AICRP on Long Term Fertilizer Experiments

Ref.: With reference to Application No. 80-01/IISS/RTI/2015 dated 16.01.2015

REPLY

The AICRP Long Term Fertilizer Experiments is operating at 17 SAUs/ICAR centers since 1970 to conduct Long Term Fertilizer Experiments to study the changes is soil quality, crop productivity and sustainability. Long Term Experiments initiated under this project are assets to the nation which have generated valuable database and are very helpful in planning strategies on production and consumption of fertilizer and formulation of efficient fertilizer use practices for enhancing and sustaining higher productivity and maintaining soil quality and environment. The work carried out at different centers of LTFE was reviewed by QRT during 1997 and recommended to enlarge the mandate and objectives of the project and changed its title as AICRP on "Long-term fertilizers experiments to study changes in soil quality, crop productivity and sustainability". The purpose of conducting long term fertilizer experiments at fixed sites in different agroecological zones (AEZ) with important cropping systems was not only to monitor the changes in soil properties and yield responses and soil environment due to continuous application of plant nutrient inputs through fertilizers and organic sources, but also to help in the synthesizing the strategies and policies for rational use and management of fertilizers to improve soil quality and to minimize environment degradation. Thus the thrust of AICRP is on productivity, sustainability and environment safety. In view of these emerging compulsions the Indian Council of Agricultural Research decided to launch the "All India Coordinated Research Project on Long-Term Fertilizer Experiments (AICRP-LTFE)" in September 1970 at 11 centres. After realizing the importance of the information generated from LTFE centres, The Indian Council of Agricultural Research (ICAR) sanctioned six new centres to cover more climatic zones and soils during 1995-96. They are at MAU, Parbhani, PDKV, Akola, KAU, Agricultural Regional Station Pattambi, RAU, Udaipur, GAU, Junagadh and IGKVV, Raipur during 1996-97. The centre at OUAT Bhubaneswar had to be shifted from the original site during 1996-97. because of acquisition of land by Airport Authority of India. Due to shortage of water the centre at ANGRAU, Hyderabad was shifted to its Regional Station Jagtial and was initiated during 2000-2001.

Research contributions from the project have led to the development of integrated plant nutrient supply and management strategies for improving soil fertility and enhancing and sustaining productivity of intensive cropping systems (rice-wheat, rice-rice, maize-wheat, fingermillet-maize, soybean-wheat and groundnut-wheat) in major soil groups of India (Inceptisols, Alfisols, Vertisols and Mollisols). Results have established that application of fertilizer N alone had a deleterious effect on soil productivity. The magnitude of crop responses to P and K application was much higher in Alfisols and Vertisols than in Inceptisols and Mollisols. Balanced and optimum use of NPK maintained soil organic carbon (SOC) irrespective of cropping system and soil type. The decline in factor productivity over the years was associated with deficiencies of sulphur and zinc. Balanced and integrated use of NPK and organic (farmyard) manure is absolutely essential for the sustainability of intensive cropping systems.

Thus, LTFE project has made significant contribution in promoting judicious use of fertilizer in diversified agro-ecological situations which are helpful in maintaining soil quality, increasing food production, generating more employment and improving environment.

A) Total Budget Allocated

The Headquarter of the AICRP on LTFE was shifted from IARI New Delhi to Indian Institute of Soil Science, Bhopal during 1997 and started functioning w.e.f. 06.03.1997. Therefore budget allocated has been furnished from 1997 and onwards:

Plan	Total Budget allocated of AICRP LTFE
IXth Plan (1997-2002)	359.00
Xth Plan (2002-2007)	603.00
XIth Plan (2007-2012)	1021.74
XIIth Plan (2012-2017)	2701.87
Total	4685.61

B) MANDATE AND OBJECTIVES

Mandate

- To conduct coordinated long term fertilizer experiments in different soil types under diversified cropping system and
- To collate information on long term soil fertility trials

