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FACULTY OF AGRICULTURE SCIENCE AND ALLIED INDUSTRIES

Green manures and bio-fertilizers

Green manures/ green manuring:-

Legume effect has been successfully utilised in green manuring. The amount of nitrogen fixed by ordinary green manure crop like Dhaincha, Sunhemp, etc. may average about 60 kg/ha. However, the amount of nitrogen accumulated by green manure crop is not likely to be able to provide to the level of nitrogen currently needed by high yielding varieties. Therefore, integrated use of both chemical fertilizer and green manuring is best solution.

Green manuring:-

The practice of ploughing or turning into the soil undecomposed green plant tissue for the purpose of improving physical condition as well as fertility of soil is referred to as green manuring and the manures obtained by this method is known as green manures. The use of green manure in crop production is recorded in China as early as 1134 BC.

Types of green manuring:-

1) Green manuring in situ: Any crop or palnt (generally leguminous) grown and ploughed in situ is called green manuring in situ. E.g.: Sesbania (Sesbania speciosa), dhaindia (Sesbania aculeate), sunhemp (Crotolaria juncea), Phillipesara (Phaseolus trilobus), cowpea (Vigna anguiculata), greengram (Mungbean) (Vigna radiata), black gram (Vigna mungo), berseem (Trifolium alexandrium) etc.

2) Green leaf manuring: Consists of gathering green biomass (tender leaves and twigs) from nearby location (bunds, field boundaries) and adding it to the soil.E.g.: Cassia auriculata, neem (Azadiracta indica), Glyricidia (Glyricidia maculate), Leucaena leucocephala, Cassia tora, Tephrosia purpurea, Vitex nigundo, karanj (Pongamia glabra), calotropis (Calotropis gigantea) etc,.

Advantages of green manuring:-

1. Helps in improving physical and chemical properties of soil. E.g. Builds up soil structure, improves tilth, formation of crumbs in heavy soil, increases water holding capacity
2. Green manure crops absorb nutrients from the lower layer of soils and leave them in the soil surface layer when ploughed in for use by the succeeding crops.
3. Helps to maintain OM status of soil.
4. Acts as source of food and energy to soil microbes and increases their population.
5. Helps in release of nutrients in available form for use by the crops. E.g. GM crop increases the solubility of lime phosphate because of increase in microbial activity.
6. Prevents leaching of nutrients to lower layers.
7. Increases aeration of rice soils by stimulating the activities of surface films of algae and bacteria.
8. It reduces soil temperature and protects the soil from the erosion action of water as it forms canopy cover on the soil.
9. Leguminous green manure plants helps in N-fixation and adds the same to the soil. E.g. 60-100 kg N/ha in single season.

