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Green Manuring: A Sustainable Practice for Soil Fertility Enhancement

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Abstract

Green manuring is an eco-friendly and sustainable agricultural practice that enhances soil fertility, as well as soil structure and other soil parameter. It involves growing leguminous crops like *Dhaincha (Sesbania aculeata)* and *Sunhemp (Crotalaria juncea)*, and that ploughed under before flowering. Practice of green manure adds 40–60 kg nitrogen per hectare through biological nitrogen fixation and increase organic carbon content by 0.1–0.3%. Regarding these several studies conducted by ICAR, institutes and over the states and researches shown that green manuring increases paddy yields by 10–25 percent. It improves soil structure, microbial activity, and water-holding capacity, while also reducing dependence on chemical fertilizers. Farmers adopting green manuring reported 15–20 per cent higher productivity in rice. Thus, green manuring is a low-cost, climate-resilient practice promoting sustainable agriculture.

Keywords: Organic fertilizers, Soil structure, Organic carbon, Soil reclamation.

Introduction

In India, land degradation presents a biggest barrier to sustainable agriculture by gradually diminishing soil productivity and fertility. Out of the total land of country (328.7 million hectares) approximately 264.5 million hectares are exclusively using for agricultural and allied activities such as farming, forestry, and biomass generation. Soil is subject to degradation from various sources, including soil erosion, nutrient loss, soil salinity, reduced organic carbon and content. According to data from the National Bureau of Soil Survey and Land Use Planning (Anonymous, 2004), degradation processes not only limit agricultural yields but also undermine the ecological integrity of agro-ecosystems.

Green manuring is one of the promising approach to minimize the challenges is green manuring, which helps to renewed and enriching soil fertility and overall eco-friendly and sustainable agriculture. The potential of green manuring explored early on, the Research Department at HDRA identified green manuring as a key research focus soon after its establishment in the 1980s (Anonymous, 2008).

Green manuring is basically the cultivation of fast-growing leguminous crops such as *Sesbania aculeata* (Dhaincha) and Sunhemp, which are incorporated into the soil at their tender green stage or at 50 per cent flowering stage. Alternatively, somewhere, green biomass grown elsewhere may also be added to the main field called ex situ green manuring. The incorporation of Dhaincha as a green manure crop has been associated with up to an 18% increase in paddy yields and it significant improve in soil organic carbon levels. Green manure biomass may also be collected from leguminous or non-leguminous plants grown along bunds or on wastelands, and when incorporated into the soil, it rapidly decomposes, enhancing soil structure and nutrient content. It significantly enhance the soil by organic matter, accelerate microbial activity, and improving nitrogen availability (Anonymous, 2018) as well as improves soil structure. Green manuring plays key component of integrated nutrient management (INM), it complements the use of inorganic and bio-fertilizers, providing a sustainable, eco-friendly, and cost-effective alternative to excessive reliance on chemical fertilizers.

Traditionally, farmers engaged in indirect green manuring by incorporating naturally grown plants

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into the soil using puddling operations prior to transplanting, particularly in paddy fields, it enhances soil organic matter and supported soil microbial activity. However, Green Revolution brought about a significant shift organic to chemical nutrient management practices. It increases reliance on high-yielding varieties and intensive cropping systems, especially in rice, and wheat. Consequently, the use of organic amendments such as farmyard manure, compost, and green manure crops has steadily declined, thereby affecting the long-term sustainability and biological health of the soil.

Overall, green manuring represents a sustainable soil fertility management practice that aligns with the principles of conservation agriculture or the way to sustainable agriculture. It not only reduces dependency on chemical inputs but also improves soil resilience and productivity, making it an essential component of long-term agricultural sustainability in India.

Objectives of Green Manuring

- To enhance nitrogen content in the soil through biological nitrogen fixation.
- To improve the physical structure of soil (aeration, porosity, and water-holding capacity).
- To increase organic matter and microbial biomass in the soil.
- To suppress weeds and control certain soil-borne pathogens.
- To reduce dependency on expensive chemical fertilizers and promote sustainable agriculture.