Objectives

- To study the effect of continuous application of plant nutrients, singly and in combination, in organic and inorganic forms including secondary and micronutrient elements (as per the need) on crop yield, nutrient composition and uptake in multiple cropping systems;

- To study the effect of application of secondary and micronutrients (as per the need) on crop yield and also on the assessment of the need for these elements under an intensive cropping programme;

- To work out the amount of nutrient removal by the crops;

- To monitor the changes in soil properties as a result of continuous manuring and cropping with respect to the physical, chemical and microbiological characteristics of the soil in relation to its productivity;

- To investigate the effect of intensive use of biocidal chemicals (weedicides and pesticides) on the buildup of residues and soil productivity;

- To make an assessment of the incidence of soil borne diseases and changes in pests and pathogens under the proposed manuring and cropping programme.

C) OUTPUT:

a) Research

- Experiment conducted across the country clearly brought out that it is not possible to sustain productivity without external supply of nutrient.
- The C-N model developed for predicting C and N pools in soils for on going Long Term Fertilizer Experiments in India.
- Green Manuring Technology (GMT) in rice-rice system has been well adopted by farmers in Kerala.
- The results of LTFE experiments are being utilized for the development of models for expressing the behavior of crop growth in relation to soil health and climate change.
- In Alfisols crop did not show response to applied N and P until K is supplied. So to sustain productivity supply of K is essential.
- Invariably in Alfisol, hidden hunger of S is recorded which resulted decline in yield. So to get the potential yield of a crop, one must ensure supply of S.
- As far as nutrient status in soil is concerned, varied with type of nutrient. Balanced use of nutrient maintains soil N status at par with initial status. Accumulation of P was noted on continuous application of fertilizer while reverse was noted in the absence of P in fertilizer schedule.
- In case of K, the scenario is different. Irrespective of treatment (supply of K), decline in available K content was noted in Vertisols. However, in Inceptisols, little improvement in K status was noted. In Alfisols both reduction and increase in K status was noted depending upon the supply of K through irrigation water. In Inceptisol irrigation water, utilization of K from deeper layer by crop and upward movement of K along with water are responsible channels for increase in K status.
- Majority of places micronutrient status is maintained above the critical level in soil. Though treatment structure is such that does not allow to decrease Zn beyond a level. In Punjab improvement in Zn status as noted may be due to decline of soil pH.
- Micronutrient status at different locations indicated that balanced application of nutrient not only maintained micronutrient status but also increased their status at many locations. This could be the reason why at many locations increase in productivity led to diminishing the micronutrient problem.
- Studies conducted on heavy metal accumulation revealed that till date there was no accumulation of heavy metal in profile due to application of fertilizer. But little increase in DTPA extractable heavy metal was noted on application of lime and FYM. This is probably due to contamination of these metals in lime whereas mobilization of heavy metal through FYM could be possible reason. But in all the treatments the content of these metals is far below the limit prescribed by WHO.
- Analysis of data generated on physical condition of soils across the soils revealed that there is no adverse effect on physical condition of soils like bulk density, infiltration rate, hydraulic conductivity etc rather improvement was noted in fertilized plot.

- Increase in soil aggregation was noted almost at all the sites on balanced application of fertilizer nutrients. Application of FYM further improved the properties. Aggregation is the property which helps in sequestering the carbon and improving aeration of soil.

- It is believed that application of fertilizer resulted decline in microbial population in soil which mediate nutrient transformations processes. Data accumulated clearly brought out that application of fertilizer nutrient resulted improvement in microbial population and enzymatic activity. This is due to addition of fresh biomass through root and rhizodeposition each year, which acted as substrate for these organisms.

- In spite of low K content of Alfisols, crop did not show response to applied K particularly in rabi season crop. This is due to addition of K through irrigation water which is not accounted in general.

