# Impact of Integrated Nutrient Management in Enhancing the Growth and Yield of Crops

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**ABSTRACT**

Alleviation of poverty and achievement of zero-hunger target and food security are significant challenges faced by agricultural planners worldwide. Improving many agronomic approaches, which have drastic effects on crop growth and yield, is urgently needed to report this aim. Integrated nutrient management refers to the maintenance of soil fertility and of plant nutrient supply at an optimum level for sustaining the desired productivity through optimization of the benefits from all possible sources of organic, inorganic and biological components in an integrated manner, has a bright solution in this area. Recently, several investigators reported that integrated use of conventional fertilizers with organic manure is becoming a quite promising practice not only for maintaining higher productivity but also for greater stability to crop production and also reduce environmental impacts. Integrated nutrient management is a tool that can offer good options and economic choices to supply plants with a sufficient amount of nutrients in need and can also reduce total costs, its improve to physical, chemical and biological properties of soil hence improve growth and yield of the crops.

## INTRODUCTION

Soil is a fundamental requirement for crop production as it provides plants with anchorage, water and nutrients. A certain supply of mineral and organic nutrient sources is present in soils, but these often have to be supplemented with external applications, or fertilisers, for better plant growth. Fertilisers enhance soil fertility and are applied to promote plant growth, improve crop yields and support agricultural intensification. Non-judicious and unbalanced application of NPK fertilizer not only deplete the native soil nutrient reserve but also cause environmental damages viz., greenhouse gas (GHG) emission, acidification, eutrophication, etc. posing a serious threat to sustainability of rice production. Integrated application of organic manures and chemical fertilizers could be the best option to overcome the adverse impacts associated with use of chemical fertilizer alone.

Integrated nutrient management is the judicious use of all possible nutrient sources to meet the plant nutrient requirement at an optimum level to sustain the desired crop productivity with minimal impact on environment. In integrated nutrient management, the immediate nutrient requirement of the crop is met through chemical fertilizers. Thus, the rate and time of chemical fertilizer application should synchronise with the real time need of the crop. Whereas, the slow and long-term release of nutrients from organic sources helps in meeting the long-term need of the crop.

***Components of integrated nutrient management***

*Organic manures*: Farmyard manure (FYM), compost, vermicompost, biogas slurry, poultry manure, crop residues and biowastes like press mud, sugarcane bagagges etc.

*Biofertilizers*: BGA, azolla, phosphate solublizers, etc. Green manures & Green leaf manures: Dhaincha (*Sesbania aculeata*), Sesbania rostrata, Sunhemp (*Crotalaria juncea*), *Pongamia globra, Leucaena leucocephala, Azadiracta indica*.

*Crop rotation with legumes:* Chemical fertilizer like urea, single super phosphate, di-ammonium phosphate, muriate of potash. Benefits of integrated nutrient management are optimizing nutrient-use efficiency and high yield production. The forms and quantities of soil nutrient contents in the root zone, which is known as soil balance and its availability to cover crop requirements (spatially and temporally). Minimizing nutrient losses, especially in the intensive agriculture system. Taking all factors affecting the plant/nutrient relationship into consideration to achieve high yield production, which is the main objective and the major gain of the application of integrated nutrient management, water use efficiency, grain superiority, high economic return, and sustainability.

