

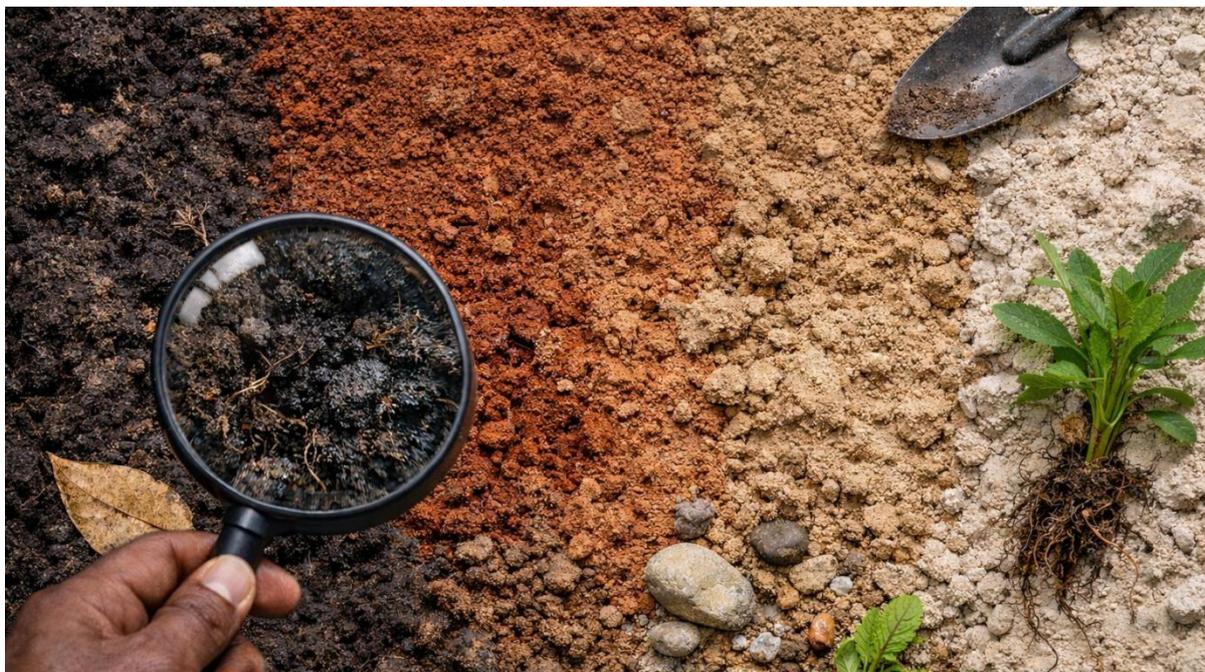


THE HIDDEN MESSAGES IN SOIL COLOUR

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Soil colour serves as a diagnostic tool that provides valuable understanding of the physical, chemical and biological characteristics of the soil. Variations in colour from black and brown to red, yellow, gray, and white reflect the differences in organic matter content, mineral composition, redox as well as moisture conditions (Wang et al., 2025). Generally, soil colour has been used as a rapid field assessment method by farmers to estimate fertility and drainage capacity. While dark soils generally suggest high organic matter and

good aeration, lighter hues often indicate poor nutrient status. Three main things that affect soil colour are:

- **Organic matter:** makes soil darker and more fertile.
- **Iron and manganese compounds:** give red, yellow, or gray colour depending on amount of oxygen present in the soil.
- **Water content:** wet soils often look darker than dry soils (Sirisathikul et al., 2025).



Even though we now have modern tools and machines to study soil physical, chemical, and biological properties, soil colour remains one of the fastest and most useful ways to assess soil health in the field.

BLACK AND DARK BROWN SOIL COLOURS (THE SOIL OF LIFE)

Dark soils especially those appear black or deep brown, are frequently used as an indicator of high fertility, rich organic content and active microbial life in soil. These colours typically result from the accumulation of well-decomposed plant and animal materials, commonly referred to as humus (Geng et al., 2025). Such soils are usually found in grassland regions and temperate climates with adequate rainfall. For example, the black cotton soils of India (Regur) and the Mollisols of the U.S. Midwest are known for their productivity. Compost enriched soils also display this dark colour indicating their suitability for growing vegetables, grains and other nutrient demanding crops. These soils also act as effective carbon sinks, storing carbon in the form of organic matter and playing an important role in mitigating climate change (Liang et al., 2025).