- In spite of high K status in Vertisols, crops have shown response to applied K. Which is due to less release rate of K from non-exchangeable to exchangeable due to mineralogical make up of these soils.

- Studies on K released indicated that application of FYM resulted increase in release of K whereas decline in K release was noted in Vertisol on continuous application of fertilizer in Vertisols. They also reported that conjunctive use of fertilizer and manure (FYM or Green manure) resulted in increase in K release from non-exchangeable K. Therefore to understand the K response of crop it is necessary to study the release pattern of K in soil.

- Demonstration conducted at farmer's field clearly brought out that soil are low in Zn and S. We shall have to ensure supply of Zn and S either through chemical fertilizer or through regular application of FYM along with NPK to sustain productivity.

- Demonstration carried out clearly indicated to enhance productivity of pearl millet-wheat, there is need to increase the amount of NPK because both the crops are heavy feeder and crop residue is not recycled back to soil.

- Analyses of data generated across the soil physical properties revealed that increase in productivity on application of nutrient in balanced form resulted improvement in soil physical condition of soil. So better productivity helped in maintaining better soil condition.

- The results indicated damage in rice through stem borer in the plot received 100% N without P and K. Which means application of N alone makes plant susceptible.

- Application of FYM increased the longevity of herbicide in soil and made it more effective. But at the same time does not have adverse effect on growth of microbial population for larger period.

- To assess soil quality soil indicators were identified. Soil indicator's varied with soil to soils. In Inceptisols available nutrient status was found to be soil indicator's in Vertisols soil physical properties like bulk density, soil aggregate and infiltration rate appeared to be more important whereas in Alfisols, soil pH, Ca, Mg and K status were noted as most important indicator which are responsible for productivity. However, in all the types of soils, one or other form of soil organic carbon showed their presence as one of the soil indicators.

b) Technologies Generated

- Generation of technology is not the mandate of the project but out of the data generated over the years following technology were generated and demonstrated in the fields;

  (i) Reutilization of accumulated P in soil: Due to continuous use of P in intensively cultivated area P is accumulated which has also been noted in the farmers' fields. So to reutilize P AICRP developed technology by reducing the dose of P half till soil attains threshold values. To be simpler if your soils attained threshold level of say 25 kg ha^{-1} then apply 100 percent dose during one year and reduced half to next two years. This saves fertilizer P worth Rs.5000 crores in Haryana, Punjab and western UP leaving asides intensively cultivated area of remaining part of the country.

  (ii) Sustainable productivity in acid soil: Acids soil are low in productivity due to several inherent problem like availability of nutrients and pH, soil condition etc.. To sustain productivity addition of lime is essential but the results of LTFE proved that addition of organic manure if not better than lime had permanent solution by chelating Al^{+3} responsible for exchangeable acidity in these soils. So on implementation of technology we can produce 25 M tomns of food grain additional annually.

  (iii) In situ green manuring: Though *in situe* green manuring is age old technology but due to non availability of water it is not in practice. In western Ghat area in between two rice crop space and residual moisture is available which can be used growing of green manure crop of dhaincha. In situ green manuring not only save 50 percent saving in fertilizer nutrient but also sequester carbon in soil . Also provides bio-available P and K and ruled out any possibility of hidden hunger of micronutrients.

c) Awards

- Chaudhary Devilal Outstanding AICRP Award (2004) to Long Term Fertilizer Experiment (LTFE), Indian Institute of soil Science, Bhopal

- Dr K.S. Reddy, Muneshwar Singh, A Subba Rao (2013) FAI Golden Jubilee Award for Excellence for "Nutrient Management in Wheat" by Fertiliser Association of India, New Delhi.

