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Green manuring as a booster for improvement of soil fertility and feasible method for reduction of global warming causing chemical fertilizer

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Abstract
Green manure crops tender a vast scope of benefits to soil and future crops. They are commonly used to improve the soil, for organic matter, nutrients or to control weeds. The benefits of a green manure crop outweigh the nutrients that they add back into the soil. They also feed the soil, which feeds the plant rather than the other way around. In feeding the soil, a green manure crop feeds all the soil organisms and improves the fertility of the soil. A biologically fertile soil produces healthy plants that able to resist disease and combat pests in addition to a healthy soil has more drought resistant. By growing green manures you provide soil microbes with a boost as well as food and an environment they can thrive in. These microbes will convert the nutrients in the green manure into available nutrients for crops. By stimulating these soil organisms and proving a food source, they also convert the unavailable nutrients in the soil into available nutrients. Hence, green manure is a viable and feasible source as a not just soil conditioner to improve the soil fertility, but also ecofriendly thereby curtails the chemical fertilizer added to a soil.

Keywords: compost, decomposition, fertility, green manure, legume

1. Introduction
Every farmer knows how much work goes into the production of a basket of compost and carrying it to the fields. But it never seems that the farm production gives an equal return for the hard work that goes into making and carrying the compost. Green manures are a method of replacing that basket of compost with a handful of seed. In this method, the plants that grow from the handful of seed are ploughed back into the soil. After a while in the soil, the plants rot down to become compost. Plants used in this way are called Green Manures. It's a very good way of increasing the fertility of the soil and can give huge benefits for farmers. Soil productivity is a very important concern for farmers because their harvests depend so much on the health of the soil they till. However, continuous cropping and frequent cultivation of the soil result in the degradation of its physical structures and depletion of its organic matter content leading to the decrease in its fertility. To cushion this effect, farmers allow their land to rest or fallow for a certain period. However, according to research the organic matter of soil continues to decrease even if it is left idle. A better alternative to fallowing is legume green manuring. This practice offers more benefits compared to fallowing. Aside from conserving the soil, it also recycles unused fertilizers back to the soil instead of being leached out to waterways leading to water contamination. Green manures, also referred to as fertility building crops, may be broadly defined as crops grown for the benefit of the soil. They 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. Although they have many roles they are still often underutilised by today's organic farmers. However, recent emphasis on reducing the environmental impact of all farming systems (stimulated by new legislation) has led to a growing interest from the conventional sector. A wide range of plant species can be used as green manures.

2. Why use green manures?
Green manures are crops grown within a rotation for the purposes of:
- Building soil organic matter and soil structure
- Supplying nitrogen and other nutrients for a following crop
- Preventing leaching of soluble nutrients from the soil
- Providing ground cover to prevent damage to soil structure
- Bringing crop nutrients up from lower soil profiles
- Smothering weeds and preventing weed seedling growth

3. Green manure dependent crops
About 70 percent of the population in India is farmers, who cultivate various crops. Green manure is seen as an essential input when cultivating these crops. Farmers say that with increased and effective use of green manures, chemical fertilizers are not necessary anymore. In addition, green manures add greater organic matter, improve the richness of the soil and help to increase crop yields.

4. How to grow green manure?

There are two ways of using green manures.

1. When land is unused, or fallow between crops;
2. While crops are still grown in the fields.

a. Using green manures as fallow

When crop land is empty after crops have been harvested, green manure seeds can be sown as thickly as sowing wheat. When the green manure plants are about to flower they can be cut and left, or ploughed into the soil.

b. Using green manures mixed with crops

This method is used mostly with any crops growing. An easy method is to sow a green manure at the same time as crops and then dig it in when it is time to weed the crops. At this time green manure seeds can also be sown and the green manure is cut and mulched or ploughed in after the crops is harvested to provide even more fertility.

5. Selection of green manures

There are many plants which can be used as green manures. In particular, the type of green manure should be selected according to the type of crop it is growing with or in between. For a large plant like maize, a large green manure like velvet bean or Sesbania should be used. For a short crop like many vegetables, smaller green manures such as mustard or buckwheat can be used.

