INTEGRATED NUTRIENT MANAGEMENT AND LOW COST ORGANIC FORMULATIONS

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This developPPP project aims to strengthen the production of cardamom (Kerala), Cumin and Dill seed (Rajasthan) turmeric (Tamil Nadu and Karnataka), Celery (Punjab and Haryana) by increasing the capacities of spice farmers and making the production practices economically, socially and environmentally more sustainable.

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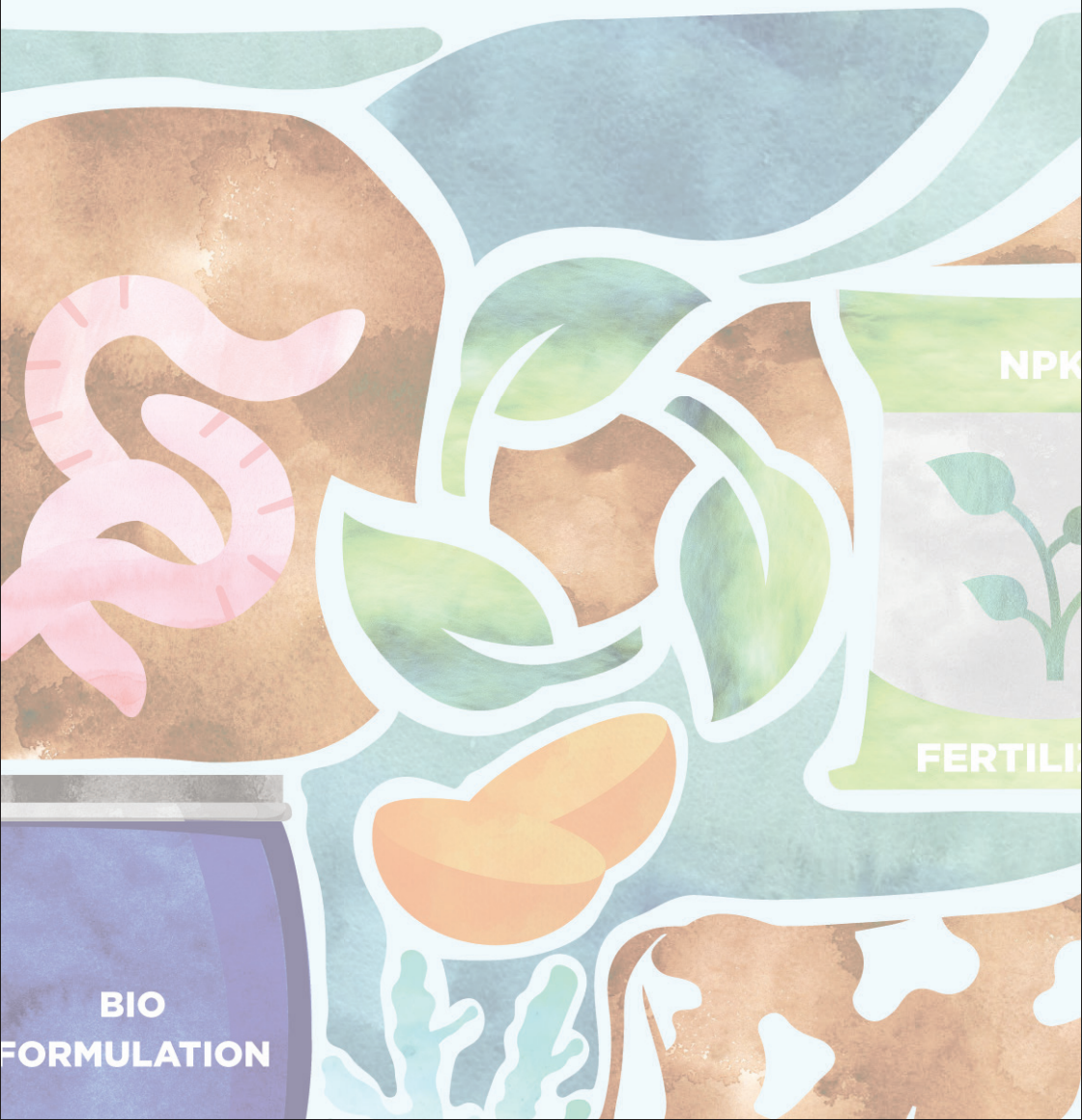

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This manual is published under develoPPP project, Enhancement of Smallholder Spice Farmers' Capacities in Sustainable Farming. It aims to raise awareness about integrated nutrient management practices, including composts, vermicompost, green manures, crop rotation, intercropping and affordable organic formulations. These practices aim to conserve soil biodiversity and sustainably enhance productivity.

CONTENTS

1. Background

India is one of the largest producers and consumers of mineral fertilisers next to China and the USA. The total fertiliser consumption in FY 2020-21 in India is 325 lakh metric tonnes (LMT), of which 108 LMT was imported and 184 LMT was produced in the country. The average nitrogen, phosphorus and potassium consumed in India is about 175 kg nitrogen, phosphorus, and potassium (NPK) per hectare in the year 2018 (Fig.1). The NPK consumption is higher in Punjab, Haryana, Bihar, Andhra Pradesh and Telangana and is more than 200 kg NPK/ha (Fig 2). After the green revolution, the use of mineral fertilisers started to increase and since the year 2002, the use of mineral fertilisers has been drastically increasing. Over the last two decades, the increasing demand for agricultural production to meet the food needs of a growing population has led to a rise in the use of agrochemicals. However, this trend has resulted in chemical land degradation, ultimately affecting soil and human health. Currently, the excessive use of chemical fertilisers presents an alarming situation. Therefore, adopting a balanced approach to nutrient management in integrated nutrient management is key for sustainable agricultural production and enhancing soil health.