Additional benefits also can be gained, i.e., produce healthy food free from contaminants and chemical residues, which is currently accepted and preferred by many customers due to the fact that they are safer and healthier compared with products which are conventionally produced under the sole application of synthetic fertilizers, regardless of their high price. Furthermore, adopting such practice also had a contribution and remarkable residual effect on yield and yield component characters of the succeeding crop. Systems can improve the soil nutrient natives and increase the solubility and availability of fertilizers to be used. Use the harmonious behavior of nutrient supplies and making them match with the crop requirements. Offer the nutritional balance to the crops and lessen the aggressive effects resulting from the opposite impact between nutrient fractions and nutrient imbalance. Advance and sustain the physiochemical and biological functions of soil properties. Reduce the rate of soil degeneration, water, and ecosystem by enhancing carbon confiscation and decreasing nutrient losses to ground and surface water forms and/or to environment pollution. Minimize higher total costs of production and raise the farmer's returns (increasing profitability). Improve the resistance to both biotic and abiotic stresses. An effective method of agricultural practices to ensure healthy food, covering population food demands alongside with many soil and environmental impacts, especially in countries with rapid growth in population. Additional benefits can also be gained; it does not only save the total costs at the satisfactory level with an increase in crop production but also can be easily practiced by farmers; therefore, it is considered one of the most promising techniques in line with the future needs. INM can have positive effects on the susceptibility or plant resistance against many types of biotic and abiotic stresses. Following INM will enable to explore a larger volume of soil in order to access water and nutrients; additionally, improved root development enables the plant to absorb water from deeper soil layers and then reflect an increase in the ability of crops toward drought resistance. Changes in awareness of farmers toward the climate changes from season to season, which have greater ecological impacts in order to produce safe food rather than achieving higher yield aiming at attaining higher profit

## Integrated nutrient management in relation to plant growth and crop yield:

*Important integrated nutrient management components for enhancing crop growth and yield:*

*Manures*: Manures are plant and animal wastes that are used as sources of plant nutrients. They release nutrients after their decomposition. The art of collecting and using wastes from animal, human and vegetable sources for improving crop productivity is as old as agriculture. Manures are the organic materials derived from animal, human and plant residues which contain plant nutrients in complex organic forms. Naturally occurring or synthetic chemicals containing plant nutrients are called fertilizers. Manures with low nutrient, content per unit quantity have longer residual effect besides improving soil physical properties compared to fertilizer with high nutrient content. Major sources of manures are:

1. Cattle shed wastes-dung, urine and slurry from biogas plants
2. Human habitation wastes-night soil, human urine, town refuse, sewage, sludge and sullage
3. Poultry Jitter, droppings of sheep and goat
4. Slaughterhouse wastes-bone meal, meat meal, blood meal, horn and hoof meal, Fish wastes
5. Byproducts of agro industries-oil cakes, bagasse and press mud, fruit and vegetable processing wastes etc
6. Crop wastes-sugarcane trash, stubbles and other related material
7. Water hyacinth, weeds and tank silt, and
8. Green manure crops and green leaf manuring material

Manures can also be grouped, into bulky organic manures and concentrated organic manures based on concentration of the nutrients.

*Bulky organic manures*: Bulky organic manures contain small percentage of nutrients and they are applied in large quantities. Farmyard manure (FYM), compost and green-manure are the most important and widely used bulky organic manures. Use of bulky organic manures has several advantages:

- They supply plant nutrients including micronutrients
- They improve soil physical properties like structure, water holding capacity etc.,
- They increase the availability of nutrients
- Carbon dioxide released during decomposition acts as a $CO_2$ fertilizer and
- Plant parasitic nematodes and fungi are controlled to some extent by altering the balance of microorganisms in the soil.

*Farmyard manure*: Farmyard manure refers to the decomposed mixture of dung and urine of farm animals along with litter and left-over material from roughages or fodder fed to the cattle. On an average well decomposed farmyard manure contains 0.5 per cent N, 0.2

per cent $P_2O_5$ and .0.5 per cent $K_2O$.The present method of preparing farmyard manure by the farmers is defective. Urine, which is wasted, contains one per cent nitrogen and 1.35 per cent potassium. Nitrogen present in urine is mostly in the form of urea which is subjected to volatilization losses. Even during storage, nutrients are lost due to leaching and volatilization. However, it is practically impossible to avoid losses altogether, but can be reduced by following improved method of preparation of farmyard manure. Trenches of size 6 m to 7.5 m length, 1.5 m to 2.0 m width and 1.0 m deep are dug.

