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Green Manuring: A Sustainable Approach to Soil Fertility Management

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Soil is the backbone of agriculture from ancient times, but due to continuous cultivation, intensive cropping, crop residues removal and imbalanced use of chemical fertilizers gradually affects the soil health. Decline of soil organic matter, nutrient depletion, poor soil structure and reduced biological activity have become important challenges to sustainable crop production. Therefore, modern agriculture needs nutrient-management practices that can maintain productivity while protecting the long-term health of the soil. Green manuring is one such simple, economical and eco-friendly practice. It involves growing a crop specifically for incorporation into the soil while it is still green and succulent. Leguminous crops such as dhaincha (*Sesbania spp.*), sun hemp (*Crotalaria juncea*), cowpea (*Vigna unguiculata*), green gram and other suitable legumes are commonly used. When these crops are incorporated into the soil, their biomass decomposes and releases nutrients and organic matter, improving the physical, chemical and biological properties of soil. Green manuring is an important practice for restoring soil fertility, particularly in intensive cropping systems. Green manuring is the practice of growing a green crop and incorporating it into the soil before it reaches maturity, generally at the vegetative or flowering stage. The crop is not primarily harvested for grain or fodder; instead, the entire green biomass is returned to the soil. Green manure crops are usually fast-growing and produce large amounts of succulent biomass. Leguminous green manure crops are particularly valuable because they establish symbiotic associations with *Rhizobium sp.* and related nitrogen-fixing bacteria, allowing atmospheric nitrogen to be converted into forms that contribute to soil nitrogen fertility

Types of Green Manuring

Green manuring can broadly be classified into in-situ green manuring and green-leaf manuring.

1. **In-situ green manuring**

In this method, the green manure crop is grown in the same field where it will be incorporated. For example, dhaincha may be grown during the period between two main crops. After sufficient growth, it is ploughed into the soil and allowed to decompose before planting the succeeding crop. Examples include Dhaincha *(Sesbania aculeata*), Sunhemp (*Crotolaria juncea*), Cowpea, Greengram, Blackgram, Clusterbean.

This method has several advantages:

- The crop is grown and incorporated in the same field.
- No transportation of bulky biomass is required.
- Nutrients remain within the field.
- Organic matter is directly returned to the soil.
- It is suitable for large-scale field crops.

For rice-based systems, dhaincha can be grown before rice transplantation and incorporated into the soil before planting rice.

2. Green-leaf manuring

Green-leaf manuring involves collecting fresh green leaves and tender branches from trees or shrubs and incorporating them into agricultural soil.

Examples include: Gliricidia, Subabul (Leucaena), Sesbania, Pongamia and other locally available green-leaf sources.

Unlike in-situ green manuring, the plant material is produced outside the field and then brought into the field

In-situ green manuring of Dhaincha in Cotton.

Ex-situ green manuring

Effects of Green manuring on soil fertility

The importance of green manuring lies in its multiple effects on soil. It improves not only nutrient availability but also soil structure, organic matter, microbial activity and water relations.

1. Addition of nitrogen

The most important advantage of leguminous green manure crops is their contribution to biological nitrogen fixation. Legume roots harbour nitrogen-fixing bacteria in root nodules. These microorganisms convert atmospheric nitrogen into biologically useful forms. A recent study shows that a well-grown dhaincha crop can contribute approximately 50–60 kg N/ha, while also improving soil organic matter, microbial activity and nutrient-use efficiency.

2. Improvement of soil organic matter

Continuous cropping often removes large quantities of organic material from agricultural fields. Green manuring returns fresh plant biomass directly to the soil. During decomposition, part of this biomass contributes to soil organic matter. Soil organic matter acts as an important reservoir of nutrients and supports many biological and physical processes.

3. Improvement in soil structure

Addition of organic matter improves soil aggregation and structural stability. Better aggregation creates favourable pore spaces for air and water movement. As a result, green manuring can improve soil tilth, reduce compaction, increase porosity, improve root penetration, enhance water infiltration, improve water-holding capacity.

4. Enhancement of microbial activity

Green manure provides an easily decomposable source of carbon and nutrients for soil microorganisms. The decomposition process stimulates microbial activity, which in turn accelerates nutrient cycling and organic matter transformation. Increased microbial activity can improve the availability of nutrients to subsequent crops.

5. Improved nutrient cycling

Green manure crops absorb nutrients from the soil and store them in their plant tissues. When the crop is incorporated, these nutrients are gradually released through decomposition. This helps recycle nutrients within the soil–plant system and reduces nutrient losses. Green manuring can therefore contribute to improved availability and cycling of nutrients like Nitrogen, Potassium, Phosphorus, Sulphur and micronutrients.

6. Reduction in dependence on chemical fertilizers

One of the major concerns associated with intensive agriculture is excessive or imbalanced fertilizer use. Green manuring can provide a biological source of nitrogen and organic matter,

thereby reducing the dependence on external inputs. However, green manuring should not necessarily be viewed as a complete replacement for fertilizers. Instead, it should be considered part of an integrated nutrient management strategy based on soil testing and crop requirements.

7. Weed suppression

A rapidly growing green manure crop competes with weeds for: Light, water, nutrients, space. This can suppress weed growth and reduce the weed seed bank over time. Green manuring may therefore contribute to reduced dependence on herbicide.

8. Protection from erosion

A growing green manure crop provides ground cover and protects the soil surface from the direct impact of raindrops and wind. The crop canopy and roots can reduce soil detachment**,** slow down runoff**,** improve infiltration**,** hold soil particles together**,** reduce erosion. Therefore, green manure crops can contribute to soil and water conservation.

Conclusion

Green manuring is a simple practice with far-reaching benefits. It converts plant biomass into a valuable source of organic matter and nutrients while simultaneously improving soil structure, microbial activity, nutrient cycling and water relations. Its importance is particularly high today because agriculture faces the dual challenge of producing more food while maintaining soil health and environmental sustainability. Green manuring addresses both challenges by returning biomass to the soil, fixing atmospheric nitrogen through legumes and reducing the dependence on external inputs. Rather than considering green manuring as an alternative to modern fertilizers, it should be viewed as an important component of integrated nutrient management. When combined with soil testing, balanced fertilization, crop rotation, residue recycling and other soil-health practices, it can help maintain productive soils for future generations. Thus, “grow it green, return it to the soil, and build fertility naturally” can be regarded as the central philosophy of green manuring. It is not merely an old agricultural practice; it is a scientifically supported, economical and environmentally responsible pathway towards healthy soils, sustainable crop production and climate-resilient agriculture.

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