, compost, bio-fertilizers) with reduced levels of chemical fertilizers should be practiced. The evidences of systematic research on the impact of conjunctive use of FYM and crop residues along with reduced level of fertilizer in black soil under rain fed conditions have been reported by Sharma and Gupta (1993). The summary of result has been depicted in Table 3.

Table 3 Effect of conjunctive use of sources of plant nutrients on soil fertility changes,productivity and water use efficiency of soybean-safflower sequence

Treatment	O.C (%)	Available nutrient status of soil (kg/ha)				Seed yield (kg/ha)		WUE (kg/ha/mm)		Uptake (kg/ha)	
		N	P	K	S	SY	SF	SY	SF	SY	SF
Initial	0.51	205	7.1	385	22.8	-	-	-	-	-	-
NA	0.38	177	5.8	624	16.1	749	744	1.22	3.62	79	12.5
NA,	0.44	198	7.7	572	13.7	1105	824	1.41	4.39	91	12.3
$N_{30}P_{20}$	0.50	208	7.9	560	13.9	1186	1134	1.50	5.71	106	16.7
N A.	0.61	233	10.2	611	12.4	1273	1366	1.64	6.45	120	17.2
N A,	0.61	233	11.9	644	15.9	1308	1254	1.69	6.35	119	15.8
FYM 6t + N P :o n	1.39	383	25.7	728	13.5	1476	1257	1.93	5.16	132	17.6
Residues 5t + $N_{20}P_{12}$	1.35	371	8.7	806	14.2	1152	1254	1.48	5.45	111	19.9
FYM 6 t	1.12	345	16.8	793	14.3	1152	1178	1.52	4.77	111	16.6
Residues 5t	1.03	335	8.7	825	14.9	1117	1328	1.46	6.04	102	16.8
CD (P=0.05)	0.09	21.9	1.1	120	NS	32.8	NS	-	-	-	-

Note: Uptake of N and P is the sum for both the crops, and WUE = water use efficiency
SY = Soybean, SF= Safflower

Use of Sewage-sludge

Utility and Importance: Application of sewage sludge, a waste from urban areas is a good source of organic matter and nutrients such as N (1.5 - 3.5%), P (0.78 - 4.0%), K (0.3 - 0.6%), B. Zn, Fe, Mn and Cu etc. Application of sewage sludge @ 20 t/ha with mineral fertilizers reduced the bulk density, increased hydraulic conductivity, pore space and available macro and micro nutrients, besides reducing the fertilizer dose by 50 per cent for two residual crops of rice (Paulraj 1989).

Refinement: Activated sludge, produoed by rapid aerobic treatment of sewage that results in coagulation and settling of suspended materials be used in place of ordinary sewage sludge. Fodder crops, sugarcane and some vegetable crops like cabbage, turnip, potato, brinjal etc. can be grown with sewage irrigation. Whereas, tomato, radish, onion, garlic and carrot should be avoided.

Night soil

Utility and importance: Night soil is richer in N, P,O. and K,0 compared to FYM or compost. On oven dry basis, it contains 5.5% N, 4.0% P,O. and 2% K.,0.

*Refinement:*Night soil should be applied directly to the soil in trenches and covered with earth or garbage. Mixing of night soil with an equal volume of ash and 10 per cent powdered charcoal produces an odourless material containing 1.3 per cent N, 2.8 per cent phosphoric acid, 4.1 per cent potash and 24.2 per cent lime.

Biofertilizers

Utility and importance: Biofertilizers have been recognized as important inputs in integrated plant nutrition systems. They make a significant contribution to soil nitrogen by trapping atmospheric

N. Use of legume crop as a component of a crop sequence is followed to achieve N-economy.

Refinement: The use of Blue green algae, Azolla and Legume green manures for rice; Azotobactor and Azospirillum for wheat, millets, sugarcane and vegetable crops; Rhizobium for pulses and oilseed legume crops, phospho-micro-organisms for a variety of crops is reported. Blue green algae is suitable for the rice crop in Chhatisgarh region. Use of phosphate solubilizing micro-organisms is recommended as bio-fertilizer for improving availability of phosphorus.

Mixed cropping/Intercropping

Utility and Importance: Growing pulse crops with cereals under mixed cropping system supplements soil fertility in terms of nitrogen and improves productivity of cereals.

Refinement: The practice of mixed cropping of legumes with cereals can be replaced with intercropping. Many promising intercropping systems have been evolved and validated for large scale adoption. Some of them are soybean-pigeonpea, sorghum- pigeonpea, sorghum-cowpea, sorghum-urd,maize-cowpea, maize-urd, maize-soybean, bajra-guar etc (Plate 6).

Plate 4 . Veriiiicomposting

Green manuring

Utility and importance: Green manure/green leaf manure adds organic matter to the soil pool. Sunhemp and *lancaena* when used as green manure resulted in substantial increase in the yield of sorghum and safflower (Vishnumurthy *et al.* 1998).

Refinement: The green manure crops when applied improve the properties of the soil. Among the green manure crops special attention is being given to *Sesbania rostrata* which bears stem nodules in addition to the root nodules (Plate 5). The amount of nitrogen contributed in terms of fertilizer nitrogen equivalence ranges from 80 to 120 kg/ha. In a field trial comparing different green manure crops, it was found that

Sesbania rostrata produced the highest biomass (20-25 t/ha) and accumulated maximum N (150 - 220 kg/ha) (Palanniappan and Siddeswaran 1990). Hence, *Sesbania rostrata* be promoted as green manure crop under transplanted as well as direct seeded rice areas of Chhattisgarh region. Similarly, this also be advocated in Central Madhya Pradesh.

Instead of burying weeds and wild rice *(karga)* in rice field, be used as mulch and subsequently for conversion as compost by NADEP method in Chhattisgarh region. ***Agroforestry***

Utility and Importance: The practice of growing scattered babool trees inside rice field increases the soil organic matter and available nitrogen (Vishwanath *et al.* 1998).

Refinement: Babool tree can be replaced by subabool and planted in a row al proper spacing with rice and other upland crops in Chhattisgarh and Kymore plateau and Satpura hills zone.

Coating of urea with indigenous material

Utility and importance: Coating of urea with locally available material reduces nitrogen losses through leaching in rice fields.

Refinement: Urea should be coated with neem/mahua/karanj/sal. Coating urea supergranules by mud balls reduced nitrogen losses significantly in rice field at Kymore plateau (Anonymous 1982). These practices be promoted for increasing N use efficiency in rice fields.

Haveli and Bandh cultivation in black soil region

*Utility and importance:*Haveli and bandh cultivation practices commonly followed in Central Narmada valley and Kymore plateau and Satpura hills zones conserve plant nutrients and rain water along with effective weed control.

Refinement: Haveli cultivation practice does not ensure effective use of land resources. Rather land is kept fallow when the water availability is assured. A system called “Raised and sunken bed system” can be used to achieve goals of haveli cultivation while ensuring land use during kharif and rabi seasons. The system consists of an array of parallel raised and sunken beds of 4 to 6 meter width and 25 - 30 cm elevation difference. Raised bed is planted to an upland crop where as sunken beds are planted to rice. Rabi crops such as gram, lentil, linseed, wheat etc. can be grown on residual moisture (Gupta and Sharma 1994).

Plate 5 : Sesbania rostrata bearing nodules on stem-a suitable plant for green manuring

Plate 6: Bajra + guar intercropping system at Northern Madhya Pradesh

The system encourages recharge of root zone with water during kharif when sunken beds remain submerged (Table 4). Nutrients washed away from raised beds during rains are retained in sunken beds.

Table 4 Influence of cost effective land treatments on conservation of natural resources(Mean values for 1988-1991)

Land Treatment	Rainfall (mm)	Runoff (mm)	Ground water recharge (mm)	Soil loss (kg/ha)	Loss of N (kg/ha)
Untreated Flat land	706	69	175	329	14.22
Broad-bed and Furrows (1.05 m)	706	49	117	274	14.40
Raised-Sunken Beds (8.4 m width, with bed elevation difference of 20 cm)	706	20	192	192	9.60

Source: (Gupta and Sharma 1994)

Bandh cultivation can be replaced by Zingg terracing in Kymore plateau and Satpura hills zone. Zingg terracing is adopted to harvest runoff from upper reaches for the benefit of crops grown in the lower side of the field especially for raising rabi crops in the level portion on conserved moisture condition. Suitable kharif crops can be grown on upper reaches.

Bunding of Fields

Utility and importance: One of the major problems in dryland regions of the state is low use efficiency of rain water. According to an estimate 10 to 43 t/ha per annum of top fertile soil is lost from black soil region (Randhawa and Rama Mohan Rao 1981). Field bunding and other mechanical structures have been recommended for control of runoff-induced soil erosion.

Refinement: The mechanical means/field bunding is expensive and require maintenance. This can be replaced by vegetative barriers. The vegetative barrier are established at suitable intervals using a locally adapted perennial grass species which is deep rooted, grows in large chumps. Once fully established, they reduce velocity of flowing water thereby reducing runoff, sediment and nutrient loss.

The vegetative barriers can be as effective as graded earthen bunds in reducing runoff, erosion and nutrient loss from moderately slopy black soils (Table 5). Grasses suitable for Malwa region are khus grass (Veteveria zizanioides), Palma rosa (Cymbopogon martinii) and guinea grass (Panicum maximum) (Ranade *et al.* 1995).

TableS Runoff, soil erosion and nitrogen loss as influenced by different vegetative andmechanical barriers on 2% land slope of black clay soils of Indore, MP

Treatments	Runoff (mm)	Soil loss (kg/ha)	Loss of N through run-off (kg/ha)
Untreated land	116	986	23.84
Graded earthen bunds	92	633	19.04
Vetiver bund	95	662	17.4
Graded earthen bund + Cymbopogon grass	94	567	17.18

Mulching

Utility and importance: Mulching has been found beneficial for minimizing evaporative losses of soil moisture. Soil mulching reduce the development of shrinkage cracks and provides a diffusion barrier for water vapours. Crop residue/weeds biomass mulch in addition to moisture conservation also adds organic matter to the soil. These effects are manifested in significant increase in crop yield (Virmani *et al.* 1991) and ultimately nutrient use efficiency.

Refinement: Any locally available mulching material such as soybean straw, rice straw, uprooted weeds can be placed in between crop rows. Certain weeds, such as *Melilotus albasenji* fix enormous quantity of atmospheric nitrogen, some of which would be available to the main crop.

CONCLUSION

It is concluded from above discussion that many traditional practices of nutrient management adopted by the farmers of Madhya Pradesh have a scientific rationale and great deal of relevance to the available resources, soil and climatic conditions of the region concerned. These could be made more effective through scientific refinements.

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CHAPTER 15

INDIGENOUS NUTRIENT MANAGEMENT TECHNOLOGY IN TRIBAL AREAS OF CHHATTISGARH

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ABSTRACT

In the tribal areas of Chhattisgarh mainly Northern Hills Zone (about 57% tribal population) and Bastar Plateau Zone (about 68% tribal population), illiterate farmers living in abject poverty are still following subsistence agriculture as the main occupation. With irrigation facilities available for less than 4% cropped area, agriculture in these areas is largely monocropped with rice and is dependent on rainfall ranging from 1400 to 1600 mm annually. Small millets, pulses and oilseeds are other major crops grown in these areas. Rolling topography and acidic nature of soil with poor fertility and low water retentive capacity' are the main characteristics of the region. Farmers in these areas follow a large number of indigenous practices which are based on the traditional wisdom derived from thousands of years of experience and cover the entire range of operations from field preparation, nutrient and water management, insect, pest, disease control through crop harvest and post harvest period. Tribal farmers generally grow traditional rice varieties which are not N responsive and barring few pockets here and there nutrient application through fertilizers is very low. They' adopt several indigenous techniques to meet the nutrient requirements of the crops. These techniques include application of FYM, Narayan Rao Pandari Pande (NADEP) compost, pig and poultry manures and growing of green manure crops in those fields where paddy is raised through the practice of transplanting. Besides, they also follow some of the practices like growing of green gram (mung) and black gram (urd) as a mixed crop with rice and of pigeonpea (arhar) with sugarcane. Mahua (Madhuca indica) and neem (Azadiraclita indica) cakes are applied as manure which also serve as pesticides. Wild rice (locally known as 'karga ') and other weeds are buried in the field itself at the time of weeding and roguing so as to recycle the nutrients taken up by them. Cultural practice ofploughing the field immediately after paddy harvest and intermittantly thereafter facilitates the decomposition of crop stubbles and weeds and recycling the nutrients into the soil. In some of the areas agroforestry practice of maintaining 100-125/ha babul (Acacia nilotica L.) as scattered trees inside rice fields is also followed which helps in increasing the soil organic matter and available nitrogen in rice fields. The pods of the babul trees are also buried in rice fields which besides adding nutrients to the soil, are perceived by the farmers as having pesticidal value. Some of the modern low cost inputs like use of cultures for pulse crops and Blue Green Algae (BGA) in rice are also gaining popularity among farmers of these areas. Indigenous technology being adopted by the tribal farmers has a scientific rationale and it could be made more effective through refinements based on locally available resources and skills and blending

with the modern scientific technology for enhanced and sustained productivity.

Chhattisgarh region of eastern Madhya Pradesh populary known as "Rice bowl of the state" is predominantly inhabited by tribals and harijans. The resource intensive modem agricultural technology is beyond the reach of large majority of illetrate tribals living in abject poverty and pursuing agriculture at subsistence. Majority of tribals are deriving their income from agriculture, rearing of livestock, agricultural wages and collection of minor forest produce. For example, Shrivastava (1982) reported that average household income of Rs 3281.8 per annum for Muria tribe in Bastar was derived mainly from agriculture (78.8%), forest (11.5%) and labour (7.6%). Similar conditions prevail in the Northern Hills region. A study in Shankargarh block of Surguja district revealed (Dasgupta 1993) that the tribals owned only 1-3 acres of land and lived by collecting fruits, leaves and other minor products from the forest and selling them in the market. They also worked as agricultural labourers in the surrounding farms. For Pahari Korwa tribe (Jaiswal 1995) various sources of income were: agricultural wages (44.1%), fanning (25.1%), non-agricultural labour (13.2%), forest products (12.5%), government service (3.9%) and business (1.1%). Similarly, in Surajpur block of Surguja district 42.2% income of tribals came from agriculture, 31.5% from agricultural labour, 9.1 % from forest produce, 5% from liquors, 4.3% from animal husbandry, 6.4% from service, 1% from business and 0.5% from other sources (Shanna 1998). Expenditure pattern showed that 68.97% income was expended for domestic consumption and only 4.92% expenditure was made on agriculture which was less than half of the expenditure made on liquor + smoking (8.25% + 2.26%). Social celebrations consumed 6.01% and house construction and maintenance 3.05%. Education received the lowest priority with only 0.81% of the income spent on it.

That the farming by tribals is at subsistence level becomes further evident from the level of fertilizer nutrient consumption in these areas. Not withstanding the low fertilizer nutrient consumption, in order to meet nutrient requirements of crops so as to sustain higher yields from local crop varieties, farmers in these areas follow a large number of indigenous practices which are based on traditional wisdom derived from their experience over a period of several centuries and cover the entire range of operations from field preparation to crop harvest (Sharma 1999),

BACKGROUND

Of the 12 agroclimatic zones of Madhya Pradesh , three viz., Chhattisgarh plains, Bastar Plateau and Northern Hills are located in the Chhattisgarh region. Northern Hills and Bastar Plateau zones, respectively with a geographical area of 5.56 and 3.91 m ha have a tribal population of about 57 and 68 per cent, respectively.

According to recently revised standards which stipulate that families having income of Rs 245.70 per month are classified as below the poverty line (Bhadoria 1999; personal communication). There are about 2,43,000 families in Bastar Plateau zone which are living below the poverty line (DRDA 1997). Thus with five members in an average size of family, 12,15,000 persons in Bastar Division are living below the poverty line. This constitutes 53.5 % of the total (2271314) and 73.1 % of the Scheduled tribes and scheduled cast (1662769) population.

In Bastar Plateau zone, the total area of 8,23,352 ha is distributed in 3,10,896 holdings with an average holding size of 2.64 ha (Anonymous 1997). On the other hand, in Surguja district, the average size of holding is 2.23 ha (Sharma 1998). Irrespective of size of holding which ranges from less than 1 ha to more than 10 ha, indigenous techniques are the integral part of the tribal farming in these areas.

Some biophysical characteristics of the concerned zones in terms of rainfall, rainy days and water availability periods and farming situations are given (Chaudhary 1995, Jaiswal *et al.* 1996, Anonymous 1998) below:

SI. No. Particulars	Agroclimatic zone	
	Bastar Plateau	Northern Hills
1. Monsoon onset	June 10	June 18
2. Rainfall (mm)	1400-1600	1400-1600
3. Rainy days	65-82	72-91
4. Water availability Period (days)	171 (22 May-7 Nov.)	134 (2 Jun- 14 Oct.)
5. Farming situation	(i) slopy upland unbunded-marhan(31%) (ii) upland occasionally bunded-tikra (27%) (iii) midland bunded- mal (22%) (iv) lowland bunded- gabhar (20%) (v) ‘ badi ’ -usually part of tikra	(i) hilly soils (1.91%) (ii) upland unbunded (29.03%) (iii) upland bunded (24.86%) (iv) lowland bunded (22.24%) (v) extreme lowland -baahaara (14.23%) (vi) badi (7.73%)

In Bastar Division (comprising all the three districts of Ranker, Bastar and Dantewada) during 1998-99 (Anonymous 1999), nutrient consumption was recorded at 8.93 kg /ha. In the plateau region of the zone, the level of nutrient consumption was even lower where Bastar district consumed 6.45 kg /ha nutrients and the least developed southern region of Dantewada district showed a nutrient consumption of only 1.16kg /ha during 1998-99. Similarly in Surguja and Jashpur districts of Northern Hills region, nutrient consumption in 1998-99 was recorded at 10.8 and 6.0 kg /ha, respectively. Cultivation of large number of local long duration rice and other crop varieties which are non- responsive especially to N and attendant risk of rainfed farming in rolling topography could be other major factors for very low nutrient consumption in these areas. The local varieties are preferred for their high straw yields (feed for cattle), resistance to moisture stress / excess as well as to insect, pest and diseases. Thus, the area under high yielding varieties is limited.

Soils of the area are red and yellow and mixed red and black in the Northern Hills zone and red and lateritic in the Bastar Plateau zone. Some small patches of these lateritic soils have also been reported in Surguja district of Northern Hills zone (Tomar e/aZ. 1995).

The red and yellow soils are grouped mostly under Alfisols and Ultisols and the soil texture varies from loamy sand to heavy clay but generally loam to clay loam. The red soils bhata, full of stones with no consistancy, occupy higher topographic positions compared to yellow soils. Yellow soils, locally called *matasi* exists with many varieties. Soil reaction mostly varies from 6.3 to 8.0 pH i.e. from slightly acidic to alkaline. Down the slope, pH changes from acidic to neutral. Iron concretions are usually present in deeper horizons. Amounts of iron and aluminium are generally high.

Mixed red and black soils are classified under Entisols and Inceptisols. In many cases in an area of predominantly red soils, while the red soils occur in terrain of elevated topographic features, the black soils are found in the lower fo^Q'gc^Vtfo situations. The black soils existing intermittantly have been classified under Vertisols or Entisols and Inceptisols with vertic subgroup. Red soils are light textured being sandy loam, sandy clay loam and sandy clay. Depending upon their topographic situations, these soils greatly differ in depth and fertility.

The red and lateritic soils of Bastar Plateau zone are highly ferruginous, vesicular and apparantly unstratified deposits and have developed under monsoon type of climatic conditions. Under these conditions the silicious matter of the rock is leached away almost completely during weathering and the sesquioxides stay behind which are then converted into irreversible iron and aluminium oxides. Laterite and lateritic soils have been classified under Oxisols, Alfisols and Ultisols. These soils have acidic reaction and the pH ranges from 5.8 to 6.8

As far as the cropping system is concerned, both the zones receive about 1400- 1600 mm annual rainfall and have a very limited (about 3-4%) irrigation facilities (Anonymous 1998). Therefore, area is largely monocropped with rice occuping 60% of the cropped area. Beside rice, small millets viz., kodo, kutki, ragi, sanwan constitute major crops followed by maize, horsegram and jowar during kharif. Large number of tuber crops, usually grown in fenced fields around homesteads locally called ‘badi’, constitute an integral part of the cropping system. In extreme uplands, niger among oilseeds and horsegram among pulses are major crops which are usually sown in September. In midlands although there is a potential for growing rabi crops, but free cattle grazing- a social constraint- acts as a discouraging factor. However, maize-toria is a predominant rotation in both the zones. Under irrigated conditions rice-wheat, rice-wheat-vegetables, rice-mustard, rice-pea and rice-gram are major rotations. In a limited area vegetables are grown throughout the year. Amongst plantation crops area under cashew is on the rise.

The area has a rolling topography and soils are prone to erosion. They are generally acidic in nature which become neutral down the slope and have low water and nutrient retentive capacity and consequently poor in fertility and productivity. The lowlands, on the other hand have a poor drainage causing inordinate delay in tilling the lands for rabi crops. In Northern Hills zone, in extreme lowlands locally called *‘‘Bahara',* water continues to flow until the end of January and hence no rabi crop could be grown in these lands.

The basic infrastructure network in terms of roads, means of transport, communication, drinking water, health care, educational facilities, markets and banks are very poor.

Practices like application of FYM (Plate 2), NADEP compost, pig manure, poultry manure, kitchen waste, cakes of mahua *(Maduca indica)* and neem *(Azadirachta indica),* growing of greengram (mung) and blackgram (urd) as mixed crop with rice (Plate 1) and of pigeon pea with sugarcane are but few to name. Green manured crops are grown in those fields where transplanting method is used for rice cultivation. Cultural practices such as burying weeds in the soil at the time of‘biasi’ (ploughing the direct seeded rice field in standing water at 30-40 days after seed germination) and weeding operations and of wild rice (locally called ‘karga’) at the time of roguing are an integral part of rice cultivation. Ploughing the fields immediately after paddy harvest and intermittantly thereafter also constitutes an important practice. Some farmers mix cakes of mahua, neem and karanj with urea before its application. In some areas, a typical agrofoestry practice of maintaining 100-125 babul *(Acacia nilotica)* as scattered trees/ ha inside rice fields is followed (Vishwanath *et al.* 1998). Babul tree pods are also buried in rice fields.

Plate 1 : Intercropping of black gram with rice

Plate 2 : Farmers collecting cowdungfrom cattle grazing area for FYM preparation

EXISTING PROBLEMS OF NUTRIENT MANAGEMENT IN TRIBAL AREAS

Nutrient management problems in these tribal areas are many fold and could be categorized to fall within the ambits of socio-economic, infrastructural and edaphic factors. Amongst the socio-economic factors, traditions and beliefs, illiteracy and\ or lack of knowledge about nutritional requirements of crops play an important role in continuance of cultivating traditional local varieties which have proved their ability to withstand the biotic and abiotic stresses but are non-responsive to fertilizer especially the nitrogen application. Abundance of cattle also makes them believe that cowdung from their cattle is sufficient to meet nutritional requirements of crops. And where there is change in attitude in favour of fertilizer responsive high yeilding varieties, poor economic status acts as a barrier in purchasing costly fertilizers resulting in their inadequate and imbalance use. Many a time farmers with small holding size are unable to buy fertilizers as per the need because of big packings.

Poor infrastructure in terms of road network and means of transport result in problem of timely availability of fertilizers especially in the remote areas which remain inaccessible during rainy season. Although retail outlets have been set up by cooperatives and other agencies in many a rural areas but there still remains a problem of transportation from these outlets to the actual site of fertilizer consumption. Sale of urea as a controlled commodity also constitute an important problem as private traders are not allowed to hold the stocks of urea.

Amongst edaphic factors, vertical leaching as well as horizental leaching (loss) of nutrients are the main problems. In poorly structured sloping upland soils which are devoid of organic matter and consequently have low nutrient and water retentivity, loss of nutrients especially the nitrogen through vertical leaching as well as horizental movement along with flowing water defers farmers from using fertilizers. Long intervening dry spells also constitute the major risk in uplands. In low lands, on the other hand, continuous flow of water through fields results in horizental loss of nutrients. Fertilizers are therefore usually applied in bunded midlands which are relatively fertile, less prone to erosion and water deficits/excess. Here again, because of their quick apparant effect on crop growth, nitrogenous fertilizer are preferred over phosphatic and potassic fertilizers leading to their imbalanced use. In Surguza, for example, Sharma (1998) reported that amongst the respondents using fertilizers, only 52 and 45 per cent were using phosphatic and potassic fertilizers, respectively. Indigenous techniques are therefore followed for management of nutrients butnot without their own problems. As there is a large population of cattle in these tribal areas, farmers use FYM in as many fields-especially rice fields, as possible. FYM in different fields is usually used in rotation. However, as no proper scientific method is followed to prepare FYM, the cowdung is onlypartially decomposed and nutrient loss takes place as it is prepared by heaping in open place. A study in Surguja by Sharma(1998) found that only 15% farmers were using fully decomposed FYM. Consequently, it is not as effective as properly prepared FYM. For preparation of NADEP compost a large quantity (about 4 tonnes) of material is required to be collected at one time for filling up of NADEP structure. Most farmers find it arduous to gather material for NADEP. As a result farmers follow the practice of NADEP compost preparation for only a season or two and discontinue thereafter. Non availibility of bacterial fertilizers like BGA for rice and cultures for pulse crops in the required quantities is a major problem in their use by farmers.

RELEVANCE OF TECHNOLOGY ADOPTED BY THE FARMERS

All the indigenous techniques used by the farmers have scientific basis and great deal of relevance in achieving the purpose of nutrient supply to the crops as well as maintenance of soil health. The soils are inherently poor in organic matter and hard setting in nature. Consequently, upper layer gets dried very quickly resulting in clod formation on tilling the land. Addition of organic matter in the form of FYM, poultry and pig manures and compost not only supplies the necessary nutrients but also tends to improve the physical properties of soils for greater water and nutrient retention as well as for good soil tilth. Moreover, while chemical fertilizers provide only the specific nutrients, organic manures meet the requirements of micronutrients as well.

Raising of pulse crops of greengram and blackgram as mixed crops with rice and pigeonpea with sugarcane helps in building up of soil fertility in terms of nitrogen. Similarly, growing of green manure crops in rice fields besides providing much needed organic matter builds up nitrogen fertility of soil.

Addition of 20-25 kg mahua and neem cakes as manure besides providing nutrients, add organic matter and act as pesticide. Karanj cake, though applied with a view of serving as pesticide, adds organic matter and nutrients to the soil. Mixing of mahua, neem and karanj cakes with urea might be helpful in enhancing the nitrogen use efficiency as well as in warding off insect, pest and diseases.

Practice of burying weeds and wild rice into the soil recycles the nutrients taken up by them back to the soil. Ploughing of fields immediately after paddy harvest and intermittantly thereafter until sowing of paddy in the next kharif season facilitates decomposition of crop stubbles and weeds recycling the nutrients besides helping in rain water storage preventing nutrient loss along with flowing water.

Agro forestry practice of growing scattered babul trees inside rice fields increases the soil organic matter and available nitrogen (Vishwanath *et al.* 1998). Addition of babul tree pods to the rice fields, usually done with a view to serve as pesticide, is bound to add nutrients to the soil.

SCOPE OF BLENDING INDIGENOUS TECHNOLOGY WITH SCIENTIFIC TECHNIQUES FOR ITS UPGRADING AND GREATER EFFECTIVENESS

With little refinements and blending with the modem scientific techniques, all the indigenous techniques followed by fanners could be made more effective and adoptable. For example, to get over the problem of application of partially decomposed cowdung as FYM, farmers could be trained on scientific method of FYM preparation. Also in view of large number of cattle in every household they may be encouraged for installation of‘Gobar-gas’(bio-gas) plants for which subsidy is already available. Such plants besides providing high quality manure as slurry will help them in meeting domestic energy requirements and thus save time on collecting fuel from forest.

Currently farmers use green manuring only in those fields where rice is raised through transplanting. The use of green manure could be extended to those fields where broadcast method is used. There are three ways to do it. First, the green manure crop like dhaincha/sunhemp should be grown in fields where facilities for water are available.

Later the material could be used in rice fields at the time of “biasi” operation. Second, farmers who go for dry rice seeding (generally done long before the onset of monsoon), may be advisedto go for dry seeding of green manure crop along with rice. This green manure crop could then be buried in soil at the time of “biasi” and whatever plants are left could be buried during weeding operation which follows “biasi”. Third, dry seeding of rice is usually done in the last week of June whereas the pre-monsoon rains normally begin around May 15 but at times around 7"’ or 8'1' May about 66 to more than 100 mm rainfall occur for the month of May. On the other hand, onset or monsoon begins somewhere between 10^{th} — 15^{lh} June. It is therefore, suggested that early decomposable green manure crop like sunhemp could be sown at the time of first pre-monsoon rains and ploughed back into the soil followed immediately by seeding of rice just before the onset of monsoon. Such a practice of green manuring may not add much nitrogen to the soil but will definitely add much needed organic matter for improvement of soil physical properties.

Practice of mixed cropping with greengram or blackgram with rice and of pigeon pea with sugarcane (Plate 3 and 4) could be advised to be replaced with intercropping. In sugarcane/pigeonpea association, sugarcane is planted in the flat basins. Ridges are made around basins to retain irrigation/rain water in basins and pigeonpea is planted on these ridges at the same time when sugarcane is planted. The rows of intercrop and main crop may be alternated in subsequent years. This will help in building up of soil fertility in the entire field and improve soil physical properties besides saving time on harvesting of intercrops.

Weeds and wild rice *(karga)* instead of burying in the field, could be used for preparation of NADEP structure from locally available materials beside rice fields. This will give farmers a quality compost which is well decomposed and without any loss of nutrients. Of course this compost could not be applied on the same crop from which weeds and wild rice have been removed but will be available for subsequent crop.

Four-pit system for continuous production of bio-vermicompost has been developed by an NGO in Maharashtra as a replacement of NADEP of compost method, which requires huge quantity of material at a time.

It is observed that a small farmer owning 2 cattle heads (a pair of bullock) generally collects 18-20 kg of cowdung and other farm wastes daily, therefore he collects approximately 300 kg organic waste/month. Four-pit system is designed for efficient utilisation of this waste generated daily, which if properly and continuously maintained can result in to 3-4 t ofcompost in a year.

Plante 3 and *4 : Intercropping pigeon pea with sugarcane*

Construction of 4-pit system is described here:

A big pit of the size approx. 12'12'x2.5'(Ixbxd) is made and divided into 4 equal parts by 9" brick wall construction. The partition walls contained small vents at alternate layers of bricks making honey comb structure. These vents are made to facilitate aeration and easy migration of earthworms from pit-1 to pit-4 one after another. The four walls of pits are also lined with bricks to prevent the mud walls from falling. After partition the dimensions of each pit is approximately 5'x5'x2.5' and 400-500 kg of biomass or cowdung can be collected in each of this pit in one month. Approximate cost of construction of 4-pit system is Rs 2000/-. If these 4 pits are made above ground in the form of 4 tanks, the construction cost may increase to approx. Rs 3000/-. Details of filling of 4 pit system is given below :

Period	Pit	Process
0-30 days	Pit - 1	Collection of biomass/cowdung
30-60 days	Pit - 1	Soaking of biomass with water in cowdung slurry and covering it with black polythene sheet
	Pit-2	Collection of biomass
60-90 days	Pit - 1	Inoculation of earthworms
	Pit-2	Biodung preparation
	Pit-3	Biomass collection
90-1 20 days	Pit - 1	Vermicompost ready and migration of earthworms into pit-2
	Pit -2	Vermicomposting
	Pit -3	Biodung preparation
	Pit-4	Collection of biomass
120-150 days	Pit - 1	Harvesting of compost and collection of biomass
	Pit-2	Vermicompost preparation and migration of earthworms into pit-3
	Pit-3	Vermicomposting
	Pit-4	Biodung preparation

In this way after 120 days compost can be harvested from Pit-1 and at 150 day compost can be harvested from Pit-2. Initially, vermicompost is prepared in 4 months from Pit-1 then after every month compost can be harvested from Pit-2, Pit-3, Pit-4 and Pit-1, respectively. In this way if this cycle is maintained continuously throughout the year approximately 3 to 3.5 tonnes of compost is prepared in a month from daily collected waste through 4 pit system.

Indigenous methods may be developed and farmers should be trained for coating of urea with locally available neem/mahua/karanj cakes which at present are only physically mixed with urea. Coating of urea by coaltar may also be advised. These practices will help in increasing N - use efficiency in rice fields.

In order to alleviate the problems of non availability of BGA for use in rice fields, farmers may be trained to prepare BGA in their own fields especially 'badis'.

Pods of babul tree may be powdered and mixed with some filler material for uniform application and greater effectiveness.

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CHAPTER 16

INDIGENOUS NUTRIENT MANAGEMENT TECHNOLOGIES FOLLOWED IN ORISSA

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ABSTRACT

The state of Orissa is rich in traditions and is one ofthe most important rice producing states in the country. Besides rice, several other food crops viz. maize, ragi, millets, pulses, oilseeds, fibre crops, plantation crops like coconut etc. are produced in the state. The state has diversified agro-climatic regions like coastal plain areas, plateau regions and hilly areas. Majority of the farmers are resource poor and operate on small production systems. The diverse cultural groups of people possess traditional skills in crop cultivation and still follow these practices in different pockets in the state. These indigenous technologies are time-tested, eco-friendly and are consistent with the farmers ' situations. The focus of this paper is to discuss various indigenous nutrient management technologies followed by the farmers related to different crops with special emphasis on rice. The technologies include use of organic manures, utilization of locally available plant materials for composting, recycling of organic wastes/excreta, green manuring, use of tank silt as soil amendment, use of salty soil for coconut plants etc. The researchers at the experimental station have the opportunity to utilize and blend this knowledge and the rich traditional wisdom of the farmers in formulating their research agenda with a view to improve the farm productivity on a sustained basis.

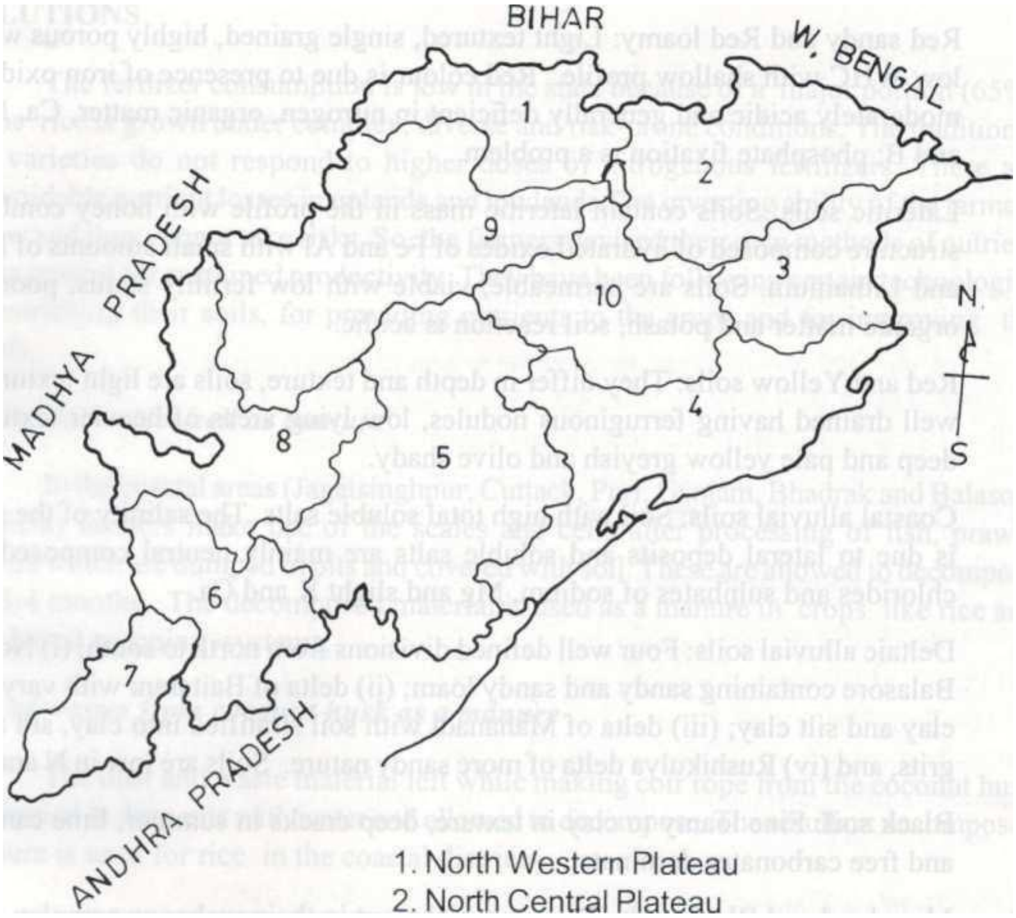
The state of Orissa located in eastern India has a gross cultivated area of 9.32 million hectares. Rice is the predominant food crop grown in an area of 4.5 million ha. The area under total cereals accounts for 79% of the gross area and that under food crops is about 90%. The other important crops include maize, ragi, millets, pulses, oilseeds, sugarcane, fibre crops, plantation crops like coconut etc., turmeric and horticultural crops.

The state has diversified agro-climatic conditions which include coastal plains, plateau regions, hilly areas etc. Socially disadvantaged groups such as scheduled tribes and scheduled castes comprise significant percentage of the population. These diverse cultural groups of people in the state possess traditional skills and wisdom in crop and animal husbandry. They use the locally available plant materials, approproate practices of organic recycling and they are conscious of environmental protection and soil fertility improvement. It would be appropriate to learn, understand the traditional wisdom of the farmers and blend the same with modem technologies to improve them for increasing the crop /farm production on a sustained basis.