Requirements for Effective Green Manuring

Green manuring is more effective when certain agronomic and environmental conditions are fulfilled:

- **Climatic Conditions:** Warm temperatures with adequate rainfall; ideal during monsoon.
- **Soil Type:** Alluvial, loamy, or sandy-loam with good drainage; avoids waterlogging.
- **Time Frame:** A window of 45–60 days before the main crop is essential.
- **Land Preparation:** Field should be well-prepared and free from hardpan or previous stubbles.

In over the state of India, farmers often opt for green manure crops before paddy transplantation, usually sowing by mid-June with the onset of monsoon (ICAR, 2020).

Types of Green Manure

- In-Situ Green Manuring: Grown and incorporated into the same field. E.g., Dhaincha, Sunhemp, lentil, barseem.
- Ex-Situ Green Manuring: Biomass grown elsewhere and applied to the main field. E.g., Glyricidia, Subabul, Karanj, Indigo.
- Leguminous Crops: Fix atmospheric nitrogen (Sunhemp, Moong, Cowpea).
- Non-leguminous Crops: Add organic matter but fix less nitrogen (Maize, Sorghum).

Common Green Manure Crops and Their Nutrient Contribution

Green manure crops like Dhaincha and Sunhemp, due to their rapid biomass accumulation and nitrogen

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fixation, are most commonly used in Chhattisgarh. Tiwari *et al.* (2020) observed that repeated use of Dhaincha over two seasons improved soil organic carbon from 0.36% to 0.59% and improved crop response in rice.

Table 1: Nutrient content of green manure crops

Plant	Scientific Name	N (%)	P_2O_5 (%)	K (%)
Sunhemp	*Crotalaria juncea*	2.30	0.50	1.80
Dhaincha	*Sesbania aculeata*	3.50	0.60	1.20
Sesbania	*Sesbania speciosa*	2.71	0.53	2.21

Furthermore, Table 1 highlights the nutrient content of green manure crops. Among the commonly used green manure species, Dhaincha (*Sesbania aculeata*) stands out with the highest nitrogen content (3.50%), along with 0.60% phosphorus (P_2O_5) and 1.20% potassium (K), making it highly effective in enriching the soil with essential nutrients. Sesbania (*Sesbania speciosa*) also shows good potential, containing 2.71% nitrogen, 0.53% phosphorus, and the highest potassium content (2.21%) among the listed crops. Sunhemp (*Crotalaria juncea*) contributes 2.30% nitrogen, 0.50% phosphorus, and 1.80% potassium. These values indicate that all three crops can significantly enhance soil nutrient status, with Dhaincha being particularly effective in nitrogen addition, which is crucial for plant growth and soil microbial activity. Therefore, the incorporation of such green manure crops into farming systems supports sustainable agriculture by reducing dependence on chemical fertilizers and improving soil health.

Table 2: Green manures and their Nitrogen contribution

Crop	Botanical Name	Dry Matter (t/ha)	Nitrogen Contribution (kg/ha)	Other Benefits
Dhaincha	*Sesbania aculeata*	23.2	80–120	Improves porosity and organic matter
Sunhemp	*Crotalaria juncea*	30.6	80–100	Nematode control, fast-growing
Moong	*Vigna radiata*	22.1	25–50	Short-duration, fixes nitrogen
Cowpea	*Vigna unguiculata*	23.2	40–70	Enhances microbial activity
Cluster bean	*Cyamopsis tetragonoloba*	3.2	40–60	Adds carbon, tolerant to dry conditions