- Dr RC Gowda, T Bhagyalakshmi, DC Hanumanthappa, K Sudhir and Singh Muneshwar (2012) Best Paper Award in 8th International Symposium on Plant –Soil Interaction at Low pH. International Steering Committee on Plant Soil Interactions

- Dr Muneshwar Singh and RH Wanjari (2014) Awarded Third Prize "Dhiru Morarji Memorial Award" for "Best Article in Agricultural Sciences 2013-14" for the article entitled "Balanced Nutrient Management: A Key to Sustain Productivity and Soil Health on Long Term Basis" published in December, 2013 issue of Indian Journal of Fertilizers by Fertiliser Association of India, New Delhi.

d) Publications

Research Bulletin

- Singh, Muneshwar and Wanjari, R. H. (2007). Research Bulletin on Lessons Learnt from Long Term Fertilizer Experiments and Measures to Sustain Productivity in Alfisols. AICRP on LTFE, Indian Institute of Soil Science, Bhopal. p. 1-18.
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Research Papers

- Singh, Muneshwar, Wanjari, RH, Dwivedi, Anil and Dalal, Ram (2012) Yield response to applied nutrients and estimates of N_2 fixation in 33- year-old soybean-wheat experiment on a Vertisols. *Experimental Agriculture,* 48: 311-325.
- Singh Muneshwar, RH Wanjari (2012) Potassium requirement of crops grown in Vertisols: Experiences from Long Term Fertilizer Experiment. *Indian Journal of Fertilisers (Indian J. Fert.)* 8(3): 26-32.
- Singh Muneshwar, RH Wanjari (2012) Potassium responses and requirement of crops grown in Vertisols: Experiences from Long Term Fertilizer Experiment. Indian Journal of Fertilisers 8(3): 26-32.
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- Singh Muneshwar and RH Wanjari (2013) Balanced Nutrient Management: A key to sustain productivity and soil health on long term basis. *Indian Journal of Fertilisers* 9(12): 72-81.
- Singh Muneshwar, RH Wanjari, MC Manna, BL Lakaria, Pramod Jha and Ch Srinivasarao (2014) Soil carbon management: Issues and Strategies. Fertiliser Association of India. Indian Journal of Fertilisers 10(5): 118-132 (May 2014)
- Singh Muneshwar and RH Wanjari (2014) Potassium response in Vertisols in long term fertilizer experiments. International Potash Institute. *Newsletter* e-ifc No. 37 (June 2014).
- Singh Muneshwar, Shri Ram, RH Wanjari and Pankaj Sharma (2013) Balance and forms of potassium under rice-wheat system in a 40 year old long-term experiment on Mollisols of Pantnagar. *Journal of the Indian Society of Soil Science* 62(1): 38-44 (March 2014).

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e) Workshops

- Held at BAU, Ranchi (January 14-16, 2002)

Important Recommendations were: It was decided that centres in collaboration with Microbiologist of the Departments should take up studies on soil biological parameters. It was decided that cowpea in the rotation at PAU, Ludhiana, IARI, New Delhi and GBPUA & T, Pantnagar should be discontinued since it was invariably delaying the sowing/ transplanting of the main crop. It was decided to go for splitting/superimposition of treatments in one replication only following nested design. The centre identified for the purpose were: IARI, New Delhi, BAU Ranchi and UAS, Bangalore. The officer in charge of these centres should get in touch with Mr. M.R. Vats at IASRI, New Delhi for details of statistical design and layout. A copy of treatments and layout should be endorsed to the Project Coordinator. It was also decided that old experiment at Ranchi going on since 195 will also be a part of AICRP and additional recurring contingencies will be allotted. It was decided that IASRI, New Delhi should isolate the effect of varieties over the years while undertaking yield trend analysis of some selected centres. Experiments at three centres initiated during 1995-96 at OUAT, Bhubaneswar, MAU, Parbhani and PKV, Akola have entirely different set of treatments. The modification of these treatments can be discussed in the QRT and final decision can be taken thereafter. However, another long term experiment having almost similar set of treatments at PKV, Akola will be a part of AICRP.