Fig 1: *Fertiliser consumption (nitrogen, Phosphorus and Potassium kg/ha) in India*

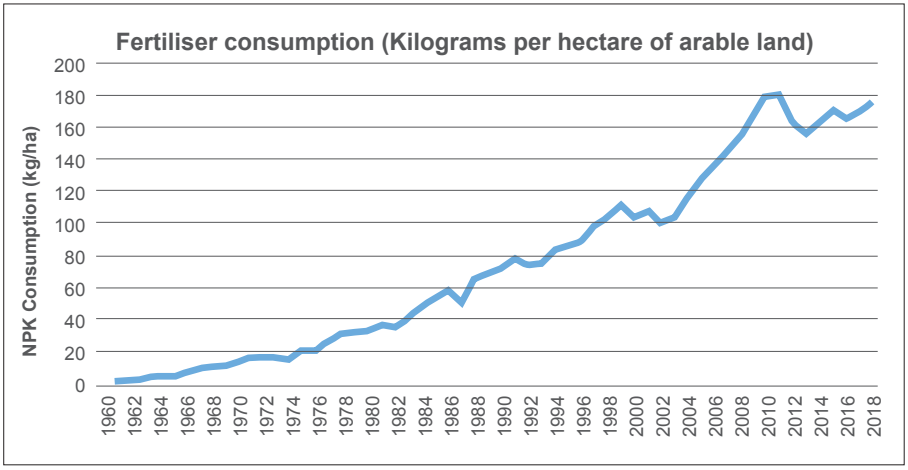
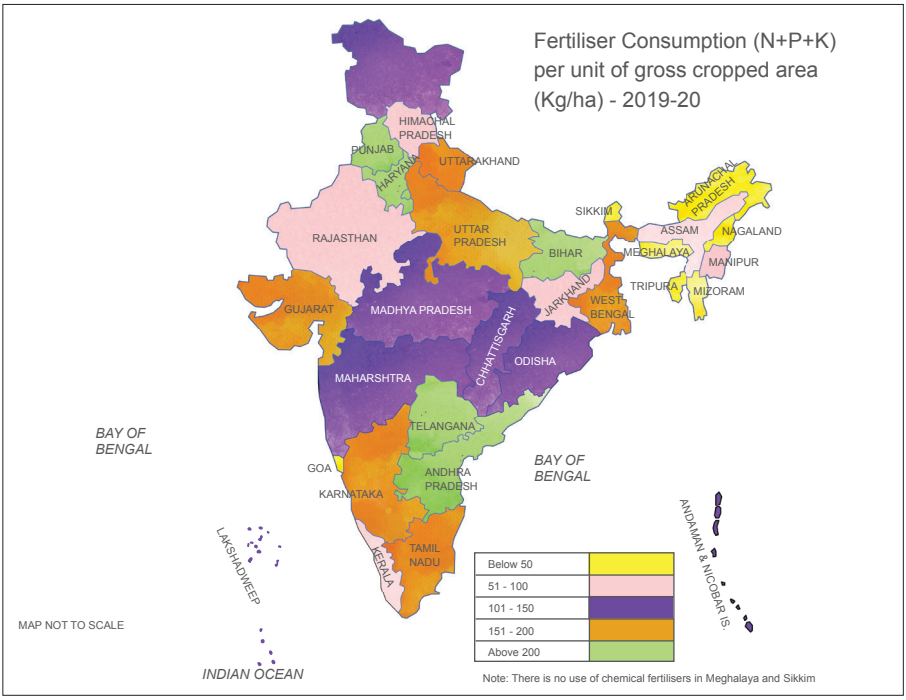


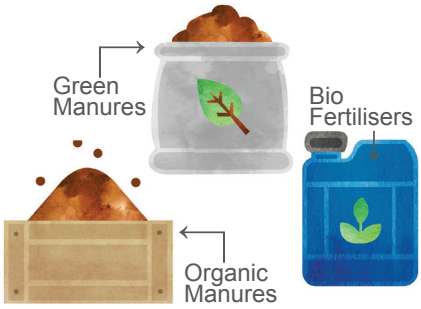
Fig 2: *State-wise fertiliser consumption in India during 2018[1].*



1 Source: https://www.faidelhi.org/general/map-gca.pdf

2. What is Integrated Nutrient Management (INM)

The concept of INM is the judicious and efficient use of mineral fertilisers together with organic manures, industrial/farm wastes and biofertilisers for maintenance of soil fertility and health, sustaining agricultural productivity and improving farmers' profitability. Thus, the objectives of INM are to ensure efficient and judicious use of all the major sources of plant nutrients in an integrated manner to get maximum economic yield from a specific cropping system.



3. Sources of Plant Nutrients

1. Soil sources

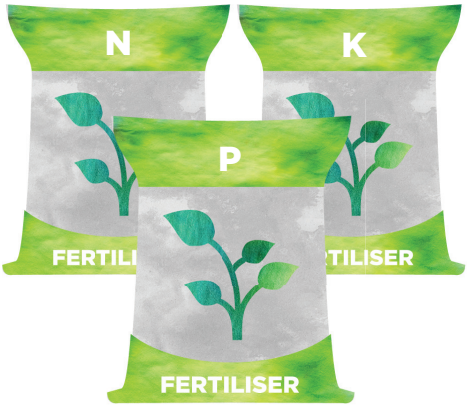
The soil is one of the major sources of supplying all essential elements to plants in abundance. The nutrient-supplying capacity of many soils has declined steadily due to continuous and intensive cultivation practices, as well as faulty agricultural practices. The low and declining soil fertility are the main causes of the low productivity of most of the cultivated lands. Intensive cultivation, monoculture and very low or no use of organic manures and crop residues also resulted in deficiencies of certain secondary and micronutrients in the soil.