All available litter and refuse are mixed with soil and spread in the shed so as to absorb urine. The next morning, urine-soaked refuse along with dung is collected and placed in the trench. A section of the trench from one end should be taken up for filling with daily collection. When the section is filled up to a height of 45 cm to 60 cm above the ground level, the top of the heap is made into a dome and plastered with cow dung earth slurry. The process is continued and when the first trench is completely filled, second trench is prepared.

The manure becomes ready for use in about four to five months after plastering. If urine is not collected in the bedding, it can be collected along with washings of the cattle shed in a cemented pit from which it is later added to the farmyard manure pit. Chemical preservatives can also be used to reduce losses and enrich farmyard manure. The commonly used chemicals are gypsum and superphosphate. Gypsum is spread in the cattle shed which absorbs urine and prevents volatilization loss of urea present in the urine and also adds calcium and sulphur. Superphosphate also acts similarly in reducing losses and also increases phosphorus content.

Partially rotten farmyard manure has to be applied three to four weeks before sowing while well rotten manure can be applied immediately before sowing. Generally, 10 to 20 t/ha is applied, but more than 20 t/ha is applied to fodder grasses and vegetables. In such cases farmyard manure should be applied at least 15 days in advance to avoid immobilization of nitrogen. The existing practice of leaving manure in small heaps scattered in the field for a very long period leads to loss of nutrients. These losses can be reduced by spreading the manure and incorporating by ploughing immediately after application.

Vegetable crops like potato, tomato, sweet-potato, carrot, raddish, onion etc., respond well to the farmyard manure. The other responsive crops are sugarcane, rice, napier grass and orchard crops like oranges, banana, mango and plantation crop like coconut.

The entire amount of nutrients present in farmyard manure is not available immediately. About 30 per cent of nitrogen, 60 to 70 per cent of phosphorus and 70 per cent of potassium are available to the first crop.

*Oil cakes:* After oil is extracted from oilseeds, the remaining solid portion is dried as cake which can, be used as manure. The oil cakes are of two types:

- Edible oil cakes which can be safely fed to livestock; e.g.: Groundnut cake, Coconut cake etc., and
- Non edible oil cakes which are not fit for feeding livestock; e.g.: Castor cake, Neem cake, Mahua cake etc.,

Both edible and non-edible oil cakes can be used as manures. However, edible oil cakes are fed to cattle and non-edible oil cakes are used as manures especially for horticultural crops. Nutrients present in oil cakes, after mineralization, are made available to crops 7 to 10 days after application. Oilcakes need to

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be well powdered before application for even distribution and quicker decomposition.

**Average nutrient content of oil cakes**

| Oil-cakes | Nutrient content (%) | | |
|---|---|---|---|
| | N | $P_2O_5$ | $K_2O$ |
| Non edible oil-cakes | | | |
| Castor cake | 4.3 | 1.8 | 1.3 |
| Cotton seed cake (undecorticated) | 3.9 | 1.8 | 1.6 |
| Karanj cake | 3.9 | 0.9 | 1.2 |
| Mahua cake | 2.5 | 0.8 | 1.2 |
| Safflower cake (undecorticated) | 4.9 | 1.4 | 1.2 |
| Edible oil-cakes | | | |
| Coconut cake | 3.0 | 1.9 | 1.8 |
| Cotton seed cake (decorticated) | 6.4 | 2.9 | 2.2 |
| Groundnut cake | 7.3 | 1.5 | 1.3 |
| Linseed cake | 4.9 | 1.4 | 1.3 |
| Niger cake | 4.7 | 1.8 | 1.3 |
| Rape seed cake | 5.2 | 1.8 | 1.2 |
| Safflower cake (decorticated) | 7.9 | 2.2 | 1.9 |
| Sesamum cake | 6.2 | 2.0 | 1.2 |

*Other Concentrated Organic Manures:* Blood meal when dried and powdered can be used as manure. The meat of dead animals is dried and converted into meat meal which is a good source of nitrogen. Average nutrient content of animal based concentrated organic manures is given as follows.

