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Green Manuring: Potential Impact on Soil Health

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Introduction

Green manuring is an important agricultural practice which involves the incorporation of fresh, without decomposition plant material into the soil for further improvement of soil fertility. Green manure crops have been used in organic agriculture from ancient times but conventional farming depended chiefly on the use of fertilizers and pesticides. Green manure is produced by sown crop parts as a biomass to incorporate into the soil in the same field so that they serve as a mulch. The green manure crops are used regularly as cover crops grown primarily for this purpose. Green manure is commonly associated with organic farming and can play an important role in sustainable agriculture. Green manures primarily perform multiple functions that include soil protection and soil health improvement.

Green manuring improves the structural improvement of soil and its tilth, enhancing the fertility of soil, improvement of crop yield and quality, pest control and population of soil micro flora and enzymatic activity. Plant growth promotion will be observed due to increased microbial activities leads to production of enzymes, hormones and metabolites, enhancing metabolic activity in plant, production of plant alkaloids, natural metabolites, biological control of plant insect pests, and pathogens. In organic farming systemic resistance has a great prospective. India has maximum number of organic growers. It was recorded that 6.7 million hectares area is covered under green manure, which accounts for 4.5 per cent of net sown area that is 142 million ha of the country.

To promote the soil health, green manures, also referred to as fertility building crops. Green manuring techniques have been used in traditional agriculture for thousands of years but conventional farming systems largely rejected them as the use of fertilizers and pesticides became more common. Organic farmers have a great scope for use of green manuring techniques in the near future.

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Types of Green Manures

- ***In-situ* Green Manuring:** In this process the short duration legume crops are grown and incorporated in the same field when they attain the age of 60-80 days after sowing. This system of on-site nutrient resourcegeneration is most widespread in northern and southern parts of India where rice is the major crop in the existing cropping systems. For *in-situ* green manuring crops used are *Sesbania aculeata*, *Crotalariajuncea*, cowpea, cluster bean, mungbean and few weeds which can be used for green manuring alongwith the common legumes to cater the nutritional demand of crops under organic agriculture are Parthenium, Water hyacinth, Trianthema, Ipomoea, Calotropis, *Chenopodium album* .
- ***In-situ* Brown Manuring:** In this technique sesbania is grown in standing rice crop and kill them with the help of herbicide for manuring. The colour of the sesbania residue becomes brown that's why it is called brown manuring. This technique of green manuring is more popular in the states like Odissa which receives high and continuous rainfall.
- **Green Leaf Manuring:** The tender plant parts and green leaves of the plants are collected from shrubs and trees growing on bunds, degraded lands or nearby forest and they are turned down or mixed into the soil. 15-30 days before sowing of the crops depending on the tenderness of the foliage or plant parts. In general when weather is dry, the leaves of Gliricidia *(Gliricidia maculate)*, Karanj*(Pongamia pinnata)*, Neem, Wild daincha*(Sesbania speciosa)*, Subabool (*Leucaena Leucocephala)* Gulmohar and Peltophorum of green manure crop should be buried at moredepth compared to moist conditions.

In intercropping systems green manures may also be used. On arable farms leys are usually established by *under sowing* them in the preceding cereal crop – this gives the green manure a longer growth period and can help in weed control. The similar technique can be done with horticultural crops but care is needed to avoid too much competition. This technique may be particularly valuable as a control measure for pests.

Techniques of green manuring

The maximum advantage of green manuring can be obtained through better understanding of suitable sowing time, stage ofgreen manure crop for incorporation and time interval between incorporation and sowing of next crop.

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- **Sowing time of Green Manure Crops:** The sowing time of green manure crops depends on for *in situ* green manuring varies according to area specific conditions, available resources and farming conditions. As a catch crop the green manure crop can be grown during summer season particularly in irrigated agro-ecosystem. The quick growing crops i.e. sunhemp and dhaincha are sown in the month of April-May and buried during June-July before the planting of main kharif crop particularly paddy. In intensive and rainfed farming areas, dhaincha is used to grow as intercrop with paddy in 4:1 row proportion whereas, sun hemp and cowpea are intercropped in alternate rows with broadly spaced crops like cotton, maize and sugarcane and incorporated in the soil when these crops attain the age of 30-45 days after sowing using hoes or mould board plough. In khariffallow lands the sunhemp, guar, cowpea and dhaincha are usually sown in June-July and incorporated in the month of August- September. This technique is most common in Punjab, Bihar, Madhya Pradesh, U.P. and Rajasthan, states.
- **Incorporation stage of Green Manure crops:** Incorporation time of green manure crops plays major role for obtaining their optimum benefits. During growing season, the chemical composition of most plants changes identically. During early period of crop growth, the contents of N, protein and water-soluble constituents are maximum, while the amount of fibre, celluloses, hemicelluloses, lignin and the C:N ratio are less. At this stage the tissues of immature plants usually decompose more rapidly as compared to those of matured plants. The green manure crops are to be incorporated in the soil when they are 2 months old and two weeks delay in the incorporation of crimson clover and hairy vetch reduced their N content and increased the C:N ratio, lignin cellulose and hemicellulose contents.
- **Time gap:** The consideration about time interval between green manure crop incorporation and sowing of main crop is more important as it is important just to facilitate the complete decomposition of the turned in green biomass. According to studies conducted at CRRI, Cuttack thatthe time interval was not so important when succulent green manure crop of eight weeks age was incorporated because transplanting of paddy immediately after burying of greenmanure crop was as good as any other treatment. The care should be taken that as to give the time interval of 4 to 8 weeks before paddy transplanting when the 12 weeks crop incorporated in the soil.

