*Indian Farming* 75 (09): 07-09; September 2025

# Healthy Soil, Healthy Food,

## Healthy life

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*In a world grappling with growing populations, climate change and declining nutrition, the solution to many of our challenges lies right in the soil. Soil is a living, breathing system that directly affects the quality of the food we eat and ultimately our health and wellbeing. The age-old wisdom 'we are what we eat' could rightly be extended to say, 'we are what our soil feeds us'. A healthy soil is alive with billions of micro-organisms like bacteria and fungi, as well as earthworms and insects. These creatures break down organic matter, cycle nutrients, improve soil structure and make essential nutrients available to plants. A healthy soil functions like a well-tuned ecosystem which supports plant growth, stores carbon, filters water and builds resilience to pests and climate stress. Sustainable agricultural practices such as crop rotations, crop residue management, efficient water management, etc. may lead to food and livelihood security and maintained the integrity of our ecological environment.*

**Keywords:** Bio-fortification, Green manuring, Paddy straw management, Soil health

SOIL is the original source of all essential nutrients both for the plants and the humans who consume them. If the soil is nutrient-deficient, the food grown on it is likely to be nutrient-deficient too. To prevent this, the use of chemical fertilizers must be carefully balanced i.e. neither excessive nor deficient. Applying only fertilizer-N without supplementing other nutrients can degrade soil health over time and result in nutritionally poor harvests. Therefore, a scientifically informed and balanced use of chemical fertilizers guided by soil testing ensures that soils remain fertile, crops are nutrient-rich, and human health is safeguarded. For improved soil health following practices may be adopted.

### *In situ* crop residue management

Crop residues are rich source of plant nutrients, and therefore, have the potential to improve the resource use efficiency along with sustainability of the agro-ecosystem. Open field residue burning after crop harvesting causes irreversible loss of nutrients, soil fertility and environment. India produces over 686 million tonnes of crop residue annually, with rice and wheat being the major crops. Estimates revealed that burning of one tonne of rice residue results in the loss of 400 kg organic carbon (C), 5.5 kg of nitrogen (N), 2.3 kg of phosphorus (P), 25 kg of potassium (K) and 1.2 kg of sulphur (S). Furthermore, rice residue burning not only results in a complete loss of N and S elements, but also causes emission of greenhouse gasses (GHGs) such as carbon dioxide ($CO_2$), carbon monoxide (CO), methane ($CH_4$), sulphur dioxide ($SO_2$) and nitric oxide ($N_2O$), posing a risk to human and animal health. It has been estimated that burning of one tonne of rice straw produces about 1460 kg $CO_2$, 3 kg suspended particulate matter, 60 kg CO, 199 kg fly ash and 2 kg $SO_2$. Therefore, to keep the soil healthy, crop residues must be recycled back to the soil so that essential nutrients may be replenished after the harvest. Rice residue management helps improve soil organic C pool. Analysis of soil samples collected from farmers' fields after partial burning of rice straw, *in situ* rice residue management for a long period of 5–10 years, 10–15 years and for more than 15 years revealed increased soil organic C by ~26, 34, 48 and 70%, respectively over the fields where rice residue was burnt after crop harvesting.

Over the years, several *in situ* rice residue management and wheat establishment methods e.g. Happy Seeder, Super Seeder, PAU Smart Seeder, Surface seeding-cum-mulching and incorporation following reversible mould board plough and rotavator tillage are developed and adopted by farmers. Happy Seeder (a modified zero tillage machine) or Super Seeder machines can be used for drilling of wheat seed directly into combine harvested rice residue without any burning or removal. Surface seeding method of wheat sowing is a low-cost and easy technique for *in situ* rice residue management for timely sown conditions. In surface seeder technique, wheat seed and basal fertilizers are uniformly broadcasted in a combine harvested rice fields, followed by one pass of cutter-cum-spreader which cut the whole straw (at 4–5 inch above soil surface). Farmers may use any of these techniques for *in situ* rice residue management and improve their soil health.