2. Mineral fertilisers

Mineral fertilisers play an important role in sustaining agricultural production. However, they are costly input and need to improve their use efficiency through optimisation of all other crop production factors, such as:

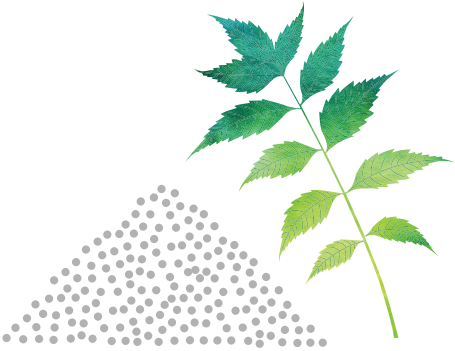
a. Making fertiliser recommendations for a cropping system instead of a single crop in the system.

b. The recommendation of mineral fertilisers should be based on the yield target soil test crop response equations (STCR).



c. Minimising fertiliser losses in the field through appropriate time and method of application.

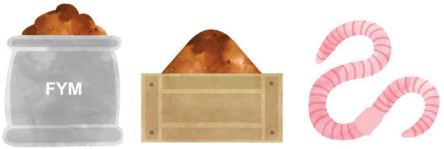
d. Use super granules, neem-coated urea, direct use of locally available phosphate rocks in acidic soil, etc.



The mineral fertilisers must be applied in the right quantity, at the right time and placed from the right source and in the right combination.

3. Organic sources

Organic manure acts in many ways in augmenting crop growth and soil productivity. The decomposition of organic matter in the soil produces humic substances or its decomposition products affecting favourably the growth and metabolism of plants. Indirectly, it augments the beneficial soil micro-organisms and their activities and thus increases the availability of major and micronutrients. The organic sources of nutrients include farm yard manure, vermicompost, animal droppings, crop waste residues, sewage, sludge, compost, green manuring human wastes and other various industrial wastes. Organic manuring also improves the physical and microbial conditions of soil and enhances fertiliser use efficiency when applied in conjunction with mineral fertilisers.



FYM Compost Vermicompost

Bio-compost Mud cakes

4. Biological sources

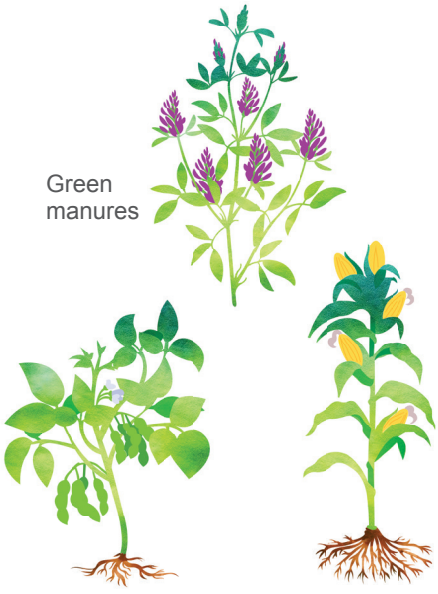
Biofertilisers are considered to be cost-effective, eco-friendly and renewable sources of non-bulky, low-cost plant nutrients supplemental to chemical fertilisers in sustainable agricultural production systems. The biofertilisers like Azotobacter, Rhizobium, and Azospirillum fix the atmospheric nitrogen into the soil and make it available to the plant. The phosphate solubilizing bacteria PSB makes the phosphorus

available to the plant. The seed treatment with biofertilisers helps to reduce the use of nitrogenous fertiliser at least by 25%. The use of biofertilisers reduces the cost of chemical fertilisers which are increasing tremendously day by day.

4. Components of INM

Major components of integrated nutrient management are:

1. Improve soil fertility by cultivating crops like green manures, legumes, cover crops etc.
2. Recycling of crop residues or incorporation of crop residues into the soil.
3. Use of organic manures like FYM, compost, vermicompost, biogas, slurry, poultry manure, bio-compost, press mud cakes, phosphor compost etc.
4. Use of Biofertilisers like Rhizobium, Azotobacter, Azospirillum etc. for seed treatment and soil application.



5. Balanced use of nutrients as per soil test crop response and yield target equations (STCR).
6. Use of organic formulations i.e. jeevamrut, amrutpani etc. that can be prepared locally by using available farm resources like cow dung, cow urine, and crop residues.

5. Common Constraints of INM

Common constraints encountered by the farmers in the adoption of INM technology are as follows:

1. Non-availability of FYM, cow urine, crop residues etc.
2. Difficulties in growing green manure crops.
3. Non-availability/timely availability of bio-fertilisers.
4. Low availability of crop residues due to the burning of these crop residues in open fields.
5. Non-availability of soil testing facilities.
6. High cost of chemical fertilisers and organic manures if purchased from the market.
7. Lack of knowledge and support from the Agriculture department.
8. Non-availability of improved seeds.

6. Techniques of Organic Manuring

6.1 Composting

6.1.1 Coimbatore method

- For the preparation of compost using the Coimbatore composting method, prepare a pit of 12 ft long × 6 ft wide × 3 ft deep. The size of the pit depends on the availability of raw materials.
- In the first layer of the pit spread the waste materials up to the thickness of 15 cm height then it is moistened with a slurry of 10 kg cow dung in 5.0 litres of water.
- Similarly, one-by-one layers as mentioned above should be given in the pit up to the height of 0.5 M above the ground level.
- It is plastered with mud for anaerobic decomposition of waste materials for up to four weeks. In the fourth week, the mass becomes reduced and the heap flattens.

- Remove mud plaster and sprinkle with water to moisten the material and turn the entire mass for aerobic decomposition.
- Left the entire mass undisturbed. The compost is ready for use after 4-5 months.

6.1.2 Indore method

- Indore method of composting is done in a pit size of 9 feet long x 5 feet wide and 3 to 5 feet high.
- The first layer of waste material is about 5 inches thick and over it is a 2-inch thick slurry layer of cow dung and urine.
- Give a similar one-by-one layer up to the 5 feet height then it is plastered with a thick layer of soil and dung.
- This prevents moisture loss and allows the temperature to rise to 60-65ºC within 3-4 days.
- After 30 days turn the waste material and sprinkle water to maintain optimum moisture.
- Another turn is given after 30 days.
- Good quality compost becomes ready within 2 to 3 months. (TNAU Aagritech portal, 2009).