In this paper an attempt has been made to compile indigenous nutrient management technologies for different crops with a special focus on rice in the state of Orissa.

BACKGROUND

The state has 10 agroclimatic zones (Fig.l). Rice is the predominant crop covering 69% of the area and is grown in all the districts. The crop is grown under rainfed (64%) and irrigated (36%) ecosystems. The. rainfed ecosystems comprise uplands and lowlands of different hydrologies. Generally rice is monocropped in uplands and lowlands and in limited areas pulses are grown on residual moisture after rice. In the irrigated ecosystem of 2263080 ha area however, farmers have several options of growing other crops like vegetables, pulses and oilseed after rice. The average cropping intensity of the state is about 138% (1996-97).



3. North Easten Coastal Plain
4. East and South Eastern Coastal Plains
5. North Eastern Ghat
6. Eastern Ghat Highland
7. South Eastern Ghat
8. Western Undulating
9. West Central Table Land
10. Mid Central Table Land

Fig. 1 Agro-climatic zones of Orissa

In the state of Orissa, there are 8 soil groups :

(a) Red sandy and Red loamy: Light textured, single grained, highly porous with low WHC with shallow profile. Red colour is due to presence of iron oxides, moderately acidic and generally deficient in nitrogen, organic matter, Ca, Mo and B; phosphate fixation is a problem.

(b) Lateritic soils: Soils contain lateritic mass in the profile with honey combed structure composed of hydrated oxides of Fe and A1 with small amounts of Mn and Lithanium. Soils are permeable, viable with low fertility status, poor in organic matter and potash, soil reaction is acidic.

(c) Red and Yellow soils: They differ in depth and texture, soils are light textured, well drained having ferruginous nodules, low lying areas of heavier texture, deep and pale yellow greyish and olive shady.

(d) Coastal alluvial soils: Soil with high total soluble salts. The salinity of the soil is due to lateral deposits and soluble salts are mainly neutral composed of chlorides and sulphates of sodium, Mg and slight K and Ca.

(e) Deltaic alluvial soils: Four well defined divisions from north to south; (i) North Balasore containing sandy and sandy loam; (ii) delta of Baitarani with varying clay and silt clay; (iii) delta of Mahanadi with soil stratified into clay, silt and grits, and (iv) Rushikulya delta of more sandy nature. Soils are low in N and P.

(f) Black soil: Fine loamy to clay in texture, deep cracks in summer, lime cankar and free carbonates dominate.

(g) Mixed red and Black soils : Due to enrichment in their exchange complex and fine textured colluvium and alluvium are predominantly red on upland ridges, whereas black soils on lower topography.

(h) Brown forest soils : Reddish brown to yellow grey brown soils associated with forest vegetation; usually fertile and slightly acidic in reaction.

The investment ability of the farmer is low and they are resource poor. Socially disadvantaged farmers-schedule castes and schedule tribes are in significant numbers in the state.The land holdings are fragmented and are 0.5-2 acres in size.

The fertilizer consumption (kg N, $P_{2}O_{5}$ and $K_{2}O$/ha per gross cropped area) in the state is low, 26 in 1997-98 and 42 in 1998-99 as against all India average of 76 and 90, respectively. The state has livestocks population of 2,23,21,705 (1991 census) where as 1,24,41,871 is the poultry population.

EXISTING PROBLEMS OF NUTRIENT MANAGEMENT AND INDIGENOUS SOLUTIONS

The fertlizer consumption is low in the state because of a major portion (65%) of the rice is grown under complex, diverse and risk-prone conditions. The traditional tall varieties do not respond to higher doses of nitrogenous fertilizers. There are unavoidable nutrient losses in uplands and lowlands.The investing ability of the farmers is low and they cannot take risks. So, the farmers devised their own methods of nutrient management for sustained productivity. They have been following certain technologies , for enriching their soils, for providing nutrients to the crops and for improving the yields.

Use of fish scales/cell as manure

In the coastal areas (Jagatsinghpur, Cuttack, Puri, Ganjam, Bhadrak and Balasore districts) farmers make use of the scales and cells after processing of fish, prawn, oesters which are dumped in pits and covered with soil. These are allowed to decompose for 3-4 months. The decomposed material is used as a manure in crops like rice and rice-based cropping systems.

Use of wastes from coconut husk as a manure

The dust and waste material left while making coir rope from the coconut husk is dumped in deep pits with water and allowed to decompose. The resultant decomposed manure is used for rice in the coastal districts.

Manure making with Jliauit (Casuarina equisitefolia) leaves

The leaves of these plants are kept in big piles near the sea coast and decomposed.
It is used as manure for rice in Konark and Puri districts, Chandipur and Cheechakali of Balasore and Chatrapur of Ganjam district.

Green leaf manuring with weed chakunda (Cassia tora)

This weed is available in plenty during the rainy season in the waste places, canal bunds and road sides. This is a legume plant with fast vegetative growth. These weeds are collected by the resource poor farmers and incorporated by working with country plough in the paddy fields at the time of puddling. The decomposition of the weeds is fast. Farmers perception is that by adding a biomass of 2.5 t/ha of this weed, , an increase in grain yield of 8-15 q/ha over no application can be obtained. This activity is prevalent in Cuttack district (Ayatpur village).

Use of Ipomoea cornea, a waste land weed as manure

Ipomoea carnea grows abundantly on the Cuttack-Calcutta road (National highway No.5) and several other places during rainy season. Farmers of Bhadrak, Balsore and Cuttack districts collect the twigs and young leaves of this weed and directly apply it in the lowland rice field at puddling (5 days before transplanting seedlings). Fanners informed that a quantity of 2-2.5 t/ha is applied. This practice is very useful in rainfed lowland rice system where runoff problem is high.

Use of water hyacinth for compost making

The weed water hyacinth grows abundantly in irrigation/drainage channels, ponds and other water bodies.This weed has been a nuisance as it obstructs water flow in the channels. The farmers collect it and dump it with upside down in heaps or some times in pits and cover the pits with tank silt. After 2-3 months, this becomes a compost, which is used for winter rice (boro rice) in coastal districts (Cuttack and Bhadrak). ***Use of forest leaves as manure***

In tribal areas of Phulbani district, the fanners collect green leaves of different wild forest plants and incorporate them in lowland rice fields at the time of puddling @ 10-15 cartloads (5-7.5 tonnes) of green leaves. This practice works very well in those situations where rain water causes runoff from bench terraced lands. Such practice produces a rice grain yield of 3-3.5 t/ha of the local varieties and 4.5-5.0 t/ha of the modem varieties.

Use offarm yard manure by the tribal farmers

In Phulbani and Kalahandi districts, the tribal farm families (women mostly) regularly collect cowdung from the cattle grazing ground . They prepare pits near their residences and dump the dung in them. They take out the entire manure from the compost pit once in a year in the summer (April-May) and apply it in rice and other crops. This practice is very common in several parts of Orissa.

Use of wood ash as a manure

In coastal districts each farm family collects the ash after burning wood in *chula* and it is stored in a place near the house. This ash which is a source of potassium is used in crops like colocassia, ginger, pumpkin etc. Besides, in the hilly areas, the tribal farmers bum some forest area and cultivate crops. This system is known as shifting cultivation or *podu* cultivation. The resultant ash is used as a manure for rice and other crops.

Manure from night soil

In coastal Orissa many of the village families have quite a large homestead area. They used to dig a pit at one comer of the area and use it as an open toilet for passing stools and urine etc. and cover the same with soil. Later they plant trees on those pits as trees grow there well because of better nutrition .

Utilization of nutrient containing tank yvater for irrigation/pisciculture

In many villages of coastal Orissa, ponds/tanks exist near the cultivated lands. During earlier years, as a custom people were using bunds of these ponds as open toilets. During rainy season, the excreta etc. on the bunds pass into the tanks alongwith water and mix with the water in the tank/pond.The water in the ponds/tanks is thus much enriched with nutrients which is used for fish culture and irrigation of the crops. ***Sheep/goat gathering in the fields (penning)***

In villages there is a system where a herd of sheep/goats are gathered in a field for 2-3 days. The droppings of goats/sheep fall in the fields and enrich the soil. A specified fee is collected from the farmers for this purpose by the owners of goats/ sheep. This is a common practice in coastal Orissa.

Green manuring with Dhaincha (Sesbania aculeata)

This is a common practice in all the irrigated areas of the state during kharif season. The seeds of dhaincha *(Sesbania aculeata)* are sown by the end of June. Around 40-45 days after germination of the plants farmers ladder them and plough down. The plants are then decomposed for a week or so and then transplanting of rice is taken up. This practice helps in better growth of the rice crop and results in higher yields. The seed of dhaincha is produced by some enterprenuring farmers by raising the plants on field bunds, waste places and within the rice field itself. However, in rainfed direct- seeded lowland rice areas, this practice is adopted to a limited extent in the district of Balasore. Dhaincha seed is mixed and sown with rice and after 40-45 days, thd plants are incorporated at the time of *beushening.* This helps in better growth of rice crop.

Fall of jute leaves in jute-rice system

In Kendrapada, district of Orissa, jute-rice system is adopted to a considerable extent. The farmers sow jute crop by April-May and harvest it by mid-August. The leaves ofjute crop fall in the fields during crop growth. Besides, they heap jute bundles in the same fields for a few days before retting them. In that process also many jute leaves fall in the field. The jute leaves that fallin the field are redistributed evenly and subsequent puddling and transplanting of rice are undertaken. During this process the transplanted rice is benefitted by the organic matter addition through the jute leaves.

Burning of rice ratoons

The lowland rice ratoons and the straw are burnt and the ash is distributed throughout the fields to supply mineral nutrients like potash. This also helps in destroying the larvae of insect pests. This practice is very prevalent in ***patta*** areas of Balasore, Cuttack and Puri districts.

Use of animal bones as a manure

In the rural areas, a specific place is earmarked for burying the dead animals like cows etc. A specific community called ***'Hadi'*** collect bones from those places and put the same in pits and cover it with soil. After 3-5 years, the bones are mineralised. Farmers collect the manure from that community people in exchange for paddy grain and use it.

Use of soil amendments-tank silt

The tank soil having finer soil particles and rich in nutrients is removed and collected during the summer season and applied in the paddy fields. Farmers believe that this method enriches the soil by increasing the nutrient status and water holding capacity.

Use of neem cake as a manure

In some of the tribal areas of Sambalpur district, the farmers collect ri^e neem fruits.The oil is extracted from the fruits for their use.The left over cake is applied in their paddy fields@500-1000 kg/ha. Farmers believe that this helps not only in providing nutrition but also controlling pests.The tribal farmers collect ripe fruits of mahua and extract oil from it for their culinary purposes. The left over mahua cake is used as an excellent manure and is applied @1.0 t/ha.

Use of calcium stone and lime stone (refined form)

The calcium stones (Gangoti-crude form) are collected from the eroded soils and are processed in small fumances. They are used as soil amendment after making it powder. The materials are used in many districts.The lime stone mostly available in Keonjhar and Mayurbhanj districts is used in lateritic red soils as a soil amendment and as a source for supplying phosphorous/calcium.

Use of gorugothama

Each village has a specified place called *gorugothama* (soil of cow gathering place) where the cows gather during morning and noon time. The dung and urine of the cows are mixed in the soil. This soil is collected and is used as a manure in vegetable fields. This practice is prevalent in coastal areas.

Incorporation of weeds in lowland rice fields

The weeds that grow in the rice field are uprooted and incorporated in the same field at the time of puddling. Similarly after transplanting, the weeds are also collected and incorporated into the fields in lowland rice without throwing them out.This practice is followed everywhere in the state. Farmers strongly believe that such a process helps in adding some nutrients to the soil.

PRESENT RELEVANCE OF INDIGENOUS NUTRIENT MANAGEMENT TECHNOLOGY ADOPTED BY THE FARMERS

The various indigenous nutrient management technologies adopted by the farmers are very much relevant in the present day context of dwindling factor productivities and nutrient use efficiencies, depletion of organic matter in the intensively cultivated multi-crop systems and continued degradation of land by its irrational use. The indigenous technology basically aims at adding organic matter to the soil, utilization of the locally available materials and rational use of natural resources. These are also environment-friendly. These indigenous technologies are the products of centuries of trial and error, natural selection and keen observation that can form a knowledge base on which researchers and extension workers can plan their research strategy (Chittiraichelvan and Raman 1993). As these technologies are evolved over a period of hundreds of year through experience under harsh environments, they are highly sustainable.

THE SCIENTIFIC BASIS AND SCOPE FOR BLENDING THE INDIGENOUS TECHNOLOGY WITH LATEST SCIENTIFIC TECHNIQUES FOR UPGRADATION OF TECHNOLOGY

The scientific basis for the indigenous technologies can be understood by critical observation and systematic testing. Infact, with the blending and integration of these indigenous technical knowledge with scientists technical knowledge, the problem get restated and scientific solutions are found (Chittiraichelvan and Raman 1993). It should rather be viewed not as a store of knowledge to be mined by the scientists, as an evidence (Farrington and Martin 1988). Development is more likely to be sustained if researchers can strenghten this indigenous technology by demonstrating its application to the problems they are researching (Bell 1979). An understanding of the local environment and the present level of technology adoption in a given area is a pre-requisite for determining what is to be transfered and acertaining whether it will overcome the main shortcomings of the prevailing technology and will satisfy the few and the identified needs of the community (Mohsin 1981)

With this philosophy certain research efforts were made at the Central Rice Research institute, Cuttack to refine and upgrade the indigenous nutrient management technologies by blending them with modern techniques to devise an appropriate integrated nutrient management package for rice. These are discribed as below :

Evaluation of green leaf manuring with Ipomoea earned alone and in combination with ammonium sulphate in transplanted lowland rice

Field experiments were conducted for six seasons on a clay loam soil of moderate fertility to assess the performance of green leaf manuring with *Ipomoea carnea* in the rice crop. Incorporation of green portions (leaves, tender twigs and bark) 3-5 days before puddling at 5 to 10 t/ha was helpful in improving the growth and yield office. Incorporation of these green portions of this plant alone or incombination with inorganic fertilizer (ammonium sulphate) resulted in increased grain yield (Table 1). Continuous application of green manure crop for six seasons in the same field left some residual fertility which resulted in increased grain yield of subsequent rice crop whereas ammonium sulphate alone did not.

Table 1 Yield of rice as influenced by *Ipomoea cornea*

Treatments	Yield(q/ha)	
	Grain	**Straw**
	***Rabi* 1975 (cv. Ratna)**	
Control(No nitrogen)	42.5	53.3
A. S. @40	48.6	56.5
IC@ 25(10 t/ha)	59.7	71.0
IC @ 12.5(15 t/ha)+ A.S.@20	59.5	62.7
CD (P = 0.05)	4.2	13.0
	Kharif	**(cv. Vani)**
Control(No nitrogen)	31.9	32.9
A.S. @40	40.8	37.3
IC @ 20(8 t/ha)	36.1	42.1
IC@ 10(4 t/ha)+ A.S.@20	35.9	36.8
CD (P = 0.05)	4.0	NS
	***Rabi* 1976 (cv. Supriya)**	
Control(No nitrogen)	30.6	32.0
A.S.@25	35.9	38.3
IC @ 12.5(5 t/ha)	49.3	52.3
IC @ 6.25(2.5 t/ha)+ A.S.@12.50	47.7	49.3
CD (P = 0.05)	4.2	7.3
	***Kharif* 1976 (cv. Vani)**	
Control(No nitrogen)	31.6	28.7
A.S.@40	36.7	33.8
IC@ 25(10 t/ha)	39.1	36.2
IC@ 12.5(15 t/ha)+ A.S.@20	36.2	30.9
CD (P = 0.05)	2.5	NS
	***Rabi* 1976 (cv. Kalinga-2)**	
Control(No nitrogen)	22.1	14.6
A.S.@25	30.9	21.7
IC@ 12.5(5 t/ha)	32.6	23.0
IC @ 6.25(2.5 t/ha)+ A.S.@12.5	33.9	24.4
CD (P = 0.05)	5.4	3.6

A.S.=Ammonium Sulphate, I C =*Ipomoea carnea* (kg N/ha) Source: (Jha *et al*. 1980)

The superior performance of *\pomoea carnea* was due to the latex of this plant containing a number of chemical compounds such as polysachharides (ipontose), glucoside, gums and alkaloids (saponins and jalpains) and growth hormones which stimulate growth of rice crop.

Use of cattleshed washings as a nutrient supplier in rice

Field and pot experiments were conducted to assess the utility of cattleshed washing as a nutrient supplier for rice. The cattleshed washing (consisting of a mixture of urine, residual dung and wash water and having N, K and hormones) has been found to be a valuable animal waste. The best time for its application was found to be during puddling. The practice not only increased the yield of rice but also resulted in less cost on weeding. Yields obtained by the application of cattleshed washing were comparable to that of inorganic fertilizer (Table 2).

Table 2 Influence of different dilutions of cattleshed washing on the yield of rice (cv. Supriya)

Treatments	**Grain yield(g/m^2)**
T, = Control(Plain water only)	247
T, = T, + P,O_5 @ 60 kg/ha	248
T_3= Undiluted washing	525
T_4= T_3 + P_2O_5@60 kg/ha	500
T_s =Diluted washing(l:l)	443
T = T_s+ P_2O_5@ 60 kg/ha	493
T_7=Diluted washing(I:3)	363
T = $T_?$ + P_2O_5@ 60 kg/ha	357
T_9=Diluted washing(l :4)	397
$T_{|0}$=T_9 + P_2O_5@ 60 kg/ha	432
T,^Diluted washing(l:5)	402
CD (P = 0.05)	113.3

Source: (Jhae/a/. 1978)

Conjunctive use of organic and inorganic sources of nutrients for sustained production in rice

A study was conducted for 5 years on transplanted rice during wet season to find out relative efficiency of conjunctive use of organic sources (water hyacinth compost, Azolla compost, FYM, green manuring with *Sesbania aculeata* and S. *rostrata)* and chemical fertilizer urea in 50:50 proportion with a total N level of 75 kg/ha. The results showed that the organic : inorganic combination produced comparable yields as that of conventional 3-split application of prilled urea (at the same N rate, 75 kg/ha) for the first four years. During the fifth year, grain yield was significantly lower in 3- way split of prilled urea compared to organic and inorganic combination (Table 3).

Table 3 Influence of different integrated nutrient management treatments on grain yield of rice

Treatments[3]	Grain Yield(t/ha)				
	1988	**1989**	**1990**	**1991**	1992
Control(no N)	4.1	4.0 (2.4)[b]	3.8 (8.5)	3.8 (7.3)	3.3 (19.2)
FYM+PU(5O:5O)	6.2	5.7 (8-3)	5.4 (12.8)	5.7 (7.0)	5.3 (13.3)
Azolla compost + PU(50:50)	6.2	5.6 (10.6)	5.4 (13.8)	5.9 (5.5)	5.2 (15.9)
Water hyacinth compost + PU(50:50)	6.3	5.3 (0.9)	5.4 (13.4)	5.7 (9.4)	5.3 (14.6)
Sesbania aculeata + PU(5O:5O)	6.4	5.6 (H.9)	5.4 (15-5)	5.6 (11-5)	5.2 (17.7)
Sesbania rostrata+ PU(5O:5O)	6.3	5.7 (10.4)	5.4 (14.6)	5.9 (7-3)	5.2 (17.1)
Conventional 3 split application of PU	6.3	5.4 (10.4)	5.4 (15.3)	5.5 (13.8)	4.7 (25.8)
USG at 7 DT	6.2	5.5 (12.0)	5.3 (15.3)	5.8 (7.7)	5.2 (17.0)
CD (P=0.05)	0.3	0.5	0.3	0.5	0.4

*N application treatments=75 kg N/ha, [b]Figures in the parentheses indicate yield decline from the first year, PU = Prilled Urea, USG = Urea Super Granule Source: (Rao and Moorthy 1994)

These studies clearly indicate that there is a scope to improve the indigenous nutrient management technology to offer better options for farmers in achieving the goal of sustained high food production.

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IV

HUMID AND PER-HUMID ECOSYSTEM

Indigenous nutrient management practices - wisdom alive in India

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CHAPTER 17

INDIGENOUS METHODS OF NUTRIENT MANAGEMENT IN NORTH-EASTERN HILL REGION

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ABSTRACT

Though, the North Eastern Region of India is endowed with rich natural resources, the faulty agricultural practices followed in the region have caused their fast depletion. Shifting cultivation has resulted in large scale land and environmental degradation in the region. However, there exists some unique, eco-friendly and reasonably productive indigenous farming systems which have remained sustainable for centuries. These farming systems have in-built soil fertility management and soil and water conservation components. In Zabo system, followed in Phek district of Nagaland, the irrigation water from the main water collection tank is passed through animal-yard and it carries all dung and urine of the animals to the field below the slope. Besides, farmers add succulent branches and leaves of trees in the field for enhancing soil fertility. Alder- (Alnus nepalensis) land use system is followed in Kohima district of Nagaland. More than 200 years old trees of alder, a non- leguminous atmospheric Nfixing tree, can be seen in the area. The branches of the trees called, coppices, are spread in the field and left for decomposition or burnt. The Apatanifarmers of Arunachal Pradesh make use of farm and house hold wastes, tree leaves and forest litter for maintaining soil fertility. The rain water from hills, usedfor irrigation, also brings forest humus to the valley and lower slopes. The 'Wet Rice cultivation ' or Panikheti farming system make use of tree leaves, cattle dung, pig and poultry droppings and farm wastes for improving soil fertility. Nutrient management in narrow valleys entirely depends on humus from the adjoining hills and semi-decomposed forest litter. The soil in the narrow valleys is generally brownish-black in colour due to high content of humus. The tribal farmers are well aware of maintenance of good soil health for higher productivity and have demonstrated their ingenuity and skill through these highly sustainable indigenous farming systems.

The mode of life of the people in any region is the result of the environment they live in, that shapes and determines the habitats and progress of civilization. The Homo sapiens had been under the awe of natural objects like oceans, rivers, forests etc. from the pre-historic age. Schilippe (1956) commented that agriculture is that sector of human activity in which there is greatest interaction between the environment and culture that has grown in and from it. The environment, local conditions and values are invariably connected with agricultural practices that are evolved in an area. With increase in the demographic pressure and growing needs of the population, the people in certain areas developed some excellent farming systems which helped in soil, water and vegetation conservation as well as maintenance of soil health. The social sanctions and belief systems maintained a balance between resource potential and their utilization without any depletion. Man's ability in exploiting the resources mainly depend on their knowledge, intelligence, awareness of living conditions, ingenuity and circumstances.

The North Eastern Region comprises seven states viz. Arunachal Pradesh, Sikkim, Manipur, Meghalaya, Mizoram, Nagaland and Tripura. It falls under six agro- climatic zones (Fig. 1) which lie between 20°81' and 29°30' North latitudes and 89°40' and 97°50' East longitudes. Sikkim is included because of having same physio- climatological condiitons but Assam is excluded because of predominance of plain land. The region is unique in biodiversity and has abundant natural resources of soil, water and vegetation. Though having a geographical area of 225, 090 sq. km, only 37150 sq. km is under cultivation. Most of the prevailing food production systems are hazardous to the natural resources (Sharma 1997). Shifting cultivation is the common mode of farming on hill slopes with an annual area of 3869 sq. km under the practice. It has caused large scale land and environmental degradation resulting in soil erosion in the hills and silting of river beds and floods in the plains. Inspite of its vast natural resources, the region has remained backward and deficient in food production. The shifting cultivation alone results in an annual loss of 88.3 million tonnes of soil and 10.67, 0.37 and 6.05 thousand tonnes of N, P_2O_5 and K_2O, respectively (Sharma and Prasad 1995), The productivity of various crops is poor. Never-the-less, there are some unique indigenous farming systems, in isolated pockets, which are productive and eco-friendly as well as conserve natural resources and have in-built soil fertility maintenance base. No chemical fertilizers are used for raising crops and yet these farming systems give two to three folds higher yield than shifting cultivation. The disasters brought about by the faulty agricultural practices, which have taken no account of the treasure of wisdom hidden in the potential and sustainable indigenous farming systems of the region, is sufficient proof for the latter's value. These indigenous farming systems needs to be studied in depth, improved and popularized under iso-agroclimatic conditions.

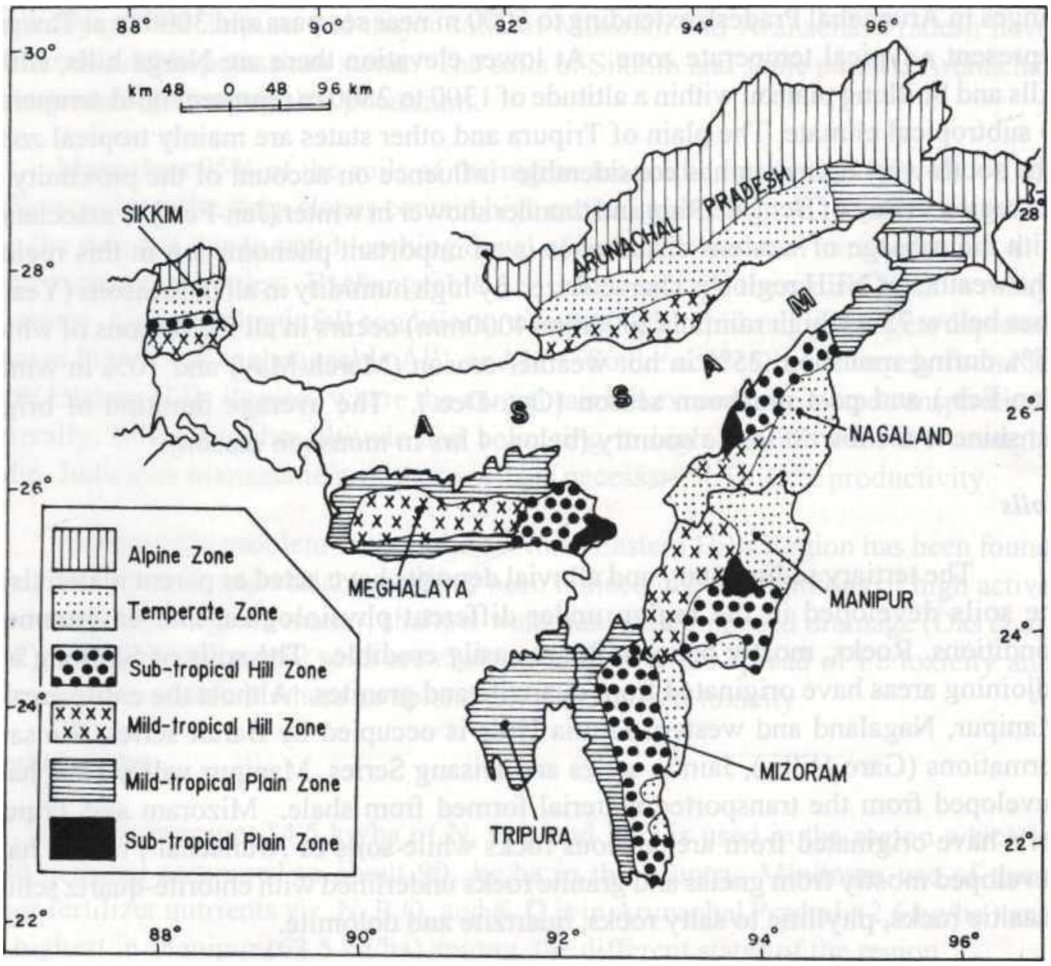

Fig. 1 Agro-climatic zones of NEH region

BACKGROUND

Climatological characteristics

The wide altitudinal differences along with varied topography contribute to a great climatic variation (Temperate-Tropical) in the entire region. The Himalayan ranges in Arunachal Pradesh extending to 5000 m near sea pass and 3000 m at Tawang represent a typical temperate zone. At lower elevation there are Norga hills, Mikir hills and Shillong plateau within a altitude of 1300 to 2500 m represent mild-temperate to subtropical climate. The plain of Tripura and other states are mainly tropical zone. The south-west monsoon has considerable influence on account of the proximity of the region to Bay of Bengal. Rain and thunder shower in winter (Jan-Feb.) in association with the passage of western disturbance is an important phenomenon in this region. The weather of NEH region is characterized by high humidity in all the seasons (Yearly goes below 75%), high rainfall (2000mm-4000mm) occurs in all the seasons of which 65% during monsoon, 25% in hot weather season (March-May) and 10% in winter (Jan-Feb.) and post monsoon season (Oct.-Dec.). The average duration of bright sunshine is the lowest in the country (below 4 hrs in monsoon season).

Soils

The tertiary sedimentary and alluvial deposits have acted as parent materials of the soils developed in the region under different physiological and environment conditions. Rocks, mostly being soft, are easily erodible. The soils of Shillong and adjoining areas have originated from quartzite and granites. Almost the entire area of Manipur, Nagaland and western Jaintia Hills is occupied by Barail series, Simsang formations (Garo Hills,), Jaintia series and Disang Series. Manipur valley soils have developed from the transported material formed from shale. Mizoram and Tripura soils have originated from arenancious rocks while soils of Arunachal Pradesh have developed mostly from gneiss and granite rocks underlined with chlorite-quartz schist, basaltic rocks, phyllitic to salty rocks, quartzite and dolomite.

In upper parts of the hills and steep slopes, the soil depth varies from shallow to very shallow, however, in valleys and lower hills, the soil depth is deep to very deep. The surface soils are in general lighter in texture and are mostly loam or clay loam or sandy loam. The soils are heavier down the profile. The soils of the region, by and large, belong to the orders; Alfisols, Inceptisols, Ultisols, and Entisols.

The entire soils of Meghalaya (excepting Pynursla and Mawkyrwat), practically all soils of Tripura; Manipur; Arunachal Pradesh, over 50% of the soils of Nagaland and Sikkim and 40% of the soils of Mizoram are low in available phosphorus (Prasad ***et al.*** 1981). The organic carbon content in the soils of the region (except Tripura) is fairly high (0.72 - 4.6%) due to thick vegetation, high rainfall and low decomposition rate prevalent in this region. Illite and kaolinite are dominant in clay in this region. The soils of south and north districts of Tripura, Subansiri district of Arunachal Pradesh and Tuensang district of Nagaland are low in available potassium. The soils of Manipur, Meghalaya, West Tripura and major soils of Mizoram and Arunachal Pradesh have medium available potassium status. The soils of Sikkim and some parts of Arunachal Pradesh are high in available potassium.

More than 95% of the soils of the region are acidic in reaction (pH 4.6 - 6.0). Shallow soils on the steep slopes contain high exchangeable AP^{+} in the surface as well as in the sub-soil due to rapid leaching down of bases and residual enrichment of AP' in the exchange complex. Exchangeable AP^{+} often exceeds the critical limit in many soil series. Under high rainfall conditions, weathering is rapid and solum gets depleted of bases but rich in exchangeable Al$^{3'}$ and H . So the acid soils are largely found in North Eastern Hills Region, where the annual rainfall exceeds the evapotranspiration. Generally, soils of higher altitude and belonging to high rainfall areas are strongly acidic. Judicious management of these soils is necessary for higher productivity.

Iron toxicity problem in the soils of North Eastern Hills Region has been found highly site specific and variable and has been noticed under conditions of high active Fe content, high organic matter, shallow water table and impeded drainage (Das ***et al.*** 1992). In general, valley soils are characterized by wide spread of Fe toxicity and deficient in available P where as upland terraces have Al toxicity.

Fertilizer Use

On an average, 14.5 kg/ha of N, P,0. and K.,0 is used in the region which is quite nominal compared to about 90 kg/ha in the country. Minimum use of three major fertilizer nutrients viz. N, P,O_5 and K,0 is in Arunachal Pradesh (2.6 kg/ha) and the highest in Manipur (63.5 kg/ha) among the different states of the region.

Cropping Systems

Generally, only one main season crop is grown in the region during March to October. There is free grazing by the domestic animals from December to February which discourages cultivation during winter season. However, in certain areas winter crops are grown. In this region, entire cropping system revolves around rice except Sikkim where maize is the main crop. Rice in upland ecosystem in this region is not remunerative but its cultivation is crucial to the agricultural economy of this region due to dependence of a large population for its subsistence. The common cropping systems according to the agro-climatic region are:

Agro-climatic region	**Cropping systems**
Alpine zone	Pastures
Sub-alpine zone	Rice-potato/vegetables,Rice/maize-mustard, Potato- cauliflower, Potato-pulses
Sub-tropical hills zone	Rice-wheat+mustard, Rice-potato, Pulses-mustard/groundnut, Ginger/ turmeric-pulse crop
Mild tropical hill zone	Maize-mustard,Rice-potato, Maize - potato, Rice-vegetables, Sesame - groundnut, Ginger/turmeric-pulse crop
Sub-tropical plain zone	Rice-groundnut, Rice-rice, Rice- potato-jute, Rice- mustard/pulses, Soybean-pulses
Mild tropical plain zone	Rice-rice, Rice-potato, Rice-pulses, Rice-wheat, Rice/maize-mustard, Jute-rice

Socio-economic constraints

The area under shifting cultivation in different states of the region (Anonymous 1995) and annual soil and nutrients loss (Sharma and Prasad 1995) has been given in Table 1. Shifting cultivation practices are so deep rooted and intertwined with the way of life of the tribal people that one can not possibly dissociate jhuming from the socioeconomic compulsion under which the system traditionally continues. Many tribal communities have socio-cultural ties with the land from which they do not want to be disturbed nor prepared to break away from the prevalent system. The land belongs either (i) to the community or (ii) to the village chief or (iii) individual ownership. While there is no difficulty in managing the land in third category, management of the land in the first and second category is a problem. The ownership of land by community or the village chief often acts as disincentive for proper development and maintenance of land. The size of holding is small with more than 78% of the cultivators having land below 2 ha, which is unec^y^onomical. The hilly terrain in the region does not permit easy communication and timely supply of inputs especially seed. High humidity and high rainfall in the area causes heavy infestation of crops with pests, diseases and weeds. Low light intensity and radiation also reduces the fertiliser use. Population explosion is the major factor responsible for land degradation and yet, paradoxically, no remedial measure is being undertaken. Comparison in the population increase in the NEH region, with respect to the country as a whole, given in Table 2, shows the high rise in human growth in the region. The jhum cycle was as long as 25-40 years even as late as till 1947. There was sufficient time for the land to naturally recoupits fertility and revegetation. It has in most of the places, come down to just a few year (2-15), in a dangerously low level because of increased population pressure on land. The indigenous land use systems have more effective land cover and protect the soil from erosion and degradation (Table 3).

Table 1 Area under shifting cultivation and soil and available nutrients loss

S.No.	State	Total Area ('000 ha)	Area affected ('000ha)	Annual loss of soil and nutrients			
				Soil (million tonnes)	N	PA	K_2O
					('000 tonnes)		
1.	Arunachal Pradesh	210	70.0	14.5	2.038	0.058	1.014
2.	Assam	139	69.6	12.3	0.984	0.061	0.640
3.	Manipur	360	90.0	20.4	2.675	0.082	1.532
4.	Meghalaya	265	53.1	14.2	1.896	0.042	1 .061
5.	Mizoram	189	63.0	13.1	1.695	0.065	0.978
6.	Nagaland	191	19.0	7.9	0.875	0.040	0.517
7.	Tripura	112	22.2	5.9	0.506	0.024	0.309
8.	NEH Region	1466	386.9	88.3	10.669	0.372	6.051

Table 2 Percent increase in population in NEH Region (1951 taken 100 as base)

Year	NEH Region	India	Developed Countries
1951	100	100	100
1961	138	121	111
1971	186	152	127
1981	236	189	138
1991	300	234	148
2001 (expected)	383	290	162

Table 3 Effective land cover under different farming systems (%)

Farming system	Forest (open, dense and scrubs)	Grazing lands	Trees & groves	Cropped area	Total
Zabo	46.5	2.90	2.20	5.40	57,00
Apatani	41.4	1.09	1.70	9.00	54.00
Agri .with Alder	33.6	3.80	3.40	9.60	50.04
Panikheti	26.0	1.40	2.30	4.30	44.00
Narrow Valley Cultivation	39.1	2.60	3.70	5.90	51.30
Shifting Cultivation	19.8	3.40	2.20	5.00	30.40

INDIGENOUS NUTRIENTS MANAGEMENT SYSTEMS

Some of the profitable farming systems continued in this region are discussed below:

Zaho farming system

In the local dilect 'zabo' means impounding of water. The system is a combination of agriculture, forestry, livestock, fishery and soil and water conservation and it is practised by the Chakhesang tribe in the Phek district of Nagaland (Sonowal *et al.* 1989, Shanna and Sonowal 1990). The Zabo system comprises protected forest land on the top of the hill, well planned rain-water harvesting tank in the middle and cattle yard and terraced rice fields towards foothills. The place of origin of Zabo is thought to be the *Kikruma* village in Nagaland, located at an altitude of 1270 m above mean sea level. The soils of the area are silty clay loam in texture with greyish brown colour and there are no means of irrigation. The soils are generally high in organic matter (1.6% to 4.5%), low in available P (4.5 to 9.5 kg/ha) and low in available K(46 to 100 kg/ha) and pH varying from 4.5 to 5.3. Though the village is surrounded by two rivers namely, Seidzu and Khuzha, these are several meters down the fields land. The village has more than 4000 ha area under forests. The chakhesang tribe people follow the old traditional clan laws.