- **Held at PAU, Ludhiana (November 6-8, 2004)**

Dr. J.S. Samra, Deputy Director General (NRM), ICAR, New Delhi chaired the sessions and Dr. P.D. Sharma, Assistant Director General (Soils), ICAR and Dr. G.S. Sekhon, Professor Emeritus & Special invitee, Dr. M.V. Singh, Project Coordinator and Scientists from all the centres offered their valuable suggestions during the workshop. Scientists from New Delhi and Junagarh centre were absent. Chair desired that based on 30 years of experimentation each centre should: (i) Identify some sustainable treatments, which does not induce any deficiency of other nutrient as well as simultaneously maintains soil health. (ii) Develop a sustainable fertilizer and manurial practices accordance with the potentiality of a soil and their evaluation in satellite experiments. (iii) Studying the effects of interventions based on long term superimposition and factors responsible for unsustainable yield, and (iv) Develop important indices for evaluation of soil quality, sustainability and environmental safety based on long term field experiment in different agro-ecological situations.

- **Held at IISS, Bhopal (January 17-18, 2007)**

A group meeting of in-charges of Long Term Fertilizer Experiment (LTFE) was called on 17-18th January to hold discussion on soil quality assessment in LTFE. Dr. A. Subba Rao, Director, Indian Institute of Soil Science, Bhopal chaired the session of the group meeting. All the centre in-charges of LTFE except Junagadh (Dr. B.A. Golakia) participated in the group meeting. The Project Coordinator, Dr. Muneshwar Singh presented the status paper on methodology available and to be

adopted for “Soil Quality Assessment in Long Term Fertilizer Experiment”. In his presentation, he covered the work carried out on soil quality assessment in India and other parts of the world. He also came out with the minimum data set and the statistical procedure to be followed for assessing the soil quality. The Principal Component Analysis (PCA) is considered to be latest and advanced tool for identification of soil quality attributes sensitive to management practice. The PCA is based on the relationship of soil attributes with yield sustainability. Through PCA, the contribution of each soil attributes to productivity will be calculated and the factors which contributes maximum will be selected. For selection of soil indicator, contribution of all soil attributes will be arranged in descending order as per their contribution. The top soil attributes sum of which is more than 85 percent would be termed as soil indicator. Dr. D.K. Sehgal covered the format of data and the basic details of steps of Principal Component Analysis (PCA) to be used to identify soil attributes as indicator for developing soil quality index. Thereafter, discussion was held on the presentation and the centre in-charges and the scientists of the institute offered their valuable suggestions.

- **Held at IISS, IGKV Raipur (December 6-8, 2009)**

Recommendations of the Workshop

In the evening of last day a plenary session was held in the Chairmanship of Dr. S. S. Khanna, Ex-Vice Chancellor and Dr. Subba Rao as Co-Chairman. The points raised by the participants were discussed in details and the following recommendations were emerged out keeping in view of importance of treatment and centre.

i. The use of 15 t FYM over and above 100% NPK seems to be higher side. The availability and the economics on addition of this much amount of FYM is questioned always by different groups. Superimposition of the treatment by 2.5 and 5 tons FYM along NPK at some of the centres seems to be enough to sustain productivity. Therefore, after long deliberation it has been decided to reduce the FYM dose to 5 tonns in place of 15 /10 tonns. The amounts should be applied strictly on dry weight basis and the content (NPK&C) of FYM should be recoded.

ii. Continuous application of P resulted in accumulation of P in soils at several places especially at old centres. After attending the workshop of AICRP LTFE held at PAU Late Dr. G.S. Sekhon former director PRII through his letter to the then DDG (NRM) suggested that P is one of the nutrient which has gone twice or thrice to the sufficiency leveling LTFE plots . He also emphasized that in good agricultural area farmers are using P and Zn carriers for quite some time and built in nutrient stock from deficiency to sufficiency or even more has been noted. In such situation reduction in P dose to half would sustain the productivity. The superimposition treatment proved that reduction of P dose to half did not have any adverse effect on productivity even after 10 years at Ludhiana. Therefore the centres (old) at which P accumulation to high label may reduce the P dose to half in 100% NP, 100% NPK, 150% NPK etc. and maintained the year of implementation to work out the balance.