The Indore method has a disadvantage in that it requires considerable labour in the construction of the heap, turning of materials, and maintenance of adequate moisture. Loss of nitrogen as ammonia gas also takes place.

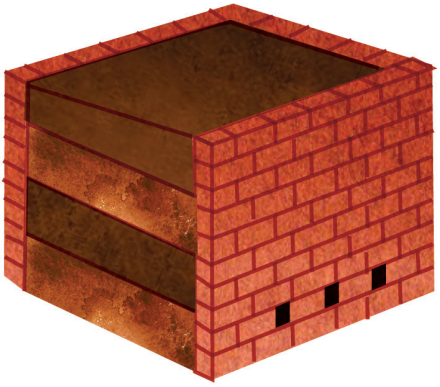
6.1.3 Bangalore method

- Dig a pit of one meter deep and width and length depending upon the availability of waste materials.
- In the first layer, spread dry waste materials of 15-20 cm thick in a pit and spread a thick slurry of cow dung and water sprinkles over it.

- Continue the process of an alternate layer of waste materials and cow dung suspension till it rises 0.5 m above the ground layer.
- Leave it exposed without covering for 15 days. After this period, turn the entire contents from the bottom of the pit.
- Cover the heap with wet mud and leave it undisturbed for about five months.
- If all operations are properly carried out, the compost will be ready in about five to six months.

6.1.4 NADEP Compost

- This composting method was developed by Narayan Devrao Pandharipande
- Prepare a brick structure measuring 10'x6'x3' on the land surface, with holes in the side of the walls for aeration during composting.



- The brick tank is filled with farm wastes, soil and cow dung layer by layer and add water to maintain 60-75% moisture.
- The upper layer with soil and cow dung slurry.
- After 75-90 days of composting, microbial cultures of Azotobacter, Rhizobium and phosphate solubilising bacteria to the mixture.
- Compost becomes ready for use within 110-120 days. One tank provides about 2.5-2.7 tons of compost sufficient for one hectare land.

6.2 Waste Decomposer

A waste decomposer is a consortium of microorganisms extracted from desi cow dung. National Center of Organic Farming (NCOF) has developed a waste decomposer culture that is used for quick composting from organic waste, soil health improvement and as plant protection agent.

Mass multiplication of waste decomposer

- Mix 2 kg of jaggery in 200 litres of water in a container and stir well.
- Open the bottle and pour the contents of the bottle into the solution (avoid direct contact of contents with hands)

- Stir the contents of the container and cover it with paper/cardboard etc. and stir it daily. Within 4-6 days the waste decomposer solution will be ready for use.

Use of waste decomposer solution

1. Composting

- Spread 1 ton of farm waste material (FYM, Crop residues etc) as a layer on a plastic sheet placed under shade.
- Sprinkle 20 litres of the above prepared solution over the first layer.
- Spread one more layer of waste materials above the existing layer.
- Sprinkle 20 litres of the solution over the second layer.
- Repeat the process for the next 4-5 layers depending upon the availability of the waste materials.
- Maintain 60% moisture during the entire period of composting.
- Turn over the compost at a 7 day interval. The compost is ready to use after 30 days.

2. Foliar Application

Spray the preparation (1:3) on the standing crop 4 times at 10 days intervals. It can be used as a growth hormone and biopesticide for the prevention of pests and disease infestation. It can be used for spraying on any crop.

3. Soil application through drip

Mix the preparation in water required for 1 acre and use it for drip irrigation. In-Situ Composting of Crop Residue. Spray the preparation on the post-harvest stalks of crop plants of 1 acre land and leave it for decomposition.

4. Seed treatment

- Wear hand gloves.
- Thoroughly mix the contents of one bottle with 30 gm of jaggery to treat 20 kg of seeds.
- Sprinkle the waste decomposer solution on seeds.
- Leave the treated seeds under shade for 30 minutes.
- After 30 minutes, seeds can be used for sowing.

6.3 Vermicompost

Compost that is prepared with the help of earthworms is called vermicompost. The earthworms may be of local species or more vigorous exotic ones. Earthworms consume large quantities of organic matter and excrete soil as a cast. The weight of materials passing through the body each day is almost equal to the weight of earthworms. The casts of earthworms have several enzymes and are rich in plant nutrients and beneficial bacteria and mycorrhizae.

Advantages of vermicompost:

1. Vermicompost is a rich source of major and minor plant nutrients. On average, vermicompost contains 3% nitrogen, 1% phosphorus and 1.5% potash.
2. Vermicompost increases the total microbial population in soil, these microbes secrete growth promoting substances like e auxins, gibberellins etc.
3. The nutrients from vermicompost are easily available to the plant as compared to the other compost.
4. Vermicompost improves bulk density and water holding capacity of soil.
5. Vermicompost minimizes the incidence of pests and diseases.
6. It enhances the decomposition of organic matter in soil.
7. Vermiwash used as growth promoting hormone also acts as biopesticide that prevents pest infestation.



Process of Vermicomposting:

In the vermicomposting process, organic waste is first partly decomposed by the action of microorganisms. After a particular stage, this semi-decomposed materials are taken up as food by the growing earthworms and are converted into nutrient rich compost. The vermicomposting process involves the following steps:

a. Selection of species

Indian conditions two species namely Eisenia foetida and Eudrillu seugineae are most suitable.