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***In-situ* Green Manure crops**

S. No.	Common Name	Botanical Name	Season
1	Dhaincha	*Sesbania Aculeta and Sesbania rostreta*	Zaid / Kharif
2	Sunhemp	*Crotolaria juncia*	Zaid /Kharif
3	Mung	*Vigna radiata*	Zaid / Kharif
4	Cowpea	*Vigna unguiculata*	Kharif
5	Guar	*Cyamopsis tetragonoloba*	Kharif
6	Senji	*Melilotus alba*	Rabi
7	Berseem	*Trifoliumal exandrium*	Rabi
8	Khesari	*Lathyrus sativus*	Rabi

Composition of Nutrients of Green Manure Crops

S. No.	Crop/Weed	Nutrient content						
		Major nutrients (%) *			Total micro nutrients (mg/kg) **			
		N	P2O5	K2O	Zn	Fe	Cu	Mn
1.	*Sesbania rostrata*	2.62	0.37	1.25	40	1968	36	210
2.	*Sesbania speciosa*	3.98	0.24	1.30	50	480	44	110
3.	*Crotalaria juncea*	2.86	0.34	1.27	30	1190	24	110
4.	*Eichhornia crassipes*	2.83	0.93	1.79	50	470	19	420
5.	*Trianthema* Spp.	2.34	0.30	1.15	30	1992	19	200
6.	*Parthenium hysterophorus*	2.66	0.8	1.29	70	470	19	160
7.	*Glyricidia*	3.49	0.22	1.30	30	550	19	150

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	maculeata							
8.	*Cowpea residue*	1.70	0.28	1.25	-	-	-	-
9.	*Mungbean residue*	2.21	0.26	1.26	-	-	-	-

Effects of Green Manuring

- **Decreasing Nitrate Leaching:** The overwinter left bare large quantities of nitrate can be lost from soil, due to this unlike other nutrient ions, nitrate is not strongly attracted to soil particles. Any that is in solution in the autumn will be washed away as water moves down through the soil with the onset of heavy winter rains. This is bad for the environment as nitrate can contribute to the formation of algal blooms in watercourses and for human health when the drinking water is contaminated. Due to this EU regulations have been introduced to control farming practices likely to result in large nitrate losses. This has resulted in the establishment of Nitrate Sensitive Areas. Leaching also represents the loss of a valuable resource particularly serious for organic farmers as it is much harder for them to replace the lost nitrogen. It is widely recognised that one of the best ways of preventing nitrate leaching is to maintain a vigorously growing crop over the winter period. Winter green manures can be very effective crops for 'mopping up' excess nitrate in the soil. Green manures differ in their ability to reduce leaching. Grazing rye is particularly effective leaching was reduced by an average of 95%. Vetch reduced losses by 45% and field beans had hardly any impact at all. The desirable is that is rapid early growth and the development of an effective root system. As just the leaching has begun the plants have very little time to take up the nitrogen before it is all washed away. If the crop cannot be established in good time it may be worse than useless as the practices used to establish the seedbed may stimulate the mineralisation of nitrogen resulted in that cannot be captured by a green manure struggling to germinate and grow under ever colder conditions. Grazing rye in relatively cold weather is suitable because it is adapted to produce large amounts of leafy growth.
- **Provision of nitrogen availability to the following crop:** Nitrogen is the most mobile nutrient in soil because it exists in so many different forms that are inter-converted by a range of biological processes – some of these forms are prone to losses by leaching or gaseous emissions of ammonia, nitrogen or nitrous oxides. For some crops belongs to

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Brassicaceae family it is particularly important that sufficient nitrogen is available at certain growth stages to ensure that the plants to produce yields of a marketable quality and correct management of green manures can be used to manipulate the availability of nitrogen. Maximum amounts of nitrogen are added to the soil by a successful green manure e.g. by early May an overwintered crop of vetch may accumulate up to 200kg N/ha. Mineralisation proceeds fastest when the soil is warm and moist.

- **Availability of other nutrients:** The availability of other nutrients in organic farming, such as P and K, are often limited in, so it is important that these nutrients are made available to crops and their losses can be reduced. Potassium can be lost through leaching out of the soil. Through surface run off and erosion losses of phosphorus are traditionally assumed to be more but some studies have shown that losses by leaching can make a significant contribution, especially if the soil is saturated with P when large amounts are applied through manures from animal origin.
- **Soil structural improvement:** Green manures capable to improve soil structure in many ways. For the improvement of seedbed structure, the widespread fine roots of crops such as rye, entangle the soil, helping to stabilise aggregates and increasing pore size. Some species have deep tap roots which help to break up compacted soil as lucerne roots as being particularly effective at penetrating hard layers, with chicory, lupin, red clover as having intermediate ability and barley the poorest to break compacted soil. The major role of green manures is the addition of organic matter to the soil as they do this at the same time as still growing, producing root exudates which provide food for microorganisms, which in turn produce polysaccharide gums, which binds soil aggregates together.

Green manuring can bring a number of advantages to the grower:

- Addition of organic matter to the soil.
- Enhancing biological activity.
- Improving soil structure.
- Reduction of erosion.
- Enhancing the supply of nutrients available to plants.
- Reducing leaching losses.
- Suppressing weeds.
- Reducing pest and disease problems.

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- Providing additional animal forage.
- Maintaining the temperature of soil by drying and warming the soil.