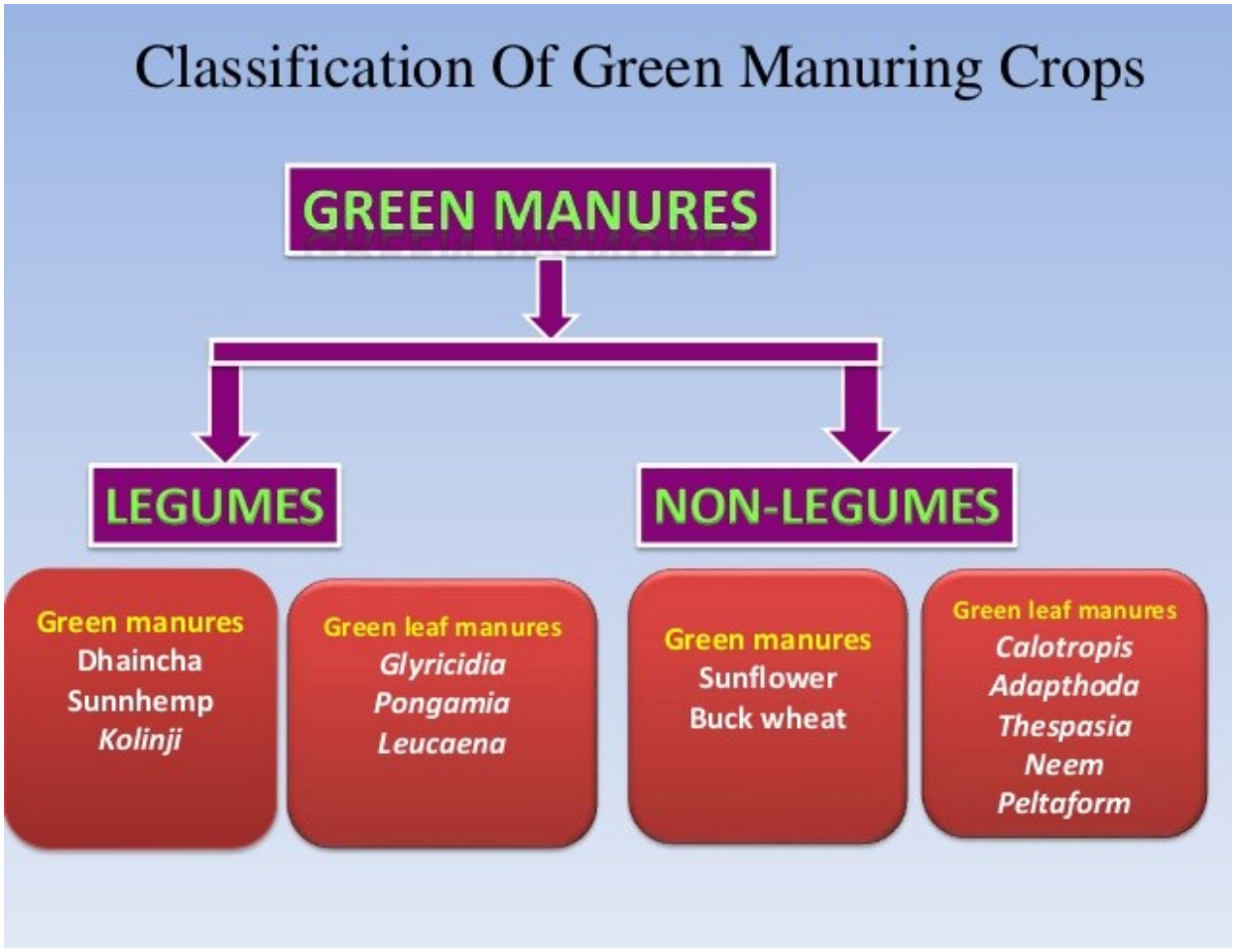
Green manures - 60 to 200 kg N/ha

Crotolaria juncea (sun hemp) - 17 t/ha biomass, 160 kg N/ha
Dhainchia (Sesbania aculeata) - 25-26 t/ha biomass, 18.5 kg N/ha

10. Helps in soil amelioration. E.g. Sesbania aculcata (Dhaincha) in soil – when applied continuously for 4-5 seasons, green leaf manuring crops like Argenone maxicana and Tamarindus indicus has buffering effect in sodic soils.
11. Certain green manure like pongamia and neem leaves are reported to control insects.
12. Increases yield to the extent of 15-20 per cent compared to no green manuring.

Desirable characteristics for legume green manure crops:-

1. Multipurpose use
2. Short duration, fast growing, and high nutrient accumulation ability
3. Tolerance to shade, flood, drought and adverse temperatures.
4. Wide ecological adaptability
5. Efficiency in use of water
6. Early onset of biological N-fixation
7. High N accumulation rates
8. Timely release of nutrients
9. Photoperiod insensitivity
10. High seed production, high seed viability
11. Ease in incorporation
12. Ability to cross inoculate or responsive to inoculation
13. Pest and disease resistance
14. High N sinks in underground plant parts



Bio-fertilizers:-

Bio-fertilizers are defined as preparations containing living cells or latent cells of efficient strains of microorganisms that help crop plants uptake of nutrients by their interactions in the rhizosphere when applied through seed or soil. They accelerate certain microbial processes in the soil which augment the extent of availability of nutrients in a form easily assimilated by plants.

Use of bio-fertilizers is one of the important components of integrated nutrient management, as they are cost effective and renewable source of plant nutrients to supplement the chemical fertilizers for sustainable agriculture. Several microorganisms and their association with crop plants are being exploited in the production of bio-fertilizers.

They can be grouped in different ways based on their nature and function

I. N2 fixers

a. Free living: Aerobic – Azotobacter, Beijerinckia, Anabaena
Anaerobic – Clostridium Faultative anaerobic – Klebsiella

b. Symbiotic : Rhizobium, Frankia, Anabaena azollae

c. Associative symbiotic : Azospirillum
d. Endophytic : Gluconacetobacter
Burkholdria

II. Phosphorus solubilizers:-

Bacteria: Bacillus megaterium var. phosphaticum B. subtilis, B. circulans Pseudomonas striata
Fungi: Penicillium sp. Aspergillus awamori

III. P mobilizers:-

a) AM fungi
b) Ectomycorrhizal fungi
c) Ericoid Mycorrhiza
d) Orchid mycorrhiza

IV. Silicate and Zinc solubilizers: - Bacillus sp,

V. Plant growth promoting Rhizobacteria: - Pseudomans spp.,and many more

Chemical fertilizers are being used in increasing amounts in order to increase output in high yielding varieties of crop plants.