iii. The soil sample for micronutrient other than Zn should be tested once in four year and if needed a common dose can be applied in all treatments. The amount of Zn applied in the NPK+ Zn should be applied whenever the status goes down near to critical limit. The unnecessary application Zn should be avoided.

iv. In spite of low K status in some soil, the response of crop to applied K either is nil or very low. All the centres must analyze the K and S content in irrigation water and should report

as base data (Kerala, Bhubaneshwar, Ludhiana, Ranchi etc.). FYM applied has great variation year to year in content of N, P, K, etc. Therefore all the centres should analyze the nutrient content and try to supply more of less similar amount of nutrient each year after adjusting the nutrient and moisture content.

v. All centres will continue to do analysis soil parameter decided in group meeting using the method indicated for each parameter.

Specific to centre:

Some issues related to individual centres were also raised by centre in-charges. The modifications suggested were discussed in the house and the recommendations are given hereunder.

- Bhubaneshwar centre has got one lime treatment in rice-rice system which is not practiced or recommended in rice-rice system in Alfisols. Moreover the response of lime is either not seen or very low. The centre can with draw the lime and maintain the treatment without lime. This treatment may be used for superimposition in future.
- Akola centre has got treatment having 75% NPK in both the crops. Which has little relevance in the present context. Akola centre can convert into a INM treatment by supplying with 25% N through FYM and henceforth treatment will be 75 % NPK + 25% FYM, to both the crops in place of 75% NPK.
- Akola and Udaipur also maintaining one organic treatment with application of 10t FYM during kharif which is not sufficient even to meet the demand of kharif crop. Because of low amount of N supplied through FYM, the yields of both the crops are low. Both the crop are suffering form nutrient specially wheat. Therefore, to sustain the productivity centre may apply 10t FYM to both the crops on dry weight basis. Similarly at Jagtial, the yield obtained in exclusively 10t FYM treatment are low because of supply of nutrient in less quantity especially N. Therefore, the centre may increase the amount of FYM to 15t in each crop.
- Ludhiala and Palampur centre raised the issue that 50% NPK treatment does not have any relevance in area where large amount of NPK is used. Therefore, they wish that this treatment may be converted into an integrated nutrient management treatment by adding 50% N though FYM. The matter was discussed .These two centre can modify the treatment into an INM treatment.

Dr. Dhayn Singh, in-charge centre of IARI pointed out that Delhi centre is assigned to grow maize-wheat but in recent past the farmers of surrounding area have switched over to pearl millet-wheat from maize-wheat system. Initially the centers was also growing pearl-millet – wheat, seeing the change in cropping system the area, centers proposed to return back to original pearl millet- wheat system. The house agreed unanimously. The other centres also think of if the same situation is encountered. But keep in the mind that system should continue for next 10 years least.

At JAU, Junagarh 25 tons of FYM is added annually to G. nut during kharif. Ground nut is legume crop and needs a booster dose of nitrogen and 10 Tons FYM is sufficient to meet the N requirement of crop during initial stages. The extra FYM may accelerate the loss of N from system trough runoff and leaching during monsoon. At Junagarh temperature will not be constraints for mineralization of FYM. Therefore remaining 15 tons FYM can be applied during rabi to wheat. This year onward centre may apply 10 tons FYM to G. nut and 15 tons FYM to wheat keeping the amount of FYM constant.

BAU Ranchi is maintaining a treatment with N supply through $(NH_4)_2 SO_4$. Ammonium sulphate is no longer practiced and popular source of nitrogen in India. The treatment has served the purpose by having a different impact on soil properties compared to urea. The treatment does not have any relevance in present context and therefore, centre can replace $(NH_4)_2 SO_4$ with urea.