b. Selection of site and site preparation

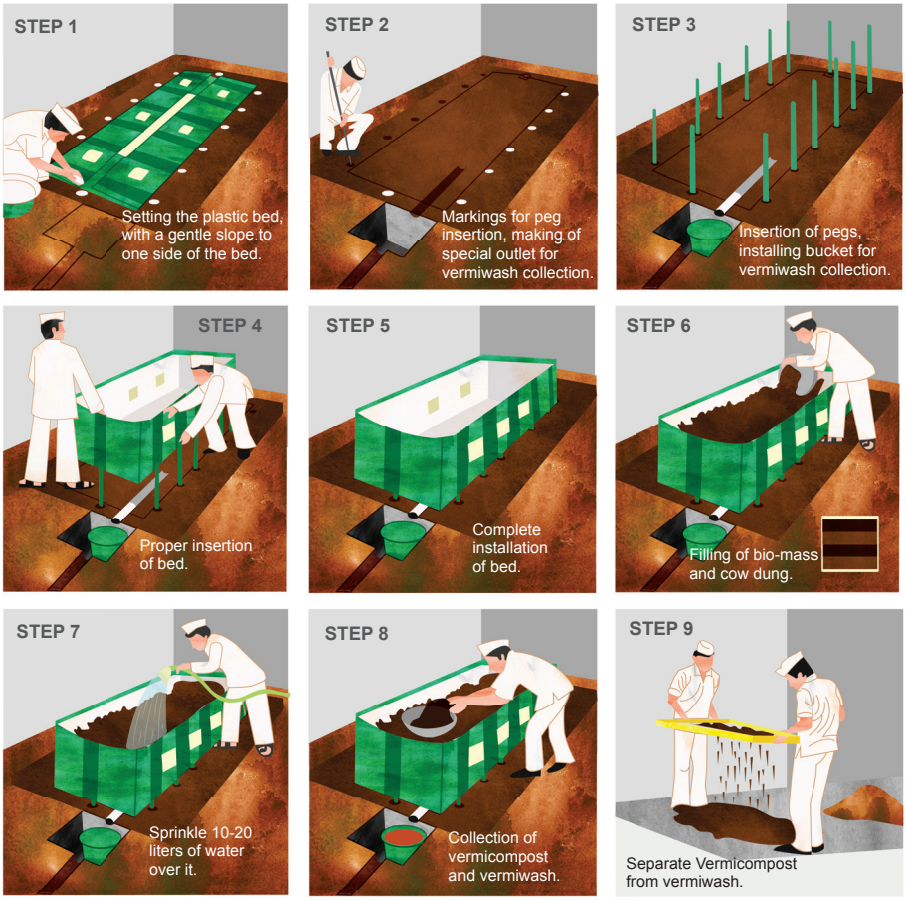
- For continuous production of vermicompost, long thatch roof sheds duly protected by greenhouse nets are most suitable.
- Thatch roofs keep the sheds cool and greenhouse nets ensure adequate humidity and low light conditions. Under the sheds, vermi beds are to be prepared.
- The length of the bed can be from 5 meters, depending upon the requirement and size of the shed.
- The width should normally be restricted to 75-90 cm.
- The height of the bed can vary from 30-60 cm depending upon the time and stage of the process.
- The distance between the two beds should be about 30-45 cm.
- In the market various types of vermicomposting bins and tanks are available for small and marginal farmers as well as for small scale growers.

c. Materials for the preparation of Vermicompost

Any types of biodegradable wastes - crop residues, weed biomass, vegetable waste, leaf litter, Waste from agro-industries, biodegradable portion of urban and rural wastes, etc. If the waste is too acidic, then it should not be considered for the preparation of vermicompost. Biodegradable waste should be free from clothes, plastic bags, blades, stones etc.

d. Making of vermicompost

1. At the time of setting the plastic bed, ensure that there is a gentle slope to one side of the bed.
2. Make a small pit at the corner of the sloping end to fit a 20 litre capacity plastic bucket to collect the vermiwash.
3. Spread the bedding materials (chopped waste) in the bottom of the container or bed.
4. The first layer should consist of chopped crop residues or partially decomposed farm waste up to 30 cm height. Sprinkle the 10-15 litres of water over it.



5. Add a second layer of fresh cow dung upto 60 cm height, followed by an alternate layer of crop residues/ waste materials.
6. Repeat the sequence until the bed gets full and the last layer of a slurry of cow dung and cow urine should be given. Sprinkle 10-20 litres of water over it.
7. After 5 to 6 days of bed filling release about 2-3 kg earthworms per ton of biomass or 100 earthworms per one sq. ft. area.
8. Cover the heap with moist gunny bags. Sprinkle water over it and maintain moisture at 50-60%.
9. Start to collect vermiwash after one week of the release of earthworms.
10. Within 30-45 days, vermicomposting bed will be ready for harvesting.

e. Separation and sieving of vermicompost

1. Harvest the ready vermicompost by hand, as we start to remove the vermicompost from the bed earthworm generally moves towards the lower layer.
2. Before 4-5 days of harvesting, keep the next set of beds ready by filling the waste materials so you can release the earthworms after the harvesting the bed.
3. Mechanical sieving by a drum screen or a moving grate at the bottom of a bin.
4. Dry the vermicast materials with a fan in a batch process, diverting worms towards the moist materials at the base.

6.4 Vermi-wash

Vermi-wash is prepared from the heavy population of earthworms reared in earthen pots or plastic drums. The extract contains major nutrients, micronutrients, vitamins (such as B12) and hormones (gibberellins, cytokinins, auxin, amino acid) secreted by the earthworms. Earthworms produce bacteriostatic substances found in the vermiwash that can protect against bacterial infections. Vermiwash can be sprayed on crops and trees for better growth, yield and quality.

Steps in preparation

- Take a big earthen pot or plastic drum with a capacity of 50/100litres (provided with a tap in the bottom) and place it in shade.
- In the bottom of the drum give a 10 cm thick layer of pebbles and sand for effective drainage.
- Soften kitchen wastes or chopped crop residue layer of 30 cm and 5 kg one-week-old dung is filled in the pot/drum. Add 4-5 litres of water.
- After 2 or 3 days, 200-300 red worms in the drum.
- After 15-20 days, collect the extract in earthen pots from the tap placed in the bottom of the pot/drum is called 'Vermiwash'.
- Extract diluted in the water (1:5 ratio) can be used as a foliar spray.