RED, YELLOW AND ORANGE SOIL COLOURS (THE RUSTY EARTH)

Red and yellow soils are commonly found in tropical and semi-arid regions and serve as visual indicators of soil drainage and mineral composition. The red or orange hue is due to the presence of oxidized iron compounds, like how rust appears on metal surfaces. This colour typically indicates good aeration and drainage, as well as long-term weathering, which frequently results in the loss of many essential nutrients. Despite this depletion, red soils can still support productive agriculture when they are properly managed with organic matter, compost and balanced fertilization. In contrast, yellow-coloured soils usually indicate the presence of hydrated (less oxidized) forms of iron, which often develop under poorly drained conditions. The difference in oxidation states between red and yellow soils reflects variations in oxygen availability and waterlogging. Over time, poorly drained soils may limit microbial activity and root respiration, reducing crop productivity unless drainage is improved. Darker shades of red or purplish soils

(orange) may indicate the higher concentrations of iron or manganese oxides, especially in areas experiencing fluctuating moisture levels or prolonged chemical weathering.

- **Red:** iron-rich and well-aerated
- **Yellow:** iron + poor drainage
- **Dark red or orange:** Accumulation of more iron or manganese

GRAY, WHITE, AND PALE SOIL COLOURS

Gray and white soils indicate the problems such as poor drainage, low organic content, or salt accumulation. Gray soils typically develop in areas where water remains stagnant, creating anaerobic conditions that limit oxygen availability and reduce microbial activity. This is especially common in paddy fields or regions with a high water table. With time, these conditions can cause essential nutrients like nitrogen and iron to leach out, reducing soil fertility. In contrast, white soils result from accumulation of salts in arid or semi-arid regions due to poor drainage or over-irrigation. In certain conditions, excessive leaching can remove essential minerals from the soil profile, resulting in the formation of white or pale color, nutrient-deficient layers composed primarily of sand or calcium carbonate (lime) (Abdelrahman et al., 2025). These types of soils are generally infertile and require significant restoration, such as gypsum application, better drainage and planting of salt-tolerant crops. If left untreated, they can severely hinder crop growth and productivity.

- **Gray soils** - Waterlogged, poorly aerated, low microbial activity
- **White soils** - High salt content or leached, nutrient-poor soil
- **Pale soils** - Indicate low organic matter and weak fertility
- **Management** - Improve drainage, add organic matter and correct salinity or pH issues (Garcia-Comendador et al., 2025)

MODERN TOOLS FOR UNDERSTANDING SOIL

Modern soil science has evolved beyond simple visual assessments. Advanced soil assessment technologies



such as colourimeters, digital soil mapping and satellite imaging now enable researchers to analyze soil characteristics with greater precision and efficiency across large geographic areas. These tools enhance the accuracy of soil classification and support data-driven decision making in agriculture and land management. Farmers are also using:

- Soil testing kits that correlate colour with pH, nitrogen and organic carbon.
- Mobile apps that use AI and camera sensors to identify different soil types and offer fertility recommendations.

WHY COLOUR STILL MATTERS

Even with lab tools and precision agriculture, soil colour remains a quick, free and spontaneous method for assessing the properties of soil. When combined with knowledge of soil texture and structure, it forms a dominant first step in sustainable land management.

CONCLUSION

Soil colour serves as a powerful indicator of nutrient and moisture levels, microbial activity, and the lands ecological history. Interpreting this natural language empowers stakeholders to make informed choices that improve land use, enhance crop yields, and protect natural ecosystems. Whether it's a farmer evaluating field conditions, a student studying environmental science, or a policymaker shaping rural development, understanding soil colour is a necessary skill. As we move towards high-tech solutions in agriculture, it is equally important to stay rooted in the basics and the colour of the soil is one of the best places to start.

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