Soil fertility management in Zabo system: The Zabo system has forest land on the top of the hill which serves as the water harvesting area during rainy season. Down the slope are desilting tank and main water harvesting tank. The harvested water is first taken into the desilting tank and kept for few days for desilting. Then the water is taken to the main tank which is plastered from inside with wet clayey soil mixed with paddy straw or husk to prevent water seepage. Down the hill slope is the animal- yard where the few families keep their livestock together. At the foot hills terraced paddy is the main crop grown *(Taryekemugah)* in entire area with seed rate of 50-60 kg/ha and the spacing of 12 cm x 12 cm. Tribal people make beautiful terraces with their ingenuity and skill. In Zabo system, the tribal farmers do not use inorganic sources of nutrients. Animal manure is the major source of crop nutrition. On an average about 10 tonnes of farmyard manure is added per ha. When the fields are to be irrigated, the water from the main tank is passed through the animal yard and it carries all dung and urine of the animals to rice fields below the slope.

The silt deposited in the desiltation tanks is dug out during off season and added to the fields. This silt is very rich in nutrients as it contains lot of forest litter. Besides containing micronutrients, it has about 4 to 8% of organic matter, 0.3 to 0.4% of N, 0.06 to 0.10% of P,O. and 0.15 to 0.4% of K,O. The addition of the silt improves the soil fertility tremendously.

Farmers also add leaves and succulent branches of alder *(Alnus nepalensis)*, *Albizia* spp. and other trash material like farm-wastes etc. to the fields and leave for decomposition. This helps in building up soil fertility and maintenance of soil health. This indigenous farming system is good example of integrated use of land, water and nutrient. Following this farming system, farmer can get 3.5 to 4.0 t/ha yield of paddy which is much higher than the average paddy yield in NEH region (0.65 t/ha). Shifting culivation, which otherwise causes soil and nutrients loss, the *Zabo* method of cultivation is eco-friendly, takes care of natural resources and soil erosion is negligible.

Agriculture with alder

Alder *(Alnus nepalensis)* is grown extensibly in Nagaland to enhance the soil fertility for growing the crops of maize *(Zea mays)*, job's tears (Cox *lacryma)*, millets, potato *(Solanum tuberosum)*, chillies *(Capsicum annum)*, pumpkin *(Cucurbita moschatoa)*, barley *(Hordeum vulgare)* etc. Alder grows well on altitudes varying from one to two thousand meters. It is a non-leguminous tree and the roots have abundant nodules which help in fixing atmospheric N. Its ability to develop and retain fertility of the soil has been fully utilized by the farmers of Angani, Chakhesang, Chang, Yimchaunger and Konyak tribes (Gokhle *et al.* 1985). Khonoma village near Kohima is proud of its alder based agriculture. The alder tree is also useful for providing shade to coffee *(Coffea arabica)* at lower and cardamom *(Elattaria cardamomum)* at higher altitudes. The tree trunks are also laid across the slope to slow down water run-off.

The best period of sowing alder trees is February. The seeds are sown on raised beds for producing seedlings and one year old seedlings are transplanted at desired sites at 6m x 6m spacing. The trees become ready for pollarding after 6 to 8 years of planting when their bark is rough and develop fissures. The entire canopy, except 5 to 6 coppices, is cut-off from the main trunk. One tree has around 100 to 200 coppices, which again grow very fast after pollarding. In Khonoma village in Kohima district of Nagaland, there are more than 200 years old alder trees and are stil 1 sprouting abundantly. Pollarding of alder is generally done from November to January and the fresh cut is covered with stone to protect the trees from frost.

Soil fertility management through alder : The roots of the Alder tree spread in larger area and are capable of binding the soil particles. The soil erosion is reduced considerably in the area where alder plantation is done. The amount of N fixed by Alder tree depends on the number of trees per ha (Prasad and Sharma 1994, Sharma and Singh 1994) and the nutrients added by alder is given in Table 4. Besides adding N to the soil, it adds phosphorus, potassium and micronutrients. Without the use of inorganic fertilizers, the yields of various crops like maize, potato, barley, job's tears, beans etc. are almost double than the shifting cultivation areas (Gokhle *et al.* 1985, Prasad and Sharma 1994). The tribal farmers, due to their centuries of experience of growing alder, have made best use of alder plantation for improving soil fertility. The farmers also add FYM to improve soil fertility and yield of crops.

Table 4 Nutrients fixed by alder

Number of alder trees per ha	**Litter yield (t/ha)**	**Litter dry matter (kg/tree)**	**Nutrients added (kg/ha)**		
			N	**PA**	**K.0**
60	3.37	56.3	48.3	4.88	32.6
101	5.48	45.3	74.5	7.83	55.0
160	8.25	48.1	110.5	11.46	74.3
280	10.50	37.5	142.8	14.49	2.7
625	13.56	21.7	184.8	17.23	104.5

Rice based farming system of apatanis

The Apatani valley lies in Arunachal Pradesh between the rivers of Pnior and Kamala at an altitude of 1524m. The valley is surrounded by high mountains and appropriately called the 'rice bowl' of Arunachal Pradesh (Chowdhury *et al.* 1994). The Apatani tribe practises wet rice cultivation and has good knowledge of soil and water management. The system of cultivation followed by the Apatani is so productive that the population density in the valley is 600 persons per sq. km as against 10 persons in the state. The size ofholding varies from just 0.02 ha to over 30 ha with 93% holdings below 3 ha. The valley has humid sub-tropical type of climate and the mean temperature varies from 6.3°C to 28.1°C in summer and 1.5°C to 18.4°C in winter. The average annual rainfall is 2340 mm.

Rice cultivation is combined with fish culture on terraces and finger millet on terrace risers with an excellent integrated land, water and nutrient management. In the Apatani system, every stream emerging from the surrounding hills is tapped. The water is carried through the main and sub-channels to the rice fields. There are primary, secondary and tertiary channels that take the water even to the remotest fields. The whole work of water diversion is taken up by the community approach for efficient flow of water and minimum soil erosion. The channels are generally pitched with boulders at the start, which checks the speed of flowing water to avoid erosion of the channels as well as surrounding fields.

Nutrient management in apatani system:

In Apatani system of farming nutrients and soil fertility management is done mainly through the recycling of agricultural wastes. Paddy straw (8-12 t/ha) is allowed to decompose in the wet terraces and finally incorporated in the soil at the time of land preparation. Besides, the farmers also sometimes burn the paddy straw in the field during January/February when the terraces are dry. Cattle dung, pig and poultry droppings, rice husk, kitchen wastes, ash of burnt wood and weeds removed during weeding are also spread on the terraces every year for improving the soil fertility. After harvesting of the rice crop, cattle are allowed free grazing in the field from December to February.

Apart from above addition of organic matter and nutrients, the additional nutrients come to the valley land through water from the adjoining ridges. About 1,500 cattle and 6,000 mithuns graze in the upper hillock surroundings which discharge huge quantity of dung every year. Since entire rain water is tapped for irrigation, it brings down the dung and nutrients to the field. Forest humus is also utilized in the rice fields. This improves the soil fertility tremendously. Use of locally available resources has made the system sustainable. Farmers get about 3.5 to 4.0 tonnes of rice per ha even without the use of chemical fertilizers.

Apatani fanners are well aware and cautious about their environment and ecology. Apart from conserv ing the soil from erosion, the farmers have taken up the plantation work with different tree species. Entire hills surrounding the valley and uplands around villages are fully kept conserved as forests. This also helps in maintaining natural resources, maintenance of ecological balance and flow of streams. Loss of nutrients through soil erosion is negligible.

Wet rice cultivation or Panikheti

Terraced rice cultivation is common in Nagaland, Manipur, Sikkim and other states of the region. Angami and Chakhesang tribes of Nagaland have developed beautiful system of terrace rice cultivation. The water can stand in the field during the rice crop and, therefore, called wet rice cultivation, locally known as Panikheti. The construction of terraces reflects the ingenuity and skill of the local fanners who have constructed these terraces manually with indigenous tools (Shanna and Sangit 1994). Due to high rainfall in NEH region, the weeds are a constraint for higher productivity in upland rice cultivation. By keeping standing water in the field, the fanners developed ten-aces for keeping the water standing. These terraces are generally located in the middle or lower level of the hills.

Soil fertility management in Panikheti system

1. The fanners make use of tree leaves, cattle dung and rice husk for increasing the soil fertility. The leaves and succulent branches (chopped) are added to the field and allowed to decompose and then incorporated well in the soil.
2. Stubbles and residue of the previous crop and dry leaves are burnt in the terraces. Weeds are also incorporated in the soil.
3. Farmers also make use of Azolla for enhancing soil fertility.
4. Recently, farmers are adding chemical fertilizers to meet the requirement of the crop for higher yield.
5. Nutrient management in narrow valleys

The tribal farmers of North Eastern Region have developed excellent skill in cultivation of crops in narrow valleys between two surrounding hillocks. Forest vegetation is fully conserved on the hills. During the early rains, the humus and semidecomposed forest litter come down from the hills to the narrow fields. The farmers go on incorporating this material in the field, so much so that top soil has brownish-black colour. It becomes a store house of organic matter and nutrients. The farmers also, sometime, collect nutrients rich top forest soil and add to the fields for improving soil fertility. Besides, the tree leaves and crop residues are also burnt in the fields when the flow of litter is less from the surrounding hills. The soils become rich in nutrients and produce bumper crops without addition of inorganic nutrient sources. Generally rice is grown in such fields, but other crops are also taken.

High attitude farming in kameng Himalaya

Indigenous method of fanning at high attitude by the Buddhist Monpas of Senge village (2500 m from mean sea level) of Arunachal Pradesh is a unique example of transition from shi fling cultivation to settled subsistence hoe fanning. Monpas fanners grow both kharif and rabi crops on the natural hill slopes without terracing it while sheep droppings and oak leaves serve as manure in kharif crops, the human waste and litters are sprayed in barley field during rabi season. The fanning is sustainable and soil fertility is restored through yearly rotation of maize and millets, minimum tillage with hoe, inter and mixed cropping of vegetables beans, pulses etc.

BLENDING THE INDIGENOUS TECHNOLOGY WITH LATEST SCIENTIFIC TECHNIQUES

Environmental degradation in NEH region due to shifting cultivation has reached at an alanning point due to population pressure which, in turn reduced jhum cycle to a dangerously low level. Therefore, under present situation it is necessary to recognize the existing local resources and utilize them in scientific manner rather than going for any new technology unsuitable for fanners. Modem agricultural technology which brought in substantial yield increase in agriculture is not always applicable to these areas because of several biotic, abiotic and social constraints. For example, shifting cultivation practices are so deep rooted in this area that it is difficult to dissociate from their socio-economic compulsion. Scientific development of “agri-horti-silvipastoraf' three tier farming system model is the modification of the indigenous fanning systems discussed. If properly followed further improvement in yield and soil fertility may be anticipated. In this scientific farming system model, trees in the higher ridges (100% slope), horticultural crops with half moon terrace in the middle portion (50-100% slope) and field crops in the lower terrace (<50% slope) can help not only in increasing productivity, and preserving ecosystem but also in maintaining an ideal hydrological behaviour of the area, inceasing soil fertility and reducing water loss. Animal rearing is the main occupation among the people of NEH region. Thus, integration of livestock in the farming system enhances the income, manure for soil health and family labour utilization.

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CHAPTER 18

INDIGENOUS NUTRIENT MANAGEMENT FOR CROP PRODUCTION IN SIKKIM HILLS

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ABSTRACT

The land use in agriculture and forestry of Sikkim Himalaya is influenced by elevation, climate and mountain terrain. The hill agriculture transformed from slash and burn to settled terraced/semi-terraced, almost in one century is based on organic manuring to replenish the nutrient lost from the system. Important farming systems, based on recycling of nutrients through organic manuring and other indigenous systems to maintain the soil fertility for sustainable production are discussed. These indigenous integrated nutrient management practices have resulted in high fertility status of acidic soils compared to other states of north-eastern region particularly in respect of P fertility'. Organic manuring is beneficial to eleminate the toxic effects of Al, for favourable plant root development and for improving the physical, chemical and biological properties of soils besides meeting the nutrient requirement ofcrops. This traditional system of nutrient management can fruitfully be blended with the latest concept of the integrated plant nutrient supply system (IPNS) to enhance the productivity of the crops with minimal quantity of chemical fertilizers without degrading the environment.

Sikkim with geographical area of7096 sq. km is located in the eastern Himalayas. Terraced cultivated fields interspersed with streams together with bamboo and tree groves constitute the traditional hill agriculture which is confined to elevation up to 2000 m. The land use pattern of Sikkim in the field of agriculture and forestry is strongly influenced by elevation, climate and mountain terrain. Forestry is the main land use pattern covering almost 40% of the geographical area followed by alpine barren land, snow and glaciers (Table 1). The cultivated area is approximately 11% of the state land and of which 70% is terraced/semi-terraced and the remaining is under fallow/scrub. The soil instability, loss of the top soil, degradation of soil fertility and shrinking of the catchment area of river systems are the major concerns of the fragile young Himalayan ecosystem.

Table 1 Area of forest cover and land use

	Particulars	Area (sq.km)	Geographical area (%)
1.	Cultivated land	776.74	10.95
2.	Forest cover	2847.81	40.13
3.	Forest blank, scrub in reserve forest and alpine scrub	836.59	11.79
4.	Alpine pasture	433.00	6.10
5.	Alpine barren and snow/glaciers	2051.93	28.92
6.	Built-up area	3.52	0.05
7.	Others(water bodies, dry river bed, land slide/rock outcrop)	146.41	2.06
	Grand Total	7096.90	100.00

Source : (Anonymous 1994)

The climate of the state varies from humid sub-tropical in lower hills to alpine cold at higher altitude. The state as a whole gets 80-90 % of the annual rainfall during monsoon season (May to September), which varies from 840 mm (Thanggu) to 4500 mm (Pangthang). Snowfall occurs at higher elevations of north and north-west Sikkim. The maximum and minimum temperatures of human habitat region varies from - 4.2 to 31,1 °C depending on season and elevations. The different agro-climatic zones of Sikkim (Table 2) provide favourable environment to grow all kinds of seasonal and perennial crops. Maize is the main summer crop in the state followed by paddy, millets, buckwheat and rice bean. Maize is cultivated in all the altitude and rice on terraces in the lower altitude only. Wheat, barley and mustard are important winter crops. Potato is cultivated in summer in the high altitude for seed production and in the winter in low altitude for tuber production. In fact, potato seed production is the most important occupation of the people located around and above 2100 meters altitude and is the only major source of income.

Table 2 Agro-ecosystems of Sikkim

Area	Climate (Altitudem)	Ecological adaptation	Agricultural and horticultural crops
Lower hills	Tropical (300-900m)	Wet and rainfed agriculture, sedentary farming, horticulture, livestock	Rice,maize,mil1et wheat, pulses, oilseeds, vegetables, potato, guava, lime, lemon, mango, ginger, mandarin.
Mid hill	Sub-tropical (900-1800m)	Wet and rainfed agriculture, livestock,horticulture and minor forest produce	Rice, maize,millet, wheat,pulses,oilseeds, vegetables, potato, mandarin,plum,peach, pearjarge cardamom.
High hills	Temperate (1800-2700m)	Rainfed agriculture, transchumance	Maize,barley, vege tabl es .potato, apple, plum,peach,peas.
High hills	Sub-alpine (2700-4000m)	Yak herding,horticulture, pastoral economy (wool, cheese, butter, hides and potato commercial commodities)	Mainly used for pasturage, seed potato and vegetables.
	Alpine (4000-5000m)		—
Very high hills	Alpine (>5000 m)	Lachenpas and Lachungpas transhumance groups visit the area, Lachenpas grow potato and vegetables.	Mainly used for pasturage, seed potato and vegetables.

Farming system in Sikkim is need based. Farmers are not specialized in a particular enterprise. Animal husbandry and horticulture play a very important role in the efforts to increase food production, rural employment and substaintial upliftment of the people of this region.

BACKGROUND INFORMATION

The Sikkim tribe Lepchas lived in harmony with natural resources, and their food habit constitued a great variety of forest produce, chiefly tubers of wild yams, and leaves used for seasoning both meat and vegetables were the supplementary dishes to relish the cultivated cereals (Gorer 1938). They were practising slash and bum cultivation *(Zomal),* consisting of clearing of the forest in early spring (March) and burning all the debris after drying, and sowing the crops in holes made in soil by pointed stick. The principal crops were dry rice and millets. After the harvest of rice or millets, fields were sown with buckwheat. Thereafter they shift to other place for regeneration of soil fertility. It was the only possible way to maintain soil fertility, prevent soil erosion and soil exhaustion with least population pressure.

The Bhutia tribe of Tibet came to Sikkim as herdsmen in 16th century in search of new pastures and trade markets. Their food habits were almost similar to those of the Lepchas and they acquired the best land and cool hills. They also started cultivation to satisfy their immediate needs without disturbing the hill ecosystem. By the end of 19th Century, almost every suitable part of the land below 1800 m was cleared for agriculture (Risley 1894). Nepalese settlers have constructed the bench terraces to cultivate irrigated rice as described by the Bhutia land lords (Kazis). Initially, Le'pchas were not interested in terrace cultivation. The British Government, after 1874-75, forced them to construct terraces and banned the destruction of reserve forest land. Thereafter, in almost one century, Lepchas themselves shifted from *Zomal* to terraced agriculture on slopy hills and former practice is almost non-existent at present.

Forest, grasslands and agricultural land constitute the main ecosystems of the Sikkim Himalaya. The existing developed farming systems of Sikkim hills are classified into *Dhankheti, Sukhabari, Elaichibari, Angambari, Khashland and Gorucharan.* Cultivation of field crops is done on terrace land. Under low land condition there is a problem of Fe toxicity but proper drainage system exists on the terraced land. Most of the agricultural crops are still raised in traditional system developed through generations involving the recycling of nutrients from organic manures, crop residues, forest litter and local grasses/weeds. Scarcity of agricultural land on the hill slopes, continuous rise in population and decreased land holdings have reduced the net cultivated area

Table 3 Area under operational holdings and per capita availability of land

Type of land		**Area in hectares**		
		1976-77	**1980-81**	**1990-91**
1.	Net sown area	64,927	78,321	63,254
2.	Current fallow	501	4,428	3,906
3.	Other cultivated land excluding fallow	4,925	4,560	10,830
4.	Fallow other than current fallow	944	9,474	9,204
5.	Culturable wasteland	1,153	681	9,807
6.	Land not available for cultivation	6,613	11,604	14,300
	Total operated area	79,062 (11-14)	109,068 (15.37)	111,301 (15.69)
		Per capita land (ha)		
1.	Net cultivated area	0.31*	0.27	0.17
2.	Operated area	0.38*	0.36	0.28
3.	For non-agricultural use	0.33*	0.38	0.21
4.	Pasture and culturable waste	0.40*	0.24	0.18
5.	Forest	1.26*	0.83	0.65
6.	Total no. of operational holdings	31,061	56,000	52,697
7.	Average size of holdings	2.55	1.95	2.11

* Data are of 1971

Source:(Anonymous 1996)

The climatic condition of Sikkim is very congeneal for severe outbreak of disease, especially soft-rot disease in ginger. Most of the soils of Sikkim are of colluvial and alluvial in origin and are identified in three taxonomic orders of Entisols (43%), Inceplisols (33.4%) and Mollisols (23.6%) with 7,12,25 and 70 number of suborders, great groups, subgroups and families, respectively (Das *et al.*1998). Darkness of soil colour, coarseness of texture, exchange acidity, organic matter and cation exchange capacity increase with increasing elevations (Gangopadhya *et al.* 1990). The dominant clay minerals are mica and chlorite with variable quantities of vermiculite, kaolinite, quartz and feldspars (Gupta 1988, Lahiri and Chakravarty 1992). The cation exchange capacity of the acidic soils of Sikkim is highly pH dependent (21-54%) with organic matter contributing more than double to the pH dependent CEC (7-96%) of the oxides of Al and Fe (Patiram and Prasad 1991). On an average, the soils of Sikkim are classified as medium in fertility status (Bhutia e/aZ. 1985).

Almost 50 per cent soils of Sikkim had the pH below 5.5 (Bhutia *et al.* 1985) which may restrict the root growth of plants due to Al toxicity. The Al sensitive crops (soybean, wheat and maize) gave the optimum yield when lime was applied at the rate of 1 -2.5 equivalent of exchangeable Al by raising soil pH and maximising the effect of chemical fertilizers (Patiram *etal.* 1991). This rate of lime can be reduced considerably (l/8th dose) by applying it in furrows every year (Patiram 1994). As such, the deficiency of micronutrient cations (Zn, Cu, Mn, Fe) has not been observed in cultivated crops (Avasthe and Avasthe 1995, Patiram 1998). The analysis of soils indicated the deficiency of B and Mo due to leaching caused by excessive rainfall (Avasthe and Avasthe 1995)

INDIGENOUS FARMING SYSTEMS BASED ON ORGANIC MANURING

The fanners of Sikkim are very conscious of the value of the organic manure application to their fields compared to fanners in other parts of the country. The use of chemical fertilizers is below 10 kg/ ha in the state (FAI 1999) which is far below the national average (90 kg/ha). Most of the fertilizer is used in ginger, maize and potato crops only. Livestock is one of the most important component of mixed farming in Sikkim. They rear different species of animals (Table 4) for draught, milk, and meat purposes and these animals also provide manure to meet the nutrient requirement of crops. In the mixed farming systems, nutrient balance depends mainly on the number and housing of stock, feeding and cultural practices. However, balance is also affected by storage and distribution methods, which should be arranged to minimize losses and the danger of pollution. The production of rural compost in the Sikkim is given in Table 4. The availability of well decomposed compost is around 2.18 t / ha based on the net cultivated area, which is highest in our country. It is found that the prepared compost contains 1,0.4 and 1 per cent N, P, K on dry weight basis, respectively.,the available compost can supply 1354, 541 and 1354 tonnes N, P and K annually to supplement the nutrient requirement of crops. This amounted to 22,9, and 22 kg NPK / ha net cultivated area, which is very high compared to chemical fertilizers used. A large part of compost is used for ginger (50%) and vegetables (15%).

Table 4 Availability and production potential of rural compost in Sikkim

Domestic animals	Population of domestic animal	Faecal matter (kg/day)	Annual production of faecal matter (lakh tonnes)	Loss of faecal due tograzing on non-agricultural lands (%)	Faecal material actually available to the crops (lakh tonnes)
Cattle	195327	8.00	5.70	40	3,240
Buffaloes	1970	10.00	0.07	40	0,042
Goat and sheep	87961	0.50	0.16	75	0,040
Horses,mules and donkeys	5436	6.00	0.12	100	Nil
Yaks	4781	6.00	0.10	100	Nil
Pigs	26975	4.00	0.39	60	0.234
Poultry	221406	0.05	0.04	60	0.024
Total production of faecal matter			6.58	43	3,760
Faecal material available for composting					3,760
Refuse,litter and other waster(20%) of the net Faecal material)					0,752
Total undercomposed rural compost and litter					4,512
Net well decomposed rural compost at 30% rec--overy level (70 per cent moisture)					1,3536
Net cultivated area of the state (1995-96)					62042.5 ha
Availability of well decomposed rural compost					2:18 t/ ha
Material/ha net area					22,9,&22kgNP
Nutrient availability through FYM /compost/ha					K

Source: (Anonymous 1998

The use patterns and systems of organic manure based specific farming systems are given below:

Ginger- maize intercropping on raised beds

It is the old but reformed system of production, which almost does not use any form of chemical fertilizer and totally depends on organic sources. Ginger is a poor man's cash crop and cultivated in around 4000 ha area. Cultivation is done on raised beds of 60-80 cm width, 15-20 cm high, with a spacing of 30-40 cm between beds to drain the rain water. To raise this crop farmers frequently apply manure up to 2001/ ha, but 40-60 t/ha is the most common rate (Patiram *et al.* 1995). Almost half of the manure is mixed in the plough layer during land preparation and remaining half is applied in the raised bed. Ginger rhizomes are planted in pits and covered with manure in the month of February and March. Maize seeds are sown either around the periphery of beds or in the space made between two beds. Whole beds are covered with leaves and twigs of various forest trees, weeds, grasses available around the field. Ferns, *Eupatorium adenoforum,* animal bedding and surplus rice straw @ 5-20 t/ha on dry basis are generally used as mulch for higher productivity of ginger.

This system of cultivation maintains crop production sustainability and proper recycling of nutrients. Farmers get more money from intercrop maize compared to sole crop as a result of heavy quantity of manure application to ginger main crop. Maize also provides shade during the early periods of ginger growth and after harvesting open space favours the development of bolder rhizomes. The mulch acts as insulator, prevents weed infestation, minimizes soil erosion and protects the young plants from heavy rain and ultimately enriches the soil nutrient status after its decomposition (Patiram *et al.* 1995). The organic manure and mulch loosens the soil for proper development of rhizomes, so farmers prefer organic manuring for ginger cultivation.

Potato cultivation

In high altitude of Sikkim, seed potato is the main source of income where it is harvested in August/September and reaches the plains by November. Farmers use forest litter and animal bedding materials along with animal excreta for preparation of compost. In the month of December and January, while ploughing the field, all the residues of crops and weeds are collected in heaps and covered with soil. The heaps are burnt and residue left after burning is spread over the field. The undecomposed portions of the prepared compost are separated and good quality of manure is heaped near the field. About 15 days before sowing of seed potato Di-Ammonium Phosphate (DAP) is mixed with well rotten compost (15-20 t/ha) or suphala @ 300-500 kg for one hectare land. The enriched compost is applied in furrows at the time of potato seed sowing and no other fertilizer is applied later on. Pea is intercropped giving a space of 4-5 furrows of potato between each row to avoid the shading effect.

In Lachen and Lachung valleys of North Sikkim, farmers bum the residues openly entirely on the field and then mix with the soil by ploughing. The method of sowing is almost same except that compost and DAP are used separately in furrows.

Zero tillage cultivation of cabbage in Lachung

During the month of April and May, cutting and burning of grasses, weeds and stubble on slopy lands are done by the farmers on entire field. Cabbage seedlings are planted by shallow digging of field without any basal fertilizer application. Top-dressing of urea is done after 30 and 60 days of transplanting of seedlings as a result of market facility provided by the state government.

Vegetable cultivation

All the vegetables (beans,cabbage, cauliflower, pea, raddish etc.) are grown using organic manure only. Organic manure is applied in furrows to get maximum output with least losses by erosion.

Relay cropping

Rice bean is grown as relay crop with maize only at higher altitudes where as soybean is commonly cultivated everywhere. Pea and French bean are intercropped in May-June in the standing maize field during the operation of interculture. After the maturity of maize plants, cobs are harvested leaving the stalks in the field for the support of intercropped rice bean, french bean and pea, however in soybean half stalks is only left.

Legumes in rotation

Rice bean, urd and moong bean are cultivated in rotation after the harvest of maize in the mid and low hills of Sikkim. Rice bean is a non-determinant type of legume, which enriches the soil by adding large amount of foliage and biological N, fixation.

Homestead gardening (Aganbari)

In Sikkim fencing around the house with bamboo is a common feature especially with Lepchas and Bhutias tribes. A complex mixture of trees (fruits and woods) and annual crops (food and vegetables) is grown all along the fence which allows the continuous use of land around the house throughout the year. This garden is only the portion of land where domestic animals are provided shelter at night. Their dung is collected for compost preparation. At the lower elevation of nearly every garden plantation of bamboo is common for easy supply of the materials.

RELEVANCE OF THE TECHNOLOGY ADOPTED BY THE FARMERS

Most of the cultivated land of Sikkim is terraced/semi-terraced and farmers have settled in their holdings in most of the areas. As stated earlier, the farmers of this mountain had realized the importance of slash and bum agriculture to replenish the loss of soil fertility with abundant availability of land and least population pressure. With the passage of time, they started settled cultivation on the basis of their traditional wisdom of transformed agriculture based on organic manuring and inclusion of legumes in cropping systems to maintain the sustainability of the land. It is practicable here, because of the availability are highly deficient in phosphorus (Prasada ***et al.*** 1981), whereas 2/3rd soils of the Sikkim are medium to high in P content (Bhutia ***et al.*** 1985), as a result of recycling of nutrients through organic manuring. There is considerable evidence that organic matter reduces the soluble and exchangeable aluminium by forming Al-organo complexes in soil (Hoyt and Turner 1975, Ahmad and Tan 1986). A field study conducted on acid-Al toxic soils of Sikkim also revealed that the benefit of fertilizer could be increased by continuous application of FYM to each crop without liming (Patiram 1996).

In general it is observed that organic manure based farming systems encourage the build up of soil organic matter, which reduces the erosion and runoff of inorganic matter to streams and rivers besides improving the physical, chemical and biological properties of pest and disease incidence by increasing species diversity, promote fungi population to control nematodes, absorb and inactivate pesticides and provide food for marginal pests to decrease their severity (Edwards 1990). The burning of crop residues and weeds (shrubs and herbs) for the cultivation of potato and cabbage temporarily raises the soil pH, increase the availability of nutrients and decrease the incidence of insect-pests and diseases (Nye and Greenland 1960). The leguminous species in intercrops and as a sole crop contribute to fixation of N and add organic matter by the decay of leaves and rotting of branches and roots.

BLENDING OF INDIGENOUS TECHNOLOGY WITH LATEST SCIENTIFIC TECHNIQUES

The soils of Sikkim are acidic in reaction and susceptible to various kinds of degradation due to high rainfall and hill agriculture (Das ***et al.*** 1998). The consumption of chemical fertilizers is below 10 kg/ha (FAI 1999) and yield of most of the crops are below the national average (Anonymous 1996) possibly because of the low level of adoption of the package of practices and other biophysical constraints. The cost of chemical fertilizers has increased tremendously after their decontrol since August 1992. Even concession given by the Government of India from time to time could not bring the prices to the level of 1991-92 due to continuous increase of imported raw material. Sustainable agriculture includes the ongoing production to maintain equilibrium with the changing demands of a growing population in view of the problems of nutrient removal and environmental degradation. Expensive chemical fertilizers have made it necessary to maintain livestock to recycle nutrients and build up of organic matter in soils to get desired level of production.

The traditional system of agricultural production based on organic manuring, crop residues, legumes in crop rotations, recycling of nutrients through slash and bum system and others is keeping pace with the demand of food requirement of the continuously growing population. It is the only cheapest mean of providing nutrients for crop production and protecting nutrient losses in the fields of the poor and marginal farmers. Large number of experiments conducted all over the country proved that integrated use of chemicals, organic and biofertiliizers can sustain the crop productivity and soil health. Integrated plant nutrient supply systemm (IPNS) is a step in the direction of sustainable agriculture development to increase the efficiency of applied chemical \of application and utilizing sources other than chemical fertilizers i.e., organic manures, biofertilizers and so on to meet part of the nutrient needs of (Patiram and Sachan 1992). In maize crop the inoculation of biofertilizers ***(Azotobacter)*** increased the yield to the tune of 3.4 to 9.4 per cent in Sikkim. Thus, there is a bright scope for IPNS to enhance the productivity of Sikkim hills, because almost every farmer has the availability of organic manure at his farm and State Government is doing its best to adopt this novel approach through extension and demonstrations.

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CHAPTER 19

Indigenous nutrient management practices - wisdom alive in India
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INDIGENOUS NUTRIENT MANAGEMENT PRACTICES FOR SOME ECO-REGIONS OF WEST BENGAL PLAINS

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ABSTRACT

The state of West Bengal, situated at the eastern part of the country (latitude of 21'30' V to 2 7° 13' N and longitude of85"5T E to 89" 52' E), occupies 2.7% of the total geographical area of the country and supports 9% of the country's population. The state has diverse agroclimatic zones ranging from hill region on one hand and coastal region on the other. The state as a whole has the humid climate and the summer and winter are comparatively dry. About 70% of the people in the state are dependent on agriculture where rice cultivation occupies 80% of the land. The greater part of the state (about two third) is flat and/or gently undulated alluvial plains with an elevation below 30 meters, part of which are agriculturally developed and the remaining is underdeveloped. In these plain lands farmers follow a large number of indigenous nutrient management practices based on traditional wisdom derived from their experience over a period of several centuries. Some of those indigenous methods are preparation of FYM, in-situ decomposition of grasses and weeds, water hyacinth compost, application of oil cake, tank silt application, crop rotation, penning of sheep etc. It may be noted that most of the indigenous practices of nutrient management revolve around rice, being the major crop in the cropping systems of the state. These indigenous techniques developed by the farmers have a scientific basis and scope exists in blending these technologies with the modern scientific integrated nutrient management systems to improve the soil fertility and productivity of crops and cropping systems.

West Bengal has occupied a significant position in Indian Agriculture since independence. It ranks first in case of rice and second in potato (next to Uttar Pradesh) in India in terms of area and production (Anonymous 1996-97). The state is broadly divided into six agro-climatic regions. ***The Hill Region***is predominantly inhabited by tribals where resource intensive modem agricultural technology is beyond their reach except some tea gardens and orange orchard farmers. They are pursuing mostly subsistence agriculture and majority of them deriving their livelihood from agriculture, rearing of livestock and collection of forest produce. ***The Tarai and Teesta Region*** dominated by poor tribals, harijans and refugees from Bangladesh, is also characterised by subsistence agriculture. ***The Gangetic Alluvial Region*** is the most developed region both agriculturally and culturally. Intensive modem agricultural technologies are being practised to produce various crops round the year. It has good irrigation, infrastructure, transport and marketing facilities. Thus it is considered as the heart of West Bengal enjoying most of the modem facilities. This region is thickly populated with different categories of people. ***The Vindhya Alluvial Region*** is developing agricultural sector but has poor infrastructure facilities. People are mostly dependent on agriculture as their main source of livelihood and unable to adopt modem crop production technology in most of the cases. ***The Coastal Region*** is dominated by harijans (fishermen) and poor farmers. Here transport and market facilities are very poor. Unprecedented cyclones and floods make life of the inhabitants of this region most miserable. They are mostly dependent on agriculture, forest and sea resources.

The Red Lateritic and Gravelly Region is also predominantly inhabited by tribals and harijans. Agricultural development in red laterite areas is relatively better than the gravelly areas of this region. Farming is still at subsistence level in this region.

Farmers of different regions of the state follow a large number of indigenous practices based on traditional wisdom derived from their experience over a period of several centuries (Pal and Das Gupta 1998). Indigenous knowledge is developed and applied on a particular ecosystem to which a specific group of people do belong. The traditional practices that rely on indigenous knowledge are considered productive and sustainable. The need for a comprehensive collection of indigenous knowledge related to integrated nutrient management is urgently felt by different individuals and organisations in recent times for multi dimensional benefits. Documentation of indigenous knowledge facilitates to amplify and accelerate research planning and development.

BACKGROUND INFORMATION

The seasonal variations occurring due to variations in rainfall, temperature, relative humidity and altitude have great influence on farming systems in West Bengal. Depending upon the soil and climatic variations, the state is broadly divided into the following six agro climatic regions (Fig. 1). The cropping intensity, net cultivated area, average fertilizer consumption and major crops grown in different regions are given in Table 1. Brief description of different regions and some indigenous practices are discussed below.

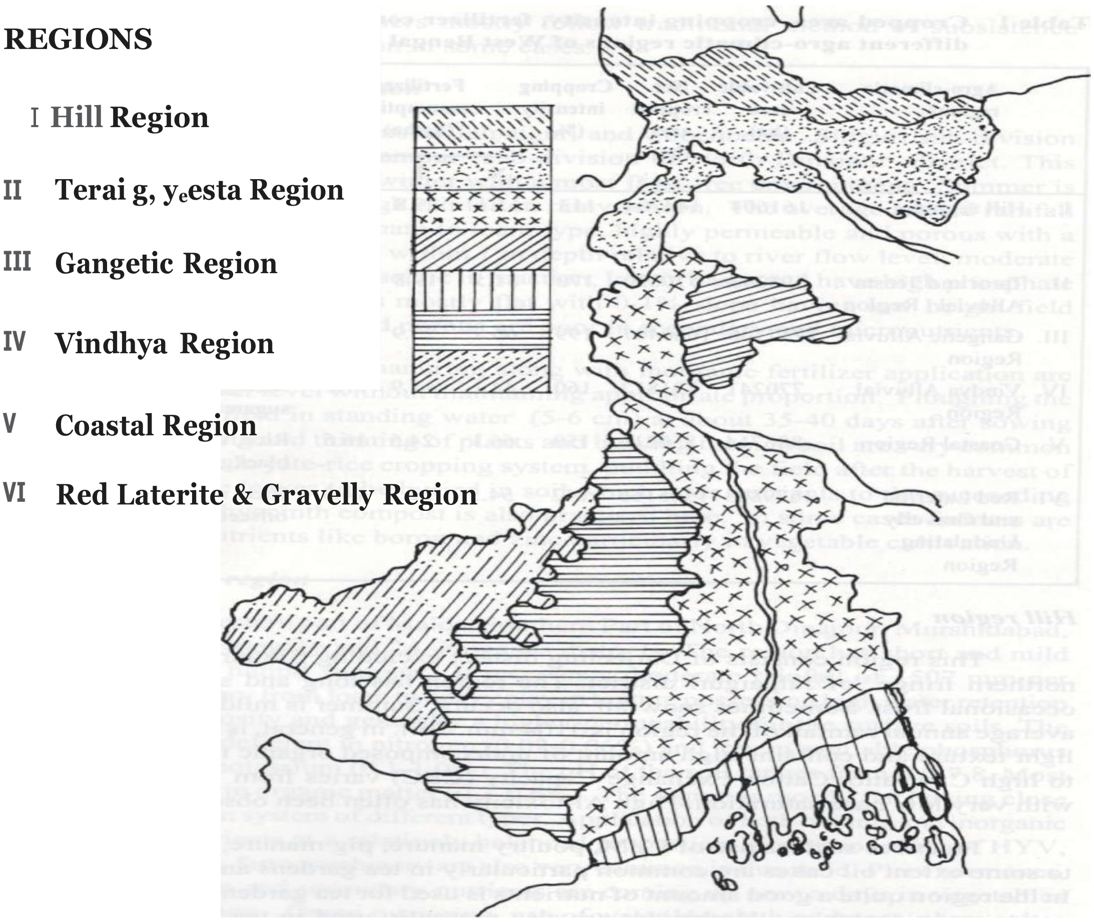

Fig.1 *Different agro-climatic regions of West Bengal*

Table 1 Cropped area,cropping intensity, fertilizer consumption and major crops of different agro-clintaticregions of West Bengal

	Agro-climatic Regions P	**Cultivable Area (ha)**	**Net Cropped Area (ha)**	**Cropping Intensity (%)**	**Fertilizer Consumption (kg/ha)**			**Major crops grow**
					N	**P**	**K**	
I	Hill region	161604	144704	113	65.1	29.8	22.4	Tea,orange,pineapple, Maize,potato,rice, Cardamom
II	Tarai and Teesta Alluvial Region	598243	570830	170	51.5	19.8	12.2	Jute,rice, maize,wheat, Oilseeds and potato
III	Gangetic Alluvial Region	1737706	1660407	199		25.9	18.2	Rice,jute,potato,oilseeds, Pulses, sugarcane, wheat
IV	Vindya Alluvial Region	770241	731812	160	44.1	14.9	11.5	Rice, jute, potato, oilseeds, sugarcane,wheat
V	Coastal Region	886714	850216	150	66.1	24.5	16.6	Rice,wheat,sugarbeet, Blackgram, chilli
VI	Red lateritic and Gravelly Undulating Region	1679893	1505163	142	54.5	22.5	14.3	Rice,maize,potato and oilseeds

Hill region

This region consists of Darjeeling district excluding Siliguri sub-division and northern fringe of Jalpaiguri district. The region has long and severe winter with occasional frost. Sometimes snowfall also occurs. Summer is mild and pleasant. The average annual rainfall of the region is 3104 mm. soil, in general, is shallow, mostly of light texture and contains high amount of undecomposed organic matter which leads to high C:N ration. Cation Exchange Capacity (CEO) varies from 10-20 cmol(p+) kg with very low base saturation. High Al-toxicity has often been observed.