Precautions

Add 1 litre of water daily or on alternate days for 20 days. After it has fully converted into compost, remove it and add fresh raw materials.

Benefits of vermiwash

- Vermiwash is an eco-friendly, natural organic formulation prepared from biodegradable organic wastes.
- It develops resistance in plants against various diseases and pests.
- It enhances flowering and fruiting in some vegetable crops.
- Act as a biopesticide when diluted with 10% cow urine, neem extract or garlic extract.
- It does not have any adverse effect on soil, plant and environment.

6.5 Green Manuring

Green manuring is the practice of incorporating large quantities of un-decomposed green materials such as leaves and twigs of plants or crops in soil by ploughing. There are two methods of green manuring.

6.5.1 Green manuring in situ

In this system, green manure crops are grown and buried in the same field, either as a pure crop or as an intercrop with the main crop. The most common green manure crops grown under this system are Sannhemp, dhaincha and guar.

Green manure crops

1. Sannhemp *(Crotalaria juncea):* Adapted to well-drained soil, suitable for upland conditions, quick growing, relatively resistant to pests and disease, and has a deep root system.
2. Dhaincha *(Sesbania aculeata):* Resistant to drought, salt and water-logging, ideal for rice, generally grown in low land, suitable for saline and alkaline soil, and has a deep root system.
3. Dhaincha *(Sesbania rostrata):* A newly introduced green manure crop that can also grow in water-logged conditions. In this crop nodule formation is on the roots and also in large numbers on the stem. So that it fixes more nitrogen than *Sesbania aculeata.*
4. Mung *(Phaseolus mungo):* It is quick growing, and drought resistant.
5. Indigo *(Indigofera tinctoria):* Suited to heavy soil (clay) and slow growing.
6. Khesari *(Lathyrus sativus):* Winter season crop.

Table 1: *Green manure crops, their yield and nitrogen added in the field*

Sr. No.	Crop name	Botanical name	Growing season	Average yield of green matter (kg /hectare)	Nitrogen added (kg/hectare)
1	Sannhemp	Crotalaria juncea	Summer and Kharif	194.7	84.2
2	Dhaincha	Sesbania aculeate	Summer and Kharif	183.6	76.9
3	Urd	Phaseolus mungo	Summer and Kharif	100.1	42.2
4	Mung	Phaseolus aureus	Summer and Kharif	37.4	38.6
5	Khesari	Lathyrus sativus	Rabi	123.0	54.9
6	Berseem	Trifolium alexandrinum	Summer and Kharif	155.0	54.2

Non-leguminous green manure crop

1. Bhang *(Cannabis sativa)*
2. Kodogira *(Vernonia cenerea)*

6.5.2 Green leaf manuring

Green leaf manuring refers to the turning of green leaves and tender green twigs collected from shrubs and trees grown on bunds, waste lands and nearby forest areas into the soil. The common shrubs and trees used are Gliricidia, Sesbania (wild dhaincha), Karanj, etc.

Green Leaf Manuring Crop

1. Gliricidia *(Gliricidia maculata)*
2. Karanj *(Pongamia glabra)*
3. Ipomoea *(Ipomoea carnea)*

Characteristics of a good manure crop

1. Green manure crops should produce a large quantity of green biomass within a short period of time.
2. It should be quick growing, especially in the beginning, to suppress weeds.
3. It should be succulent and have more leafy growth than woody growth so that its decomposition will be rapid.
4. Preferably is a legume, so that atmospheric 'N' will be fixed.
5. Have a deep and fibrous root system so that it will absorb nutrients from the lower layer of soil and add them to the surface soil.
6. Green manure crops can grow on poor and problematic soil.

When should green manure crops be incorporated into the soil?

A green manure crop may be turned in just before the flowering. The majority of the green manure crops require 6-8 weeks after sowing at which there is maximum green matter production and most succulent.

Techniques in green manuring

1. Green manure crops can be grown in any type of soil, provided there is sufficient rainfall or an alternate irrigation facility is available.
2. Leguminous green manure crops seed should be treated with proper strain of bacteria.
3. The green manure crop should be sown with a higher seed rate than usual so that there will be a good canopy produced very quickly.
4. The application of phosphatic fertilisers improves the growth of leguminous crops markedly and promotes the fixation of nitrogen by profuse nodulation.
5. The best stage at which the crop should be incorporated in the soil as green manure is when it reaches the flowering stage. Sannhemp crop is ready for turning in at the age of 7-8 weeks whereas dhaincha crop is ready for incorporation when 5-6 weeks old.

6. The burying of green manure crops is done in different ways. In some cases, the plants are cut close to the ground and the green materials are put in the furrows opened by a mould board plough and is later buried. One of the methods is to press the material down with a heavy plank or log, and then plough the field. The other method is to mix the uprooted or cut plant materials (green leaf manure) using a disc harrow. In drier areas, this method has been proven to be more effective than ploughing.
7. Immediately after ploughing the materials, careful packing of the soil should be done by suitable implements to ensure proper decomposition. Packing (compacting) is especially necessary if the soil moisture supply is deficient.
8. Under certain favourable circumstances, green manure crops such as dhaincha can be sown in between the rows of cotton or jowar. When the dhaincha is sufficiently tall it can be uprooted and mixed with the soil by inter-cultivations.
9. Under limited moisture supply conditions, it may be advisable to grow the green manure crops in one field and add the green materials to another field, thus conserving the moisture required for growing the green manure crop.
10. For proper decomposition, the crop should be buried deeper in light soils compared to heavy ones..

Advantages of green manuring:

1. It adds organic matter to the soil and stimulates the activity of soil micro-organisms.

2. Green manuring improves soil structure, increases water holding capacity and decreases soil loss by erosion.
3. It takes nutrients from lower layers of the soil and adds to the upper layer in which it is incorporated.
4. It is a leguminous crop, it fixes 'N' from the atmosphere and adds to the soil for being used by succeeding crops.
5. It increases the availability of certain plant nutrients like P2O5, Ca, Mg and Fe.
6. Growing green manure crops in the off season reduces weed proliferation and weed growth.
7. Green manuring helps in the reclamation of alkaline soils and can also control root knot nematodes.
8. Green manures can act as habitats for general predators and encourage good populations of lacewings and parasitic wasps.