## Integrated and balanced nutrient management

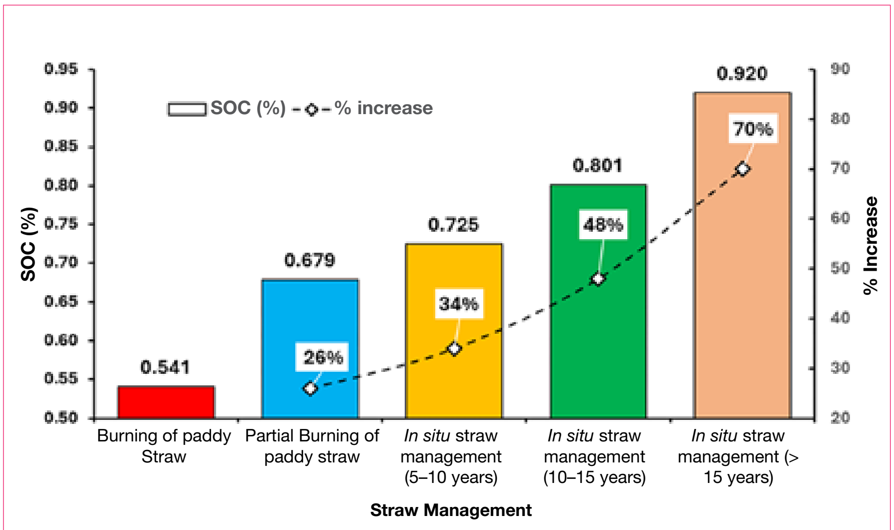
Integrated and balanced nutrient management refers to the combined use of chemical fertilizers, organic manures, bio-fertilizers, and crop residues to maintain soil fertility and crop productivity. It ensures a balanced supply of essential nutrients, improves soil health, reduces dependence on synthetic fertilizers, and minimizes environmental hazards. By integrating different nutrient sources, integrated and balanced nutrient management promotes sustainable agriculture, enhances nutrient-use efficiency and supports long-term food security.

***Organic manures*:** Although organic manures provide much less amount of essential nutrients, but they are good for soil health. Farmers can use well decomposed farm yard manure (FYM), poultry manure, gobar gas slurry, *parali char*, etc. Soil application of well decomposed FYM before sowing can reduce 2 kg of N and 1 kg of P/tonne of FYM applied. Similarly, only 138 kg urea/ha and no phosphorus is required in wheat sown after potato that received 25 tonnes of FYM. Similarly, 6.2 tonnes/ha of poultry manure or 5.9 tonnes of gobar gas plant slurry/ha when applied to paddy, N and P requirements may be reduced by 25 and 50%, respectively, in wheat. After sowing leguminous crops, wheat only need 198 kg urea/ha in equal splits. Furthermore, application of 5 tonnes/ha *prali char* to wheat before last ploughing saves 87 kg urea/ha. It increases the yield and improves soil health. Similarly in paddy, application of 6.2 tonnes poultry manure or 15 tonnes pressmud/ha may result in saving of 136 kg urea/ha. Furthermore, application of 15 tonnes FYM or 6 tonnes gobar gas slurry or 5 tonnes of *prali char*/ha may result in saving of 87 kg urea/ha (PAU 2025). It has been observed that integrated nutrient management through combined application of chemical and organic fertilizers results in improved soil health as well as higher crop yields.

***Green manuring*:** Green manuring with *dhaincha*/cowpea/sunhemp is another practice of improving soil health and help reduce the use of chemical fertilizers. Incorporation of 6–8 weeks old *dhaincha*/cowpea/sunhemp in soil one day before rice transplanting help saving of 136 kg urea/ha. Similarly, incorporation of moong after picking of pods before transplanting help reduce fertilizer N dose by one-third.

***Bio-fertilizers*:** Bio-fertilizers are substances that contain living micro-organisms, which when applied to seeds, plants or soil, colonize the rhizosphere or the interior of the plant and promotes growth by increasing the supply or availability of primary nutrients to the host plant. They help mobilize nutrients like fixing atmospheric N and P solubilisation and augmenting plant growth by producing growth hormones. Moreover, they increase crop yield, improve soil health and are cost-effective and eco-friendly in nature. Wheat seed inoculation with 500 g consortium bio-fertilizer increases grain yield as well as maintains/improves soil health.

***Chemical fertilizers*:** Soil testing is pre-requisite for fertilizer application. A soil test commonly refers to the analysis of a soil sample to determine nutrient content, composition and other characteristics such *p*H and concentration of soluble salts (EC). Therefore, it is always advisable to apply chemical fertilizers on soil test basis. It has been observed that farmers usually concentrate on one fertilizer viz. urea for every problem, but actually there are many reasons for the poor plant growth. For example, rice grown on alkali soils generally shows zinc (Zn) deficiency and requires application of zinc sulphate at rates higher than those recommended for normal soils. So, application or spray of recommended dose of zinc sulphate should be applied to obtain good yield.