Practices like organic manuring along with inorganic fertilizer application are common but at lower level without maintaining appropriate proportion. Ploughing the direct seeded rice field in standing water (5-6 cm) at about 35-40 days after sowing followed by weeding and thinning of plants and burying them in soil are very common in rice cultivation. In jute-rice cropping system, puddling the field after the harvest of jute allows the jute leaves to be buried in soil which adds nutrients to the succeeding rice. Use of water hyacinth compost is also practised here. In some cases farmers are also using micronutrients like boron and zinc particularly in vegetable cultivation.

Gangetic Alluvial region

It covers Western part of Malda, Southern Part of North Dinajpur, Murshidabad, Nadia, Burdwan, Hooghly and 24-Parganas districts. The region has short and mild winter with warm humid summer. It receives a moderate rainfall of 1507 mm per annum. The soils vary from loam to heavy clay in texture possessing high water retention capacity, good porosity and generally a higher permeability for the surface soils. The soils are generally deficient in nitrogen (0.02-0.06%) and low in available phosphorus (0.03-0.15%) and potassium (0.1- 1.0%). The pH ofthe soil ranges from 6.0-

7.8. Most of the soils are low in organic matter (0.3-0.6%). The region is mostly flat having close network of irrigation system of different types. Application of both organic and inorganic forms of plant nutrients at a relatively balanced proportion is common. Use of HYV, fertilizer, pesticides, farm machinery are also very common in this zone. Plant hormones, biofertilizers, micro and secondary nutrients are coming up now a days in vegetables and potato cultivation. Green manuring, use of water hyacinth compost, neem cakes in rice and other oil cakes in potato are also very common here.

Vindya Alluvial region

This region consists of eastern part of Malda and South Dinajpur district. The topography of the region ranges from flat to rolling type. Bench terraces are made in rolling topography areas. The region has very short and mild winter with relatively hot summer. It receives an average annual rainfall of 1410 mm. Soils are sandy loam to silty clay loam in texture according to land situation. In general, soils are moderately well drained, moderately acidic to neutral in reaction and low in organic matter. The soils are poor to moderate in nitrogen (0.02 to 0.08%).

Practices of organic manuring along with the use of inorganic fertilizers are very common here but at a low rate and inappropriate proportion.

Coastal region

This region covers southern portion of North and South 24-Paraganas districts, Howrah and Midnapore district. It has very short and mild winter with very humid summer. It receives a moderate rainfall of 1427.4 mm per annum. Soils, in general are deep, fine textured, poorly drained and restricted leaching of soluble salts with varying levels of salinity. Soil reaction ranges from 4.0 to 8.5 with electrical conductivity (Ec) varying from 3.0 to 18.0 dS/m mainly due to accumulation of sodium chloride. In canning area EC reaches as high as 30 dS/m, but in the Kakdweep area EC values range from 10 to 15 dS/m, organic carbon varies from 0.7 to 0.9% whereas the available phosphorus ranges from 30-60 kg/ha. The deposits through various rivers are rich in plant nutrients and when reclaimed support a good crop of rice. The region is lowlying basin type flat, in general, facing problem of intrusion of sea water.

This region faces problem of salt injury and thus restricts the choice of crops to be grown here. Organic manuring is very common but in a limited areas due to paucity of organic manures. Nutrient consumption data shows that this region consumes quite good amount of NPK per ha, mainly because of vegetable cultivation to cater the needs of greater Calcutta. Field crops generally require very low amount of plant nutrients. Traditional rice varieties occupy the dominant position in rainfed rice monoculture system.

Red Lateritic and Gravelly Undulating region

It covers part of Birbhum, Burdwan, Bankura, Midnapore and Purulia district with pockets of Malda and West Dinajpur. The region has mild and short winter with dry and warm summer. It receives moderate rainfall (1200 mm). Soils are shallow to deep with light textured surface and heavy sub-surface, well drained due to deep water table and has scope of lateral seepage, acidic in soil reaction, low in base, organic matter. Lateritic soils of this region have 50-60% upland (locally called ‘ ***Tard'*** or ***'Baid'),*** 20-30% medium (locally called ***'kanali'}*** and 10-20% low land (locally called ***''Shole'*** or ‘***Bahai")***. Soil fertility levels are very poor having 0.01% nitrogen and 0.05% phosphorus. Calcium and potash contents vary from 0.01 to 0.04%. Thus soils are responsive to nitrogen and phosphate fertilizers. The CEC is very low and soils are of high degree of aggregate stability and well drained. Moisture stress frequently occurs. The region is mostly bunded and bench terraced on moderate slope, having irrigation facility in some areas.

Practices like burying the weeds in soil during weeding of transplanted rice are very common. Low spread of HYV, low input use particularly of plant nutrients coupled with occasional moisture stress are common in rainfed agriculture resulting in poor yield. In the irrigated areas, the limited availability of water also restricts the choice of crop varieties to be grown and its input optimization. Organic manuring is practiced.

INDIGENOUS NUTRIENT MANAGEMENT TECHNOLOGIES

Different indigenous technologies practised by the farmers of different regions of West Bengal plains are discussed below:

Indigenous method for preparation offarmyard manure from cowdung

Traditionally, cowdung is collected daily by the farmers from the cowshed and is put in a heap. During the summer season, the heaps are cut into pieces and spread over on the surrounding space of the heap. Then the decomposed material are kept as such for sundrying so as to bring it in a friable condition. These are again cut and ground at the optimum moisture condition which otherwise contains clods of cowdung. The finely powdered form of decomposed farmyard manure is generally applied to the kharif rice. This is also used for winter crops like mustard, wheat, potato and vegetables. This pc Adered farmyard manure is easy to apply and the use efficiency of this processed cowdung is generally more compared to application of farmyard manure directly from the heaps which contains lot of clods and is difficult to incorporate in the soil.

Application of stubble compost

In the red & lateritic soil belt of West Bengal, winter crops are grown just after han esnng of early rice (locally called ***'aus'*** rice). Rice stubbles are removed from the field before sowing of rabi crops particularly potato. These stubbles are heaped in a comer of the plot and latter on these are utilised in kharif season for raising rice. It may be noted that sufficient time is allowed for the stubbles in heaps to decompose. This practice ensures the clean cultivation for potato and recycling of organic matter as **well.**

In-situ decomposition and incorporation of grasses and other weeds into the soil

Kharif rice is usually transplanted with the onset of South-West monsoon. Grasses mainly Dhoob ***{Cynodon dactylori)*** are naturally grow in the rice fields with the early monsoon. These grasses have high root density and root biomass. A preparatory tillage is normally given to incorporate Dhoob grass and other weeds ***in- situ.*** This is a very common practice in all the rice growing areas of West Bengal particularly in the districts of Burdwan (rice bowl and greenery of Bengal), Coochbehar, Bankura, Murshidabad, Malda, Nadia and Hooghly. This practice of incorporating grasses and other weeds enriches the organic carbon status of the soil.

Water hyacinth compost

Water hyacinth ***{Eichhornea crussipes)*** is an aquatic weed commonly found in the lakes, ponds, tanks and small ditches in West Bengal (Plate 1). Fanners collect this weed and heap it in a nearby pit. The fresh material in the heap is allowed to decompose for nearly 30-40 days. This compost is then sundried, applied in the plots and incorporated in the soil through summer ploughing. Subsequently fields are puddled for transplanting rice during kharif season. This water hyacinth compost adds nutrient to the soil. This is also applied to wheat, mustard and vegetables. It helps in improving the physical, chemical as well as biological condition of soil.

Plate 1 : Water hyacinth in a pond

Incorporation of rice stubble (crop residues) to boro rice in a rice-rice cropping system

Rice-rice cropping system is predominant in many parts of West Bengal. Farmers grow kharif rice prior to boro (winter) rice. Kharif rice is harvested during November- December. The stubble left after harvesting of kharif rice are kept in the field as such. During the land preparation of boro rice, the soil is saturated first and then the stubbles are incorporated with the help of power tiller, hired on collective basis in the villages. Boro rice is transplanted during the end of January to the first fortnight of February. This practice improves the soil organic matter content in the rice-rice cropping system and enriches the fertility status of the soil.

Greengram as catch crop

In the red and lateritic region, some parts of vindhya alluvial region and tarai region of West Bengal, farmers grow greengram during summer season as a catch crop between the harvest of previous rabi crop (potato, wheat) and planting of kharif crop (rice). Pods are harvested by three to four hand pickings and left-over crop residues are partially incorporated ZJJ ***situ*** with a summer ploughing. Subsequently, with the onset of South-West monsoon crop residues are properly incorporated and rice is transplanted in these fields during the kharif season.

Jute leaves as potential source of manure

The jute-rice crop rotation is commonly practiced in the districts of Nadia, Hooghly, Murshidabad, Coochbehar, Malda, West Dinajpur. Jute is harvested from the base of the plants. Harvested jute bundles are arranged in heaps and are kept in the field itself for 7-15 days for partial sun drying wherein gradually leaves get detached from the plants and deposited in the field. The deposited leaves are incorporated ***in- sitn*** before growing next crop of rice.

Penning sheep in the cultivated fields

Seasonal migratory sheep owners move to the plains with their fleet of sheep after the harvest of kharif rice and also after wheat (Plate 2). They confine their sheep to a particular field for a certain period (10-15 days) with the permission of the land owner. For that, they are paid either some nominal cash or daily food materials by the owner. When the contact period is over, they shift their fleet of sheep to the other field of the different owner. Such a shifting is continued before sowing of the next crop. Sheep droppings and the urine have very good manurial value. It helps to improve the soil quality and enhance the fertility of soil.

Plate 2 : Penning of sheep in the harvested wheat field

Application of wood/coal/rice husk ash to boro rice and onion

Soil and air temperature at the end of December are generally low which affect the germination and growth of rice and onion seedlings raised in the nursery. The poor and marginal farmers in the state use wood and coal as fuel for cooking. They collect ash in the morning and heap it at a place for use in agriculture. Rice husks is produced from rice mills. This husk is burnt to ash for direct application to the field. The ash is spread over the nursery bed of rice and onions. It helps to enhance soil temperature so as to improve germination. Potassium requirement of onion is very high. Therefore, farmers spread ash in the main field also after transplanting. Ashes are a very good source of potassium. In this way potassium requirement of rice and onion is fulfilled.

Bone tneal/fish meal application

Bones from different slaughter houses are collected by tribal farmers of Purulia, Bankura, Birbhum and Murshidabad districts of West Bengal and are crushed to make bone meals. Similarly, fishmeal is prepared from fish spines and bones. These bonemeal and fishmeal are then applied to the fields at the rate of 2-3 jute bags/bigha and are incorporated to the soil during summer season. Subsequently, puddling is done through repeated ploughing with the onset of monsoon and rice is transplanted. In these areas farmers normally do not apply any phosphatic fertilizer to the rice as these indigenous manures improve the soil phosphorus and calcium status. Now-a-days these materials are readily available in the local markets.

Application of oil cake

Potato is an important cash crop to the farmers in Hooghly, Nadia, Howrah, Bankura, Malda and Burdwan districts. Farmers apply ground mustard and sesame cakes obtained from oil-extracting machines (locally called ***Ghanis)*** to the potato crop. Before application these finely powdered materials are generally mixed with urea and MOP and are generally band placed near the potato rows during earthing up (30 to 35 days after planting). The advantage of these methods as perceived by the farmers is that this concentrated organic manure helps to build up the fertility of the soil, enrich the nutrient status and improves physical health of the soil. It also supplies micronutrients to this crop.

Application of biogas slurry

Many biogas plants are now-a-days installed for cooking and lighting in the villages. The slurry is the most important by-product of this biogas plant. This slurry is used for growing vegetables like brinjal, chilli, tomato, bhindi etc.

Crop rotation

Farmers are very particular in adopting some of the crop rotations which have relevance to the economics and efficient use of nutrients. Farmers usually change crop rotation in every three or four years to have a better growth and performance of the cropping system in terms of yield sustainability and nutrient use. For example, after every three to four years rice-wheat-greengram are replaced by rice-mustard-greengram and ***vice-versa.***The basic advantage is that having differential nutrient requirements and root system for wheat and mustard, crops utilize nutrients from different layers of soil. Similarly, rice-potato-sesame and rice-potato-jute crop rotation have an added advantage. Potato is a heavy feeder of nutrients. The left over nutrients applied to potato are taken up by the succeeding crops in the sequence.

Tank silt application

In West Bengal there are myriad number of small, medium and large sized tanks and ponds. During summer, when most of the small and medium tanks/ponds are dried, farmers go for desilting to harvest more runoff water for raising fish in it. The dried or semidried silts from the ponds are carried to the rice fields and are incorporated into the soil through summer ploughing. This is a common practice followed by the rice growers of the state.

PRESENT RELEVANCE OF INDIGENOUS TECHNOLOGIES ADOPTED BY THE FARMERS

The relevance of different indigenous technologies is discussed below:

SI. No.	Indigenous techniques	Present relevance of the techniques adopted by the farmers
1	***Greengram as catch crop***	*Adds organic matter to the soil and improves soil health and sustains productivity of the crop.
2	***Jute leaves as potential source of manure***	*Release of nutrient after decomposition ofjute leaves enhances fertility level of the soil and also improves the physical and biological properties of the soil.
3	***Application of wood/coal ash to boro rice and onion***	*It acts as surface mulch, which increases the soil temperature of the nursery in the winter season. *It also acts as an alternate source of potassium, which at least partially fulfils the K requirements of ***boro*** rice seedlings in nursery and onion, a high K responsive crop.
4	***Tank silt application***	*More rainwater can be harvested as desilting increases storage capacity of the ponds. *Tank silts are rich in nutrients and high in organic matter content. These additions to rice field enhance its fertility status. *Finer particles also improves the water holding capacity of the soil.
5	***Penning of sheep in the cultivated fields***	*Addition of organic matter to the surface soil through the urine and excreta of sheep penned in the plots. *Enriches the nutrient status of the soil.

	Bone meal/fish meal application	*In tribal region where this practice is mainly followed, this acts as a cheap source of manure, which supplies nutrient to the plant.
7	***Application of oil cake***	*Fertilizer requirement of potato is very high; oilcakes supplements a part of the macro and micronutrient requirement of the crop. *Also improves physical health of the soil.
8	***Water hyacinth compost***	*It improves organic matter content of soil and thus improves soil health.
9	***In-situ decomposition and incorporation of grasses and other weeds into the soil***	*It adds organic matter to the soil.
10	***Indigenous method for preparation of FYMfrom cowdung***	*FYM acts as an excellent source of plant nutrients specially micronutrients in organic form. *Improves soil physical and biologi cal health.
11	***Crop rotation***	*Nutrient requirements and nutrient extraction patterns from the soil profile are different for different crops under rotation as their root distribution system varies. This enhances the overall nutrient use efficiency of the land. * Legumes in rotation helps in supply of N through atmospheric N fixation.
12	***Application of rice husk ash***	*Rice-husk ash acts as a source of K. when applied to field. *It increases the water-holding capacity of the surface soil and acts as soil surface mulch.
13	***Incorporation of rice stubble (crop residues) to boro rice in a rice-rice cropping system***	*It adds organic matter to the soil.
14	***Application of biogas slurry***	* It improves the soil fertility and productivity.
15	***Application of stubble compost***	* It adds organic matter to the soil.

SCOPE OF BLENDING WITH SCIENTIFIC TECHNIQUES

Farmers over a long period of time have evolved numerous indigenous farming practices. These indigenous practices have much practical relevance, which can be widely used in scientific farming system. Indigenous knowledge are developed as per the needs and available resources in a particular location. It has values not only for the culture in which it is evolved but also for the scientists and planners from outside. These indigenous practices require low inputs and are highly sustainable in nature as these are practiced and modified over a long period of time. However, the scope still remains to blend these indigenous technologies with modem technical know-hows, which could lead to an efficient resource management strategies with more emphasis on productivity and sustainability. Some of the probable blendings are recorded below:

1. In traditional methods of FYM making from cowdung results in partial decomposition and also loss of much nutrients through leaching from waterlogged ditches or open place heaps. These organic wastes can be recycled after preparation of "phosphocompost" or "vermi-compost" alongwith biofertilizers, micronutrients and low cost minerals like rockphosphate, pyrite etc. Trials conducted with vermicompost in contrast to ordinary FYM shows spectacular yield differences in most of the crops in different regions in West Bengal (Chattopadhyaya ***et al.*** 1999). But for preparing vermicompost, occasional turning of the materials, watering etc. is a labour expensive and thus stand in the way of its spread.

2. Instead of application of oilcakes of different kinds directly to the field, it can be blended with inorganic fertilizers to improve fertilizer use efficiency by retarding the rate of nutrient release from the fertilizers. Fertilizers can also be applied after coating it with neem, mahua or karanj cakes to increase their use efficiency and build up soil fertility.

3. Mixed or intercropping cereals with legumes and introduction of legumes in a cropsequence will increase total productivity and also improve soil health.

4. Integrated nutrient supply system needs to be developed for each cropping system in different regions in which emphasis should be made on supply of plant nutrients from all the available sources, such as organic manures, green manure including green leaf and weeds, town compost, oil cakes etc., biofertilizers, chemical fertilizers and even growth regulator to derive best results out of this integrated nutrient supply system (Ghosh, 1999). Trials conducted in the boron deficient soils of Tarai region showed that recommended dose of NPK combined with 10 t FYM/ha could mitigate the boron and zinc deficiency of mustard and greengram (Table 2).

Table 2 Yield of mustard and succeeding greengram as influenced by integrated nutrient managementtreatments

Treatments	Mustard seed yield(kg/ha)	Greengram grainyield (kg/ha)
T. Control	723	474
T, 100% RD*	1332	827
T. 100%RD + FYM	1692	1123
T_4 100% RD + Borax	1556	1030
T; 100% RD + ZnSO4	1462	951
T 100% RD+Borax+ ZnSO,	1683	1121
CD (P=0.05)	38	43

*RD = Recommended dose of N, P,Os and K,O Source: (Mandal and Sinha 2000)

5. Last but not the least is the need of development of proper linkage among the scientists, extension specialists and farmers for rapid and proper transfer of modem technology to the farmers for its spread over wide areas across the regions for the development of agriculture and welfare of the society (Das Gupta 1998).

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CHAPTER 20

INDIGENOUS PRACTICES OF NUTRIENT MANAGEMENT IN WEST BENGAL

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ABSTRACT

West Bengal has diverse agro-ecological zones. Farmers of the different zones follow various indigenous practices for nutrient management in their fields. These practices are mainly centered on the use of organics in different forms viz., tank silt, fishmeal, night soil, sewage-sludge, leaf mold, green manuring etc. Besides, ingenuity in pattern of land use and crop rotations such as fallowing, paira cropping etc. are also important indigenous practices followed by farmers of the state to maintain the soil health. These practices are found to be location specific and socially and culturally related to the way of life of the farmers in different zones. These age-old indigenous practices followed by the farmers of West Bengal have been documented and the scientific principles and rationales involved in them have been analysed in the present article.

The state of West Bengal has unique geographical settings. It has hilly region in the north, on one hand and on the other, it has low-lying coastal areas in the south. It has diverse agro-ecological zones varying in climate ranging from temperate perhumid in the district of Darjeeling to hot dry subhumid in the districts of Bankura and Purulia and warm moist subhumid in Sunderbans in the districts of 24 -parganas. Diverse types of soils viz., brown-forest, vindhya alluvial, old and new alluvial, coastal saline and red lateritic occur in the state. The annual average rainfall of the state is 1645.1 mm, out of which 1252.1 mm (76.1%) is received during June to September and the rest 393.0 (23.9%) mm is received during the remaining months. Only 50.0% of the total cultivated area is under assured irrigation. On an average, the state has 165% cropping intensity and rice-rice, rice-mustard, rice-jute and rice-wheat constitute the major cropping systems. Average fertiliser consumption of the state is about 120 kg/ ha, with an average land-holding of 0.96 ha.

Productivity of the different agro-ecological zones of the State varies significantly. This is fairly high in the new and old alluvial soil zones in the central plains comprising the districts of Burdwan, Hooghly, Nadia and Murshidabad; while it is comparatively low in all the other zones where the soils are either red lateritic or acidic or saline. The high productivity in the old and new alluvial soil zone, where the soils are non-saline and nearly neutral in reaction is due to the large-scale adoption of high - yielding varieties of crops, use of high amount of chemical fertilisers and plant protection chemicals and better irrigation facilities. The low productivity of the other zones is associated with soil-related constraints and also due to inadequacy in irrigation facilities. Farmers of these low productive zones are risk-prone and therefore reluctant to switch over to the so-called high input agriculture in preference to their age-old low input fanning. They follow a number of different low cost indigenous practices for meeting the nutritional needs of their cultivated crops, which have sustained the productivity of land for quite a long period.

The high input agriculture of new and old alluvial soil zones has met with a number of problems and is being observed to adversely affect the long-term sustainability of the production system. This has already deteriorated the ambient environment particularly soil, water and air quality. Because of these inherent shortcomings and perceived inadequacies of modem agriculture vis-a-vis sustained productivity of low input agriculture, people are now interested to know the scientific principles of the indigenous practices in sustaining agricultural productivity. These have been developed based on experiences, experimentations, trials and keen observations of the farmers for generations together. They are, in general, eco-friendly, socially acceptable, economically feasible and are based on utilising locally available cheap resources. It is believed that incorporation of some of the indigenous soil and land resource management practices into our present high input production system may be useful in sustaining productivity of land. In the past there was hardly any attempt to look into the scientific principles involved in the age-old indigenous practices followed by the farmers to maintain their land productivity. This was possibly due to the initiation of agricultural research in this country by the Britishers who primarily relied on laboratory or experimental farm based research without taking into cognizance the ingenuity of the native farmers and their cultivation practices for augmenting and/ or stabilizing yield of their fields. These left the scientific validity of different indigenous practices unexplored and therefore it remained much obscured.

With this background an attempt has been made here to collect and document the indigenous practices followed by fanners of West Bengal in different areas for nutrient management and analyse them so that the scientific principle/basis behind them can be properly understood. Once it is done, these age-old practices may be suitably blended with the modem scientific technologies to make the system more effective for achieving sustainability in agricultural production.

EXISTING PROBLEMS OF NUTRIENT MANAGEMENT AND INDIGENOUS SOLUTIONS

Sinking of deep tubewells for irrigation during late sixties in many districts of the state has brought about substantial increase in crop yield. In many places the deep tubewell water, however, contains lot of soluble iron. Because of continuous irrigation with this water a widespread problem of Fe-toxicity occurs in rice fields, where young rice seedlings often turn yellowish in colour. To combat this problem, farmers mix raw cowdung with irrigation water in application channels and apply it to rice fields. Such practices are found to lessen the severity of Fe-toxicity problem. It is believed that the soluble Fe in irrigation water when comes in contact with the suspended cowdung, it gets inactivated either due to adsorption or chelate formation and can no longer cause toxicity to rice seedlings

INDIGENOUS PRACTICES AND PRESENT RELEVANCE OF THE TECHNOLOGY ADOPTED BY THE FARMERS

The old practices, which are even now followed by farmers in different parts of the state, are described below:

Fallowing

An indigenous practice is still followed for cultivation of an excellent variety of winter chilli (bigger size, erect, perfectly red and with thick skin) in north Bengal particularly in the district of Dinajpur (South). In this case, the crop is grown in kharif fallow without use of any chemical fertilizer. It is believed that fallowing alone can regenerate soil fertility at an optimum level for harvesting good quality produce. It may be mentioned that chilli (locally known as ***citi*** and cz'//z) produced in kharif fallow are in great demand in the market because of its high quality.

Use of sawdust in acid soils

Acid soils occur extensively in the districts of the northern part of the state, where productivity is low due to the adverse effects of soil acidity. Poor farmers of this region, who cannot afford to use lime, use saw-dust, which is locally available and also cheap to ameliorate the soil acidity related problems and thus to increase the productivity of their land. They apply it to soil at the rate of about 50 to 100 kg per hectare once in 2-3 years before the onset of monsoon depending on the local availability of the materials. It is believed that the saw-dust itself or their partially decomposed products can reduce the adverse effects of soil acidity such as Fe and A1 toxicity by binding their ionic forms and thus inactivating them. It also improves the physical conditions particularly water - holding capacity of the soil.

Use of raw coyvdung

Soils of different districts of north Bengal are light (sandy) in texture and low/ deficient in nutrients. The poor farmers apply about 3-4 t raw cowdung per hectare while puddling the land before transplanting rice seedlings. As a result of decomposition of applied cowdung, nutrients are also released to the soil. It also increases water - holding capacity of soil and thereby decrease the leaching losses of nutrients. All these positive effects result in an increase in the yield of rice.

Use of common salt for coconut

Coconut trees need high quantity of K. Use of common salt (NaCl) at the time of planting coconut saplings and also almost in every year is a common age-old practice in the state. On an average, one ser (900 g approx.) is applied per plant. The Na in NaCl may replace non-exchangeable form of K from soil sites and make it available to the plants. This is how use of salt is beneficial to the trees. This practice has been in use since long before the fertilising value of KC1 was known.

Use of khari-laban for rice

Quite often the rice plants in the field turn yellowish in colour and the growth becomes stunted. The farmers in the district of Murshidabad since long are known to call the malady by a local term ***"'Paki-legechhey".*** This malady in all probability is due to inadequate supply of readily available nitrogen. To rectify the problem, they use an indigenous material called "Khari-laban", a salt like material @ 1-2 ser per bigha (1 bigha = 0.113 ha) which is procured from north Bihar and Nepal by scraping some fallow land there. This "Khari-laban" is believed to have KNO, as one of its ingredients, which acts as a source of readily -available nitrogen.

Karan (ploughing over standing rice crop)

Over a vast area of land in the coastal areas in the district of Midnapore, rice is grown as deep-water paddy. Rainwater stagnates in the low-lying coastal areas due to poor drainage condition and the depth of water sometimes attains a height of 4-8 feet. Farmers sow the crop as direct seeding with a relatively higher seed rate well before the start of monsoon. As rice grows, the water depth also increases; no fertiliser is applied, because of the attendant difficulties. When the crop attains about one feet height, farmers go for a light ploughing of the field with cattle drawn ***desi*** plough. This operation of ploughing over the standing rice plants under submergence is called ***'''Karan".*** Yield of rice with ***"Karan"*** is found to be higher than that without it. It is hypothesised that the ***"Karan"*** operation besides helping in weeding and thinning excess plant population also augments nutrient release from subsoil. This practice is followed in other low- lying flood prone areas also of the state.

Use of tank silt

Use of tank silt (dried bottom mud of tanks/ponds) in crop and plantation crops is an age-old popular practice in the state in general and in the western part in particular. During summer months the village ponds are dried by pumping out water in a rotation once in an interval of 5-10 years for the purpose of deepening the pond. When the bottom mud gets fairly dried it is dug out, transported by bullock carts to crop fields and it is directly applied to the plantation crops like banana, mango, bamboo bush etc. which are planted on the embankment of the pond. It is believed that the longer the period of interval between two successive drying of the ponds, the better (as to its nutritional values) is the quality of the tank silt produced by a pond. Besides, the darker the colour and the lighter the weight per unit volume the richer is the tank silt in nutrients. The darker colour and the lighter weight signify the presence of large amount of humidified organic matter. When applied to the crop field it not only supplies nutrients to crops but it improves the soil texture and structure owing to the presence of a good amount of organic matter and clay.

In some places where both FYM and tank silt are used, farmers usually take the FYM to their fields in cartload during summer months and dump it there in the form of small heaps scattered all over the field. They cover up the heaps with tank silt and keep it as such till it is mixed with soil at the time of puddling. If the FYM is kept in the field exposed to open sun a lot of N is likely to be lost from the manure, while keeping the heap covered with tank silt may check the loss of N from manure heap and thus help in maintaining its manurial quality.

Replacement of surface soil with tank silt

In the Hooghly district, many cultivated fields have become less fertile due to continuous cropping coupled with high inputs use. The surface layer of soil of those fields is sold out to the brick-manufacturers, which they use for brick making. The excavated field is later filled up with tank silt from nearby sources. Such replacement of the impoverished top soil with tank silt rejuvenates the field and brings back to productive. Besides, the farmers also earn some money by selling the surface soil of their unproductive land, which may compensate for the loss of one crop season.

Use of decomposed animal carcasses

In many villages some wastelands usually located outside the village are earmarked for disposal of animal carcasses. A series of pits are dug, which are filled up with carcasses and covered with mud to facilitate decomposition of the dead body. After few months the pits are uncovered and the decomposed corpses are taken out for use in crop fields as manure which is considered to be rich in nutrients.

Use of old straw thatches

Most of the farmers in the villages live in mud-houses usually thatched with rice straw. After a period of 3-4 year the rice straws of the roof usually lose their utility because of their getting partially oxidized and decomposed, when these are removed and replaced with new straw. The old materials are stacked in a suitable open comer of the farmhouse and kept as such for another season for further decomposition when they become very brittle and can easily be turned into powdery material. These materials are considered as ideal organic manure and are preferred by farmers for growing vegetable crops particularly brinjal, chilli and other ***solanaceous*** crops without use of any fertilizers.

Use of mohua oilcake

Mohua trees are available in plenty in the district of Midnapore. After extracting oil from the seeds, the cake remained is sometimes mixed with rice seeds before they are sown in the field for direct seeding. Mohua oilcake is also used extensively in fishponds particularly to kill predators before they are stocked with fingerlings of commercial fishes.

Lathyrus as paira crop with rice

Rice fields in the coastal areas of the state including the Sunderbans delta suffer from high water stagnation/flooding almost every year. Application of chemical fertiliser under this situation is not possible. Farmers of this area hence, apply only FYM or compost and sow direct seeded rice before the onset of monsoon. By the time water stagnation/flooding occurs, rice plants attain sufficient height. Nutrient released from the organics on decomposition/mineralisation provide nutrients for the crop. When floodwater recedes and rice crop almost matures, farmers broadcast ***Lathyrus*** (khesari) in the moist field. This system of crop culitvaiton is called paira cropping . ***Lathyrus*** being a legume fixes N from the atmosphere and enriches the soil. It is believed that the cultivation of ***Lathyrus*** spp. also increases the friability of soil and prevents the accumulation of salt in the surface layer of the soil in the field. Incidentally, formation ofhardpan in rice fields in this zone is of common occurrence and it is one of the main constraints against introducing sunflower or any other salt tolerant crop in this saline zone of the state. This age-old practice namely organics - rice - ***Lathyrus*** system maintains the fertility of soil and provides sustainability in yield in the area for generations together.

Utilization of jute leaf falls for rice

Jute followed by rice is one of the most common cropping pattern practiced in the new as well as old alluvial soil zones of West Bengal. With this cropping pattern, fanners hardly use any fertilizer particularly basal dose to rice. After harvesting jute, fanners usually keep the plants on their fields for about a week for partial drying of the plants and shedding off of all leaves on the ground. At the time of land preparation for the following rice crop, the leaves are incorporated into the soil and the field is kept as such for a week before transplanting rice seedlings. When the incorporated jute leaves get decomposed, they contribute at lest 10-20 kg of nitrogen per hectare depending upon the yield of jute crop. This is believed to be sufficient to harvest a good crop of rice.

Summer ploughing for kharif rice

In many districts of the state where the land remains fallow during summer months prior to the kharif rice cultivation, fanners give a light ploughing in their fields with ***desi*** plough just after a northwestern shower. It is observed that such practice helps to increase the yield of the following kharif rice. Because of the ploughing, the weed population in the field is checked which helps to maintain soil fertility at a higher level for the rice. Besides, this operation may accelerate decomposition of soil native organic matter and thus facilitates release ofN from organic pools, which is subsequently utilized by rice. Further, such summer ploughing causes a lowering of energy requirements for puddling operation before transplanting of rice and may therefore lessen the demand for labours at peak period of their requirements for cultivation of the crop. There is a similarity between this practice and the practice of "soil solarisation".

Use of ash

Ash, particularly from rice husk and cowdung cake is an important material for agricultural use in the state. Farmers use it in the seedbeds to raise seedlings of rice, brinjal, onion, cucurbits, gourds etc. It is considered that the ash provides nutrients particularly Si and K and imparts friability to the seedbed soil which facilitates germination of seeds and also the easy uprooting of the seedlings. The spread of ash provides a thin cover over the seeds sown and thus protects them from the damage caused by birds. Moreover, the ash is often used for spreading on the leaves of the vegetable crops, which protect the plants from the attack of insect pests, particularly

jassids and red beetles. There is also a belief that if the ash is spread on bhindi plants, the fruits become straight and not oblique possibly due to better nutrition and/or less pest/disease attack. This improves the marketability of the produce.

Use of water hyacinth for cultivation of vegetable crops

Use of water hyacinth for cultivation of pointed gourd, bitter gourd etc. is a common practice followed by farmers of the districts of Nadia, Hooghly, 24-parganas (N) etc. Its use in potato cultivation is also common in the district of Malda. Farmers cover hills/rows of planted seeds/cuttings/tubers of the crops with a layer of water hyacinth. It is believed that such cover acts as mulch and regulates the soil temperature of the hills/rows and helps to conserve soil moisture, which facilitate germination/ sprouting of seeds/cutting/tubers etc. On decomposition, water hyacinth plants add organic matter and some nutrients to the soil for the benefit of the growing crops.

Use of riverbed soil for vegetable crops

The riverbed/charland is generally used for cultivaiton of some summer vegetable crops when water recedes . In north Bengal the farmers dig pits on riverbed when water recedes, fill them up with dried stubbles, herbs, shrubs and rice straw etc. and bum them to ashes. With a short shower or with addition of water they sow seeds of watermelon in those pits and harvest a good crop without use of any fertiliser. The ash is supposed to cause an increase in the fertility of the soil in the pits on the riverbed. In some places (Bankura and Purulia district) the farmers, however, collect the riverbed soil and broadcast it to their fields with the belief that it contains lot of essential plant nutrients.

Night keeping of sheep herds

Owners of big herds of sheep roam from place to place like nomad to feed their animals through grazing during lean season when there is no crop in the field. The local farmers invite the herd owners to keep their herd on their fields at night and pay them some money for that. During their stay at night, lot of excreta of sheep both solid and liquid fall on the field and it increases fertility and productivity of the field. The practice is quite popular among the farmers belonging to the districts of Burdwan and Hooghly.

Use of bone meal

Use of bonemeal to kharif rice @ 10-15 ser per bigha is a practice followed almost throughout the state wherever the material is available. It is known that this material is a rich source of phosphorus and its application increases yields of crop in phosphorus deficient soils.

Use of forest litters in the hilly areas

In hilly areas of the state farmers use only organics as a source of plant nutrients. Farmers dig pits and fill them up with FYM and forest litters. They leave the pits as such for a few weeks to allow decomposition of the organics and grow vegetables like cauliflower, cabbage and other cole crops in the pits. However, for growing maize they broadcast FYM, compost etc. to the fields, mix them thoroughly with soil during land preparation and then sow the maize seeds. Such application of organics alone proves to be sufficient for a good harvest of the crop.

Ginger is an important cash crop in the hilly region, which is grown following ridge and furrow method. In the furrow uprooted plants of ***Lantana*** spp., are spread and covered up with soil followed by application of a layer of cowdung. The rhizome of ginger is sown in the ridges. Such practice of using ***Lantana*** spp. and cowdung as organics provides sufficient nutrients to ginger plants for a good harvest. However, for citrus, compost of leaf mold is used in the pits at the time of planting of saplings. Subsequent application is done once in a year.