**Average nutrient content of animal based concentrated organic manures**

| Organic manures | Nutrient content (%) | | |
|---|---|---|---|
| | N | $P_2O_5$ | $K_2O$ |
| Blood meal | 10 - 12 | 1 - 2 | 1.0 |
| Meat meal | 10.5 | 2.5 | 0.5 |
| Fish meal | 4 - 10 | 3 - 9 | 0.3 - 1.5 |
| Horn and Hoof meal | 13 | - | - |
| Raw bone meal | 3 - 4 | 20 - 25 | - |
| Steamed bone meal | 1 - 2 | 25 - 30 | - |

*Blue-Green Algae:* Blue-Green Algae are a type of photosynthetic bacteria consisting either of single cells or colonies which is also known as the Cyanobacteria. Cyanobacteria contain only one type of chlorophyll, Chlorophyll a, a green pigment. In addition, they also contain pigments such as carotenoids, phycobilin.

These bacteria grow naturally in marine and freshwater systems. They thrive in dams, rivers, reservoirs, lakes and even in hot springs. These bacteria normally look green and sometimes turns blue when scum is dying. Almost all species of these bacteria are buoyant and float on the water surface and forms floating mats.

The accumulation of these algae is termed as 'blooms'. These blooms discolour the water and produce unpleasant taste and odour. They affect the fish population and reduce water quality. The decomposition of these blooms depletes the oxygen and triggers the killing of fish.

Examples of cyanobacteria: Nostoc, Oscillatoria, Spirulina, Microcystis,Anabaena.

***Role of Blue-Green Algae in Paddy Fields:***

Cyanobacteria are the major microbes which fix nitrogen in paddy fields. The agricultural importance of cyanobacteria in rice cultivation is because of their nitrogen-fixing ability and other positive effects on soil and plants.

Nitrogen fixation is the process of converting inert atmospheric nitrogen into combined compounds like ammonia, nitrate, nitrite etc.

The cyanobacterium Anabaena forms a nitrogen-fixing symbiosis with Azolla and fixes atmospheric nitrogen in the presence of significant quantities of oxygen.

*Vermicomposting:* Vermicomposting is generally defined as the solid phase decomposition of organic residues in the aerobic environment by exploiting the optimum biological activity of earthworms and microorganisms (Garg, Gupta, 2009). Vermicomposting is described as "bioxidation and stabilization of organic material involved by the joint action of earthworms and mesophilic micro-organisms". Vermicompost produced by the activity of earthworms is rich in macro and micronutrients, vitamins, growth hormones, enzymes such as proteases, amylases, lipase, cellulase and chitinase and immobilized microflora.Vermicomposting involves the composting of organic wastes through earthworm activity. It has proven successful in processing sewage sludge and solids from wastewater, materials from breweries, paper waste, urban residues, food and animal wastes, as well as horticultural residues from processed potatoes, dead plants and the mushroom industry.

*Production methods:*

Vermicomposting is done by various methods. Among them, bed and pit methods are more common.

1. Bed method

2. Pit method

***1. Bed method*:** Composting is done on the pucca / kachcha floor by making a bed (dimension: 6 x 2 x 2 feet) of organic mixture. This method is easy to maintain and to practice.

***Procedure*:**

1. Processing involves collection of wastes, shredding, mechanical separation of the metal, glass and ceramics and storage of organic wastes.
2. Pre-digestion of organic waste for twenty days by heaping or dumping the material along with cattle dung slurry. This process partially digests the material and fit for earthworm consumption.
3. Preparation of earthworm bed. A concrete base is required to put the waste for vermicompost preparation. Loose soil will allow the worms to go into the soil.watering will dissolve nutrients which will go into the soil along with water.
4. A layer of 15-20 cm of chopped dried leaves/grasses should be kept as bedding material at the bottom of the bed.
5. Beds of partially decomposed material of size 6x2x2 feet should be made. Each bed should contain 1.5-2.0 q of raw material and the number of beds can be increased as per raw material availability and requirement.
6. Red earthworm (350 -360 worms per m3 of bed volume) should be released in the upper layer of the bed.
7. Water should be sprinkled with can immediately after the release of worms.