Green manure crops contribute significantly to sustainable agriculture through their nitrogen-fixing ability and additional agronomic benefits. As shown in the table, Sunhemp (*Crotalaria juncea*) produces the highest dry matter yield at 30.6 t/ha and contributes 80–100 kg/ha of nitrogen, along with providing control against nematodes due to its allelopathic properties and fast growth. Dhaincha (*Sesbania aculeata*) follows with 23.2 t/ha dry matter and the highest nitrogen contribution range of 80–120 kg/ha. It is particularly beneficial for improving soil porosity and enhancing organic matter content. Cowpea (*Vigna unguiculata*) and Moong (*Vigna radiata*) produce similar amounts of dry matter (23.2 and 22.1 t/ha respectively) and contribute 40–70 and 25–50 kg/ha nitrogen, while enhancing microbial activity and offering a short-duration cropping option, respectively. Cluster bean (*Cyamopsis tetragonoloba*), although producing lower biomass (3.2 t/ha), still contributes 40–60 kg/ha nitrogen and is valued for its drought tolerance and carbon addition. These crops,

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when integrated into farming systems, not only reduce dependence on synthetic fertilizers but also enhance overall soil health, structure, and biodiversity.

Cultivation of Green manure crops-

Farmer generally grow green manure crop of Dhaincha through broadcast the seed in sufficient moisture condition of the field without nutrient supplements and other agronomic practices. However, agronomic package of practices are required for production enhancement of green manure.

Seed Rate:

Green manuring Crop	Seed Rate (kg/ha)
Dhaincha	20-25
Sunhemp	40–50
Moong	15–20
Cowpea	20–25
Berseem	25–30
Cluster bean	20–25

Sowing Time:

- *Kharif*: With onset of monsoon (15 June to 15 July).
- *Rabi*: October–November (mainly Berseem under irrigated conditions).

Sowing Method:

Line sowing at 20–25 cm spacing for better biomass spread and easy incorporation.

Seed Treatment:

Inoculation with Rhizobium culture is essential to enhance nitrogen fixation (Tiwari *et al.,* 2020).

Fertilizer Management

Although green manures grow in low-input conditions, 10–15 kg P_2O_5/ha is often applied to support early growth and enhance nodule formation. Application of Single Super Phosphate (SSP) helps where phosphorus levels are low (ICAR, 2020).

Irrigation Requirement

Generally Rainfed during Kharif with one light irrigation may be provided at 20–25 DAS if dry spell occurs.

Identification of Cutting Stage

The optimal stage for incorporation is just before flowering (45–60 DAS), when nutrient content is at its peak and lignin content is low. Delayed cutting leads to woody biomass, which decomposes slowly and may temporarily immobilize nitrogen.

Cutting of Sunhemp at 50 DAS before flowering resulted in faster decomposition and better rice yield compared to 70 DAS.

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Incorporation of green manures

The process of green manure incorporation involves ploughing under the biomass of green manure crops before flowering, usually around 45–60 days after sowing, when nutrient content and biomass are at their peak. This ensures rapid decomposition and the release of nutrients in a form readily available to succeeding crops. Leguminous green manures such as *Sesbania aculeata, Crotalaria juncea (Sunhemp), Sesbania rostrata*, and Pillipesara are commonly used due to their high nitrogen-fixing capacity.

Incorporation of green plant biomass improves the physical, chemical, and biological properties of the soil. It increases the organic carbon content, improves soil structure and porosity, enhances microbial activity, and boosts the availability of macro and micronutrients, especially nitrogen. Green manuring thus serves as an essential component of the Integrated Nutrient Management (INM) system, reducing the dependence on synthetic fertilizers.

According to Anonymous (2018), incorporating green manure crops significantly improves the nitrogen economy of the soil, contributing to sustainable crop production. In the context of Chhattisgarh, particularly the Bastar plateau, the use of green manuring with crops like Dhaincha has shown remarkable results.

Green manures can be incorporated directly by ploughing the in-situ biomass grown in the field or by adding externally sourced green leafy materials from bunds or wastelands. This is particularly useful in regions where land availability is limited. The main objective remains the same: to enhance soil health by improving its nitrogen status, adding organic matter, and creating a conducive environment for microbial activity.

Precautions for Green Manuring

- Timely incorporation (15–20 days before next crop sowing) is critical for decomposition.
- Proper mixing of green biomass using rotavator or disc harrow.
- Select crops as per regional climate and soil type.
- Ensure adequate moisture for seed germination and early crop establishment.

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