Use of sewage and sludge

City compost, night soil, sludge and sewage water are used by the vegetable growers around the metropolitan city of Calcutta. These wastes on decomposition release nutrients to the soil, which are considered to be adequate to meet the needs of vegetable crops. The farmers also use sewage water for aquaculture. Before stocking the ponds with fingerlings farmers let in sewage water from high-drain into their ponds. The sewage water is very rich in nutrient and, therefore, encourages an abundant growth of planktons and other food organisms for good growth of fish. After the harvest of fish, they discard the impoverished water by draining it out from the ponds and recharge them with fresh sewage water. By this way farmers get benefit out of the sewage water of city for years together.

Some other interesting age-old practices of nutrient management for crops, still followed in different parts of the state, are enlisted below:

- Use of spent up battery (torch) (possibly a source ofZn and Mn) and rice husk ash at the base of coconut tree
- Use of day-old thin watery like gruel of rice (“baci faan”) to the base of bottle gourd plants
- Use of fish meal, fish-scale and other waste materials of fish at the base of lemon tree
- Application of used tea-leaf at the base of lemon tree
- Use of soil of old earthen walls of dilapidated mud-houses for growing vegetables
- Use of blood meal particularly for Mahogany, rubber tree and also in potato
- Use of bonemeal in deep water paddy
- Use of twig of ***Ipomoea*** spp. as green leaf manure
- Use of organics in lowlands in preference to uplands under limited supply situations

The inventory of different indigenous practices followed by the farmers in the different parts of the state of West Bengal for integrated nutrient management indicates that most of them are primarily centered on the use of organics in different forms as available at different locations. These include mainly FYM, compost, leaf mold, sewage sludge, night soil, fish meal, tank silt, old straw, green manuring, leaf manuring etc. Besides, ingenuity in pattern of land use and crop rotation such as fallowing, paira cropping has proved to be helpful for maintaining nutrients in soils in a sustained manner for years together without any deterioration of the production system. These practices are, however, location specific and socially and culturally related to the way of life of the fanners of the respective areas where productivity of land is comparatively low and the fanners can not afford to use any costly input. These practices are also very difficult to be quantified since the quantity and quality of the indigenous materials used in these practices vary widely and accordingly attempt to have a quantitative importance of the various practices in nutrient management becomes almost futile. Understanding the scientific principles behind the use of these indigenous practices may increase their efficacy and become helpful in achieving sustainable productivity of farmland.

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CHAPTER 21

INDIGENOUS TECHNOLOGY FOR NUTRIENT MANAGEMENT IN ASSAM

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ABSTRACT

Indigenous technology for nutrient management in soils of Assam is vital for exploiting the natural resources of the state in a bid to sustain agricultural production and to protect the environment. Some of these technologies date-back to time immemorial and are still in vogue in many parts of the region due to strong belief of the farming community. However, due to decline in land to population ratio, these indigenous technologies need to be upgraded to achieve desired result per unit of land area. What really needed is the critical review of these various indigenous practices, and then blend with innovative ideas after proper verification, so that these technologies become eco-friendly, sustainable and cost - effective for promoting agricultural production of the region.

Rice occupies a significant position in Assam Agriculture. Residue management in wetland rice is important in the context of Fe-toxicity which becomes very critical in presence of highly reducing organic substances in soil. Fresh cowdung has multifaceted use namely, for conservation of soil moisture in light-textured soil and for mobilization of nutrients in the wetland rice. Another promising material is water hyacinth having multipurpose use. On one hand, it is used as mulch for rabi crops and later on its incorporation helps in building soil fertility and organic matter status for the next summer crop; on the other hand, it is used to produce high quality compost. The practice of relay cropping with winter rice also holds promise in the nutrient management and moisture conservation for summer crop.

Assam is situated in the sub-tropical humid zone with an average rainfall of 2,355 mm per annum. Soils of Assam are mostly acidic in reaction. Rice is the principal crop in Assam. The average productivity of rice is given in Table 1. Agriculture in Assam is basically weather dependent, so the stability of rice production is sharply influenced by the extent, time and distribution of rainfall. After 1980's, the newtechnologies ***viz.,*** high yielding variety (HYV), fertilizer, irrigation, pesticide ***etc.,*** have played an important role in the agricultural production.

Table 1 Average productivity of different rice culture

Rice culture	Area occupied (million ha)	Productivity (kg/ha)
Summer ***ncc(Bao)***	0.128	1,619
Autumn ***rice(Ahu)***	0.639	839
Winter rice ***(Boro)***	1.805	1,513

Source: (Anonymous 1996)

The rainfall in Assam is high, but its distribution over space and time is not uniform. During pre-monsoon months (March-May) 24.7% of the rainfall is received but its intensity and distribution are very erratic and unpredictable. The maximum rainfall (65.2%) occurs during June to September. During October and November rainfall is low (7.4%), whereas the period from December to February is practically dry with 63 mm rainfall.

The floods are recurring feature affecting rice production in Assam. On an average, 0.5 million ha of ***Sali*** rice is damaged by floods every year. The drought is another inhibitory feature affecting the rice production. The erratic rainfall distribution often creates drought spells during crop establishment period or the vegetative growth period. In the dry season also, the drought spell occasionally affects the ***Boro*** crop during February and March. Apart from the rainfall, an unpredicted Hood and drought, overcasting of clouds and low temperature affect the productivity of rice crop in Assam.

BACKGROUND INFORMATION

Agro-climatic zones

Based on rainfall, terrain and soil characteristics, Assam has been broadly delineated into the following six agro-climatic zones (Fig. 1). These are 1) North Bank Plains (NBP), 2) Upper Brahmaputra Valley Zone (UBVZ), 3) Central Brahmaputra Valley Zone (CBVZ), 4) Lower Brahmaputra Valley Zone (LBVZ), 5) Barak Valley Zone (BVZ) and 6) Hill Zone (HZ). Physiography, soil, climate, crops and cropping patterns (agricultural practices) vary greatly from zone to zone leading to diversity in constraints and opportunities for agricultural production

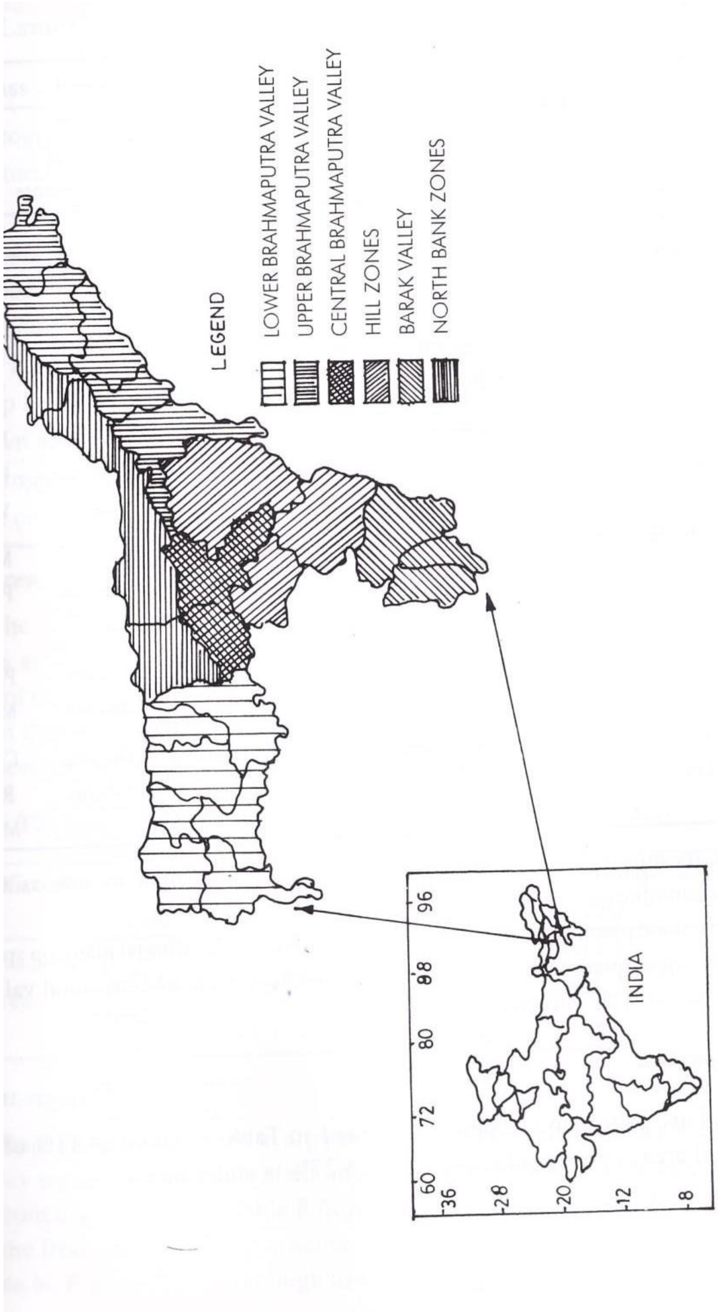

Fig. 1 Agro-climatic zones of Assam

Table 2 Features of Agro-climatic zones of Assam

Zone	Area (km²)	Annual Rainfall (mm)	Physiography	Cropping intensity (%)	Kharif cropped area (%)	Kharif crop in order of importance	Rabi crop in order of importance
NBP	14,421 (18.37)	2,741	Afp, yap, pp. sh	121.9	79.4	*Sali* rice, *Ahu* rice. Jute	Mustard. Pulses, Wheat
UBVZ	16,013 (20.40)	2,042-2,739	Afp, yap, oap, pp. sv, dh. sh	107.1	88.5	*Sali* rice, ,4/iu rice	Mustard. Wheat
CBVZ*	5,561 (7.08)	1,129-1,795	Afp, yap, oap, dh, sh	125.0	81.6	*Sali* rice, *Ahu* rice, Jute	Mustard, Pulses. Wheat
LBVZ	20,222 (25.75)	1,616-3,000	Afp, yap, upp, lpp, dh	130.9	80.5	*Sali* rice, *Ahu* rice, Jute	Mustard. Pulses
BVZ	6.962 (8.87)	3,227-3.500	Afp, yap, up	133.8	88.8	*Sali* rice. *Ahu* rice	Pulses/ Mustard
HZ	15,222 (19.39)	1,200-1,622	Afp, yap, sv, dh. sh	105.0	80.2	Hill rice, *Sali* rice	Cotton, Rapes & Mustard

*30% of its area falling under rain-shadow belt has a rainfall as low as 600 mm. Values in parentheses indicate % of state area

Afp : active flood plain, yap : younger alluvial plain, oap: older alluvial plain, pp: piedmont plain, upp : upper piedmont plain, lpp : lower piedmont plain, sv : structural valley, dh : denudational hills, sh : structural hills

Land Use pattern

Land use pattern in Assam is presented in Table 3. About 54.11 % of the total geographical area is under cultivation and 25.27% is under forest.

Table 3 Land Use/Land Cover Data for Assam

Use Class	Area (ha)	Total area (%)
Total geographical area	78,52,300	100.00
Agricultural land	42,48,639	54.11
Forest	19,84,449	25.27
Waste land	3,15,664	4.02
Water bodies	5,57,180	7.10
Shifting cultivation	7,44,937	9.49
Mining area	1,428	0.02
Built-up land	21,147	0.27
Net sown area	27,81,000	34.42
Total cropped area	34,60,082	44.06
Double cropped area	14,87,041	-

Forest area

The forest cover in the state which is fairly consistent with the national norm, measures an area of 3,071 thousand ha including unclassed forests accounting for 39 per cent of the geographical area (Table 4). The extent of coverage including unclassed forests in the plain is 60.68%, while in the hills it is 39.32%. Incidentally, unclassed forests account for nearly 29.92% of the total forest area in the state.

Table 4 The classification of forest in the state (Area in '000 ha)

Classification	Reserve dforest	Proposed reserve forest	Unclasse dforest	Total
General area	1395.2	120.6	347.5	1863.3
Hill area	347.1	289.0	571.3	1207.5
Total	1742.3	409.6	918.8	3070.8

Nutrient status

Soils of Assam are rich in organic matter and the fertility classes vary widely in the valley region due to their varied physiographic situations. In general, available N varies from high to low, available P from medium to low and available K from high to low in the Brahmaputra valley; whereas in the Central and Lower Brahmaputra valley available N, P and K vary from high to low. Sedentary soils of Assam are rich in total and easily reducible, exchangeable and available Mn. These soils contain fairly high amount of total Zn and low levels of available B and Mo which again decrease with depth. These soils generally contain high amounts of total and available Cu, whereas B and Mo are deficient almost in all acid soils of Assam due to leaching.

Demographic feature

The population of Assam according to the estimate of 1991 Census is 22.29 million and ranks 13th position in the country. Rural population constitutes 88.92 per cent of the total indicating thereby slow growth of urbanization. The literacy percentage is 61.87 and 43.03 for male and female, respectively, with an average of 52.89 for the state.

Land holding

The average size of operational holding in Assam is 1.27 ha as against the national average of 1.69 ha. The distribution of operational holding in the state is characterized by predominance of small and marginal farmers and inequality in ownership of operational holdings. The per capita income of Assam at constant price (1980-81) is Rs 3971 per adult per year.

Livestock

Livestock population and dung production in Assam are given in Table 5. About 57.89 million tonnes of dung is being produced per annum from 22.21 million livestock population.

Table 5 Category-wise livestock and dung production

Category	Livestock population (million)	Dung production (million t/year)
Cattle	7.28	43.67
Buffalo	0.62	7.13
Sheep	0.06	0.03
Goats	2.14	. 0.82
Horses and Ponies	0.01	0.12
Pigs	0.64	0.41
Poultry	8.46	4.23
Ducks	2.99	1.50
Total	22.21	57.90

Crops and Cropping systems

The basic feature of cropping in Assam is the predominance of cereals where rice occupies a major position, occupying about 75 per cent (2.572 million ha) of the total cropped area. Rice in Assam has been grouped into four major cultural types ***viz., Ahu, Sali, Bao*** and ***Boro*** (Duara 1974, Watable ***et cil.*** 1980, Borkakati ***et cil.*** 1997) based on the combinations of the land and hydrological characteristics, the maturity duration of the rice genotypes, the length of the growing season and the growingconditions. ***Sali rice*** is grown as a transplanted crop between June and December, where crop establishment entirely depends on the rainfall and the general hydrological conditions in the area (Phukan 1992). ***Ahu*** or autumn rice is an important cultural type on small farm holdings in high and medium lands with shallow water depths at the time of maturity. It may be sown by broadcasting using the traditional cultivars or may be transplanted using the intermediate to short duration high yielding varieties of rice. Broadcasting is done in March-April and the harvesting in July-August. The transplanted ***Ahu*** seeds are sown in March-April, transplanted in April-May and harvested in July-August. The ***Bao*** rice is the deep water or floating rice. As in the ***Ahu*** rice the dry seeds of the ***Bao*** rice are broadcast in March-April on the land that becomes dry during February and harvested during November-December, The ***Boro*** rice is transplanted in very deep areas or the peripheries of the perennially wet natural depressions and marshy lands, mostly with zero tillage or minimum tillage. The crop is sown during October- November, transplanted during December-January and harvested in April-May.

About 80 per cent population of Assam is dependent on Agriculture. Farmers follow the rice based cropping systems ***viz.,*** rice followed by toria/mustard, pulses (black gram, mung, pea, bengal gram ***etc.),*** jute, wheat, maize ***etc.*** This is, however, mostly practised in medium land situation. In marshy lands ***Boro*** rice can be grown in the ***rabi*** season. Irrigation is necessary for ***Boro*** cultivation. In typical medium lowland or lowland situations with heavy textured soils monocropping with rice ***(Sali*** rice) is prevalent.

The harvest of ***Sali*** rice precedes the ***Bhogali*** or ***Magh Bihu*** which is celebrated with a community feast with new harvest sometime in the middle of January. This is followed by ***Rongali*** or ***Bahag Bihu*** in the middle of April coinciding with the Onset of spring season, in which the nature wears a festive look and the farmers give a holy dip to their cattle/bul locks in rivers/ponds to make them ready for cultivation of rice in the ensuing season. Another 5Z7?M is celebrated in the month of October ***viz., Kongali bihu*** coinciding with the flowering/grain-filling of rice, wherein farmers put a light in their respective fields to protect their crops from insects. They also put a branch of a plant in the center of a field as a plateform for the insect eating birds.

Chemical fertilizer use

So far as use of pesticide is concerned, barring the tea gardens its use in Assam is low due to cost factor as well as environmental concerns. The fertilizer consumption of the state is as low as 13 kg/ha as against the all India average of 90 kg/ha. The low fertilizer consumption in Assam is mainly due to the following reasons :

- Agricultural practices are largely in the hands of marginal and poor farmers.
- Risk involved in fertilizer use due to uncertainty of rainfall particularly during pre-monsoon and winter seasons, as area under irrigation is only 17%.
- High rate of leaching of nutrients during the rainy season.

INDIGENOUS NUTRIENT MANAGEMENT AND SCOPE OF BLENDING THEM WITH MODERN TECHNOLOGIES

Indigenous technologies traditionally being followed for nutrient management, with scope for blending some of them with modem technologies are given below : ***Incorporation of crop residue***

a) Crop residues left after harvest of ***Sali*** rice are ploughed into allow sufficient time for decomposition thereby helping in recycling of nutrients for the next crop.

b) For decomposition of residues of ***Autumn***rice, the farmers' practice in certain areas involves application of fresh cowdung (about 300 kg/ha) to the soil during land preparation for ***Sali*** rice.

Scientific base: Ten kilogram of N in the form of urea per ha may be suggested, which is by and large half of the N from fresh cowdung to improve upon the technology for early decomposition of crop residues before transplanting of ***Sali*** rice. An investigation is of course needed to substantiate this effect of lowering down the C:N ratio for decomposing the material substituting of organic N with readily available inorganic N source.

Spitting as indicator of nutrient status

Spitting after chewing of arecanut with betel-vine and lime on puddled soil indicates pH of the soil. If the spit turns ***deep black*** in contact with puddled soil, it indicates ideal physical condition for transplanting of rice seedlings and optimum condition from the standpoint of nutrient availability.

Water hyacinth

i) In low lying areas, water hyacinth floating on flood water are dried and burnt in the field before the next summer crop for enrichment of K. fertility and to facilitate ploughing. This is a common practice across the state. Water hyacinth is also used for composting with fresh cowdung in pit size of about 2.5m (length)x2m(breadth)xl.5m (depth) in upland situation.

ii) Water hyacinth is a popular mulch material for conservation of soil moisture for “Maghi” potato cultivation (var. local) sown during January first week and harvested by the of March. After harvest of potato the material is incorporated into soil to build up soil organic matter and to maintain fertility.

Scientific base: Use of urea (about 3 kg) plus SSP (about 2 kg) may be tried for upgradation of technology. This technology may be upgraded by application of fertilizers

based on soil test values.

Burning of residue

In deep water rice *(Bao)*, long residues are burnt after harvest during dry period to increase K. content of soil and to facilitate ploughing besides controlling nematodes *(Ufra* disease) and insects/pests. This practice is in vogue in Barak valley, LBVZ and NBP.

Efficient crop combinations

Sowing of direct seeded upland rice *(Ahu* rice) with some seeds of *Hibiscus subdariffa (var.* local) (Tengamara) helps in mining of nutrients by the latter from lower soil depths, thereby helping in maintenance of surface soil fertility through incorporation of foliage of the deep-rooted *Hibiscus* spp. This practice is followed mostly in CBVZ and LBVZ after every 3-4 years interval. In jute-rice sequence also, rice is benefitted from jute following the mining of nutrients by the latter from lower depths and later incorporation of its foliage in the soil.

Application of fresh cowdung

A suspension of fresh cowdung with water when sprayed over light-textured soil, followed by light pulverization helps in conservation of soil moisture and in supply of important nutrients to the crops. This practice is followed mainly in *char areas* dominated by light textured soil for growing various *rabi* crops. About 2 kg of fresh cowdung in 5 litres of water is generally used for the purpose.

Scientific base:A. systematic study involving application of DAP with fresh cowdung is needed to improve upon the technology. Application of fresh cowdung in lumps for at least thrice into the submerged rice field in the early stage of crop supports luxuriant crop growth and crop yield and is well supported by experimental findings of AAU, Jorhat. Activation of microbial growth and high temperature of standing water *probably help in mobilizing the nutrients to rice at the time* wfien the requirement maximum. Effect of timing and frequency of fresh cowdung application need to be investigated forupgradation of technology.

Application of Farmyard manure (FYM)

Well decomposed FYM applied with oilcakes to *rabi* crops minimises insect pest attack and builds up soil fertility. This practice is prevalent elsewhere subject to the availability of material mainly oil cakes. In case of potato this is practised to minimize the attack of red ants.

Relay cropping

Relay cropping of pea *(Pisum sativum)* or khesari *(Lathyrus sativa)* with *Sali* rice helps in exploiting soil nutrient reserves at a time when the nutrient removal by rice declines (flowering stage), and thereby facilitates the requirement of soil fertility forthe next summer crop (Plate 1). This practice is prevalent in about 10% rice growing area of the state.

Plate 1 : Relay cropping of pea with sali rice

Use of wood ash/fish wash

Top dressing of wood-ash on rapeseed and mustard at the stage of flowering dispels aphid infestation and increases K content in soil. Soil application of fish-wash to gourds, citrus, cucumber *etc* is said to increase nutrient contents with special reference to N, P as well as K, along with increase in crop yield. This practice helps in reducing the fertilizer requirement of crops. This is a general practice in the rural areas in the homesteads/kitchen gardens.

Plant acuipuncture

In cucurbitaceae family, splitting of the basal portion of the stem with a thorn of citrus prevents the uptake of excess nutrients from the soil, thereby arresting the vegetative growth of the plant and facilitating the entry into the reproductive phase.

Use of char of river bed for vegetables

For management of sand deposit from recurring flood water in char areas, farmers dig a hole in shallow deposit of sand and put a bamboo structure therein to prevent sand fall. Then grow crops like cucurbits directly in the original soil for exploiting its natural mineral reserve.

Practice of walking between rice rows to mitigate iron toxicity

In Assam iron-toxicity is a problem in some areas in rice ecosystem particularly under lowland condition as well as under rainfed situation. The problem is associated in acid soils with enhanced Fe solubility, low available P and K content and in presence of highly carbonaceous crop residues incorporated into soils prior to land preparation for ***Sali*** rice. Besides managing P and K nutrition, the farmers' practice for controlling the disorder involves walking down the paddy field or running down a paddy weeder between the lines to facilitate aeration and to get ferrous iron oxidized to ferric iron. This makes iron insoluble and unavailable to rice. As a result, intake of metabolized form of $Fe^{2+}$is reduced and the extent of iron toxicity decreases (Plate 2). As stated by fanners of LBVZ comprising Nalbari and Borpeta districts of Assam, more than 50% disordered plants recovered within 3-4 days following the practice of walking between the lines.

Plate 2: Iron toxicity (left) and recovery (right) in sali rice after indigenous treatment

For upgradation of technology, about 10kg K/ha may be top ; at the time of development of bronzing symptoms in older leaves as per the rec; namendation of AAU, Jorhat.

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V

COASTAL ECOSYSTEM

CHAPTER 22

Indigenous nutrient management practices - wisdom alive in India Acharya C L,
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INDIGENOUS TECHNOLOGIES OF NUTRIENT MANAGEMENT FOR KONKAN REGION OF MAHARASHTRA

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ABSTRACT

Sustainable agriculture is ideally based on integrated nutrient supply system including use of chemicalfertilizers, organic manures, crop residues, other recyclable materials and biofertilizers. Konkan region of Maharashtra state is the 19"' zone of agroeco- region of Maharashtra state with coastal ecosystem and is blessed by nature with plentiful renewable organic resources. Before adoption of new modern technologies of nutrient management in rice, ragi, vari, mango, coconut, arecanut, sapota and cashew, the people were fully dependent on indigenous nutrient sources including crop residues and animal wastes/by-products before 1975. Studies were, therefore undertaken to know the socio-economic aspects and the present status of extent of use of organic manures and chemical fertilizers in some parts of the region where the farmers are following indigenous nutrient management technologies. The existing nutrient management problems of the region are observed to be many, resulting in poor soil fertility and low crop production. Due to poor economical conditions and credit facilities the farmers are adopting there own practices of nutrient management taught by their forefathers, which include recycling of crop residues, animal wastes/by-products, forest by-product and marine wastes. The various ways for blending the indigenous technologies with modern technologies for improving soil fertility and sustainable crop production are, therefore suggested, in this paper.

The introduction of high-yielding varieties and intensive cultivation with increased use of chemical fertilizers and improved irrigation techniques has resulted in spectacular increase in yield of crops. The recent energy crisis and consequent price hike of fertilizers and purchasing power of the farming community have again renewed interest in organic recycling throughout the world. An integrated approach to plant nutrient management gained momentum and importance in recent years with an objective to integrate the judicious and economic use of all the major sources of plant nutrient such as soil, mineral, organic and biological in a manner so as to get maximum economic yield from a particularcrop or from a cropping system.

Continuous use of organic manures helped in maintaining and improving soil properties and gave higher crop yields compared to application of chemical fertilizers alone in permanent manurial trials (Singh 1998). It is now sufficiently clear that a good progress can be achieved by efficient recycling of locally available resources (Mehta and Talashilkar 1997, Tandon 1995). The time is now riped to look back into the indigenous technologies for blending with latest modem scientific techniques, which can form soundfooting for sustainable agriculture.

Studies were, therefore undertaken on socio-economic aspects of the farmers, existing problems of nutrient management and indigenous solution adopted by the farmers from

Konkan region of Maharashtra, which is categorized under Agro- ecological region No. 19 and described as western Ghats and Coastal Plain, hot humid per-humid eco-region with red, lateritic and alluvial derived soils and growth period 2 10 + days with coastal ecosystem.

MATERIALS AND METHODS

The details of methodologies used for conducting various studies are narratedbelow:

Study No. 1

The study was conducted in Sindhudurg district with an object to understand the various aspects of extents of use of manures and fertilizers including types of fertilizers used, per hectare rate of nutrient application, time and methods of application by rice growers. The personal and socio-psychological characteristics of the rice growers were considered as independent variable while the extent of use of fertilizer was considered as a dependent variable. The details of the methodology followed were discussed by Kesarkar (1985).

Study No. 2

The study was conducted in raigad district having maximum area (31,800 ha) under coastal saline soils. One hundred forty one respondents were interviewed for knowing the various aspects of use of manures and fertilizers in coastal salt affected soils. The methodology used was detailed by Hatiskar (1985).

Study No. 3

A survey of one hundred twenty five-mango growers from Deogad tahsil receiving good harvest of Alphonso variety was conducted for knowing the quantity of various types of organic manures used for mango. The per cent distribution of the Farmers was estimated by simple arithmetical calculation.

Study No. 4

In order to know the existing nutrient management problems and the indigenous solution, five hundred farmers scattered all over the villages from four districts were interviewed personally. Some of the quantitative data regarding nutrient content of organic manures, effect of organic manures on yield of arable and horticultural crops, etc. were collected and documented by the senior author while working in Operational Research Projectand National Demonstration Scheme during 1983 to 1993 (Anonymous 1989, 1990 and 1992).

BACKGROUND INFORMATION

Location

The Konkan region of Maharashtra comprises Thane, Raigad, and Ratnagiri and Sindhudurg districts forming narrow strip running north to south along the western coast of India. This region lies between 15°37'to 20°27'N latitude and 70°7' to74°13' E longitude. The width towards north is about 100 km and it is 20 km towards south. All the four districts are surrounded by Sahyadri hills to the east beyond which there are boundaries of six districts of western Maharashtra region. Gujrat state is located towards north, Arabian Sea to the west and Goa to the south. It has a coastal line of 720 km.

Topography

The Konkan is divided into three natural zones from the point of view of topography viz: i) The coastal zone which is marked by rice cultivation on low lying areas and plantation of mango on hill slopes, coconut and arecanut along seacoast, ii) the plateau surface which is used for cereal crops like rice, ragi etc, and cashewnut on hill slopes, iii) the hilly zone includes ranges of Sahyadri on the eastern boundary with highly uneven natural surface and are agriculturally poor, however, possessing good forests.

Climate

Konkan has three seasons i) the summer from March to June; ii) the rainy season from June to middle of October and iii) the winter from middle of October to end of February, and it receives average rainfall of 3000 mm. Humidity is high throughout the year ranging form 65 to 95 per cent. The variation in temperature during the day and through the season is not large.

Maximum temperature at the sea coast rarely goes beyond 38° C and in the interior it seldom crosses 40°C.

Area and Population

Comparative statistics of area and population of the region districtwise for the year 1994-95 is given in Table 1. Total geographical areas of the Konkan is 30042.5 sq. km with 5352 total number of villages in the region. The total population of the region is 94.5 lakh. The proportion of rural population is low (59%) in the region compared to average rural population in Maharashtra (61%).

Table 1 Comparative statistic of area and population of the region district wise for the year 1994-95

SI. No.	Particulars	Maharashtra	Konkan	Thane	Raigad	Ratnagiri	Sindhudurg
1.	Area (sq. km)	307710.0	30042.5	9558.0	7148.0	8249.0	5087.5
2.	No. of towns and cities	336	54	23	19	8	4
3.	Number of village						
	a) Inhabited	40412	5773	1679	1851	1515	73.6
	b) Unhabited	2613	79	18	57	4	-
	c) Total	43025	5852	1697	1908	1519	736
4.	Rural population	48396000	5527000	1856000	149600	1406000	769000
		(38.69)	(58.48)	(35.36)	(81.97)	(91.06)	(92.42)
5.	Urban	30542000	3923000	3393000	329000	138000	63000
	Population	(38.69)	(41.51)	(64.64)	(18.03)	(8.94)	(7.57)
6.	Total population	7893000	9450000	5249000	182500	1544000	832000
		(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)
7.	Density of population	257	1155	549	255	187	164
8.	Population of SC&ST	16076000	1596000	1223000	285000	42000	46000
		(20.36)	(16.88)	(23.29)	(15.61)	(2.72)	(0.90)
9.	Literacy percentage a)						
	Male	76.60	79.10	77.55	75.94	76.64	86.23
	b) Female	52.30	57.74	60.28	52.20	51.61	66.87
	c) Total	64.9	68.00	69.54	63.95	62.70	75.81

Land Utilization

Land utilization pattern in Konkan region for the year 1994-95 is given in Table 2. The distribution under different categories of land utilization indicated that the proportion of barren and uncultivated land is very high (18%) in comparison to those from Maharashtra (Table 2). This has reduced the new sown area considerably to only 28 per cent in Konkan. The proportion of area under forest is also high (18.9%), thus indicating more availability of recyclable forest residues and by-products.

Table 2 Land utilization pattern in Konkan region

SI No.	Particulars	1 <onkan	Thane	Raigad	Ratnagiri	Sindhudurg
1.	Total Geographical area	29790 (100.00)	9337 (100.00)	6869 (100.00)	8164 (100.00)	5040 (100.00)
2.	Forest	5541 (18.60)	3538 (37.89)	1600 (23.29)	57 (0.70)	331 (6.57)
3.	Barren and unculturable land	5339 (17.92)	676 (7.24)	1284 (18.69)	2308 (28.27)	998 (19.80)
4.	Land under non-agril. Uses	1932 (6.48)	892 (9.55)	490 (7.13)	134 (1.64)	205 (4.07)
5.	Culturable land	3838 (12.92)	408 (4.37)	381 (5.55)	1344 (16.46)	1688 (33.49)
6.	Permanent pasture and other grazing land	1192 (4.00)	648 (6.94)	399 (5.81)	138 (1.69)	1 (0.01)
7.	Land under miscellaneous tree crops and groves not included in net area sown	472 (1.58)	59 (0.63)	225 (3.27)	69 (0.84)	119 (2.36)
8.	Current fallows	549 (11.84)	111 (1.19)	145 (2.11)	280 (3.43)	11 (0.22)
9.	Other fallows	2531 (850)	107 (1.114)	4459 (6.68)	1346 (16.50)	597 (11.84)
10.	Net area sown	8386 (28.15)	2898 (31.03)	1886 (27.46)	2487 (30.46)	1090 (21.63)
11.	Total cropped area	9114 (30.59)	3056 (32.73)	2174 (31.65)	2581 (31.61)	1278 (25.36)

Livestock and poultry

The Livestock and Poultry population (1994-95) for Konkan region is given in Table 3. The livestock statistics indicated that the number of cattle per 100 hectares of total area is 62 in the Konkan region. The percentage of buffaloes to total livestock is 21. The goat and sheep rearing is not very common in this region.

Table 3 Livestock and poultry population

SI.	Particulars	KonkanNo.	Thane(No.)	Raigad (No.)	Ratnagiri (No.)	Sindhudurg(No.)
1.	Total Cattle	1863610 (61.16)	385287 (41,18)	482286 (59.52)	564324 (78.41)	257519 (61.97)
2.	Total buffaloes	651134 (21.37)	1179387 (19.17)	173703 (21.38)	90058 (12.51)	113850 (27.40)
3.	a) Total sheep	16950 (0.55)	505750 (16.60)	696 (0.07)	204739 (21.88)	887 (0.10)
	b) Total goat	152805 (18.81)	47 (0.006)	65233 (9.06)	74 (0.01)	51085 (12.30)
4.	Horses and ponies	3660 (0-11)	465 (0.04)	1327 (0/16)	27 (0.003)	0 (0.00)
5.	Total livestock	3046904 (100.00)	935516 (100.00)	812108 (100.00)	719689 (100.00)	415528 (100.00)
6.	Poultry	6731518	1731179	1473173	138886	890926
7.	No. of cattle per 100 ha of total area	62	41	70	69	51

(Figures in parentheses are percentages to total livestock)

Fishery

The marine fishing is practiced all over the coastal line of 720 km in all the four districts. Total marine fish production during 1995-96 was 2.22 lakh tonnes and a number of seafood canning units are coming up in the region. As 50 per cent portion of any fish is treated as waste and bony and unedible species are not consumed, a lot of fishery waste is available for conversion into enriched organic manures.

Gobar gas plants

Number of Gobar gas (Bio-gas) plants (1995-96) available in different districts is given in Table 4. The total number of Gobar gas plants, utilizing animal dung for gas production installed in the region are 45,736 which are about 11 per cent of the total biogas plants installed in the state.

Table 4 Number of gobar gas plant

SI. No.	District	No. of gas plant
1.	Thane	19571
2.	Raigad	400
3.	Ratnagiri	12207
4.	Sindhudurg	13558
5.	Konkan	45736
6.	State	4415012

Major crops grown and area occupied

Major crops grown and area occupied by them in the region (1994-95) is given in Table5. Rice and ragi are two major crops of the region occupying 50.7 per cent and 7.2 per cent oftotal cropped area, respectively. The proportion of area under food grains is 67.1 per cent.

Table 5 Major crops and area occupied by them

Sl.NO	Particulars	Konkan	Thane	Raigad	Ratnagiri	Sindhudurg
1.	Rice	4621 (50.70)	1532 (50.13)	1461 (67.61)	816 (31.61)	812 (63.53)
2.	Ragi	659 (7.23)	197 (6.44)	122 (5.61)	286 (11.08)	54 (4.22)
3.	Total cereals	5659 (62.09)	11843 (60.30)	1679 (77.23)	1257 (48.70)	880 (68.85)
4.	Total pulses	430 (4.71)	210 (6.87)	102 (4.69)	46 (11.78)	72 (5.63)
5.	Total food grains	6115 (67.09)	2045 (66.91)	1803 (82.93)	1319 (51.10)	948 (74.17)
6.	Coconut	81.87 (0.90)	3.72 (0-12)	9.15 (0.42)	13 (0.50)	56 (4.38)
7.	Total edible oilseeds	33 (0.36)	5 (0.16)	5 (0.22)	23 (0.89)	0 (0.00)
8.	Mango	414 (4.54)	13 (0.41)	34 (11.56)	194 (7-51)	173 (13.53)
9.	Cashewnut	193.92 (2.12)	N.A. (2.12)	2.74 (0.12)	31.51 (1.22)	158.67 (12.41)
10.	Total fruits and vegetables	870 (9.54)	107 (3.50)	56 (2.57)	293 (11.35)	414 (32.39)
11.	Fodder crops	2763 (30.31)	1688 (52.23)	293 (13.47)	719 (27.85)	63 (4-93)
12.	Total food crops	6809 (74.70)	2140 (70.40)	1752 (80.58)	1537 (59.55)	1380 (107.98)
13.	Total non-food crops	3079 (33.78)	1760 (57.59)	310 (14.25)	816 (31.61)	193 (15.10)
14.	Total cropped area	9114 (100.00)	3056 (100.00)	2174 (100.00)	2581 (100.00)	1278 (100.00)
15.	Net sown area	8386	2896	1886	2487	1090
16.	Cropping intensity	108.68	105.45	115.27	103.77	117,22

(Figures in parentheses are percentages of total area)

The proportion of area under fruit and vegetable crops in the Konkan region (9.5%) is higher than that of Maharashtra (2.5%). The proportion of area under fodder crops is also more (30.3%). However, the region lagged behind in the area under oilseeds. Cropping intensity of the region is 108.7 per cent. Among the districts, the highest intensity is in Sindhudurg district (117.3%) (Tadakhe 1999).

Production of major crops

The percentage share of production of rice (41.0) and ragi (39.4) crops is very high. However, it is only 1.45% in case of pulses in comparison to those in the state. The percentage share of Konkan region in the total production under of coconut and cashewnut in Maharashtra is 100.0 and 98, respectively.

Area irrigated by different source

The total net area irrigated in the region is 48,400 hectare constituting only 5.87 per cent of the net area, the highest being in Sindhudurg district (19.6%) while the percentage of irrigated area of total cropped area is very low i.e. 5.3 per cent, again the highest in the Thane district (16.74%). About 4.71% of net area sown is under surface irrigation where 1.06 is under well irrigation.

