Green Manure: Aspects and its Role in Sustainable Agriculture

Abstract

Continuous cropping and frequent soil cultivation contribute to the breakdown of soil aggregates and the removal of organic matter, which reduces soil fertility and production. Green manuring is a low-cost and efficient approach for reducing the expense of inorganic fertilizers and preserving soil fertility. Due to the mounting problems facing agriculture, including climate change, extreme weather events, soil deterioration, and land contamination as a result of the overuse of chemical fertilizers, many farmers are adding green manuring into their methods to prevent soil erosion, improve soil structure, control weed growth, and most importantly increase the soil's fertility. The use of green manure has drastically decreased, raising concerns about the sustainability of soil fertility. Field crops may experience a temporary setback following the integration of organic residues with a high C-N ratio. By enhancing the soil's structure, fertility, and nutrient content, green manuring functions as a restoration factory to maintain the soil's fertility for sustainable agriculture. Green manure is therefore essential for growers that seek to decrease the use of dangerous chemicals for soil fertilization. Many farmers must use green manure in their operations to avoid the usage of chemical fertilizers in agriculture.

Keywords: Green manure, nutrient management, soil fertility, agricultural sustainability.

INTRODUCTION

A component of organic farming is green manuring. The practice of ploughing under or incorporating any green manure crops into the soil while they are still green or shortly after they start flowering is known as "green manuring". "The value of green manuring lies in the incorporation of organic matter into the soil". The primary reason for growing cover crops is to enrich the soil with nutrients and organic matter (Valizadeh *et al*., 2023), and it is one of the soil's most important components for true soil fertility. Organic fertilizers, such as green manure crops, have grown in popularity in recent years as a result of environmental concerns and a desire to reduce input costs (Pappa *et al*., 2006). The soil is given organic matter as a result of the agricultural usage of green admixture crops and their integration, making green manures essential for achieving assembly sustainability. Many farmers have made the decision to use green manures and have vowed to support long-term agricultural sustainability through improved soil fertility management. Green manuring is not used by all farms nowadays, though, the availability of the soil nutrients is impacted by the breakdown of this organic matter.

Farmers here have just been using green manuring for decades. According to estimates, a green manure crop that is 40–50 days old can provide up to 80–100 kg N/ha. A green manure crop can replace 50–60 kg of fertilizer N/ha, even if only half of this N is used by crops (Sharma *et al.*, 2013). Some of the potential green manuring legumes are dhanicha, sunhemp, cowpea, mung, bean, guar and berseem *etc*. As green manure crops, dhanicha, sunhemp, mungbean, and guar grown during *kharif* season have been shown to contribute 8–21 tons of green matter and 42–95 kg of nitrogen per hectare. Similarly, khesari, cowpea, and berseem, these crops can provide 12-29 tons of green matter and 67-68 kg of nitrogen per hectare when cultivated during the *rabi* season (Mishra and Naik, 2004). Green manuring is a useful tool for the crop's optimum growth. It helps maintain soil fertility and the general health of the soil by integrating nutrients like nitrogen into the soil (Table 1). Green manuring promotes the growth of beneficial microorganisms and broadens soil diversity. The soil environment is improved in a number of positive ways, increasing the physical, chemical, and microbial properties of the topsoil and increasing crop yield (Singh et al., 2022).

Table 1: Nutrient composition of green manure crops

Green manure crop	N%	P%	K%	Ca%
Dhaincha	0.6	3.7	1.69	0.5
Sunn hemp	0.4–0.8	0.1	0.5	0.4
Cowpea	0.5–0.7	0.2	0.6	0.6
Senji/Indian clover	0.5	0.3	0.7	0.3
Pigeon pea	0.6–0.8	0.2	0.6	0.6
Guar/cluster bean	0.62	0.057	4.32	0.13
Berseem	0.43	0.21	4.59	2.2

Source: Tanveer *et al*. 2019

Despite being commonly used previously, green manuring has lost popularity recently as a result of rising demand for food, the existence of other lucrative and competing crops, and the availability of both affordable and expensive artificial fertilizers. Due to difficulties with soil accessibility, the depletion of soil fertility, and public concern over overuse and energy conservation, green manures have lately regained importance for both organic producers and low-input farms employing conventional agronomic methods (Kumar *et al*., 2014).