6. Criteria for selection of green manures include

- Plants are fleshy and soft
- Fast growing;
- Fast to decompose;
- Leguminous;
- Don't attract pests and diseases;
- Don't compete with crops;
- Provide nutrients needed in the soil

7. Value of green manures

It was observed that as the 6.7 million hectare area is covered under green manure, which accounts for 4.5 per cent of net sown area (142 million ha) of the country. The practice of green manuring is most common in rice growing states like A.P., U.P., Karnataka, Punjab and Orissa which contribute 41, 16, 11, 6 and 5 per cent to the total area under green manuring in India, respectively. Whereas, the share of Gujarat (3%), M.P. (3%), Himachal Pradesh (2%) and Haryana (1.7%) is not very encouraging and concerted efforts are to be made out at all levels to bring more area under green manuring that too in irrigated areas, if nutritional need of organic farming is to be made. India has the maximum number of organic growers (400551).

Biomass production of green manure crops varies due to various factors such as species of the legumes, environmental conditions, soil fertility and crop management practices and age of green manure crops. *Sesbania aculata* and *Crotolaria juncea* have higher rate of biomass production and both can produce dry matter to the extent of 16 to 19 t/ha within a short period of 45-60 days and on an average about 5t/ha dry matter can easily be produced, which is sufficient for meeting out nutritional demand of a crop either in kharif or rabi season. Beside these, some weeds, particularly *Eichhornia crassipes* have a maximum rate of biomass production and one can get about 70 q/ha dry matter within a period of 46-60 days and could be used for ex-situ green manuring. Weeds like *Parthenium hysterophorus* and *Trianthema portulacastrum* are abundantly found in different habitat with better nutrient content and dry matter production cab be used to cater the need of the organic farming in our country (tables 3 and 4). Normally, all GM crops which are used for in-situ or ex-situ green manuring contain all the plant nutrients essential for completing the life cycle of any plant. Among the different GM crops, daincha and Sunnhemp have higher accumulation of major and micro nutrients on account of more biomass production and better nutrient composition compared to food legumes which are inferior due to low contents of nutrients coupled with less dry matter production. Water hyacinth has great biomass production and nutrient accumulation and it could contribute 198 kg N, 63.0 kg P_2O_5, 125.3 kg K_2O when about 70 q/ha dry matter is added to the soil. It could be a good source of plant nutrients through ex-situ green manuring.

8. Decomposition of Green Manuring

The green manure applied to soil undergoes a series of chemical changes the nutrient contents in the plant become available and the humus is manure. The type of decomposition and the products formed are found in the controlled by the following important factors.

1. Organisms present
2. Temperature
3. Aeration
4. Moisture supply
5. Soil factors
6. Nature of green manuring

Putting all the above factors, the decomposition can be broadly studied two categories.

a. Aerobic decomposition

The plant material incorporated into the soil is made up of numerous compounds. But, for studying the decomposition processes the various compounds can be roughly brought under three groups.

- Carbon compounds consisting of carbohydrates, fats, oils, organic acids, lignin and other cyclic organic compounds
- Nitrogen compound consisting of proteins, amino acid and other non-protein nitrogenous substances
- Mineral salts

b. Anaerobic decomposition

This is found to take place in soils which are poorly aerated or under waterlogged condition. Under these circumstances, only the organisms capable of thriving in the absence of oxygen well develop and they will decompose the various constituents present in the plant body.

- Protein and other nitrogenous compounds
- Hydrolysis by enzymes produced by bacteria
- Polypeptides, peptides, peptones
- Hydrolysis
- Amino acid
- Ammonifying bacteria
- Ammonia
- Gaseous nitrogen

9. Future needs

- Surveying the green manure species available for different cropping patterns in the world
- Classifying green manure species into use categories (grain green manure, non-grain green manure, including forage green manure and leafy green manure)
- Identifying cultivars that are genetically resistant/ tolerant to pests and diseases.
- Using cellulolytic microbial cultures to accelerate decomposition of green manures
- Maintaining legume-rhizobial germplasm and identify legume species-specific rhizobia for acid, saline and alkali soils
- Identifying fast growing requirements and cost in green manure production in different areas

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