Fertilizer consumption

The fertilizer consumption for the year 1994-95 is given in Table 6. About 35,716 tonnes of NPK fertilizer were consumed in the region (Table 6). Average per hectare fertilizer consumption in the region was 39.2 kg showing very low consumption in comparison to fertilizer consumption in the state of Maharashtra (64.6 kg). The per cent consumption of fertilizer was the highest in Raigad district (48.46 kg), followed by Sindhudurg district (44.31 kg), while it was the lowest in Ratnagiri district (28.30 kg).

Table 6 Fertilizer consumption in different districts (tonnes)

Sl. No.	Particular	Konkan	Thane	Raigad	Ratnagiri	Sindhudurg
1.	N	26998 (3.09)	9569	8449	5748	3232
2.	P	5523 (1.60)	1738	1436	875	1475
3.	K	3195 (1.91)	905 (0.54)	652 (0.40)	682 (0.41)	956 (0.57)
4.	Total NPK	35716	12212	10537	7305	5663
5.	Consumption of fertilizers (kg) per hectare of gross cropped	39.18	39.96	48.46	28.30	44.3

(Figures in parentheses are percentage to total of Maharashtra)

Use of manures and fertilizers in heavy rainfall lateritic zone

A study was conducted in a representative area of Sindhudurg district of Konkan region to understand the various aspects of the extent of use of manures and fertilizers by the rice growers; such aspects as types of fertilizers used and rates, time and methods of application of fertilizers.

a) *Extent of use offertilizers:* For studying the extent of use of fertilizers by the respondents, a scale was developed. The responses were quantified by assigning suitable scores. The extent of use score for individual respondent was worked out. On the basis of this score, the respondents were grouped into three categories as shown below :

Sl.No.	Extent of use of fertilizer	Respondents	
		Number	Percentage (n=145)
1.	Low extent	36	24.82
2.	Medium extent	71	48.96
3.	High extent	38	26.22

It is observed that majority of the respondents (48.96%) were using the fertilizers to the medium extent while 26.22 per cent of the respondents were using the fertilizers to the high extent. About one-fourth of the respondents (24.82%) were using the fertilizers to the low extent.

b) *Types of fertilizers used:* The distribution of the respondent into broad categories made on the basis of types of fertilizers is given below :

SI. No.	Extent of use of fertilizer	Respondents	
		Number	Percentage (n=145)
1.	Organic manure	115	79.3
2.	Nitrogenous fertilizer	105	72.4
3.	Complex fertilizer	66	45.5
4.	Mixed fertilizer	51	35.2

It is observed that majority of the respondents (79.3%) were users of organic manures whereas 72.4 per cent respondents were users of nitrogenous fertilizers only and 45.5 per cent respondents were users of complex fertilizers. Only 35 per cent respondents were users of mixed fertilizers.

c. *Combination of manures andfertilizers used:* The respondents were found using manures and fertilizers in various combinations. Further, it is observed that maximum number of the respondents (30.34%) used the combination of organic manure + nitrogenous fertilizers + complex fertilizers,while 21.37 percent respondents used thecombination of manures + nitrogenou s fertilizers +mixedfertilizers. It is alsoobserved form the data thatequal number ofrespondents (7.59%) were user of organic manures alone and organic manures + nitrogenous fertilizers. The combinations of organic manure + mixed fertilizers and organic manures + complex fertilizers were also used by the equal number (6.21%) of the respondents. Of the respondents, 4.14 per cent each were users of nitrogenous fertilizers alone and mix fertilizers alone. Distribution of respondents according to the combinations of manures and fertilizers used is as under:

SI. No.	Extent of use of fertilizer	Respondents Ni imber	Percentage (n=145)
1.	Low extent	36	24.82
1.	Users of organic manures	11	7.59
2.	Users of nitrogenous fertilizers	6	4.14
3.	Users of mixed fertilizers	6	4.14
4.	Users of complex fertilizers	5	3.45
5.	Users of organic manures + nitrogen fertilizers	11	7.59
6.	Organic manures + mixed fertilizers	9	6.21
7.	Organic manures + complex fertilizers	9	6.21
8.	Nitrogen + mixed fertilizers	5	3.45
9.	Nitrogen + complex fertilizers	8	5.51
10.	Nitrogen + organic manure + mixed fertilizers	31	21.38
11.	Organic manure + nitrogen + complex fertilizers	44	30.34
12.	Total		100.00

Use of manures and fertilizers in coastal salt affected area

It was observed that 94.53 per cent of the farmers were applying either organic manures or chemical fertilizers or both to the rice crop, while 5.37 per cent of the farmers were not applying manures and/or chemical fertilizers to rice crop.

It is further observed that 41.84 per cent of the farmers were applying only organic manures to rice crop while 41.14 per cent of the farmers were applying both organic manures as well as chemical fertilizers. About one-fifth (17.02%) of the farmers were applying only chemical fertilizers to rice crop.

Among the users of organic manures (n=117), 95.73 per cent of the farmers applied cow dung, while 4.27 per cent of the farmers applied cow dung and fish meal to rice crop. The average quantity of organic manures applied to rice crop was 5.57 cart loads per hectare, while the users of chemical fertilizers had applied NPK to the tune of 56:2:2 kg per hectare (Hatiskar 1985).

Users of organic manures to fruit crops

Distribution of mango growers according to the type of manures/fertilizers used to the adult tree (> 15years) is given below:

The results of survey of 125 mango growers revealed that 75 per cent of the farmers were usersof organic manures prepared from indigenous sources.

SI. No.	Type of manure/fertilizers	No. of growers	Quantity/tree (kg)
1.	No use of manures	2(1.60)	-
2.	Green leaves with other manures	39(31.20)	25.50
3.	Cowdung	4(3.20)	10.50
4.	Sheep droppings	41(32.80)	21.01
5.	Fish meal	3(2.40)	11.09
6.	Poultry manure	1(0.80)	10.00
7.	Bone meal	2(1.60)	12.31
8.	Groundnut cake	2(1.60)	4.67
9.	Mixed organic manures	2(1.6)	10.00
10.	Straight fertilizers	7(5.60)	8.00
11.	Mixed fertilizers	19(15.20)	7.43
12.	Complex fertilizers	3(2.40)	11.00
13.	Total	125	

EXISTING PROBLEMS OF NUTRIENT MANAGEMENT

A number of problems of nutrient management existing in the region are narrated below:

1. Socio-economic problems

a) Lack of awareness of the doses of fertilizers to be the applied

b) Non-availability of fertilizers when needed,

c) Poor infrastructure.

2. Edaphic factors

a) Losses of nutrient from soil due to leaching and fixation

b) Losses of nutrient form soil due to surface runoff and volatilization under intense precipitation

c) Acidic reaction of lateritic soils

d) Land situation

e) (i) Slopy land

Low lying areas resulting in waterlogging

(ii) Coastal land resulting in salinity

f) Poor physical properties

Some of the problems experienced by rice growers were quantified and the data are given below:

SI. No.	Constraints	Respondents	
		Number	Percentage (N=123)
1.	Non availability of fertilizers when needed	94	76
2.	High cost of fertilizers	85	69
3.	Lack of knowledge regarding use of fertilizer	56	46
4.	Unaware of the doses of fertilizers	33	27
5.	Non-availability of quality manure and fertilizers	16	13
6.	Higher doses of fertilizers required to be used	14	11
7.	Clumsy and time consuming procedures of borrowing of money or loan	11	9

Source : (Kesarkar 1995)

From the data presented above, it is observed that, in the opinion of majority of the rice growers non-availability of fertilizers when needed (76%), high cost of fertilizer (69%) and lack of knowledge regarding use of fertilizers (46%) were the major constraints in the use of fertilizers, non-availability of quality fertilizers, higher doses of fertilizer required to be used and clumsy and time consuming procedures in borrowing the crop loans were reported by the rice growers in the order of their importance.

INDIGENOUS SOLUTION AND PRESENT RELEVANCE OF THE TECHNOLOGY ADOPTED BY THE FARMERS

Use of animal bedding material for preparation of compost

Animal bedding of 1" to 2" thick of the local grass and sawdust is spread. This material absorbs urine. The bedding material comprising uneaten portion of the grass and rice straw is used for compost making in the pits of suitable size. This facilitates faster decomposition of organic residues and enriches final compost products. ***Soaking of animals urine in rice husk and bran***

A small pit is dug outside the cowshed for collection of animal urine. Rice husk and bran are allowed to absorb animal urine. After sundrying the enriched materials, solid product is used for manuring of rice and pulse crops.

Use of goat and sheep droppings

The farmers collect goat droppings from farm, waste lands and animal sheds. After drying, the excreta is ground into powder form and then used for application by broadcasting, spot application or band placement.

Sheep is not a pet animal in this region. Hence the farmers invite flock keepers of sheep from upghat area i.e. Pune and Satara districts during the months of October to May. A flock of 500 animals is allowed to graze for a period of 2 days in one-acre area and a farmer pays an amount of Rs. 200/- to a flock keeper.

Spraying of fresh cowdung suspension on foliage of vegetables

A suspension of cowdung is prepared in a container and spread over the green foliage of vegetables like chilli, brinjal, tomato, etc. which leads to an increase in yield of said crops by 10 to 25 percent as reported by the farmers.

Use of fish by-products/residues

The non-edible fishes and the byproducts of fishes are allowed to decompose in ash from chullaha for a period of 3 to 6 months in closed chambers of bricks coated with mud. The well-decomposed fish meal (fish kuti) prepared by this method is then applied to transplanted rice and to the fruit crops. Farmers have experienced significant increase in yield of the various crops.

Application of night soil

It is an age-old practice to collect night soil from open latrines and to apply it directly to the field or after proper decomposition in the pits of suitable size prepared at the outskirts of the villages. An average nutrient composition of night soil is as follows; N -1-3%, P_2O_5 - 0.7% and K_2O-0.5% (on oven dry basis).

Use of excreta of bats

This is collected from bats colonies from the big trees of banyan existing in wastelands. Bat excreta is mixed with ash and then applied to the fields before sowing of vegetable seed or applied as top dressing.

Green manuring

The traditional green manure crops used in the region are: Bhend, Kudza, Rui, Takla, Nivdung, Bagvel etc. Two common methods followed for their applications are as follows:

1. Spreading of green leaves and tender twigs before puddling in rice fields.
2. Ring method: In this method a channel is dug around the periphery of the tree at a radius of around one metre depending upon the crown size of the tree. The green leaves and tender twigs are buried in the channel and the same are covered with thick layer of soil. This method is followed for plantation crop like mango and coconut.

Use of coconut and arecanut by-product for composting

Coconut being a perennial tree crop produces large quantities of leaves, flower stalks, spates, petioles besides husk and pith. These materials are rich in plant nutrients and the recycling of these by-products of coconut adds considerable quantity of organic matter to soil. Since above mentioned by-products are resistant to decomposition, they are allowed to soften by various ways such as mulching, soaking in shallow ponds and are then used for composting.

Use of leaf litter for horticultural crops

The common plantation and horticulture crops grown in the region are mango, cashew, jackfruit, kokum etc. while the forest species grown are teak, shivan, ain, kinjal etc. The dried leaves of the said crops are mixed together and used for compost making along with some quantity of cowdung. Another way of nutrient recycling is to bury the leaves of above-mentioned trees in the trenches dug around the tree in the trenches of respective crops.

Use of edible and non-edible oilcakes

Coconut cake, mahua cake, karanj cake, undi cake are commonly used for manurial purpose besides their pesticide properties after extraction of oil. Coconut is grown extensively along the coastal belt of the region, while mahua, karanj and undi trees are being grown in forest areas of the region. They are known to have very good manurial value.

Use of ash

Ash is prepared by burning of dried leaves of horticultural crops and forest trees and crop residues like straw, stalk, stubble, husk etc. of the field crops like rice, pigeon pea and mustard.

The following methodologies are used for application of ash:

1. Ribbing: It is a practice of *in-situ* burning of organic matter and raising of rice seedlings. The seedlings raised by this method are observed to be healthy and free from weeds.
2. Direct application of ash before sowing seed of the crops.
3. Mixing of ash with fertilizers and placing 1" to 2" deep into soil.

Use of local earthworms for in-situ decomposition of residues

This techniques is followed for the crops like sapota, coconut and vegetables grown on organic sources nutrients.

Use of seaweed

The farmers residing on the seashore collect the seaweed from the seashore and use it for manurial purpose to coconut and arecanut crops. About 20 per cent increase in yields was reported by the users of this type of organic manure.

Use of sodium chloride (NaCl)

It is a common traditional practice to apply sodium chloride @ 1 to 4 kg per tree of mango and coconut crops. No doubt the foremost purpose is to prevent the attack of some soil borne pests like termites, ants etc., the reporting fanners have noted considerable increase in yield of nuts from the palms.

Mixed cropping of cereals with pulses

The seed of black gram, a nitrogen fixer is sown after transplant of seedlings of hill millets like finger millet (ragi), vari etc. The proportion of the seed used is 8 (finger millet): 2 (black gram).

Fallowing

The land is kept fallow for a period of 2 to 3 years after following a crop rotation of ragi followed by vari and niger.

The districtwise distribution of above-mentioned technologies is enlisted below:

Thane district

A. Use of animal bedding nutrient for preparation of compost.
B. Soaking of rice husk and bran in animal urine.
C. Spraying of fresh cowdung suspension on foliage of vegetables.
D. Use of night soil.
E. Use of coconut and arecanut by-products for composting.
F. Use of non-edible oil cakes.
G. Use of local earthworms for *in-situ* decomposition of residues.
H. Mixed cropping of cereals with pulses.

Raigad district

A. Use of animal bedding material for preparation of compost.
B. Soaking of rice husk in animal urine.
C. Use of goat and sheep droppings.
D. Spraying of fresh cowdung suspension.
E. Use of night soil.
F. Use of water hyacinth for green manuring.
G. Use of coconut and arecanut by products for composting and *in-situ* application.
H. Use of forest leaf litter for mulching.
I. Use of ash for raising seedlings in rice nursery.
J. Fallowing of land.

Ratnagiri district

A. Soaking of rice husk and bran in animal urine.
B. Use of goat droppings.
C. Application of fish by-products/residues.
D. Use of night soil.
E. Application of green manure crops.
F. Use of coconut and arecanut by-products for composting.
G. Use of leaf litter for horticultural crops.
H. Use of edible and non-edible oil cakes.
I. Use of ash.
j. Use of local earthworms for *in-situ* decomposition of residues.
K. Use of sodium chloride.
L. Mixed cropping of cereals with pulses.
M. Fallowing of land.

Sindhudurg district

A. Soaking of rice husk and bran in animal urine.
B. Use of goat and sheep droppings.
C. Application of fish by-products/residues.
D. Use of excreta of bats.
E. Use of indigenous green manure crops.
F. Use of arecanut and coconut by-products for composting.
G. Use of leaf litter, horticultural and forest trees for composting and *in situ* application.
H. Use of edible and non-edible oil cakes.
I. Application of ash.
J. Use of seaweed.
K. Use of sodium chloride.
L. Mixed cropping of cereals with pulses.

UPGRADATION OF INDIGENOUS TECHNOLOGY WITH LATEST SCIENTIFIC TECHNIQUES

The work should be conducted to identify the soils and crops most responsive tothe indigenous sources of nutrients

Studies were conducted to assess the amount of excreta and nutrients added in soil due to allowing a flock of sheep in the field for a period of 2 days in an acre/land. The details of amount of excreta and nutrients added in soil due to this practice are given below:

1. Quantity of sheep droppings added in one acre : 400 kg
2. Quantity of sheep urine dropped in one acre : 250 kg
3. Quantity of nutrient added in one acre :
    a) Nitrogen : 60 kg
    b) Phosphorus : 20 kg
    c) Potassium : 10 kg

The results of the experiments conducted on the research farms of the region also indicated possibility of 50 per cent saving in chemical fertilizers recommended to rice crop with the use of fish manure (Table 7).

Table 7 Effect of fishmeal alone and in different combination with mineral fertilizer onyield (t/ha) of rice

Fishmeal level (t/ha)	Levels of recommended dose of fertilizers(NPK)			
	0%	50%	100%	Mean
0	2.97	3.36	4.61	3.65
1	3.42	4.19	5.56	4.40
2	3.88	5.67	6.98	5.50
3	5.30	7.05	7.36	6.57
Mean	3.90	5.07	8.18	
C.D. (P=0.05)	M=0.2l	F=0.18	FXM = 0.11	

Recommended dose of fertilizer: N - 100, P,O_S - 50 & K,0 - 50 kg/ha

Studies conducted with poultry manure also revealed favourable response to this source of organic manure (Table 8).

Table 8 Effect of poultry manure alone and in different combination with inorganicfertilizer on dry pod yield (t/ha) of groundnut

Fertilizer Level (F)	Poultry manure (PM) in t/ha				Mean
	0	1	2	3	
F0	1.47	1.81	1.96	2.04	1.82
F50	1.83	1.96	2.27	2.78	2.21
F100	2.01	2.16	2.49	2.88	2.39
Mean	1.77	1.98	2.24	2.57	2.14
	Fertilizer	Poultry Manure	Fertilizer x Poultry Manure		
CD (P=0.05)	0.02	0.02	0.03		

FO, F50 and FI00 represent 0, 50% and 100% recommended doses of N (25 kg/ha) and P(50 kg/ha)

Source; (Talashilkar ez a/. 1998)

Development of fast growing high N fixing green manuring crop varieties under diversed climatic and soil crop situations

Nutrient composition of indigenous green manure crops was determined in one of the studies and the same are given in Table 9.

Table 9 Nutrient composition (%) of indigenous green manure crops

Name	Scientific name	Nitrogen	Phosphorus	Potassium
Blend	*Thespasia populnea*	2.19	0.45	1.02
Kuda	*Holorrhena Antidysentrica*	2.10	0.60	0.80
Rui	*Colotropis procera*	1.80	0.85	0.80
Taka	*Cassia tor a*	1.85	0.80	0.82
Nivdung	*Opuntia nigricans Haw.*	1.70	0.30	0.75

The results of some of the replicated trials conducted on fanners' fields on the effect of indigenous green manure crops on yield of rice (Table 10) revealed that the yield of rice increased by 10 to 25 per cent (Anonymous 1992).

Table 10 Effect of green manure application on the grain yield of rice

Treatments	Grain yield (q/ha)
Recommended dose of NPK (100+50+50+ kg/ha)	40.50
50 % recommended dose of NPK + Gliricidia @ 5t/ha	44.86
50% recommended dose of NPK + Bhend @ 5t/ha	42.64
50% recommended dose of NPK + Kuda @ 5t/ha	43.58
50% recommended dose =of NPK + Shivan @ 5t/ha	42.20
CD (P=0.05)	5.10

Source : (Anonymous 1992)

Quantification is needed on the effect of incorporated residues on biological Nfixation in soil

The quantity of nutrients added through recycling of coconut byproducts was studied by Pillai and Davis (1963) and the data are given in Table 11.

Table 11 Nutrient addition through recycling of coconut byproducts

Byproducts	Nutrient (kg/ha)		
	N	PA	K_2O
Nuts	9.7	4.4	21.5
Spadices	1.0	0.8	4.2
Spathes	0.8	0.3	0.9
Leaves with sheaths	9.2	5.0	4.2
Total	10.5	10.5	30.8

Source: (Pillai and Davis 1963)

The potential of nutrients of some of the common cakes collected from the region was evaluated by Talashilkar (1998) and the same is given in Table 12.

Table 12 Nutrient content of some of the cakes used in the region

Name of the cake	Nutrient (%)		
	N	PA	K_2O
K.aranj cake	4.0	1.0	1.2
Mahua cake	2.5	0.7	1.5
Neent cake	5.0	1.0	1.0
Undi cake	3.2	1.2	1.5
Coconut cake	3.0	1.5	1.4

Source: (Talashilkar 1998)

The seaweed commonly found in coastal area of the region was found to possess good manurial potential as its average nutrient content is as follows: N-l-5%, P,O_S - 1.0% and KiO-2.2%.

Vermicomposting has to be established on scientific basis. Identification and detection of indigenous strains of worms for vermicomposting and soil inoculation for improving soil fertility should be a priority area

The local species of earthworms identified by the researchers (Patekar 1992) of the university are as follows :

1. *Perionyx* spp.
2. *Hoplochaetella kempi*
3. *Pontoscolex corethrurus*
4. *Hoplochaetella khandallaensis*
5. *Drawida karnarensis*
6. *Metaphire houlleti*

The methods of vermicomposting and large scale production of earthworms are standardized by the researchers (Talashilkar 1998)

Research should he intensified on the proper management and utilization of the residual slurry of the biogas plant

There is a critical need for economic disposal of some of the wastes like coconut shells, rice husk, wastes from sea food canning industry, cashew processing units and fruits and vegetable canning industry etc. The integrated use of these materials with inorganic fertilizers may be helpful to supplement and economize on the latter. This requires development of efficient integrated nutrient supply systems including fertilizers, organic sources and biofertilizers.

In the field of use of night soil, researcher should develop techniques to kill even the most resistant pathogens in a few days. Biological control of pathogens is an area, which holds a lot of promise.

Development and evaluation of low cost farm implements for effective incorporation of green manures and other organic residues in different rice ecosystems.

The nutritional value and other benefits likely to be obtained by the use of common salt be assessed thoroughly. The inferences drawn on the benefits of salt from some of the experiments conducted at C.P.C.R.I, Kasargoad, Kerala (Nair *et al*. 1993) are enlisted below:

Sodium (Na) to certain extent substitutes the role of potassium when K supplies are inadequate.

Chlorine is second most important nutrient next to potassium in coconut nutrition. Leaf analysis revealed that the critical level of Cl in seedlings is likely to be 0.70 to 0.80 per cent.

Salt application results in greater absorption of nutrients, vigorous growth, increase in female flower production, nut yields, copra production and thickness of kernel.

Addition of salt in pits before planting of seedlings results softening of lateritic rock and helps in easy penetration of tender roots.

Palms become resistant to leaf blight.

It carries adequate iodine which is essential for biosynthesis of oil.

The cost of application of K fertilizer is reduced substantially, if 50 per cent dose of K is substituted by NaCl.

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CHAPTER 23

INDIGENOUS NUTRIENT MANAGEMENT TECHNOLOGY IN GOA

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ABSTRACT

Soil organic matter is the key to soil fertility and productivity. The regular recycling of organic wastes (plant and animal) and other cultural practices traditionally handed down from generations is the most efficient and relevant method for maintaining optimum levels of soil organic matter in soils. The removal of NPK nutrients at the present level of crop production has been estimated at 125 kg/ha approximately whereas the annual addition is not more than 75 kg/ha resulting in the depletion of nutrient reserves of the soil. The organic materials most commonly used to improve soil conditions and fertility include farm yard manure (FYM), animal wastes, crop residues, urban organic waste, green manure, biogas spent slurry, vermicompost, sewage sludge etc. The traditional practices involving the conservation and utilization ofplant nutrients in an integrated manner is followed by some of the farmers in the state of Goa even today after the advent of high external input agricultural practices. However, no attempt has so far been made to document the prevailing practices concerning nutrient management or to find the scientific rationale or it's relevance in modern day agriculture. This paper, therefore, makes an attempt to compile and list out some of the traditional practices followed by the farmers in different cropping systems. It is an attempt to document such information and case studies gathered from selected pockets / areas where the transfer of technology projects of the ICAR Research Complex for Goa have been in operation.

Plants require nutrients in order to grow. Some nutrients are supplied by rain and irrigation water, by soil minerals and by micro-organisms living in the soil. The farmers traditionally supplemented these by recycling farm by-products and by crop rotations and intercropping particularly of legumes which fix atmospheric or biological nitrogen with the help of symbiotic bacteria. Western farming gets most of it's fertilizers from the mining of non-renewable sources, a practice which is naturally unsustainable.

In every other traditional practice, the "manures" used by the traditional farmers serve several purposes. They act as pesticides, nematicides, herbicides and also supply organic matter which create a favourable physical regime in the soil. While sufficient nutrients may be initially present in a virgin soil and water, the farming practices remove part of the soil fertility and exports it in harvested produce. Nutrients are also lost from the soil by leaching and soil erosion. Nitrate-nitrogen is also lost by conversion to nitrogen gases (denitrification) while ammonia is lost by volatilization. Such losses were traditionallly made up by recycling the organic wastes and bringing in nutrients from the pastures and forests. Organic matter in soil act as a food source for soil microorganisms which decompose leaf litter, root residues and other compounds into the elements which can easily be taken up by the plants.

Among the various components of organic farming, the composting process that artificially speeds up the natural nutrient recycling process, producing assimiable nutrients in a few weeks. Mulches have the advantage of supporting a wider range of soil microorganisms, of keeping the soil cool, preventing evaporation and erosion and smothering weeds. Live mulching like lab-lab, cowitch, swordbean and jackbean are a few examples. Farm yard manure forms an important component of traditional fanning. Other animal wastes from poultry, sheep, goat serve as a good source of manure. Fish wastes also form an important item in nutrient recycling.

In the Integrated Plant Nutrient Supply System (IPNS) the available organic and biological sources of nutrients which are renewable in nature are utilised alongwith mineral fertilizers in order to benefit from the positive interactions resulting from such integrated use. It has been found that the addition of organic manure over and above the recommended nutrient rates applied through fertilizers has raised crop yields to levels which are not obtained by mere use of chemical fertilizers.

The fertilizer management technology followed under the field demonstrations conducted by the transfer of technology wing of the ICAR has taken cognizance of these age old traditional practices followed by the farming community in selected pockets and emphasized it’s importance and favourable role in crop productivity through extension methodologies like the participatory rural appraisal (PRA) and deciding upon the technological intervention points.

BACKGROUND

The state of Goa, lies between 14° 53' 57" N Latitude and 73° 40' 75" E longitude on the west coast of India. It has a characteristics of warm and humid climate with cool and pleasant weather during the winter months The maximum and the minimum temperatures experienced are 32 °C and 22 °C. The diurnal variation of temperature narrows down during the monsoon months to 4-6 °C with high humidity (90% and above) while the diurnal variation increases to 8-10 °C in the winter months. The diurnal variation of temperature also increases gradually from coastal to interior hilly tracts. The monsoon sets in by first fortnight of June and brings abundant rainfall (2500 mm to 4000 mm) in about 100-120 rainy days till September.

The evaporation is about 6 mm/day during April and May and about 4 mm during other months. The atmosphere is calm without any strong winds for most part of the year except the monsoon months. There is abundant solar radiation during winter and summer months (7-9 hours of bright sunshine) while it is relatively less during the monsoon months due to cloudy weather (3-4 hours of bright sunshine).

The state has an undulating terrain with diverse soils which make it possible to cultivate a wide range of field, plantation and horticultural crops. The major cropping system of the coastal plains include the thick coconut groves that spread intermittently in the rice lands. High elevations and slopes of transitional sub-mountainous region are used for cashew plantations while the small pockets of concave valleys are with a mixed plantation of coconut, arecanut and banana in the periphery and rice in the typical low-lying wet lands in the centre. The interior hilly regions are with natural rain forests at higher elevations. The North east zone is mostly hilly with lateritic soils while soils in the south-west zone and the coastal regions are sandy, marshy and saline.

The soils of Goa are predominantly lateritic and laterite (73.40%) followed by alluvial and marshy (11.70%), sandy coastal (10.11%) and saline (4.79%). The entire territory is underlined by crystalline and metamorphic rocks belonging to the pre- cambrian age which comprises granite, gneisses, metagraywackes, phyHites and meta basalts. These rocks are overlined by laterite, lateritic soils and alluvium, soils are deep to very deep. Majority of soil series are coarse to medium textured soils well drained but with poor water holding capacity. The organic carbon content ranges between 0.5 to 11.5%. The soils are medium in available nitrogen and deficient in available phosphorus and potassium (Venugopal 1986).

The agriculture profession is pursued by about 30-35% of the total population. The geographical area of the state is 3,61,113 ha. The total cropped area is about 1,65,400 ha, of which 40% area is under the grain crops and the remaining 60% area is under the horticultural and vegetable crops. The less fertile uplands, hitherto growing coarse cereals particularly ragi and other minor millets, part of such lands are being gradually brought under the horticultural crops like cashew (Table 1).

Table 1 Land utilization pattern in Goa

SI.	Item	Area (ha)	Percentage to total geographical area
1	Total Geographical area according to land survey	3,61,113	100.00
2	Area under forest	1,05,294	29.16
3	Land not available for cultivation	33,137	9.18
4	Other uncultivable land	79,341	21.97
	I) Permanent pastures and other grazing lands	1,305	0.36
	ii) Land under other miscellaneous tree crops and groves not included in the net sown area	580	0.16
	iii) Cultivable waste (including fallow)	77,456	21.45
5	Net sown area	1,43,341	39.69
6	Area sown more than once	12,249	3.39
7	Gross cropped area	1,55,590	43.08

Unlike other states in the country, agriculture in Goa does not play a very dominant role in the state's economy. The per cent contribution to the state domestic product is hardly about 17% as against it's contribution of around 40% to the national income. Around 38% of the total area is available for cultivation as against the national average of 55%. The percentage of cropped area is 44% compared to the national average of 56%. The land holding of more than 50% farmers is below 0.5 ha both in South and North Goa (Table 2).

Table 2 Districtwise number and area of operational land holdings in Goa

Size class (in ha)	Number of holdings		Area operated (ha)	
	North Goa	South Goa-	North Goa	South Goa
Below 0.5	22,456 (53)	19,193 (58)	5,244 (12)	4,165 (13)
0.5 - 1.0	9,848 (23)	6,702 (20)	6,752 (15)	4,635 (14)
1.0 -2.0	5,883 (14)	4,384 (13)	7,862 (17)	5,889 (18)
2.0 -3.0	1,981 (5)	1,418 (4)	4,656 (10)	3,328 (10)
3.0 - 4.0	748 (2)	473 (1)	2,520 (6)	1,614 (5)
4.0 - 5.0	426 (1)	275 (1)	1,866 (4)	1,200 (4)
5.0- 7.5	430 (1)	364 (1)	2,606 (6)	2,183 (7)
7.5 - 10.0	247 (1)	169 (1)	2,133 (5)	1,442 (4)
10.0 -20.0	197 (-)	229 (1)	2,770 (6)	3,042 (9)
20.0 - 30.0	58 (-)	62 (-)	1,412 (3)	1,477 (4)
30.0- 40.0	24 (-)	6 (-)	837 (2)	213 (1)
40.0 - 50.0	6 (-)	11 (-)	250 (-)	502 (1)
50.0 and above	40 (-)	30 (-)	6,149 (14)	3,372 (10)
Total	42,303 (100)	33,316 (100)	45,057 (100)	33,072 (100)

Note : Figures in brackets indicate percentage to total

Agriculture continues to be the important sector as it supports more than 30-35 % of the total population in the state. However, this sector is confronted with various setbacks and constraints mainly because of tourism, housing and industrialization.

Rice is the principal crop in the state grown in 54625 ha. The following rice based cropping systems are adopted in the state:

Rice - Rice - Pulse

Rice - Groundnut

Rice - Groundnut - Pulse

Rice -Vegetables

Rice - Sweet potato - Pulse

Similarly, under the horticulture, cashew is the major crop with an area of 52204 ha followed by coconut (24788 ha). The state also has other horticultural crops like mango, banana, arecanut and minor fruit crops (Table 3).

Table 3 Total area under principal crops, productivity and total production in Goa state

Crop	Area (ha)	Yield (kg/ha)	Total production (Metric tonnes)
Paddy			
Kharif	41,000	3829	1,57,166
Rabi	14,534	4225	64,087
Total	55,534		2,21,253
Rice			
Kharif	41,000	2553	1,04,779
Rabi	14,534	2817	42,724
Total	55,534		1,47,503
Ragi	2800	899	2,476
Maize	150	4000	600
Pulses			
Kharif	1,000	498	194
Rabi	9,000	746	7,400
Summer	275	746	205

Total food grain production including pulses			1,58,378
Groundnut			
Kharif	350	1471	447
Rabi	1087	1754	2105
Total	1437		2552
Sugarcane	1300	48,000	62,400
Cashew	52,204	100	5220
Coconut	24,788	4841nos	120.00(million nuts)
Arecanut	1,450	1241	1800
Mango	3990	10000	3990
Banana	1875	5680	10,650
Pineapple	300	15000	4500
Vegetables	7550	9200	69,460
Other fruits	5400	12,153	65,628

There are many areas in the state having a mixed cropping or intercropping systems in the coconut and arecanut gardens. Some farmers have also adopted the high planting density models where the nutrient management is practised in an integrated manner with heavy reliance on use of cowdung manure, compost, mulching, neern cake, fish meal, bone meal and even vermiculture.

INDIGENOUS NUTRIENT MANAGEMENT PRACTICES

Lesson from Krishi Vigyan Kendra

The transfer of technology project operated through the Krishi Vigyan Kendra of the Institute has been actively working in some of these areas. The traditional practices and the wisdom of the farmers has stood the test of time and some of the indigenous practices followed are listed below:

SI.	**Village**	**Approx. Area (ha)**	_ - -- - -- - - -
1	Nerul	120-130	Use of FYM / poultry manure Use of fish manure Use of wood ash Crop rotation with legumes

2	Sangolda	65-80	Use of FYM / poultry manure Use of fish manure Use of wood ash Crop rotation with legumes
3	Taliegao	40-50	Use of fish decoction Use of wood ash Use of green manure Use of poultry manure and cowdung
4	Pilar	70-85	Use of pig manure Use of poulrty and fish manure Crop rotation with legumes Use of silt from inland water bodies
5	Amthane	30 -40	Use of wood ash Crop rotation with legumes Use of green manure Use of FYM / compost & poultry manure

Lesson from case studies

A typical rice based cropping system can be seen on the farm of Mr. Minguel Fernandes, a marginal fanner from Taliegao village. On his fanu, rice forms the base crop grown during the kharif season over an area of 0.5 ha followed by vegetables like brinjal in rabi season (Taleigao variety which is a novelty in the state). Another farm of Shri Shripad Palienker of Sangolda village representing the similar cropping system where rice is grown as the base crop over an area of 1 ha followed by groundnut during the rabi season on purely residual soil moisture and a third crop of local cowpea "Alsando" during summer on life saving irrigation.

The nutrient management strategy being followed by these farmers like many other farmers of the locality where sustainable yields are obtained by these farmers by integrating various age old as well as modem methods like composting, use of fish decoction, use of wood ash, green manuring and poultry manure,

Farm 1: Mr. Minguel Fernandes has a typical well dug into his farm where the fish waste is allowed to decompose in water and this decoction is mixed with irrigation water to supply the required nutrients to the rabi vegetables. The use of poultry manure and burnt wood ash also form the integral part of the manuring schedule in Sangolda village. The practice is to apply sufficient quantities of cowdung manure or poultry manure and also liberal of wood ash for rice as well as for groundnut crop. The inorganic fertilizer useis limited and based on the soil test reports the fertilizer dose is kept sub-optimum in these farms thus reducing the input costs. The economic records suggest that Mr. Fernandes harvests 18-20 q paddy from his half hectare farm during kharif fetching hima net profit of Rs 3500/-. He also earns Rs 6000/ during rabi season from brinjal.

Farm 2: The farm of shri Palienker is another typical example of sustainability in production. The fertility level of his farm is maintained by regular use of liberal, quantities of organics supported with optimum levels of inorganic NPK. Shri Palienker on his one hectare farm grows improved rice variety. He gets a bumper harvest of about 48 q of paddy during kharif fetching him a net income of about Rs 8000/-. But his major share of earning comes from groundnut during rabi season. Integrated nutrient management practices which is a result of his own wisdom and KVK interventions fetches him an yield of over 24 q of dry pods with a net income of over Rs 18000/- and the third crop of “Alsando” (cowpea) yield around 6-7 q fetching him net income of about 12000 /ha.

Farm 3: Under the horticulture or coconut/cashew based fanning systems the fann belonging to M/S Narsinmha Plantation located at Sanguem taluka covering an area of 80 acres where crops like arecanut, banana, coconut cashew and spices are cultivated with intercrops.

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Farm 4: Shri Keshav Naik, a progressive farmer has given up the use of chemical fertilizers completely. His nutrient management strategy is the recycling of farm waste by using bacterial culture which he gets regularly from Pune. He has standardized the technology and skill after getting the necessary expertise through the training courses offered by KVK. His farm has the typical nutrient management system which includes mulching with organic waste, use of FYM / compost prepared on his farm, use of green manures from Gliricidia and other locally available shrubs. *In-situ* build up of local species of earthworms and vermicasts around the tree basins is also noticed. Mr. Naik believes that his non adoption of chemical fertilizer has not in any way hindered the handsome profits he gets from his farm which he claims are economically viable and of better quality.

Farm 5: Another typical coconut based and arecanut intercropped farming system can be seen at the farm of Shri Sawaiker, a progressive farmer having his 4 acre farm located at Tamsurli ward of Marcel village of Ponda Taluka. His farm is a typical example of high density plantation of arecanuts with intercrops like banana, pepper, nutmeg, cardamom and other spices. The nutrient management strategy of shri Savoikerhas been the use of compost, green manuring with Gliricidia, “Kinal” and “matti” leaves from the plants which he has grown on the periphery and bunds. He uses liberal quantities of cowdung manure and practices *in-situ* vermiculture as the basins of most of the plants/trees are covered by thick mulch. Mr. Savoiker today gets a gross profit of Rs 75,000/ from one acre of his farm which means a gross income of Rs 3 lakhs/yr and a net income of Rs 1.60 lakhs /yr from his four acre plantation.