Disadvantages of green manuring:

When the proper technique of green manuring is not followed or when the weather conditions become unfavourable, the following disadvantages are likely to become evident.

1. Under rainfed conditions, it is feared that proper decomposition of the green manure crop and satisfactory germination of the succeeding crop may not take place if sufficient rainfall is not received after burying the green manure crop.
2. An increase in diseases, insects and nematodes is possible.
3. A risk is involved in obtaining a satisfactory stand and growth of the green manure crops if sufficient rainfall is not available.

6.6 Amrutpani

a. Materials Required

i. Fresh cow dung - 1 kg
ii. Cow urine - 1 litre
iii. Green neem leaves - 1 kg
iv. Chickpea flour - 1 kg
v. Jaggery - 100 gm
vi. Water - 10 litres

Cow dung

Cow urine

Neem leaves

Chickpea flour

Jaggery

Water

b. Method of Preparation

Take a 15 litre capacity plastic bucket. Then mix all the materials into the bucket. Stir it vigorously with a wooden stick; to mix all the materials properly. Cover the plastic bucket with a lid and keep it in shade for 10 days. The mixture should be stirred with a wooden stick clockwise and anti-clockwise for 5-10 minutes everyday early in the morning and evening. After 10 days, the mixture should be filtered with a cotton cloth. The extract is ready for spraying.

c. Dose of Application

Spray Amrutpani, (150ml/15 litres) of water to enhance the growth and development of the plant as well as increase resistance to pests and disease infestation.

d. Advantages

- It is useful for spraying in all crops seedlings to the pre-maturity stage of the crop.
- It is beneficial to prevent pests and disease infestation.
- It enhances flowering and fruit setting in the fruits and vegetable crops.
- It gives lustre to the crop/ grains and increases yield.
- It reduces the input cost of growth hormones.

6.7 Jeevamrut

a. Materials Required

i. Fresh cowdung - 10 kg

ii. Cow urine - 10 litres

iii. Gram flour - 2 kg

iv. Jaggery - 1 kg

v. 200 litres plastic barrel

vi. Water - 180 litres

Plastic Barrel

Water

Cow dung

Cow urine

Chickpea flour

Jaggery

b. Method of Preparation

Take a 200 litre capacity plastic barrel. Keep the barrel in a shade and then mix all the above materials into the barrel and add 180 litres of water to it. Then stir it with a wooden stick clockwise and anticlockwise and cover it with cotton cloth and lid. Keep it for six days. Every day early in the morning and evening stir the content for 5-10 minutes. After 6 days, Jeevamrut is ready for application to the soil.

c. Dose of Application

Apply 200 litres of Jeevamrut slurry for 1 acre area along with irrigation or drenching of jeevamrut should be done through a drip or spray pump for fruits and vegetable crops.

d. Advantages

- It is low cost and useful for all crops.
- It increases the vegetative growth as well as white roots growth of the plant.
- Jeevamrut enhances microbial activities and population in the soil and makes nutrients available to the plant roots.
- It also helps to maintain the C:N ratio of the soil.

6.8 Biofertilisers

Biofertilisers are preparations containing beneficial microorganisms like nitrogen fixers, phosphate solubilisers in a viable static state intended for seed or soil application and to improve soil fertility and make nutrients available to the plant.

6.8.1 Rhizobium Inoculants

Rhizobium is a group of bacteria that fixes nitrogen in association with the roots of leguminous crops. Rhizobia can fix 40-120 kg of nitrogen per acre annually depending upon the crop. They help to improve soil fertility, plant nutrition and growth and have no negative effect on soil or the environment. Every leguminous crop requires a specific *rhizobium* species.

6.8.2 Azotobacter inoculants

Azotobacter fixes nitrogen non-symbiotically and benefits the plants by growing in the rhizosphere of plants. *Azotobacter* inoculation could save about 15-20kg N\ha and increase grain yield by about 10%.

6.8.3 Azospirillum inoculants

The group of gram-negative nitrogen fixing spirilla, which was originally named as *spirillum lipoferum,* has been reclassified into at least two species in the *genus Azosperillum, A. Brasiliense* and *A. lipoferum.* Field trials showed that sorghum and pearl millet usually responded to inoculation with *A. brasilense* cultures and could save about 20-40 kg N\ha. Similarly, wheat showed a significant response to *A. lipoferum.*

6.8.4 Blue green algae inoculants

Wetland rice fields are an ideal ecosystem for algal nitrogen fixation values ranging from 40-80 kg N/ha/year. Algal inoculation can increase grain yield by about 10-20% . BGA is also reported to produce growth promoting substances.

6.8.5 Azolla

The water fern Azolla fixes atmospheric N due to the presence of heterocystous. The chemical composition of Azolla (dry basis) is 3-4% N, 0.5-0.6% P, 2-6% K, 9-10% ash, 5% crude fat, 9% crude fibre and 20-30 % crude protein. It is thus a good source of organic N and can also be used as a green manure. Its satisfactory growth requires an optimum P supply, temperature range 25-30ºC and adequate moisture.

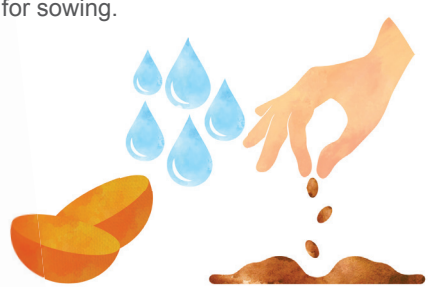
6.8.6 Mycorrhiza

- Mycorrhiza is a sweeping term for a number of species of fungi that form a symbiotic association with the plant root system. Of these, the most important in agriculture is vesicular-arbuscular mycorrhiza or VAM. VAM fungi are mycorrhizal species of fungus that live in the roots of higher plants. They develop a symbiotic association with the plants in the roots of these plants.