Change in soil organic C pool following long-term *in situ* rice residue incorporation at farmers' fields of Sangrur district, Punjab (India). (*Source*: Author collected data)

## Management of salt-affected landscapes

A high concentration of soluble salts has a detrimental effect on plant growth and the general health of the soil. The build-up of soluble salts in the soil causes rise in osmotic pressure and hindering plant uptake of nutrients and water. In general, salt-affected soils are broadly categorized as saline (high neutral salts), sodic (high exchangeable sodium), or saline-sodic (high in both). Green manuring with *dhaincha* should be preferred in *kallar* (salt affected) soils. The affected soils need 25% more N than recommended. Saline soils where electrical conductivity is >0.8 dS/m, require application of organic manures/green manures/ crop residues. Sodic soils can be reclaimed by using recommended dose of gypsum. Farmers are advised not to apply gypsum to saline soils.

Additionally, testing irrigation water quality is important as poor quality irrigation water may lead to poor soil in long run. Based on irrigation water quality, water is classified as either sodic (containing sodium carbonates and bicarbonates) or saline (containing sodium chlorides and sulphates). Different management strategies like adequate drainage, land leveling, crop selection, use of poor quality water on sandy soils, applications of gypsum, organic amendments, conjunctive use of poor and good quality water, etc. are recommended for judicious use of poor quality irrigation water.

### Organic farming and bio-fortification

Organic farming is a method of agriculture that avoids the use of synthetic fertilizers and pesticides. It relies on natural inputs like compost, green manures, crop rotation, and biological pest control to maintain soil fertility and crop health. This system promotes healthy soil, safe food, environmental protection, and long-term sustainability. It also forbids the use of synthetic agrochemicals. Bio-pesticides are used to control disease and insect pests. Although the crop yields of organic crops are less than the inorganically grown crops during initial 3–4 year but later on, they may become equal.

Further, there is a need to grow crops and special purpose varieties, viz. PBW Zinc 2 wheat variety recommended by Punjab Agricultural University (PAU), Ludhiana. This variety is characterized by higher grain zinc (Zn) concentration which is good for human health. Zn bio-fortification technique which helps improve inherent Zn status of the edible portion of plants is possible simply by spraying $ZnSO_4$ solution onto the crop at a proper dose. For nutritionally good quality wheat grains, Zn content can be increased by giving one or two sprays of 0.5% zinc sulphate heptahydrate (21% Zn) solution from anthesis to early grain development stages in the evening hours. In case of barley, PL 891 is a hull less variety of PAU, Ludhiana that contains 4% β-glucan content and 12% protein content. β-glucan is helpful in preventing heart diseases and type-II diabetes. For obtaining nutritionally good quality gram, Zn content in grains can be increased by tank mix foliar spray of 0.5% zinc sulphate heptahydrate (21% Zn) (1850 g/ha) + 2% urea (7.4 kg/ha) using 370 L of water at 90 and 110 days after sowing.

Another wheat variety (PBW RS1) has been the special quality wheat variety of PAU, Ludhiana having high proportion of resistant starch in the grains. Consumption of the high resistant starch products do not cause spike in blood sugar levels, rather it acts as the dietary fiber and thus have low glycemic index.

For *Brassica* cultivars or hybrids with less than 2% erucic acid in the oil and less than 30 micro moles of glucosinolates per gram of defatted meal, the term 'canola' is widely used. Erucic acid-rich oil is undesirable for human consumption since it thickens arteries and causes heart health related issues. Similar to this, using defatted non-canola meal as animal feed lowers appetite, productivity, and thyroid function, which can result in thyroid-related health issues. A rise in the percentage of beneficial MUFA (oleic acid) from 18–20% to roughly 60–67% occurs when erucic acid is removed from canola oil. Humans can safely consume these canola types. GSC 6 and GSC 7 varieties of gobhi sarson, RLC 3 and RCH 1 variety of raya, and hybrid of raya, respectively and PGSH 1707 and PGSH 2155 hybrids of gobhi sarson are among the various types/hybrids of rapeseed-mustard that the PAU recommends.

PAU also recommends CoPb 96, CoPb 92, Co 118, CoJ 64 and CoJ 88 varieties of sugarcane for excellent quality of *gur* (jaggery). Grain purpose composite variety of bajra, PCB 167, possesses better nutritional characteristics, especially crude protein, crude fibre, and resistant starch along with high iron (Fe) and Zn content.

### SUMMARY

Healthy soil is the cornerstone of sustainable farming, nutritious food and human well-being. Therefore, improving soil health through *in situ* residue management, integrated nutrient use, organic farming and balanced fertilizer application not only sustains productivity, but also enriches the nutritional quality of crops. Equally important is the adoption of special-purpose varieties, which can help address malnutrition and lifestyle-related health issues. By combining soil-focused practices with nutrient rich crop varieties, we can ensure that the food we grow nourishes both people and the planet. Truly, healthy soil leads to healthy food, and healthy food ensures a healthy life.

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