However, chemical fertilizers cause pollution of water bodies as well as ground water, besides getting stored in crop plants.

Therefore, environmentalists are pressing for switch over to organic farming.

Organic farming is the raising of unpolluted crops through the use of manures, bio-fertilizers and bio-pesticides that provide optimum nutrients to crop plants, keeping pests and pathogens under control.

Bio-fertilizers are micro-organisms which bring about nutrient enrichment of soil by enhancing the availability of nutrients to crops. The micro-organisms which act as bio-fertilizers are bacteria, cyanobacteria (blue green algae) and mycorrhizal fungi. Bacteria and cynobacteria have the property of nitrogen fixation while mycorrhizal fungi preferentially withdraw minerals from organic matter for the plant with which they are associated.

Nitrogen fixation is the process of conversion of molecular or dinitrogen into nitrogen compounds. Insoluble forms of soil phosphorus are converted into soluble forms by certain micro-organisms. This makes the phosphorus available to the plants. Phosphate is also solubilised by some bacteria and by some fungi that form association with plant roots.

The various bio-fertilizers are as follows:-

(i) Free Living Nitrogen Fixing Bacteria:-

They live freely in the soil and perform nitrogen fixation. Some of them are saprotrophic, living on organic remains, e.g., Azoto- bacter, Bacillus polymyxa, Clostridium, Beijerinckia. They are further distinguished into aerobic and anaerobic forms.

The property of nitrogen fixation is also found in photoautotrophic bacteria, e.g., Rhodopseudomonas, Rhodospirillum, Chromatium. Inoculation of soil with these bacteria helps in increasing yield and saving of nitrogen fertilizers. For example, Azotobacter occurring in fields of Cotton, Maize, Jowar and Rice, not only increases yield but also saves nitrogen fertilizer to the tune of 10-25 kg/ha. Its inoculation is available under the trade name of azotobactrin.

(ii) Free Living Nitrogen Fixing Cyanobacteria:-

A number of free living cyanobacteria or blue-green algae have the property of nitrogen fixation, e.g., Anabaena, Nostoc, Aulosira, Totypothrix, Cylindrospermum, Stigonema. Cyanobacteria are photosynthetic. Therefore, they add organic matter as well as extra nitrogen to the soil.

Aulosira fertilissima is considered to be the most active nitrogen fixer of Rice fields in India (Aiyer et al, 1972). Cylindrospermum licheniforme grows in Sugarcane and Maize fields. Cyanobacteria are an extremely low cost biofertilisers. In Tamil Nadu, the technique of cyanobacteria inoculation to rice fields is being followed. Phosphate, Molybdenum and Potassium are supplied additionally.

(iii) Loose Association of Nitrogen Fixing Bacteria:-

Certain nitrogen fixing bacteria like Azospirillum live around the roots of higher plants without developing any intimate relationship. It is often called rhizosphere association. The bacteria obtain some plant exudate and use the same as part of their food requirement. The bacteria fix nitrogen and exude a

part of the fixed nitrogen for use by the plant. The phenomenon is termed as associative mutualism (= associative symbiosis).

(iv) Symbiotic Nitrogen Fixing Bacteria:-

They form a mutually beneficial association with the plants. The bacteria obtain food and shelter from plants. In return, they give a part of their fixed nitrogen to the plants. The most important of the symbiotic nitrogen fixing bacteria is Rhizobium (pi Rhizobia). It forms nodules on the roots of legume plants. There are about a dozen species of Rhizobium which form association with different legume roots, e.g., R. leguminosarum, R. lupini, R. trifolii, R. meliloti, R. phaseoli.

These bacteria, also called rhizobia, live freely in the soil but cannot fix nitrogen except for a strain of Cowpea Rhizobium (Me Comb et al, 1975). They develop the ability to fix nitrogen only when they are present inside the root nodules. In the nodule cells, bacteria (bacteroids) lie in groups surrounded by membrane of the host which is lined by a pink-red pigment called leghaemoglobin. Presently cultures of Rhizobium specific for different crops are raised in the laboratory.