- To work out the balance sheet of nutrients many centre are using available status of nutrient which does not give true picture and may mislead .To work out nutrient balance depth wise sample should be drawn and should be work out on the basis of total content. This balance may be worked out on five yearly basis.

- It has been observed that at some universities transfer of the scientists of AICRP- LTFE is quite very frequent (TNAU, JNU). Some time twice in years. The AICRP LTFE has fixed treatment with specific mandate. By the time scientist understands the philosophy of the experiment. He is transferred to other scheme. Due to frequent transfer business the quality of data generated is of poor quality which does not have any scientific value. Therefore, all the universities authorities are requested not to transfer the scientist frequently and both the scientists should not be transferred together.

In last workshop, it was decided that each centre will carry out satellite experiment to demonstrate the technology generated at their centre. Some of the centre did satellite experiment but some could not do. The centers which have not conducted satellite experiment to demonstrate the technology generated out of experiment should survey the farmers of the area and find out common practice used by them for growing the crop. Analyze the survey data and make 3-4 interventions in farmer practice on the basis of results of your centre and demonstrate farmer's participatory mode. This should be given priority.

- **Group Meeting IISS , Bhopal (Jan 5-6, 2012)**

In addition to the scientists in charges of different centres the Scientis from crop science, horticulture division of ICAR, soil scientist of all SAUs , farmers and the fertilizer firms were called. Presentations were made on different aspect of nutrient management for sustaining the productivity and soil health. Farmers were also asked to put their views which can be incorporated into our programme

- **Held at IISS, CSKHPKV, PALAMPUR (June 2-3, 2014)**

Recommendations of workshop

After presentation work of all the centers in technical session, a plannery session was organized to have discussion and recommendations. The session was chaired by Dr. R. K Tewatia and additional director FAI, and co-chaired by Dr. B. S Dwivedi, HOD Soil Science, IARI and Dr. P. Dey, P C (STCR). After lots of discussion following recommendations were emerged;

Development of carbon and nitrogen model to predict different forms carbon and nitrogen under different management options. To address the issues, I have associated three scientists of the institute who has knowledge of modeling and computer to develop carbon and N model using the data available in LTFE. In the leadership of Dr. Promod Jha a good progress has been made and presented in the workshop.

A carbon model has been developed by Dr. P. Jha, Senior Scientist, IISS, Bhopal and he also made a presentation about model and minimum data required to run the model. Soil initial characterization in terms of soil texture i.e. silt + clay percent, soil bulk density, organic carbon content (WBC original value), mean rainfall and mean annual temperature are required to predict the carbon accumulation in soils. For another data set grain yield and harvest index also required. There were some doubts for developing regression equations and calibration of the model, therefore, responsibilities given to IASRI centre to rectify the problems and help out Dr. Jha. It was also decided that the center will supply the input parameters to validate the model. The members were of opinion that a short training of handling the model should be given to scientists by IISS, Bhopal.

i. Identification of climatic parameters influence soil productivity and to develop strategy to mitigate/ harness the impact of changing climate

AICRP agro-meteorology and LTFE have many common centers. Data on agro-climate is available. With the help of PC Agro-meteorology, a programme has been developed. Data on soil, productivity, and cultural practices over the years will be made available to find out climates factor responsible for change in productivity and soil health.

ii. Development of strategies for sustainable management of acid soils.

The productivity of acid soil is very low because of inherent problems associated with these soils. So address the issues related to sustainability of acid soil programme will be developed by involving the scientist from the Institute and work on basic aspect will be undertaken. Dr. A. K. Patra, Director IISS, told to work out superiority of manure over lime. So work would be undertaken to study;

a) Impact of lime and manure on active, exch. and reserve acidity

b) Frequency and amount of lime application

iii. Assessment of green house gases and development of strategies to minimize and assessment of soil biodiversity as influenced by management.