PRESENT RELEVANCE OF THE TECHNOLOGY ADOPTED BY THE FARMERS

Farm Yard Manure and Compost

Application of FYM stimulates VAM interactions while short fallows betweenharvesting of one crop and the sowing of the next crop during the rainy season reduces themycorrhizal spores (WaniandLee 1995). Due to dynamic nature of the microbial biomass it quickly responds to the changes in soil management. The soil biota may include a wide range of decomposers, predators and parasites that influence the decomposition process and the structure of the agricultural soils. The crop production efficiency of FYM is about 30 percent that of the fertilizer nutrient on one harvest basis in addition to the non-nutritional benefits it confers on the soil as an organic manure. The other benefit derived by the use of FYM and compost is the supply of micronutrients to the nutrient stress soils, which help in correcting the micronutrient deficiencies besides augmenting the uptake of major nutrients. The farmers of Goa have been using this valuable input in their soil nutrient management practices traditionally. The problem is not so acute in the rural areas where the daily and poultry enterprises as well as gobar gas units invariably find a place in their farming set up. ***Green Manuring***

Though the use of the green manuring in Goa has been an age old practice, it's importance has been eroded in recent years.

In Goa, the most commonly used green manuring crops include Dhaincha *(Sesbania aculeata), Cassia hirsuta, Gliricidia sepium, Leucaena leucocephala* and also other wild species like *Cassia tora, Calopogonium mueunoides* and some shrub trees like *Cassia auriculata, Calotropis gigantea* and *Pongamia pinnata.*

The contribution of nitrogen from the leguminous green manure crops is well documented (Yadav and Agarwal 1961, Kanwar ***el*** *al.* 1968, Singh *et al.* 1991). The accumulation of nitrogen ranges from 25 to 338 kg/ha for many legumes bearing root nodules and 9.8 to 532 kg/ha for the stem nodulating green manuring crop like *Sesbania rostrata.*

Crop rotation

Following the monoculture over long periods, the crop yields start declining after few years despite the continued adoption of standard cultural and agronomic practices. Soil sickness denotes the condition of soil at which the yield reduction sets in. Soil sickness related problems have been reported in the monocultures of rice, greengram, cowpea etc. Major factors responsible for soil sickness are :

- Unbalanced use of plant nutrients and micro-nutrient deficiencies
- Destruction of soil physical properties
- Multiplication of phytopathogenic microflora
- Disproportionate development of several groups of microflora
- Increased infestation of pests and weeds
- Changes in soil pH
- Accumulation of phytotoxins during the decomposition of crop residues and root exudates

Good crop rotation maintains the crop productivity, controls the pest and overcomes soil sickness or autotoxicity in crops. Crop rotation corrects the problem of soil sickness which arise from monoculture (Patrick and Koch 1963). Crop rotation ameliorates soil conditions and overcomes problems such as accumulation of phytotoxins in soils, multiplication of phytopathogenic soil microflora, increased incidence of pests and destruction of soil physical properties (Narwal 1994).

In Goa, it is a common practice to see the rice based cropping systems with the inclusion of root nodulating legume crops like groundnut, pulses, cluster bean which has helped the soil to add biologically fixed nitrogen in rice lands. The ICAR Complex has also introduced cover crops and nitrogen fixing plants like *Mimosa* spp. for use in the coconut gardens with multiple uses like smothering of the weed growth in the interspaces of widely spaced horticultural crops. Similarly, the use of bio-fertilizer in crops like groundnut and cowpea has resulted in better nodulation and yield increase in groundnut to the tune of 27% over control (no chemical fertilizers) and 11.4% over plot with recommended fertilizer. In case of cowpea, the respective increase has been 25% and 8.6%, respectively.

BLENDING THE TRADITIONAL PRACTICES WITH MODERN TECHNIQUES AND UPGRADATION OF THE TECHNOLOGY

An overview of the integrated farming practices followed in the state suggests that there is a need to scientifically document the contribution of organic inputs as well as balanced use of chemical fertilizers to raise the per unit productivity levels of most of the crops. The yields realised from organically maintained farms can be further enhanced by the balanced combination of organic manures as well as inorganic fertilizers so as to enable the farming community to meet the growing demand of food and other agricultural produce in the state without affecting their quality.

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CHAPTER 24

INDIGENOUS TECHNOLOGIES FOR NUTRIENT MANAGEMENT - EXPERIENCE OF FARMERS OF COASTAL KARNATAKA

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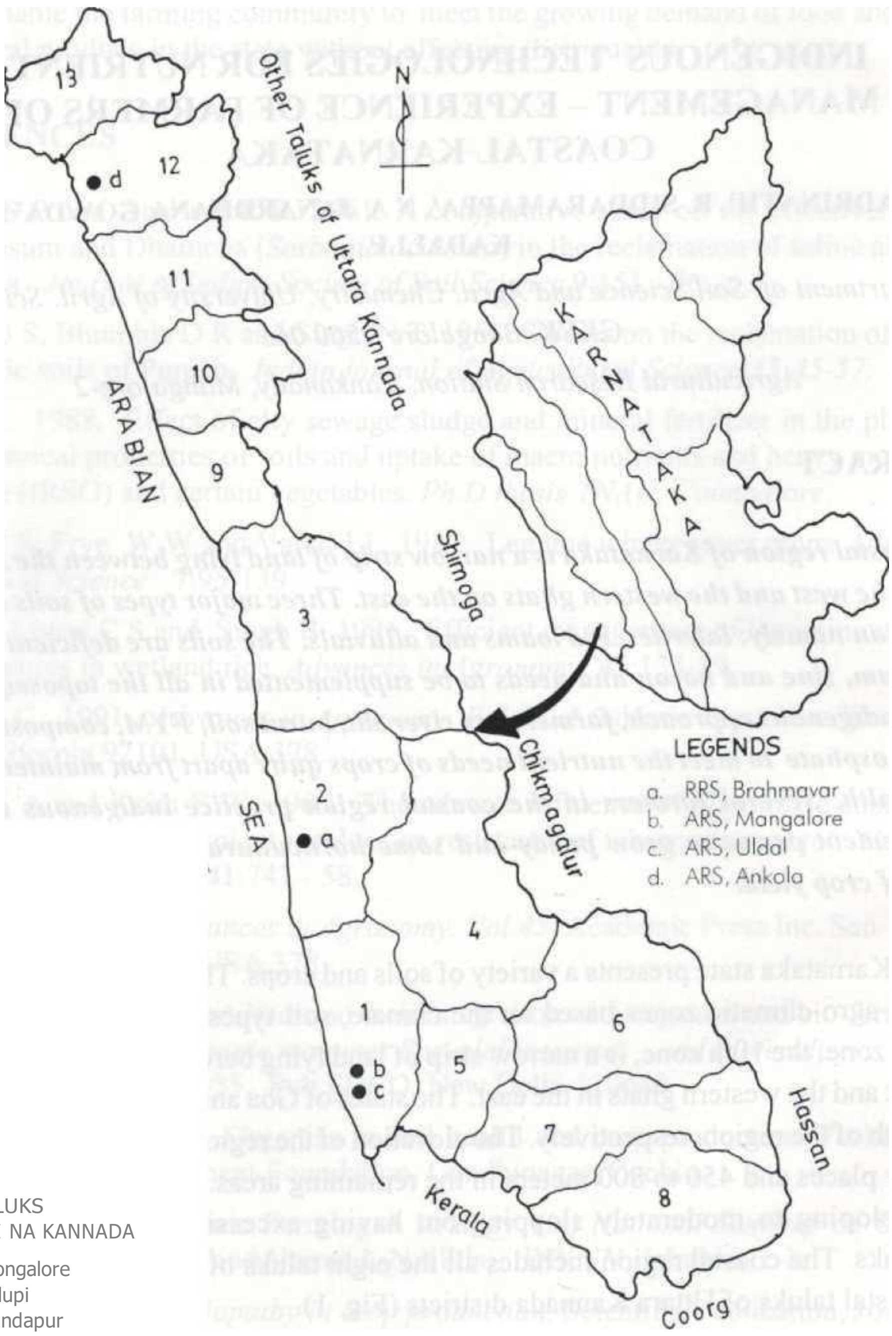
ABSTRACT

The coastal region of Karnataka is a narrow strip of land lying between the Arabian sea on the west and the western ghats on the east. Three major types of soils occur in the region namely: laterites, red loams and alluvials. The soils are deficient in lime, potassium, zinc and boron and needs to be supplemented in all the toposequences.

I s ***an indigenous approach, farmers use river silt, burnt soil, FYM, compost besides rock phosphate to meet the nutrient needs of crops quite apart from maintenance of soil health. Several farmers in the coastal region practice indigenous nutrient management per se to grow paddy and some horticultural crops despite the low levels of crop yield.***

Karnataka state presents a variety of soils and crops. The stale has been divided into ten agro-climatic zones based on the climate, soil types, crops, topography etc. Coastal zone, the 1 Oth zone, is a narrow strip of land lying between the Arabian Sea on the west and the western ghats in the east. The states of Goa and Kerala are on the north and south of the region, respectively. The elevation of the region is less than 300 meters in many places and 450 to 800 meters in the remaining areas. The topography is very gently sloping to moderately slopping but having excessive relief and plains in riverbanks. The coastal region includes all the eight taluks of Dakshina Kannada and five coastal taluks of Uttara Kannada districts (Fig. 1).



TALUKS
DAKSHI NA KANNADA

Mongalore
Udupi
Kundapur
Karkala
Banwal
Belthanqady
Puttur
Sullia
UTTARA KANNA
9 Shatkol
10 Honnavar
11Kumta
12 Ankola
13 Kawai

Fig 2 *Agro-ecological situations in coastal zone*

BACKGROUND INFORMATION

Coastal zone can be divided into three belts based on the topography and cropping pattern *viz.*, (i) a narrow low lying coastal belt adjoining the Arabian sea where paddy is the principal crop, (ii) the main land in the middle portion, between the coastal and the hilly belts where paddy and pulse or oilseeds are raised, and (iii) the valley and hilly belt towards the eastern part where paddy and plantations are noticed.

Climate

Agro-ecological situations in coastal zone are shown in Fig. 2. The climatic conditions prevailing in the region are quite different from those in other regions. The coastal region receives an annual rainfall of 3010 mm (Karwar taluk) to 4694 mm (Karkal taluk), of which 80 per cent is received during June-September. The variations in the temperature are narrow. The maximum temperature of 36.2 °C is recorded during April and minimum temperature of 20.9 °C in January. The region is characterized by the prevalence of high hmuidity throughout the year.1

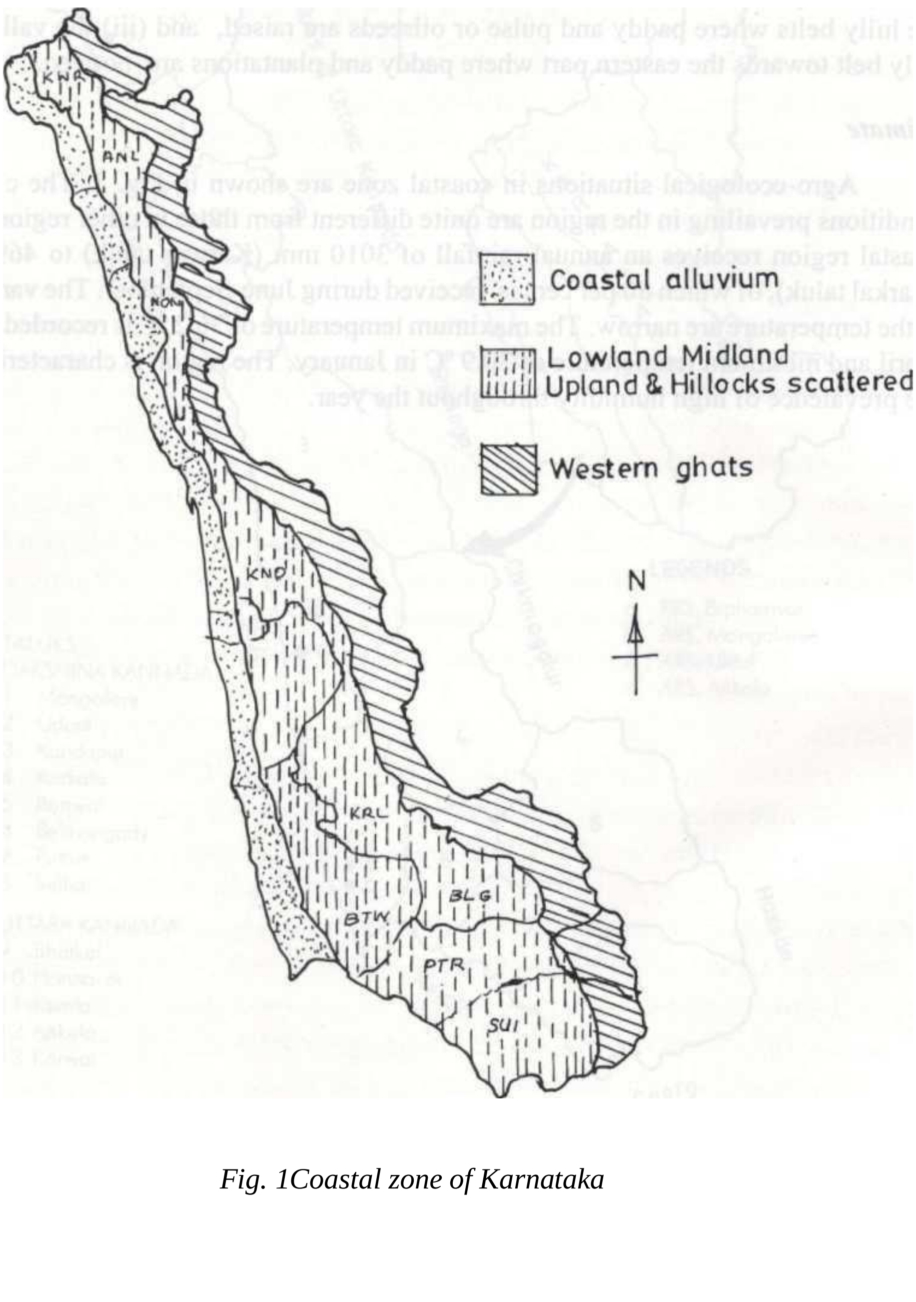


Fig. 1Coastal zone of Karnataka

Area and Land Use

Total geographical area is 11.674 lakh hectares, of which, 4.79 lakh ha is under forest, 2,487 lakh ha net cultivable land, 0.464 lakh ha fallow land, and 2.164 lakh ha wasteland. Of the total cropped area 23.8% is upland, 24.5% midland, 26.9% low land, 12.1% coastal alluvium, 2.6% western ghats and 10.1% hillock.

Soil

Three alluvials are encountered in the region (Fig. 3). The soils are naturally deficient in lime and are acidic in reaction within safe limits of salts. The organic matter is medium to high, available phosphorus and potassium are low to medium. Coastal salinity is noticed in portions of land in the proximity to the sea or backwater.

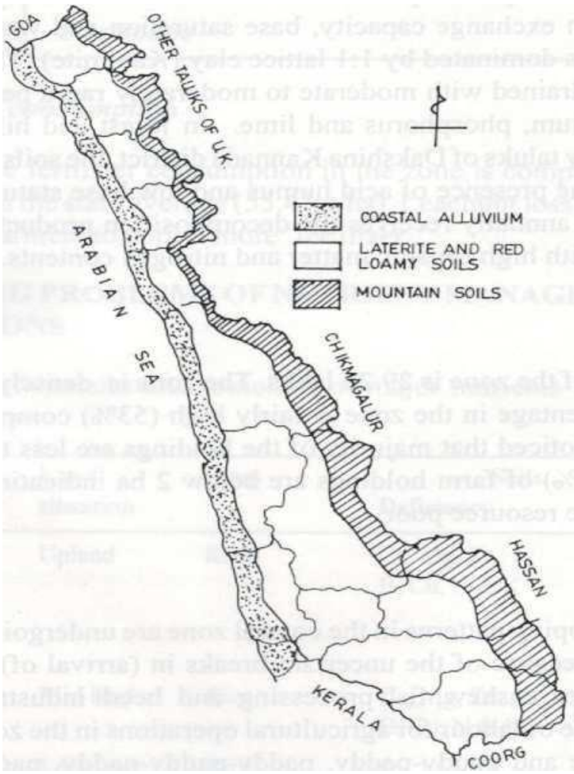


Fig. 3 Soils of the coastal zone

Coastal Alluvium: These soils are found in the western coast particularly in the district of Dakshina Kannada and Uttar Kannada. The soils consist of materials washed down from the Western Ghats as well as by the action of the sea and deposited in the area. In texture, soils vary from drift sand to loams and stiff clays. The surface soil is generally grey, varying from yellow to light brown and the intensity of the colour increasing with depth. Soils are deficient in lime and are acidic in reaction.

Laterite and Red loamy soils: These soils mainly occur on gently undulating topography of the region. Leaching of bases and silica and accumulation of sesquioxide are seen in these soils. The laterites of the coastal region are of recent origin and are characterized by a compact to vesicular mass in the subsoil horizons composed essentially a mixture of hydrated oxides of aluminium and iron. The soils are deep to very deep, yellowish red to dark red, clay loam to gravelly sandy loam on the surface and clay loam to gravelly sand clay or clay in the sub surface horizon. They are acidic in reaction and low in cation exchange capacity, base saturation and water holding capacity. The clay complex is dominated by 1:1 lattice clay (Kaolinite). The soils are well drained to excessively drained with moderate to moderately rapid permeability. Soils are deficient in potassium, phosphorus and lime. In forest and hilly belts of Sulya, Puttur and Belthangady taluks of Dakshina Kannada district, the soils are formed under acid conditions with the presence of acid humus and low base status. The area has deep surface soil, which annually receives the decomposition products of virgin forest. The soils are fertile with high organic matter and nitrogen contents.

Socio-economic characters

The total population of the zone is 29.26 lakhs. The zone is densely populated (282/km^2). The literacy percentage in the zone is fairly high (53%) compared to the state average (38.5%). It is noticed that majority of the holdings are less than one ha (61.6%). The majority (82.9%) of farm holdings are below 2 ha indicating that the majority of the cultivators are resource poor.

Cropping systems

The crops and the cropping patterns in the coastal zone are undergoing changes since two to three decades because of the uncertain breaks in (arrival of) southwest monsoon. Springing up of tiles, cashew, fish processing and beedi industry etc. have caused a conspicuous shortage of labour for agricultural operations in the zone. Paddy is the main crop in the zone and paddy-paddy, paddy-paddy-paddy, paddy-pulses- oilseeds, paddy-pulses/oilseeds/vegetables are the crop rotations followed. Monocropping of sugarcane is also common to some extent. Among the plantation crops and other horticultural crops, arecanut, coconut, cashew, pepper, cocoa, banana, mango, jack, pineapple, jasmine etc. are grown mostly and they contribute substantially to the economy of thezone. The per cent area occupied by different crops is given below:

Crops	% area occupied
Paddy	5.2
Pulses	6.4
Plantation crops	31.2
Vegetable crops	4.2
Fruit crops	3.6
Oilseeds	2.0
Sugarcane	0.6

Fertilizer consumption

The fertilizer consumption in the zone is comparativley lower (50.6 kg/haof NPK.) than the state average (55.4 kg/ha). Leaching loss of nutrients due to high rainfall restricts farmers to apply more fertilizer.

EXISTING PROBLEMS OF NUTRIENT MANAGEMENT AND INDIGENOUS SOLUTIONS

Deficiencies and toxicities of major nutrients in different land situations are given below :

Season	Land situation	Crop	Soils Deficiency	Soils Toxicity	Adverse situation
Kharif	Upland	Rice	Ca, Mg, Zn, B, Cu, N & K		Uncontrolled water due to heavy down pour of rain, floods in low lands
	Mid land	Rice	Ca, Mg, Zn, B, Cu, N & K		
	Low land	Rice	Ca, Mg, Zn, B, Cu & K	Fe, Al, Coastal salinity	
Rabi	Mid land and Low land	Rice, Pulses and Oilseeds	P, Ca, Mg, Zn	Coastal salinity	Partial soil moisture stress due to poor retention of water
Summer	Mid land and Low land	Rice, Pulses and Oilseeds	P, Ca, Mg and Zn	Coastal salinity	Crops depend on irrigation

The topography of the region is sloppy and undulating as a result of which there is excessive erosion of the surface soil. This is a very serious problem that warrants effective soil and water conservation measures including aforestation. Leaching losses of nutrients is a common phenomenon in the coastal soils. The increasing cost of cultivation of crops and escalation in the cost of chemical fertilizers have made farmers to opt for better utilization of indigenous materials for sustainable crop production in coastal Karnataka.

INDIGENOUS NUTRIENT MANAGEMENT AND RELEVANCE OF THE TECHNOLOGY TO THE FARMERS

A survey has been done to document the indigenous technologies adopted by the farmers in the coastal zone of Karnataka. Farmers of the coastal zone of Karnataka continue to practice the following indigenous techniques of nutrient management for sustainable crop production.

1. Application of burnt soil
2. Application of ash (from tile factory)

3. Application of phosphate rock to compost
4. Spraying of cowdung slurry
5. Use of jungle wood, hard wood, wild mango, soft wood leaves extensively
6. Opening of trenches between the teak trees for soil and nutrient conservation under hilly situations

During survey, the farmers have stressed the need for use of burnt soil, FYM and compost for the better quality of crops and soil. Invariably these farmers maintained 2 to 35 livestocks/cattle on their farm and recognise the importance of the use of urine and dung.

Burnt soil application (Sudumannu)

A unique feature of the indigenous nutrient management by coastal farmers is application of *"Sudumannu"* (Burnt soil). *Sudumannu* is the soil collected from paddy fields, burnt slowly in a specific manner. This is prepared *in-situ* from the soil collected from top 10-15 cm layer of the paddy field after the harvest of the crop. Soil clods and dry twigs are arranged in alternate layers to a height of around one-meter in a cone shape. They are burnt for a period of 3-4 days and allowed to cool for 15-20 days. After cooling the material along with the ash *(Sudumannu')* is used for nursery plots or garden lands. *Suduniannu* is rich in available potassium (622-893 kg/ha). The pH of the material ranges from 6.51 to 6.98 while the electrical conductivity values (<0.5 dS/m) are normal. The fanners recognize that the fallen leaves and other waste materials should not be removed from their fields and hence they use these along with soil for preparing *Sudumannu*. Farmers' perception is that *Sudumannu* is good means of checking soil erosion, improve crop growth through better root growth etc.

Opening of trenches

This is another method of soil and nutrient conservation practice followed by Monappa Karkeras, a teak farmer. The practice involves opening of small trenches between teak trees to collect fine particles along with organic materials in the trench. The collected mass in the trench is allowed to decompose and it will be distributed around the teak tree at a later stage. The teak trees are healthy, well grown with good girth. This method has been successfully employed in areca and other plantations in his Mangala farm at Mundur village in Puttur taluk of Dakshina Kannada district. Obviously the approach conserves soil and nutrients specially in the steep terracing of the farm.

Burnt ash

Use of burnt ash is a common practice among the fanners in coastal Karnataka. Ash is prepared by burning all the dried leaves as well as silt. The burnt material is used as manure to supplement potash. Many times the second crop was observed to be better than the first crop.

The other local methods related to indigenous nutrient management in coastal Karnataka are use of poultry manure plus burnt soil, tile factory ash, groundnut cake and *Kesaru mannu. Kesaru mannu* is the silt plus organic material deposited by the flowing water during rainy season.

Use of ash, burnt soil, FYM, compost, spraying of dung slurry and urine shall go a along way in improving the physical condition of the soil *viz.*, improvement in water holding capacity and aggregation. This process will not only help root development but also solute movement and quality of the crop. Soil and water conservation could also be achieved by adopting these local technologies as they have relevance to the coastal situation.

SCOPE OF BLENDING THESE INDIGENOUS TECHNIQUES WITH MODERN TECHNIQUES

Sudumannu is known to contain higher amount of potassium. The coastal soils being low in K due to leaching loss of this nutrient, the farmers find indigenous technology of adding *Sudumannu* practice of nutrients supply system by a harmonious blending of the technologies.

Similarly, the practice of addition of *Kesaru mannu* has also found to be beneficial since it carries a heavy load of organic matter, silt and other plant nutrients. The practice of adding *Kesaru mannu* to paddy field is in vogue even to this day in the coastal region. The fact that it supplies nutrients besides improving soil quality. Because of this it has attracted the farming community to practice this also with the modem fanning practices.

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CHAPTER 25

INDIGENOUS NUTRIENT MANAGEMENT PRACTICES IN KERALA

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ABSTRACT

Kerala has an undulating topography stretching front the east with a series of hills and valleys intersected by rivers and streams. Based on the topography and the land resources of the state, well defined natural divisions have been identified. Traditionally, farmers adopted many measures for maintaining and improving the organic matter content of our soils. For rice, cowdung and green leaves are applied before ploughing and thoroughly incorporated into the soil before transplantation. In the case of coconut, the basins are opened before the start of south-west monsoon and these organic manures are applied annually at the onset of monsoon. Vegetable cultivation is done with the use of fresh cow dung in the pits. Stubbles and dried leaves are collected, burnt and the ash is used for cultivation. Farmers also aim at improving the physical properties of the soil by using alluvial deposits and clay. Application of pure river sand to rice soils of lateritic origin improves the silica alumina ratio of the soil and reduces the Fe and Mn toxicity. Indigenous practices followed by the Kerala farmers illustrate how well they are capable to manipulate and derive advantage from local and natural resources. Though these practices are less efficient, modern practices can be integrated into the farming systems. The community plays an important role in the generation of indigenous practices, but many local and cultural barriers restrict the dissemination and conservation of this specialized knowledge.

In recent years there has been a growing scientific interest in locally developed systems and technologies. The traditional practices that rely on indigenous knowledge are considered for sustainability and production stability in modern agriculture. The local or indigenous knowledge is derived from the local people and from past farming experience, both that handed down from previous generations and that of the present generations. The information base for a society's indigenous knowledge is dynamic in nature. They are highly localised, restricted and often integrated with beliefs, systems and cultural norms. Indigenous nutrient management aims to make the best use of diverse sources of local origin such as organic manures, biological wastes etc. The positive effect of indigenous materials has been proved through several ways including the addition of nutrients, improving the physical properties and increasing the microbial activity of soil. So systematic documentation of these indigenous practices is inevitable to conserve the old farming traditions and knowledge of the farmers from being lost.

BACKGROUND INFORMATION

Kerala state lies in the south-west comer of the Indian peninsula as a long narrow strip of land, 32-130 km wide, between the Western Ghats in the east lays and the Arabian Sea in the west with 580 km long coastal line. The total geographical area of the state is 38855 sq. km. According to 1991 Census, it supports a population of 29.10 million. Kerala has an undulating topography stretching from the east with a series of hills and valleys intersected by rivers and streams. Out of 44 rivers originating from the Western Ghats, 41 flow towards the west into the Arabian Sea and the remaining three towards the east into the Bay of Bengal. The rivers of Kerala are generally monsoon fed and are fast flowing. The total cropped area is about 30,48,000 ha. The area under irrigation is 6,97,025 ha which is only 22% of the net cropped area. Crop- wise area under irrigation is given below:

Crop	Area irrigated (ha)
Paddy	272772
Tubers	859
Vegetables	5676
Coconut	172486
Arecanut	227099
Clove & nutmeg	1342
Other spices and condiments	2110
Banana	10331
Betelvine	840
Sugarcane	2260
Other crops	1250
Total	697025

Based on the topography and the land resources of the state, well defined natural divisions have been identified. They are high ranges, high lands, mid lands and low lands each running almost parallel with the north-south orientation. Twelve agro- climatic zones have been identified. The crops grown in the different zones also vary with the characteristics of the zone as shown below:

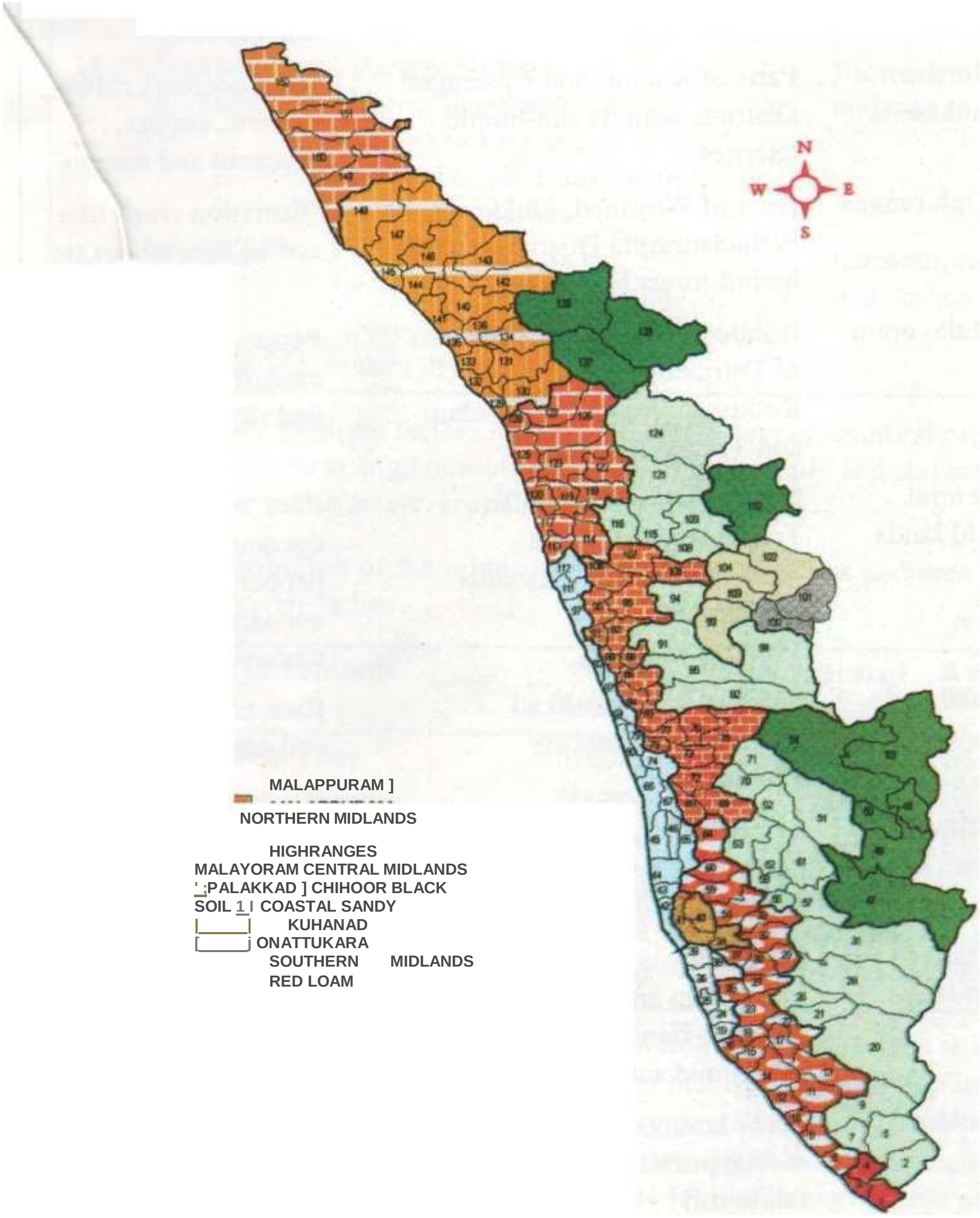

Fig. 1 Agro-climatic zones of Kerala

SI. No.	Zones	Location and soil type	Main crops grown
1	Malappuram	Malappuram District of Kerala with its humid and sub-humid laterites	Rice, coconut, cashew, pepper, arecanut, cassava and banana
2	Northern mid lands	Parts of Kannur and Kasaragod Districts with its sub-humid laterites	Rice, coconut, rubber, cashew, pepper, arecanut and mango
3	High ranges	Parts of Wayanad, Idukki and Pathanamthitta Districts with humid forest loam	Plantation crops like coffee, tea, rubber etc.
4	Malayoram	Isolated pockets in the districts of Thiruvananthapuram, Kottayam, Idukki, Emakulam and Trissur Districts	Pepper, tea, cardamom, cassava and rice
5	Central mid lands	Major parts of Emakulam, Trissur, Palakkad and Malappuram Districts with wet laterites	Rice, cassava, coconut, rubber, pepper, arecanut, cocoa, mango and cashew
6	Palakkad	River beds in Palakkad District with semi dry alluvium soil	Rice, coconut, cassava and sugarcane
7	Chittoor black soil	Eastern parts of Chittoor in Palakkad District with semi dry black soil	Rice, coconut and cotton
8	Coastal sandy	Coastal areas of Alappuzha, Emakulam and Trissur Districts with sub-humid alluvium and sub-humid saline soils	Rice and coconut
9	Kuttanad	Areas around Vembanad Lake in Alappuzha District with acid saline soil	Rice and coconut

10	Onattukara	Parts of Mavelikkara, Karunagappally and Karthikapally Taluks of Alappuzha District with humid greyish Onattukara	Rice, coconut, cassava and sesame
11	Southern mid lands	Parts of Kollam, Thiruvananthapuram, Neyyattinkara and Nedumangad Taluks with semi dry laterites	Rice, coconut, cashew and mango 1
12	Red loam	Southern pockets in Thiruvananthapuram and Neyyattinkara Taluks with semi dry red loam	Coconut, cassava, rice and cashew

There are multiple factors responsible for the low agricultural productivity of these regions. Of these, high rainfall, soil erosion, soil acidity and soil salinity caused by the sea water intrusion etc. are of major significance.

The distribution of the number of operational holdings and area operated by size classes is given below:

Class & size of holdings	**No. of holdings**	**Area operated (ha)**	**Average size (ha)**
Marginal (below 1 ha)	5016079	879472	0.18
Small (between 1 & 2 ha)	280900	381437	1.36
Semi medium (between 2 & 4 ha)	97698	253797	2.06
Medium (between 4 & 10 ha)	21384	112755	5.37
Large (10 ha and above)	3128	174362	55.7
Total / average	5419189	1801823	0.33

It is evident that the size of average holding is 0.33 ha which is less than the national average of 1.57 ha. From this it is clear that the impact of population growth on the size of land holdings and the land fragmentation are the important factors restricting the agricultural productivity of the state. Kerala with its limited land area and increased population offers very little scope for increasing the area under plough. Hence, the only alternative to increase food production is the intensive cultivation using integrated nutrient management practices. Kerala with its humid tropical climate poses soil problems of various kinds. There are different types of soils in Kerala. The unique combination of climate, physiography and vegetation of the state provides a wide diversity in the soils. About 60% of the land area of the state is covered by soils of lateritic origin. In the real sense, all soils of Kerala are problem soils which require special management practices for sustained agricultural production. Major problem soils identified are Kuttanad soils, distributed in and around Vembanad lake in Alappuzha, Kottayam and Pathanamthitta districts; *Pokkali*, *Orumundakan* and *Kaipad* soils of Emakulam, Trichur, Alappuzha, Kollam and Kannur district; Kole lands of Trichur and Malappuram districts and *Poonthalpadom* of Palakkad district.

The fertilizer consumption in the state, on an average, is on the increase mainly due to the awareness of farmers through extension and fertilizer promotion activities. The average consumption of fertilizer at present is 67.6 kg/ha.

INDIGENOUS PRACTICES

Use of farm waste

Farm waste used as manure in the state includes farmyard manure, cowdung, poultry manure, goat manure and other crop residues.

Dung as manure: Since animals are part of many farming systems their manure is a low-cost source of nutrients. According to farmers the dung from buffaloes is slowly decomposed compared to cow dung. Horse and elephant dungs are resistant to decompose, so these should be composted well before use. The farmers also caution that *in-situ* application of the same is possible only after the addition of enough water.

Usually dried cow dung is used by the rice farmers of Kerala, before the transplantation of seedlings. However, fresh cow dung as well as the dilute solutions of cow dung slurry is used for vegetable cultivation. A mixture of cow dung and groundnut cake is used in banana cultivation. The cake enhance the decomposability of the dung. Cow dung is also used for seed treatment. Seeds absorb the available K and N from the manure, which act as a booster dose for the seedling.

The cut rhizomes of amorphophallus and diascorea are dipped in cow dung slurry, dry in the shade and stores before sowing. The farmers have been adopting this practice as it is a cheaper means of obtaining vigorous plants.

Cattle penning: Cattle’s penning is a regular practice in Palakkad district. This is a practice of keeping the cattle herd overnight on the cultivated land so that the dung and urine are directly absorbed by the soil. According to fanners, if 500 goats are allowed to graze for 10 days that much quantity of organic manure required for one hectare of land may be available from the goat. Hormones present in the urine are also beneficial for the crops.

Composting: Certain composting techniques have been developed by rubber farmers as a part of integrated rubber based organic farming systems using crop residues, poultry manure, fish manure, cow dung, cattle-shed washings, vegetable wastes, aqueous weeds etc. in laterite soils of Idukki district. The system consists of a pit of 6.3 m length, 4.8 m width and 5 m depth. A well like structure is built in the middle of the pit by lowering down precast concrete rings of 0.9 m height, 1.5 m diameter and 7.5 cm thickness. The well floor is plastered and it is 1 m deeper than that of the pit. The floor of the pit is also plastered and slanted towards the well. The pit is gradually filled with different waste materials. Water is added periodically to the pit, so that the height of the water column is always maintained at a level of 0.9-1.2 m below the surface of the material being put into the pit. During the decomposition water rises up in the well as a dark brownish viscous liquid. This liquid is pumped back on the material in the pit. The liquid is rich in bacteria and hastens the decomposition process. Decomposition rate is rapid in this method and it takes only 30 days for decomposition. At any given time only the upper level of the material in the pit undergoes aerobic decomposition while the rest of the material which is underneath and not in contact with air undergoes anaerobic decomposition. By applying an anaerobic process to this mixture a greater volume of compost is obtained. Relative increase in compost volume is an indicator of an increase in the population of microorganisms and earthworms.