Frankia, a nitrogen fixing mycelial bacterium (actinomycete), is associated symbiotically with the root nodules of several nonlegume plants like Casuarina, Alnus (Alder) Myrica, Rubus etc. Leaves of a few plants (e.g., Ardisia) develop special internal cavities for providing space to symbiotic nitrogen fixing bacteria, Xanthomonas and Mycobacterium. Such leaves are a constant source of nitrogen fertilizer to the soil.

(v) Symbiotic Nitrogen Fixing Cyanobacteria:-

Nitrogen fixing cyanobacteria (blue- green algae) form symbiotic association with several plants, e.g., cycad roots, lichens, liverworts, Azolla (fern). Out of these, Azolla-Anabaena association is of great importance to agriculture.

Azolla pinnata is a small free floating fresh water fern which multiplies rapidly, doubling every 5-7 days. The fern can coexist with rice plants because it does not interfere with their growth. In some South-East Asian countries, especially China, the rice fields are regularly provided with Azolla.

Anabaena azollae resides in the leaf cavities of the fern. It fixes nitrogen. A part of the fixed nitrogen is excreted in the cavities and becomes available to the fern. The decaying fern plants release the same for utilization of the rice plants. When field is dried at the time of harvesting, the fern functions as the green manure, decomposing and enriching the field for the next crop.

(vi) Microphos Biofertilizers:-

They release phosphate from bound and insoluble states, e.g., Bacillus polymyxa, Pseudomonas striata, Aspergillus species.

(vii) Mycorrhiza (pl-Mycorrhizae Frank, 1885):-

It is a mutually beneficial or symbiotic association of a fungus with the root of a higher plant. The most common fungal partners of mycorrhiza are Glomus species. Mycorrhizal roots show a sparse or dense wooly growth of fungal hyphae on their surface. Root cap and root hairs are absent.

The shape is irregular, tuberous, nodulated or coralloid. The fungus remains restricted to the cortex of the root. The vascular strand and growing point are not affected. Mycorrhiza often remains in the upper layers of the soil where organic matter is abundant. Depending upon the residence of the fungus, mycorrhizae are of two types— ectomycorrhiza and endomycorrhiza.

(a) Ectomycorrhiza (= Ectotrophic Mycorrhiza):-

The fungus forms a mantle on the surface of the root. Internally, it lies in the intercellular spaces of the cortex. The root cells secrete sugars and other food ingredients into the intercellular spaces for feeding the fungal hyphae. The exposed fungal hyphae increase the surface of the root to several times. They perform several functions for the plant—

(i) Absorption of water,

(ii) Solubilisation of organic matter of the soil humus, release of inorganic nutrients, absorption and their transfer to root,

(iii) Direct absorption of minerals from the soil over a large area and handing over the same to the root. Plants with ectomycorrhiza are known to absorb 2-3 times more of nitrogen, phosphorus, potassium and calcium,

(iv) The fungus secretes antimicrobial substances which protect the young roots from attack of pathogens. Ectomycorrhiza occurs in the trees like Eucalyptus, Oak (Quercus), Peach, Pine, etc. The fungus partner is generally specific. It belongs to basidiomycetes.

(b) Endomycorrhiza (Endotrophic Mycorrhiza):-

Fewer fungal hyphae lie on the surface. The remaining live in the cortex of the root, mostly in the intercellular spaces with some hyphal tips passing inside the cortical cells, e.g., grasses, crop plants, orchids and some woody plants. In seedling stage of orchids, the fungal hyphae also provide nourishment by forming nutrients rich cells called pelotons. Intracellular growth occurs in order to obtain nourishment because unlike ectomycorrhiza, the cortical cells do not secrete sugars in the intercellular spaces.
The hyphal tips passing into cortical cells either produce swollen vesicles or finely branched masses called arbuscules. Therefore, endomycorrhiza is also called VAM or vesicular-arbuscular mycorrhiza. The major benefits of VAM to the plant are the supply of inorganic nutrients as well as enhanced water absorption. Phosphate which is mostly present in the unavailable form in the soil, becomes abundantly available to the plant. A single fungus may form mycorrhizal association with a number of plants, e.g., Glomus.

Importance of Bio-fertilizers:-

(i) They increase the yield of plants by 15-35%.

(ii) Bio-fertilizers are effective even under semi-arid conditions,

(iii) Farmers can prepare the inoculum themselves,

(iv) They improve soil texture,

(v) Bio-fertilizers do not allow pathogens to flourish,

(vi) They produce vitamins and growth promoting bio-chemical,

(vii) They are non-polluting.