Application methods of Biofertilisers

1. Seed treatment

The biofertiliser like Rhizobium, Azospirillum, Azotobacter and PSB used for seed inoculation. For the seed treatment with biofertilisers use 25gm crop specific biofertilisers to treat one kg of the seed. Take the required quantity of seeds for one hectare area and uniformly sprinkle the solution of jaggery (50 gm in 250ml of water) after that mix well the required quantity of crop specific biofertiliser and make a uniform coating over the seed. Keep it in shade for 30 minutes for drying and after that use it for sowing.



2. Seedling root dip

This method is used for transplanted crops. For the seedling treatment of one hectare area, prepare the solution of 5 kg inoculant mix in 50 litres of water. Dip the roots of the seedling into the solution for 5-10 minutes before the transplanting.

3. Soil treatment

The soil treatment with biofertiliser is done with the application of biofertiliser in soil by mixing and incubating with FYM or compost. Mix 4 kg biofertiliser in 400 kg of FYM and incubate it for 2-3 days and apply for once an acre at the time of sowing.

4. Use of VAM Biofertiliser

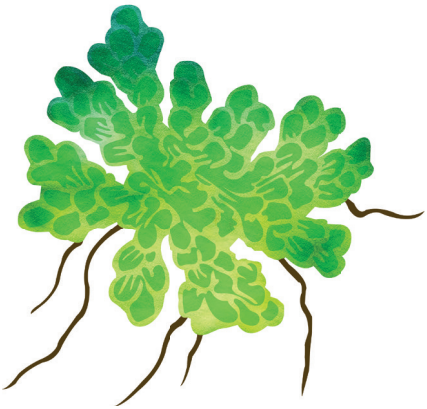
The VAM inoculum should be applied 2-3 cm below the soil at the time of sowing. The seeds are sown or cuttings planted just above the VAM inoculums so that the roots may come in contact with the inoculums and cause infection.

5. Use of Blue Green Algae (BGA)

Algal culture is applied as dried flakes at 10 kg/ha over the standing water in field rice. The application of culture should be done after 2-3 days of transplanting in loamy soils and six days after transplanting in clayey soils. The field is kept water logged for a few days immediately after algal application.

6. Use of Azolla

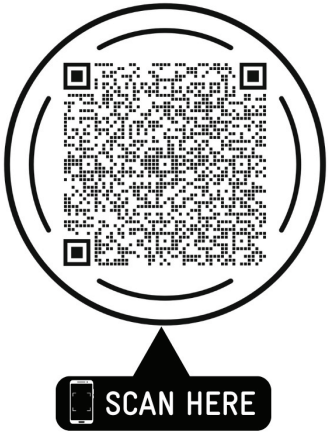
Apply azolla, (0.6-1.0 kg/m2) (6.25-10.0 t/ha) and incorporate it into the soil before transplanting of rice. Azolla is applied, 100 g/m2 (1.25t/ha), one to three days after transplanting of rice and allowed to multiply for 25-30 days. Azolla fronds can be incorporated into the soil at the time of the first wedding.



Best Practices for Procuring and Utilising Biofertilisers

- Biofertilisers should be stored in cool and dry place. Avoid direct contact from sunlight and heat.
- Ensure that the crop specific biofertiliser strain should be used.
- Other chemicals should not be mixed with the biofertilisers.
- While seed treatment with chemical pesticides, follow the sequence as Fungicide, Insecticide and then treat the seeds with biofertilisers.
- While purchasing biofertilisers, ensure that each packet is provided with necessary information like name of the product, name of the crop for which intended, name and address of the manufacturer, date of manufacture, date of expiry, batch number and instructions for use.

- It is important that the biofertilisers should be incubated at least for a week along with the organic manures while soil application.



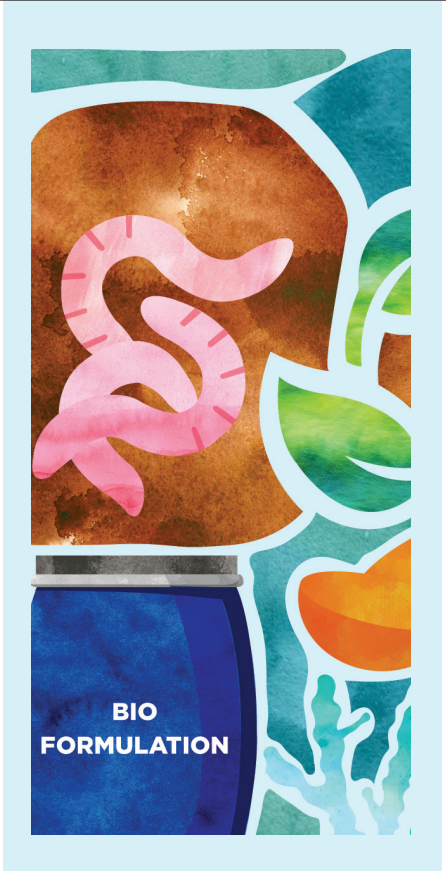
OTHER AVAILABLE RESOURCES ON THE WEBSITE:

- Handbooks on Concept and Methods of Integrated Pest Management in Sustainable Agriculture, Soil Sampling and Soil Testing, Integrated Nutrient Management and Low-Cost Organic Formulations (English, Hindi, Kannada and Malayalam).

- Farmers' Manuals on Sustainable Production Practices for Cardamom (English and Malayalam), Cumin (English and Hindi) and Turmeric (English, Kannada and Tamil).

- Farmers' Diaries on Cumin (Hindi), Turmeric (Tamil), Dill seed and Celery (Hindi).

- Animated Video Series on Practicing Sustainable Agriculture, Sustainable Food production, organic farming and more (English, Hindi, Kannada and Malayalam).



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