Ash and ash products

The main sources of ash are rice bran, rice hull, paddy straw, grasses, weeds and saw dust. The ash obtained from the burning of coconut leaves is also used all over the state. The nutrient contents (%) of some of these materials are listed as follows:

Material	Ash recovery	Potassium	Calcium	Magnesium	Phosphoric acid	Silica
Rice bran	9.5	0.56	0.09	0.69	1.14	Traces
Rice hull	16.5	0.32	Traces	Traces	0.09	12.23
Paddy straw	10.5	1.41	0.19	0.07	0.09	4.35
Grass & Weeds	7.0	1.80	0.18	0.10	0.25	1.42

The ash obtained from coconut leaves has more nutrient value compared to paddy straw, which is rich in silica. Farmers often use rice hull ash as a source of silica for rice. It is applied @ 0.5 kg/m^2 before sowing the seeds. According to farmers of southern Kerala, ash is the best source of manure for solanaceous vegetables and tuber crops.

There is a practice of burning the land before sowing the vegetable seeds. Just before the rainy season, the basins for vegetable seedling are prepared and dry leaves, twigs etc. are burnt to ash in these basins. This practice not only controls pests but also adds fertility to soils. The vegetable growers in Kannur and Thalassery taluks sprinkle a mixture of leaf ash and burnt soil on cucumber plants when plants are young. This ensures vigorous growth and ready supply of nutrients for the plants (Manju 1997).

Coconut fanners of Kerala often clean the top of the palms. Coconut garden is also cleaned once in a year by collecting all the husk, leaves and peduncles and burnt together. This practice checks fall of premature nuts. Another practice of applying wood ash to fields infested with weeds is common. The alkali in the ash inactivates the metabolite that signals the seeds to germinate.

In homesteads of Kerala just before the onset of monsoon (during March-April), the entire homestead is swept and dried leaves of trees like mango, jack, coconut, arecanut are heaped in between plants and then this debris is burnt. By this practice the weed seeds and roots are burnt and the soil fertility is improved (Sureshkumar 1994).

Kuttadan variety of rice is usually sown during the first crop season and the rice grows in height with the rising level of water and finally the ear head is harvested. The bulky straw is burnt during summer which improves the fertility of the soil in parts of Emakulam district.

Green manure and cover crops

Farmers cultivate leguminous crops like cowpea and black gram in the summer fallows. After harvest, the crop's stubbles are incorporated into the soil. Gliricidia *(Gliricidia maculata)* is the best source of green manure as it decomposes rapidly. Farmers use the old agro-forestry approach of growing gliricidia on bunds or hedges near the cultivable land. They get a green leaf biomass of 2-3 t/ha within 2-3 years of planting. Some farmers till the soil, apply lime and then grow green manure crops like dhaincha *(Sesbania aculeata)*, calapagonium *(Calapagonium mucunoides)* etc. in the plots of plantation. This increases the nutrient content of the soil along with control of weeds. In the eastern parts of Palakkad, wild indigo plants which are not palatable to animals are grown as green manure crop. It can withstand drought to a large extent. For coastal areas sunhemp *(Crotalaria juncea)* is preferable. In the lands subject to soil erosion puereria *(Puereria phaseoloides)* is grown as green manure cum cover crop. Vetiver *(Vetiveria zeylarica)* cultivation is done to protect the soil from erosion and also for the better extraction of soil nutrients by its extensive dense root system.

Banana pseudostem is used in coconut and arecanut basins for mulching. However, dried pseudostems are preferred to avoid insect attack. Farmers cut these into small pieces and bury in coconut basins. In betelvine crop, dried leaves of cashew is used as a mulch. Arecanut leaves are also found to be beneficial for moisture conservation in these gardens.

Mucuna bracteata is used as a cover crop in pepper gardens. This protects the land from excess water to some extent by utilizing water, as the roots of pepper are sensitive to water logging. Mucuna and Pueraria are ideal leguminous cover crops in rubber plantations. Nutrient contents of these cover crops is given below:

	Nutrients supplied (kg/ha/year)	
Nutrient	**Mucuna**	**Peuraria**
Nitrogen	220	120
Phosphorus	11	8
Potassium	68	58
Calcium	18	22
Magnesium	9	8

Growing of perennial trees like cashew *(Anacardium occidentals)*, mangium *(Acacia catechu)*,subabul *(Leucaena leucocephala)* offers the benefit of promoting soil conservation in humid ecological regions.

Green leaf application

Green manuring with thick leaves like that of mangoes, jack, cashew etc is preferred since the residual effects last longer. There is a proverb in Malayalam “It is better to buy a field under mango cultivation in exchange of a field under jack cultivation” pointing to the fact that mango leaves contain more nutrients compared to jack leaves. Farmers believe that the stain in mango leaves (tannins) reduces root diseases and soil acidity. Leaves of jack tree are considered better for pepper gardens. Direct application of teak *(Tectona grandis)* or bamboo *(Bombax celba)* leaves is not good for crops due to allelopathic effects. But once they are burnt and applied as ash, are useful to the crops.

In iron toxic belts, farmers apply leaves of benth *{Chylstanthus colenus)* plants @ one bundle per 8-10 bundles of other leaves. This practice improves soil health by reducing all types of toxic effects. Nutrient contents of different types of green leaf manures (on dry weight basis) is given below:

Crop	Local name in Malayalam	Nitrogen (%)	Phosphorus (%)	Potassium (%)
Albizzia	Vaka	1.65	0.1	0.6
Cassia	Konna	1.20	0.2	0.7
Dhaincha	Dhaincha	1.10	0.1	0.4
Neem	Aryaveppu	1,00	0.3	Traces
Crotalaria	Kilukki	0.90	Traces	Traces
Calotropis	Erukku	0.40	0.1	0.2
Cashew	Kashumavu	0.50	0.1	0.2
Mango	Mavu	0.60	0.1	0.6
Calophyllum	Punna	0.50	0.1	0.2
Thespesia	Poovarasu	0.90	0.2	1.0
Forest litter	-	0.40	0.1	0.1

Industrial products and other waste materials

Industrial products like sawdust, wood scrap, cakes of different types, fish wastes etc are used by farmers. In Idukki district sawdust is used for cardamom cultivation. Farmers are of the view that it is better to compost the sawdust for one year before application. Composted cakes contain more nitrogen compared to ammonium sulphate and neutralize the adverse effects caused by chemical fertilizers. Enough water is needed immediately after the application of cakes. They are useful for the cultivation of vegetables, coconut and sugarcane. Application of neem cake along with lime is found to be beneficial for ginger cultivation.

In coconut growing areas coir pith is used as the best mulching material and it increases the water holding capacity of coconut basins. Coir pith also supplements enough potassium to the soil. Farmers apply coir pith @20 kg/planl/year. They strongly believe that the yield can be boosted, if the material is applied in three split doses. In recent years, it is found that compost made from coir pith is superior to direct application of coir pith. It is used @ 50 kg/coconut palm. The farmers follow a unique practice of its application; only half the portion of basins is opened in one year and the other half during the next year. Compost is applied to the area opened (Jothimani 1994).

Miscellaneous materials and techniques

In coastal areas there is a practice of applying fresh fish to coconut gardens. During decomposition, a number of worms also infest the fish, when fishes dry up, the worms also decay and become additional manure to coconut. Fishmeal is also used in these places in coconut and vegetable cultivation. In Kasaragod district, which is popularly a tobacco belt, fishes are collected and buried in soil for several weeks, dug out and applied to crops along with soil.

In rocky laterite soils, there is a practice of addition of common salt to pits before transplanting coconut seedlings. The salt softens the hard laterite bed and helps easy penetration of tender roots. Certain farmers follow a practice of applying salt along with neem cake. Almost, all farmers support the application of salt to coconut basins. It is a usual practice to incorporate 25 kg salt/pit/year before planting. When laterite stones are encountered while taking pits for planting coconut, sodium chloride is applied on the stones at the fag end of north east monsoon. Sodium chloride causes speedy disintegration of the laterite stones allowing early root penetration.

The alluvial soils of Vettiyar, Kunnam near the river Achankovilar, in Pathanamthitta district are rich in organic matter. Vegetable cultivation is found to be highly enterprising on these soils. Certain vegetable growers use equal quantity of river sand along with surface soil. The surface soil which is removed and unused during a particular year is used in the next year.

Clay from kayal areas and small ponds is used for coconut cultivation in coastal areas. Clay from rivers improves physical properties of sandy soils. The clay deposits are rich in organic matter and several nutrients. Application of a mixture of sand, salt and ash in pits before transplanting is another practice found beneficial for coconut seedlings. Sand improves the physical properties of the soils, which facilitates easy rooting of seedlings.

Application of cashewnut shell @ 60 kg / ha at the time of main field preparation ofrice can substitute lime application in acid soils. Cashewnut shell contains a mixture of alcohols and phenols. In terrace cultivation followed in urban households, the algal growth produced on the terrace is used to enrich the soil. Tea waste is also used along with dried leaves and crop residues in terrace cultivation. Rubber farmers usually apply dried *Eichhornia crassipes* and *Salvinia molesta* or other plant debris to the basins of young rubber seedlings.

In Palakkad district there is a special practice of banana cultivation in rice fields which is known as "Chettuvazha" (banana in mud). The suckers are planted along the borders of puddled paddy lands and later as they germinate and grow, earthing up is done with mud and soil. Along with the fertility enrichment of banana basins, the interval of irrigation can be reduced considerably.

There is a practice followed in Thiruvalla and Pandalam areas of Central Travancore (Pathanamthitta district) which is known as induction of reflushing of cucurbitaceous vegetables. Cucurbits like bitter gourd and snake gourd are grown on "pandals". When the leaves become senescent in about 100-120 days, as visualised by yellowing and drying, the farmers remove all the dried leaves and small fruits. The basins are then strengthened, fresh cow dung is spread along with groundnut cake, mixed and forked. Then the crop is irrigated twice a day (morning and evening). This practice seems to rejuvenate the crop with new flush and enables harvesting of second crop.

In Ernakulam district three years crop rotation is practised involving ginger, amorphophallus and tapioca. This practice increases the soil fertility and the net income from the unit area. The large amount of organic matter (15-30 t/ha) applied to ginger benefits the amorphophallus and subsequently tapioca, which is a soil exhausting crop.

EXISTING PROBLEMS OF NUTRIENT MANAGEMENT AND INDIGENOUS SOLUTIONS

Barring the small patch of black soil, the soils of the state are acidic in nature with kaolinite as the most dominant clay mineral. The abundance of iron and aluminum oxides results in a large percentage of gravel in the soil. As a result, the soil in general possesses low cation exchange capacity and nutrient retentivity. In other words, the soils are not inherently fertile. The phosphate fixation is very high. Due to high rainfall during south west monsoon, a major part of the applied nitrogen and potassium is lost in run off and leaching. The fertilizer use efficiency is only 30-35 % for N and 50-60 % for K in wet lands. Toxicity due to higher concentration of soluble iron and aluminum occurs in low-lying areas subjected to rice culture.

NPK consumption ratios is not sufficiently balanced; the consumption of P and K is much less than that of nitrogen. The ratio suggests the lack of application of fertilizers at the recommended rate. This may be due to the high cost of fertilizer and the low price of agricultural produce.

The fertility problems of Kerala are so complex and diverse that it is not possible to use the same fertilizer practices through out the entire state. Decline of organic matter in soils of Kerala is very fast, due to high temperature and rainfall characteristics of tropical climate which are conducive for the rapid rate of microbial decomposition. Deforestation is estimated to decrease the organic carbon level by 25-57% from the s. top 5 cm depth and 17-30% from the next 5-15 cm depth in three years. Inclusion of crops that produce large quantities of crop residues in soil with wide C/N ratio in cropping system is one way of replenishment of organic matter in soil.

Land slides and soil erosion lead to loss of rich top soil which can be prevented to certain extent by providing proper vegetative cover.

To reduce the gap between the nutrient requirement and nutrient consumption more importance should be given to the optimum nutrient use. This can be ensured by the use of farm wastes, ash and ash products, cover crops, green leaf, industrial waste materials and above all with the better management techniques. With the establishment of location specific research work, the efficacy of all the indigenous practices must be tested and popularized.

Indigenous practices followed by the Kerala farmers illustrate how well they are capable to manipulate and derive advantage from local and natural resources. Though these practices are less efficient, modem practices can be integrated into the farming systems. The community plays an important role in the generation of indigenous practices, but many local and cultural barriers restrict the dissemination and conservation of this specialized knowledge.

PRESENT RELEVANCE OF THE TECHNOLOGY ADOPTED BY THE FARMERS

Traditionally, farmers adopted many measures for maintaining and improving the organic matter content of our soils.

For rice, cowdung and green leaves are applied before ploughing and throughly incorporated into the soil before transplantation. In the case of coconut, the basins are opened before the start of south west monsoon and these organic manures are applied annually at the onset of monsoon. Vegetable cultivation is done with the use of fresh cowdung in the pits. Stubbles and dried leaves are collected, burnt and the ash is used for cultivation. These are very old practices not involving high cost and can be practised with ease. Moreover those practices do not result in any residue hazards in the environment.

Farmers also aim at the improving the physical properties of the soil by using alluvial deposits and clay. This is a low-cost technology.

Farmers appreciate the beneficial effect of ash application. Plants get macro and micronutrients accumulated in the soil due to the burning of leaves. Application of sodium chloride improves the moisture absorption and retention capacity of the soil.

The beneficial effect of NaCl has been proved experimentally (Joseph *et al.* 1993). It promotes flowering and increases yield in coconut. Studies have also revealed that sodium would substitute K to the extent of 50% of the present recommendation of 1.2 kg K,O/palm/year.

Application of pure river sand to rice soils of lateritic origin improves the silica alumina ratio of the soil and reduces the Fe and Mn toxicity. The farmers are traditionally in favour of application of organic manures for almost all crops, irrespective of seasons. This practice may improve the micronutrient status of our soils. But the major lacuna is the availability of enough organic resources.

SCIENTIFIC BASIS AND SCOPE OF BLENDING THE INDIGENOUS TECHNOLOGY WITH LATEST SCIENTIFIC TECHNIQUES

Almost all the indegenous practices are evolved by farmers over a long period of time. So these indigenous practices have much practical relevance and benefits from these indigenous practices should be tested through scientific farming system approach. Our present scientific techniques aim at high productivity with costly inputs at the expense of soil health. But the indigenous practices make use of low inputs to attain sustainability in agriculture. So we have to compromise somewhere to resolve a new technology by blending indigenous knowledge with modem scientific tools. This technology must be location specific, feasible, viable and sustainable in nature.

Above all, abstracting the science underlying indigenous knowledge system would help us to develop newer concepts to accelerate the pace of technological change on a sustainable basis. New research projects with an integration of indigenous knowledge with modem technical know-how would lead to an efficient resource management with more emphasis on productivity and sustainability.

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VI

ISLANDS ECOSYSTEM

CHAPTER 26

Indigenous nutrient management practices - wisdom alive in India
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INDIGENOUS NUTRIENT MANAGEMENT TECHNIQUES PRACTICED BY FARMERS OF ANDAMAN AND NICOBAR ISLANDS

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ABSTRACT

Agriculture in Andaman and Nicobar Islands is only 140 years old. Plantation based single and multistoried cropping systems on hill slopes and paddy in the coastal plains are the two distinct types of agriculture practiced in these islands. Fertilizer consumption in A and N Islands is very low because of fragile environment, poor socio-economic status and small land holdings of farmers. Farmers have been using indigenous technologies to meet the nutrient requirement of crops. Among these, biomass waste incorporation, weed incorporation, green leaf manuring from live fences and growing leguminous cover crops in plantations are very common. In rice based cropping system, green leaf manuring, weed incorporation and application of FYM and poultry manure are common. Experiments conducted at CARI, Port Blair have shown that these indigenous nutrient management techniques can add substantial amount of plant nutrients to the system and significantly improve the productivity of the system. These indigenous technologies should be encouraged to prevent any possible environmental problems in future in this fragile Tropical Island ecosystem.

The Andaman and Nicobar Islands comprise a chain of 572 Islands, Islets, reefs, and isolated rocks spread in the Bay of Bengal at a distance of 1200 km from the East Coast of Mainland India. They extend to a length of 700 km between Lower Myanmar and the upper Sumatra region of Indonesia (Latitude 6° and 14 °N and Longitude 92° and 94 °E). The geographical area of this Union territory is 8293 sq. km and 86 per cent of it is under reserve and protected forests. Net area under cultivation is 42101 ha of which, 12612 ha is under paddy and 25000 ha is under coconut. Owing to a number of factors only one crop of rice is grown during rainy season and hardly 6 per cent area is cultivated more than once. The Islands receive an annual rainfall of 3000 mm between May to December. Soils are acidic, medium in organic matter and low in both available P and K. The soils are classified (Ganeshamurthy *et al.* 1987) into three orders (Entisols, Inceptisols and Alfisols), seven sub orders (Fluvents, Orthents, aquents, Psamments, Aquepts, Ochrepts, Ustalfs) and eight series (School line, Garacharma, Dhanikhari, Rangachang, Tushnabad, Pahargaon, Wandoor and Little Andaman). On hilly soils single and multistoried plantations are grown. Fertilizer consumption in these Islands is very low (less than 5 kg/ha) as against the national average of 68 kg/ha/year in plantation crops (Nair *et al.* 1996).

Maximization of economic returns has now become the key to success in agriculture. The current practices recommended for crops to maximize production are largely through the system of chemical farming i.e., high input technology which may be appropriate for large estate farming but not for small holdings. Small holdings, fragile environment and other economical constraints often discourage large-scale application of chemical inputs. But organic farming practices or integrated farming systems through recycling of organic wastes, crop and animal residues lead to

Substantial increase in the benefit:cost ratio of these farming systems. Hence the relevance of the indigenous nutrient management techniques practiced by farmers since ages should be looked into in the present perspective.

BACKGROUND INFORMATION

Andaman and Nicobar Islands experience hot humid tropical climate. This region falls under **"Agroecoregion 20: Hot humid per humid ecoregion with red loamy and sandy soils".** The annual rainfall is 3100 mm with eight rainy months from mid April to mid December. The mean annual minimum and maximum temperature is 23.7 °C and 30.5 °C, respectively with day- night temperature difference not exceeding 5 °C. Relative humidity ranges from 82% in peak monsoon to 75% in peak dry period. Crop growth period extends beyond 250 days.

Agriculture in Andaman and Nicobar Islands is not very old (140 years). The original inhabitants belong to aboriginal tribes: the Ongis, Jaravas, Sentinelees, Shompanes, Chauras and the Nicobaries. Except the Nicobaries (who were brought to Nicobar from Malaysia) these tribes lived in isolation and depended for food on forest and the sea. Cultivation of crops was unknown to them. Conventional plant cultivation was witnessed for the first time in these Islands in 1779, but failed due to death of the settlers for various reasons. Actual cultivation started in 1858 when the convicts of the first war of independence cleared some land for cultivation. Since then settlement took place in batches and modem agriculture started only in 1945 with the establishment of the Department of Agriculture.

Distinctly two kinds of agriculture are practiced in the Bay Islands. The hilly land is put under multistoried plantation crops and the coastal plains are put under paddy. Each settler farmer is allotted with a patch of both hilly land (2 ha) and coastal plain land (2 ha). Hence most of the land holdings are very small and the farmers are economically very poor. Agricultural inputs are mainly supplied through Department of Agriculture of the A & N Administration. Transportation system has recently been developed with most villages linked with pukka road. Construction of Andaman trunk road (300 km) linking Port Blair with North Andaman has facilitated in easy movement from south to north of the Islands. Ferry system also operates from Port Blair linking different Islands and the mainland. Most of the farmers are migrants from the then East Pakistan, Sri Lanka, besides, Moplas of Kerala and the Ranchi tribes of Bihar. Therefore, agriculture witnessed in Andaman and Nicobar Islands is a blend of the practices being followed originally at those places. Besides, due to non-exposure to modem agricultural techniques, farmers at many places follow indigenous practices in pristine purity. Some of the indigenous techniques of nutrient management are discussed here.

INDIGENOUS TECHNIQUES FOR NUTRIENT MANAGEMENT

Nutrient Management in Plantations

Major area of the hilly land in Andaman Islands is under plantation crops. Coconut is the dominant crop followed by arecanut and oil palm. These plantation crops are commonly intercropped with spices like clove, cinnamon, nutmeg and black pepper. Farmers generally do not apply any inorganic fertilizers to plantations. As a result the general yield of the crops is low. However, the system is sustainable, though at lower yield levels through unique nutrient management techniques followed by these farmers. These techniques are briefly discussed below.

Cover crops: Coconut and arecanut are grown in all types of soils irrespective of thephysiographic position. These are grown even in sloppy soils having more than 60 per cent slope. Asa result soil erosion is a severe problem in these plantations.

Myanmarees who came to these Islands brought with them seeds of Pueraria and Atylosia. These are used as cover crops in plantations. Being legume these crops grow very well and cover the ground rapidly and bind the soil against erosion (Plate 1). They form a mat like cover which helps in conserving soil moisture. It has been found that a cover crop with Pueraria produces on an average 2- 5 t/ha of biomass annually and can supply 16 to 34 kg N/ha, 2.8-6.2 kg P/ha and 11.8 to 26 kg K/ha tothe system.

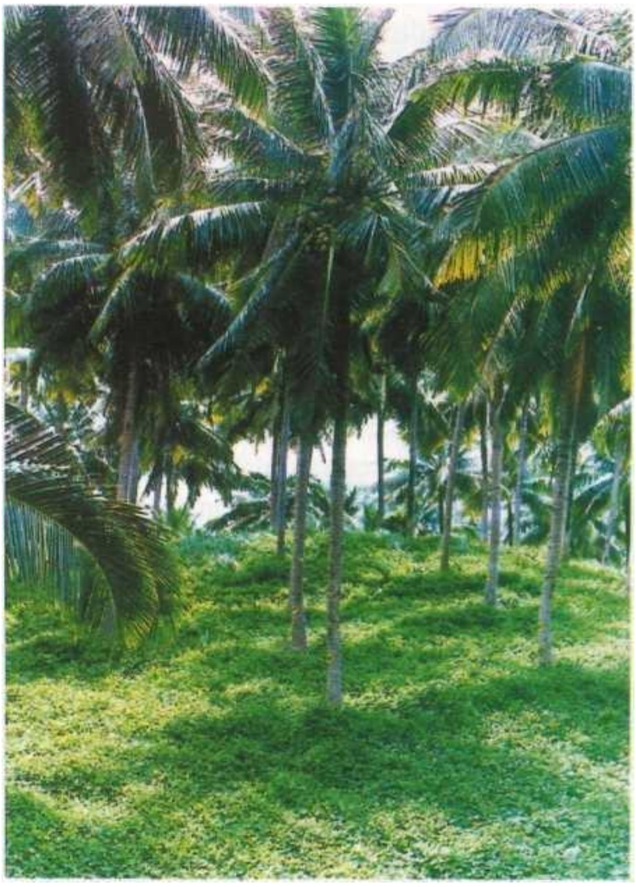

Plate I : Pueraria cover crop in coconut plantation

Recycling of plantation biomass : In plantations either in single or multistoried, large quantity of biomass is produced through falling fronds, crown cleaning, bunch wastes, leaf fall from spice crops etc. The farmers in A & N Islands do not generally remove the various forms of biomass from the plantation area. Even the cinnamon branches and the stern are left in the plantation for decomposition. An estimate of the biomass produced in single and multistoried plantations and the quantity of nutrients cycled through this biomass is given in Table 1. This is one of the sources of nutrient supply for plantation crops in these Islands.

Table 1 Biomass* added and nutrients cycled through plantation wastes

Plantation	Biomass (t/ha)	Nutrient cycled (kg/ha)					
		N	P	K	Ca	Mg	S
Coconut **	6.4	85	9.0	121	34	21	6.9
Arecanut	8.5	110	11.8	114	37	26	9.4
Multistoried arecanut plantation with black pepper,Cinnamon and clove	10.6	141	15,1	182	45	32	11.8

* Include spadices, bunch wastes, sheeth, inflorescence, husk, branches and wood of cinnamon, leaf litter of spices

** Excluding coir

Live fence as source of green leaf manure: Live fences of plantation with *Gliricidia, Leucaena, Thespecia* etc. are very common in these Islands. Farmers generally prune these fences at 1.0 to 1.5 m above the ground three to four times a year and incorporate 6-7.5 tonnes of biomass every year into the plantation. An estimate of the biomass produced by such fences and the nutrients cycled through this showed (Table 2) that 52 to 92 kg N is added to the system and a sizable amount of other nutrients are effectively cycled within the system.

Table 2 Annual biomass addition and nutrients cycled through live fences around the plantations

Live fence	Biomass* (t/ha)	Nutrient cycled (kg/ha)					
		N	P	K	Ca	Mg	S
Gliricidia	7.5	92	65	39	28	5.3	
Leucaena	6.5	71	4.6	39	32	24	4.6
Thespecia	v 6.0	52	4.2	48	34	27	4.6
Mixed fence	**6.0**	61	4.4	52	36	25	4.8

* Fresh weight (moisture content=65%)

Weed incorporation: Generally the rate of biomass production of weeds in Andaman is very high because of well distributed rainfall and tropical climate. Farmers cut these weeds at ground level and leave it for *in-situ* decomposition. Annually at least three to four such clearing is done, one during April-May after first monsoon showers, second in September-October and the third in December-January. The estimated biomass cut and incorporated each time in coconut and arecanut plantations and the amount of nutrients cycled through this is given in Table 3.

Table 3 Amount of biomass addition and nutrient cycled through incorporation of weeds in plantations in Andaman Islands

Plamtatopm	Biomass* (t/ha)	Nutrient cycled (kg/ha)					
		N	P	K	Ca	Mg	S
Coconut							
I cutting	4-7	29-52	3.5-6.1	19-33	17-29	11-20	2.8-4.9
II cutting	6-8	44-59	5.3-7.0	29-38	25-34	17-22	4.2-5.6
III cutting	4-8	29-59	3.5-7.0	19-38	17-34	11-22	2.8-5.6
Total	14-23	102-177	12.3-20.1	67-109	59-97	39-64	9.8-16.1
Arecanut							
I cutting	3-5	22-37	2.6-4.4	14-24	13-21	8-14	2.1-3.5
II cutting	4-6	29-44	3.5-53	19-29	17-25	11-17	2.8-4.2
III cutting	4-6	29-44	3.5-53	19-29	17-25	11-17	2.8-4.2
Total	11-17	80-125	9.6-15.0	52-82	47-71	30-48	7.7-11.9

*Fresh weight (moisture content=65%)

There is intense activity of surface casting earthworms in these plantations. It is estimated that annually 50 t/ha of earthworm cast is produced in tropical soils (Ganeshamurthy *et* a/. 1998). The earthworms decompose this biomass within 45-50 days and make the nutrients available to plants.

Coconut garden management by Nicobari tribes

Soil: Nicobar group of Islands is very young coralline Islands. These soils are basically Psamments with a rich organic surface horizon below, which is the partially weathered coralline material. The soils are sandy and highly permeable and alkaline (pH=7.5-8.5).

The dominant vegetation in Nicobar group of Islands is coconut. Nicobaries depend mainly on coconuts, pandanas, pigs, nicobari fowls and fish for their food of which coconut constitutes the major part. The coconut farming system practiced by these tribes is a unique organic farming system. The gardens are the result of natural establishment of coconuts in which the fallen nuts leftover on the ground germinate zn- *situ* and establish as a fully-grown tree. One can see a staircase of coconut palms starting from juvenile stage to trees as tall as 50
m. The gardens are thus over crowded with close spacing. However, the crowns of trees which have gained entry into the open sky are excellent bearers with more than 100 nuts per palmand the under growth trees having no nuts at all. It has been observed that these shaded trees on getting entry into open sky due to death of over mature trees start bearing well. The Nicobari tribes generally do not harvest the nuts from the trees but collect only over ripe fallen nuts, de-husk them in the garden itself and bring home only the de-husked nuts. Except for this no other biomass is removed from the gardens (plate 2). The shells of the consumed coconuts are also finally returned to the gardens.

Plate 2 : Luxuriant Nicobari coconut garden showng rich biomass added to the system

These tribes rear, in addition to cattle, a sizable number of indigenous pigs, which are mostly fed with coconuts, wild tubers, and kitchen wastes. They also feed on the human excreta. These pigs and Nicobari fowls inhabit the coconut gardens. This adds regularly a sizeable amount of pig and poultry manure to the gardens. The indigenous surface casting earthworm activity along with coir-decomposing microorganisms facilitate a rapid rate of decomposition of the coconut biomass. Over long time this system has stabilized and appears very sustainable.

*Nutrient management in rice:*Rice is the only field crop grown in coastal plains during monsoon season in A & N Islands. Settlers from Kerala, Sri Lanka and , Bangladesh are the main rice growers. The average yield of rice in A & N Islands is 20 q/ha. This level of yield is achieved through application of organic manure, weeds and FYM to rice fields.

Green leaf manuring : The settlers from Kerala and Sri Lanka brought with them the seeds of *Gliricidia maculata* and within a span of 50 years this plant has spread to all parts of Andaman and Nicobar islands and has become a dominant live fence in paddy lands and plantations and has spread even to forest area. Due to favorable environment this plant grows extremely well and produces a biomass of 4-5 kg/m of fence in a span of three months (Plate3). The plant nodulates with the native rhizobia and fixes atmospheric N to the tune of 80-100 kg N/ha. Relative to other green leafy manures the N content of Gliricidia is very high and the C: N ratio is also very narrow (10.42). Because of this Gliricidia decomposes at relatively fasterrate and makes the N available to plants.

Plate 3 : Luxuriant growth of Gliricidia maculata as live fence around paddy land

Weed incorporation: Weeds are abundantly available in the vicinity of rice fields in Andaman and Nicobar Islands. Farmers generally cut these weeds at the time of sowing rice nursery and incorporate these weeds into rice fields. Cassia and Chromolaena are two such dominant weeds, which are generally incorporated at 10 to 15 t/ha.

FYM application: Andaman and Nicobar Islands have a sizeable population (Venkatasubramaniam and Bandyopadhyay 1998) of livestock (160096) and poultry (614250) and annually produce 258 thousand tonnes of manure. The entire FYM produced is applied to crops as farmers in these Islands do not use dung cake as fuel. Generally FYM and poultry manure are applied to paddy before planting of paddy in the month of May-June and also to vegetable crops.

SCIENTIFIC BASIS AND SCOPE OF BLENDING THE INDIGENOUS TECHNOLOGY

The indigenous nutrient management techniques followed by the farmers of these Islands have strong scientific basis. However, not all the techniques have been scientifically evaluated to ascertain the present relevance of the techniques and to fine- tune these to suit to present day situation. Some of these evaluations are described below:

Cover crops in plantations

Experiments on cover crops conducted at CAR.I, Port Blair have shown that growing cover crops in coconut plantations effectively reduces soil erosion, improves the overall productivity of soils and efficiently conserves soil moisture. The biomass incorporated over a period of five years resulted in significant build-up of organic C, N content and microbial count (Table 4) thereby improving the overall productivity of the system. This is further supported by the significant increase in the activity of the fertility associated enzymes in soil.

Table 4 Biomass added, relevant soil properties and enzyme activities as influenced by covercrops in a coconut plantation

Treatment	Biomass added* (t/ha)	Nutrients added			Organic C	Total N	Mineral N	Dehydrogenase mg TPF/g soil/24h
		N	P	K				
		kg/ha —			- mg/g			
Control	-	-	-	-	4300	371	8.32	28.7
Peuraria	23	170	31	130	7500	640	24.32	79.5
Centrosema	12.2	80	17	78	6400	550	18	54.7
Atylosia	18.8	125	27	118	6800	580	20.12	68.2
Calopogonium	9.3	85	14	59	6000	510	15.21	50.2
CD (P=0.05)	3.1				323	16	1.7	6.3

*Means of 5 years

Attempts to rejuvenate Nicobari coconut gardens

Attempts were made to thin out the gardens to reduce the population and to increase productivity. Also the department of Agriculture has planted coconuts following modem packages of practices. In spite of the best efforts not only the nut yields could reach the level of traditional gardens but also depleted the surface layer organic matter content. The basic reason for this being that the Nicobar Islands is corraline Islands. More than 90% of the nutrients in the system are locked-up in the above ground part of the vegetation. If this biomass is reduced by way of removing the excess trees and by doing so the rate of addition of biomass being reduced, the equilibrium existing in these gardens receives a rude shock andthe indigenous nutrients will not be sufficient to meet the demands of the crops, Added nutrients through inorganic fertilizers get leached out of the root zone as these soils are very coarse textured and highly permeable and the area receives a mean monthly rainfall of more than 400 mm spread over eight months. Hence the existing system of organic farming practiced by these tribes should not be disturbed.

Green leaf manuring in rice

It has been found experimentally that application of *Gliriciclia* as green leaf manure to rice increases grain and straw yields of rice significantly over control but could not match with the yields at recommended levels of inorganic NPK fertilizers (Table 5). Hence in addition to green manuring, rice should receive recommended levels of fertilizer nutrients. Analysis of soil samples at the end of three years showed that continuous application of *Gliricidia* improve organic carbon and available nutrient status of the soil (Table 6)

Table 5 Effect of Gliricidia application on yield of paddy

Treatment	Grain yield of paddy (q/ha)			
	I yr.	II yr.	III yr.	Mean
T,	33.6	19.5	21.9	25
L	50.9	36.7	39.2	42.3
L	49.9	26.1	31.9	36
T_4	49.7	26.8	33.2	36.6
CD(P=0.05)	6.9	7.2	6.7	4.4

T = control; T,= recommended N: P: K at 90:60:40;

T_3= Gliricidia equivalent to 90 kg N/ha;T_4 = 50% recommended NPK + 50% Gliricidia

Table 6 Changes in soil fertility due to continuous application of Gliricidia as green manureto paddy

Treatment	PH	EC (ds/m)	Organic C (%)	Available nutrients (kg/ha)		
				N	P	K
T,	5.59	0.08	0.48	208	9	91
L	5.57	0.09	0.54	228	12	102
L	5.62	0.08	0.56	238	12	113
T_4	5.6	0.09	0.54	244	11	112
CD(P=0.05)	NS	NS	0.14	10	1	13
Initial	5.58	0.08	0.45	220	10	102

T,= control; T_2= recommended N:P:K at 90:60:40;
T_3= Gliricidia equivalent to 90 kg N/ha;
T,= 50% recommended NPK + 50% Gliricidia

Weed incorporation

Field experiment conducted on farmers' fields showed (Table 7) that incorporation of *Cassia and Chromolaena* at 10 t/ha in the field 30 days before planting increased the rice grain yield compared to control and the yield levels were similar to that of 80 kg N/ha as urea. These weeds can effectively be included as a component in the development of an efficient integrated nutrient supply systems in rice based cropping systems in Andaman Islands.

Table 7 Effect of weed incorporation on growth and yield of rice

Treatment	Plant height (cm)	No of panicles/ m'	1000 grain weight (g)	Yield (q/ha) Grain	Straw
Weeds					
No weed	100	232	25.2	23.9	31.8
Chromolaena	106	240	25.6	26.4	34
Cassia	110	248	25.4	28.7	41.3
Colocasia	**116**	230	-	27.8	41.9
Urena	112	234	-	28	42.2
Mikania	98,	220	-	27	38.3
CD (P=0.05)	3	6	NS	2.8	5.6
Nitrogen					
N_o	98	219	25	21.7	28.2
N_{40}	105	238	24.8	25.4	40.6
N_{80}	107	246	25.2	27.7	42.4
$^{n}i20$	111	258	25.8	30.7	46.5
CD (P=0.05)	3	4	NS	3.2	4.9

FYM application

Field testing of FYM and poultry manures at rates equivalent to recommended N and at 50% of the recommended N+50% FYM or poultry manure (N equivalent) significantly increased the grain and straw yields of paddy and significantly improved the fertility status **of** the soil (Table 8).

Table 8 Effect of FYM and poultry manure on paddy yield

Treatment	Grain yield of paddy (q/ha)				Straw yield of paddy (q/ha)			
	I yr.	II yr.	III yr.	Mean	I yr.	II yr.	III yr.	Mean
T,	33.6	19.5	21.9	25	58.7	39.3	29.8	42.6
T_2	50.9	36.7	39.2	42.3	66.3	54.8	49.4	56.8
T,	42	27.4	38.2	35.9	58.9	45.1	45.2	49.7
T_4	50.6	35	44.4	43.5	60.6	47	52.2	53.3
L	41.7	26.2	32.9	33.6	65.8	43.9	43.7	51.1
T_6	48.5	32.3	40.1	40.5	64.9	52.9	52.5	56.8
CD (P=0.05)	6.9	7.2	6.7	4.4	NS	NS	8.1	7

Tj= control; T,= recommended N: P:K at 90:60:40; T_3= poultry manure equivalent to 90 kg N/ha;T_4= 50% recommended NPK + 50% poultry manure; T_s= FYM equivalent to 90 kg N/ha; T_f=50% recommended NPK + 50% FYM

Thus the nutrient management techniques practiced by the farmers of these Islands are scientifically very sound and has a direct bearing on the overall health and sustainability of this fragile agro-eco system and has resulted in a definite savings in the inorganic fertilizer consumption in these Islands.

Conclusion

The soils of Andaman and Nicobar Islands are very young and the ecosystem is very fragile. The terrain and the physiography combined with tropical storms spread over eight months in a year is not suitable for intensive farming through heavy input of inorganic fertilizers and pesticides. The current approach of intensive chemical farming practiced elsewhere may lead to serious degradation of the environment. Hence the indigenous nutrient management practices of recycling all organic materials produced in these farming systems in the Islands must be encouraged to keep the island ecosystem intact and prevent from a possible environmental disaster otherwise.

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