Necessity of Green Manuring

In order to retain the soil's ability to produce, green manuring is a complementary, essential technique because:

- The soil has been physically and chemically degraded by increased and diversified farming per unit area or time.
- The present spike in inorganic fertilizer prices, occasional lack of availability, and adulteration could not keep up with the demand for fertilizer from high-yielding synthetic types and hybrids.
- Farmyard manures are in low supply since fewer animals are used in farming as a result of mechanical cultivation. Green manuring is required to address their shortage.

Low crop yields are documented by the acceptance of ineffective soil management strategies, widespread burning of agricultural residues, and rash adoption of agronomic practices and asymmetric nutrients management (Florentin *et al*., 2011). Reduced levels of organic nutrients in the soil weaken the interaction between the soil and water, reduce water retention, and reduce the capacity of the soil to assimilate nutrients, including cations exchange capacity. All of these ultimately contribute to less nutritional absorption through the degradation of organic material (Bonini and Alves, 2010). Additionally, rigorous and expedited agronomic procedures encourage significant organic depletion as well as regulate nutrient release, which creates an imbalance in soils after bushing with manures or crop residues. The use of organic manures is the only remedy, and green manuring should be taken into consideration when adding organic materials to deficient soils (Maitra *et al*., 2018). The objectives of green manuring may be perfect, and it can have a variety of effects by providing N and organic matter to the soil (Table 2).

Table 2: Amount of nitrogen and organic matter turned under by some green manure crops

Green manure crop	N turned under (kg ha^{-1})	Organic matter (kg ha^{-1})
Sunn hemp	75–80	18,500
Guar	60–118	18,500
Dhaincha	75–88	15,950
Senji	113	14,250
Berseem	60	14,000
Arhar	45	–
Cowpea	58	–

Source: Tanveer *et al*. 2019

In addition to conventional farming, organic farming is receiving more attention in these trying times. This type of farming ensures a convalescent ambiance for the environment and involves the management of nutrients from organic sources, among which green manuring demands special attention.

Utilizing Green Manure for Sustainable Agriculture

Sustainable agriculture depends on using green manure instead of synthetic fertilizers. Sustainable production techniques are a component of organic farming and aid in re-establishing the natural equilibrium that has been disturbed by improper farming methods. A lot of benefits exist for the economy and the environment when using green manure on agricultural land. Methods including green manure must be used as a new agricultural approach for sustainable growth. Green manure technologies were found to provide farmers with a range of benefits, such as increased yields, carbon sequestration, nitrogen fixation, an increase in SOC content, biodiversity preservation, etc. A system of ecological compensation as a novel approach to sustainable farming may become widely adopted as a result of high ecosystem service values and low farmer economic rewards.

The use of green manure is thought to be a crucial strategy for reducing the effects of salt stress. The importance of including green manuring crops in crop rotations cannot be overstated because they boost the soil's labile organic matter, N, P, and K content, which in turn increases crop output (Irin and Biswas, 2022). Legume green manure crops that have been incorporated into the soil emit organic compounds like organic acid, amino acids, carbohydrates, vitamins, and mucilage both during crop growth and after decomposition (Shukla *et al*., 2011). They are recognized for having a substantial impact on soil health and are seen as essential to sustainable agriculture (Laishram *et al*., 2020). The use of green manure improves the physical, chemical, and biological characteristics of soil in salt-affected areas, resulting in improved plant growth and development. Soil remediation with green manure technology is crucial for sustainable land use and crop productivity (Wong *et al*., 2019).