The LTFE experiments are in progress since 1971 at different centres with different nutrient management options, so these can be utilize to monitor the green house gases emission like methane, nitrous oxide, carbon dioxide in rice-rice and rice-wheat cropping systems. The centres were asked for facilities and every centre was agreed for such studies. The three centres were selected like Hyderabad for rice-rice, Pantnagar and Ludhiana for rice-wheat system with four treatments i.e. control, 100% NPK, 150% NPK and 100% NPK+FYM.

Though the scientist associated with the project do not have expertise in the field but the work will be undertaken by inviting the scientist from IISS and SAUs.

iv. A good discussion was also held on treatment structure. The treatments decided at that point of time were based on the requirement. Many of the members were of opinion that some of treatments may be modified to address the new emerging issues. So after long discussion following changes were suggested in treatment

100% chemical N application treatment can now be converted into full organic treatment with full 100% N or an INM treatment. After detailed discussion it was felt that it should be continue as such i.e. 100% chemical N because its shows the negative impact of unbalanced fertilization on crop productivity and soil health, which is demonstrated to farmers by the

centres on number of occasions and no one agreed to modify this treatment. However, following changes were suggested to incorporate in the treatment sets of LTFE, other treatments will remain as such

Present treatment	Proposed to be Converted into
50% NPK*	100% PK
100% NPK+HW	100% P should be supply through rock-phosphate (in acid soils only)
	100% NK (except acid soils)

**This treatment has fulfilled it objective and does not have much relevance in present context so treatment is proposed to be modified.*

v. The fourth objective was to study the change in soil born disease and pest and pathogen. The issues was addressed but no significant change was noted on this aspect , so objective may be dropped and place of this house propose to add new objective "To study impact of changing climate on soil productivity "

vi. A carbon model has been developed by Dr. P. Jha, Senior Scientist, IISS, Bhopal and he also made a presentation about model and minimum data required to run the model. Soil initial characterization in terms of soil texture i.e. silt+clay percent, soil bulk density, organic carbon content (WBC original value), mean rainfall and mean annual temperature are required to predict the carbon accumulation in soils. For another data set grain yield and harvest index also required. There were some doubts for developing regression equations and calibration of the model, therefore, responsibilities given to IASRI centre to rectify the problems and help to Dr. Jha. It was also decided that the model should provide to some centres those can easily handle the data and run the model. A short training of handling the model will be given to scientists by IISS, Bhopal.

vii. Alternative source of P in acid soils

Different alternative sources were discussed with their merits and demerits, and finally rock-phosphate was selected as alternative P source in acid soils. Treatment i.e. 100%NPK +HW will be converted into rock-phosphate treatments at Ranchi and Palampur centres. Roc-kphosphate will be supplied by Udaipur centre to above centres for the study. Before application of rock-phosphate, a detail characterization of rock-phosphate has to be done as per FCO guidelines.

viii. Assessment of micronutrient/heavy metals using uniform protocol in collaboration of AICRP-Micro- and Secondary Nutrients

After detailed discussion, it was finalized that analysis of soil should be done as per following guidelines:

Soil fertility parameters like organic C, N, P and K have to be analyzed every year after end of cropping system.

Soil physical and biological parameters, and micronutrient and heavy metal analysis have to be done once in five years using the same protocol.

ix. QRT recommendation were discussed in details and action was taken on all the points except one 'Incorporation legume in cropping system".

Though at the time of inception of programme, three crops were there in the system and one of them was legume crop but due to management problems third crop was discontinued. Another

reason for discontinuation of third crop was delay in sowing of one crop delays the subsequent two crops which led to poor productivity and the treatment potential is not harnessed. However, at five places still legume component is already exiting to address the issue.

x. Dr. Ch. Srinivasarao, PC AICRP Dry land suggested that after examining the trend in an area may be converted into policy.