Growing green manure crops not only helps to protect the soil but also improves the soil's quality by producing biomass and capturing sunlight. This strategy also has several unintended advantages, including increased aesthetic value and the potential to produce animal feed, reduced compaction and greater field trafficability. A low-cost method of increasing agricultural yields, green manuring requires little additional work. When there is not enough animal manure available on a farm and it is not viable to import natural fertilizers from abroad, green manures are especially crucial. Despite the impression that using green manures would require more labour, there are several ascendancies:

Enhancing soil fertility and improving soil properties: Green manuring increases the physical and chemical characteristics of the soil by preventing nutrient losses through leaching, increasing water holding capacity, and increasing organic matter reserves (Pandey *et al*., 2008). The ability to recycle nutrients was also increased by the use of green manures between crop cycles. According to several studies, the abundant abeyant of green manure for nutrient exchange to crops (Adediran *et al*., 2004) and the advance of soil properties (Carvalho *et al*., 2015). Soil microbial biomass is recommended as an ecological feature to evaluate changes in attributes of soil usage and management because it is a significant biological property (Santos *et al*., 2012). According to several research, using legumes as green manures significantly increased the soil microbial biomass (Shah *et al*., 2010).

It was acknowledged that adding green manures to the soil increased soil quality and abundance by promoting soil microbial activities (Eriksen, 2005). In light of the microbiological activity of the soil, it should be noted that green manures offer nutrients as carbon source for the microbe that converts bare nutrients in bulb leftovers to available for the crops and it improves variety of soil micro-organisms. Leguminous green manures can hold beneficial levels of organic nutrients in the soil and fix a significant quantity of atmospheric N_2. The organic nutrient in soil can be accessed by non-leguminous green manures alone (Tejada *et al*., 2008). By taking into account modified green admixture crops in agricultural systems, we can further our understanding of these conclusive findings on soil microbial populations.

Preventing soil erosion, nutrient loss and increase nutrient availability: The continuous use of heavy implements and monoculture crops in the modern era contributes significantly to the formation of hard pans, decreased water holding capacity, surface compaction, runoff, and soil erosion; conventional tillage systems offer dominance of bare soils in which intensive and direct rainfall breaks soil aggregates and obstructs soil pores. As a result, the soil surface becomes sealed and there is less infiltration, which prevents soil erosion (Yadav *et al*., 2021). As the canopy covers the top soil, green manuring and covering crops anticipate nutrients being leached from the soil. Through the ideas of effective ability absorption and land management, acceptable agronomical abundance can be achieved. Assimilation of green manures may also have additional benefits, such as a reduction in soil erosion, increased soil water absorption, better assimilation of additional crop nutrients, and less reliance on off-farm actinic inputs.

By preserving soil health over time and guarding against erosion and nutrient leaching into the deeper layers, green manure crops promote sustainable productivity. Additionally, it prevents direct raindrops from falling on the soil and slows down surface runoff by serving as a barrier for water movement. Additionally, green manures aid in keeping soil in place by preventing roots from penetrating it (Schumann *et al*., 2000).

By penetrating the soil deeply with their roots and assimilating these nutrients into the green manure plant tissue, green manuring increases the availability of plant nutrients like nitrogen, phosphorus, potassium, and sulphur. These are broken down, making the nutrients easily accessible to the following crop. The nitrogen from the atmosphere is also fixed in the soil in usable form by legume green manuring crops. However, other nutrient inputs, like P and K, are frequently constrained in organic systems, therefore it's critical to make these nutrients available to crops and reduce their losses (Yadav *et al*., 2000).

Reclamation of Problem Soil: To solve the soil's issues and make it suitable for both good agriculture and accessible agriculture, soil modification is essential. Organic carbon is scarce in sodic soils, and additional organic carbon are reduced if the land is left fallow. In sodic soil, green manuring is incredibly beneficial since it replaces fallowness, raises soil organic content, and increases abundance in the right ways (Khan *et al*., 2000). By improving the concrete and actinic backdrop of the soil, *Sesbania* green manuring significantly improve the saline-sodic soils Baig and Zia (2006). Due to the production of organic acids and an increase in the availability of Ca^{2+} that exchanges with Na^+ of clay complex to create a favourable environment for microbial activity, the application of organic amendments in the form of green manures and crop residues lowers the pH and ESP of the alkali soils (Mahmoodabadi *et al.,* 2013). Green manuring fertilizer is used to increase the percentage of organic carbon and the availability of various nutrients for crop production in saline and alkaline soils. Examples include the concentration of certain cations and anions like Cl^-, SO_4^{2-}, HCO_3^- and CO_3^{2-} being reduced by Dhaincha and sunhemp green manures (Shirale *et al*., 2018).

Rice and wheat crops continuously extract nutrients from a particular rooting zone, which poses unique management challenges. Introducing green manuring, which can play a significant role in improving the soil health by increasing the organic matter contents and by improving the nitrogen status of the soil, is one of the strategies to address some of the soil fertility issues in this crop rotation. The adoption of Sesbania species, which can adapt well to the fallow time between the rice and wheat crops, makes this possible (Tanveer *et al*., 2019).

Effectiveness of Green Manures on Crop Productivity: Grain yield reflects the effects of green manuring on soil organic matter and other soil characteristics linked to an increase in nutrition to growing crops. Numerous studies have shown that green manures continuously deliver nitrogen (N), and because of the gradual release of N following incorporation in soils, this would coincide with the requirement of N by plants, leading to increased crop production. When incorporated right before the main crop's growing season, Sesbania aculeata can generate dry matter ranging from 2.4 to 6.6 t/ha when planted for 45 days following wheat harvest. With sufficient irrigation, Sesbania rostrata holds a lot of promise for lowland rice. Depending on the current soil conditions, rice yield can improve by 15% to 60% when Sesbania green manure is used. More reports of these increases have been made in recently reclaimed soils. According to Tanveer *et al*. (2019), adding phosphorus to Sesbania rostrata increased rice yield by 15%. Sesbania green manuring appears promising and is crucial for boosting and maintaining the rice-wheat system's output. The timing of its application affects how rice reacts to green manure.

Green Manure on Plant Protection: Low fertility of the soil and pest attack is the important factors which reduce productivity. Due to its sustainability and environmental friendliness, the usage of green manure crops is helping to lower the incidence of soil-borne diseases and restrict the growth of weeds and other pests. The promotion of sustainable crop farming is thus aided by the use of green manuring (Parajuli, 2011). Several on-farm tests showed that the early shoot borer incidence was lower when dhaincha was planted at 15 kg per hectare on the third day of planting cane and incorporated at the base of the crop with partial earthing up, compared to the control field, where it was 39% 60 days after sowing. The dhaincha plant between cane rows likely contributed to a decrease in borer incidence by raising the relative humidity (over 85%) in the cane crop's environment.

To manage nematodes, harmful soil-borne bacteria, and weeds, green manuring may be beneficial. According to Blackshaw *et al*. (2001), green manuring is beneficial for bulb protection because it suppresses weeds, improves variety, and lessens the likelihood that they will adapt to a specific agricultural system. Certain allele-chemicals are buried into the soil by some green manures, including rye and clovers, which prevent the growth of edger berries. In arid land, weeds can quickly proliferate; however, green manures cover the soil; research edger progress and effectively lessen the crop-weed competition for nutrients and natural resources.

Several soil-borne rhizome pathogens experience less pain when they use green manuring. Green manuring can be used to manage soil-borne fungal illnesses (Larkin and Griffin, 2007). According to Pung *et al*. (2004), *Brassica* green admixture crops successfully controlled the soil-borne fungus *Sclerotinia spp*.

CONCLUSION

Agriculture can be more sustainably produced by using green manure as a conservation technique. Due to improper agronomic methods, there was a significant loss of soil fertility, which is a very bad example of human-induced land degradation. The use of fertilizers has an impact on a number of variables, such as crop yield, soil nutrient content, the amount of agricultural output, and environmental implications. Green manures can be very important since they can improve the soil's physical, chemical, and biological quality as well as its fertility. Green manuring not only enhances soil quality but also fixes atmospheric nitrogen in the soil. Green manuring is also safe in terms of controlling pest insects, illnesses, and weeds. In conclusion, it may be stated that green manuring may be one of the many appropriate alternatives to achieve desired ecological and agronomical sustainability and thus increase agricultural yields.

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