**Fig 1. Preparation of Cow dung slurry, mixing the organic waste with cow dung slurry and Vermibeds covered with gunny bags.**

8. Beds should be kept moist by sprinkling of water (daily) and by covering with gunny bags/polythene.

9. Bed should be turned once after 30 days for maintaining aeration and for proper decomposition.

10. Compost gets ready in 45-50 days.

11. The weight of the finished product is about 75% of the raw materials used.

***2. Pit method:*** Composting is done in the cemented pits, wooden boxes, plastic buckets,silpaulin bag, baskets, etc. The unit is covered with thatch grass or any other locally available materials.

*Procedure:*

1. Pit size of dimensions 10´x 4´ x 2´ of either cement or vermin bag is maintained. The lengthand width can be increased or decreased depending upon the availability of material but not the depth because the earthworms' activity is confined to 2 feet depth only. 1st layer: bedding material of 1" thick with soft leaves2nd layer: 9" thick organic residue layer finely chaffed material3rd layer: dried cattle dung + water equal mixture of 2" layer.The layer is continued until the pile is filled up.

2. On 25 days old unit, 795-820 worms are introduced into the pit (350 -360 worms per m3 of bed volume) without disturbing the pit.

3. Proper moisture and temperature is maintained by frequent watering, turnings and subsequent staking.

4. The turnover of the compost is 75% (If the total material accommodated in the pit is 1000 kg; the out turn will be 750 kg).

5. The filled materials are watered and turned at regular interval.


**Fig 2. Preparation of raw material, filling up the vermin bag and spreading of cow dung layer**

**3. *Recomposting and In-situ vermicomposting***

Recomposting is done in the same pit or bed following the same steps as described in the above-mentioned pit/bed methods.

In-situ vermicomposting can be done by direct field application of vermicompost at 5 t/ha followed by application of cow dung (2.5 cm thick layer) and then a layer of available farm waste about 15 cm thick. Watering should be done at an interval of 15 days.

***PROCESS***

Earthworms play an important role in organic waste system by colonizing organic waste along with consumption, digestion, and assimilation of high rates of organic wastes. Stabilization of organic matter due to mutualistic interaction is seen between earthworms and microorganisms during vermicomposting (Edwards & Fletcher, 1988). The micro-organisms not only mineralize complex substances into plant available form, but they also synthesise biologically active substances (Tiunov & Scheu, 2004)

- In an organic waste system, earthworms ingest, grind, and digest organic waste with the help of aerobic and anaerobic microflora present in the gut of earthworms.
- The physical and biochemical actions are performed in waste system by earthworms. The example of physical actions includes substrate aeration, mixing and actual grinding.
- Biochemical actions by earthworms include microbial decomposition of substrate in the intestine of earthworms
- As a result of this activity, rapid mineralization and humification process start, which convert the unstable organic matter into relatively stable and microbially active material.
- During this stabilization process, chelating and phytohormonal elements are released, which make the organic matter into stabilized humic substances with high microbial content.
- Earthworms ingest organic waste as well as soil which pass through their body where it mixes with digestive enzymes and reduced by the grinding action.
- The material that is excreted by the worms after digestion is nutrient rich and termed as "castings."
- All these roles are better played in moist soil and well-aerated soils with low acidic value.
- Vermicomposts produced after digestion and excretion by earthworms are actually nutrient-rich organic soil amendment and has considerable potential in crop production.
- Vermicomposts are peat-like material with high porosity, aeration, drainage, water-holding capacities, and low C:N ratios.
- The resulting worm castings (worms manure) are reported to be rich in microbial activity, plant growth regulators, and fortified with pest repellents.
- The enzymes secreted through the digestive epithelium of gut of earthworms are cellulase, amylase, invertase, protease, and phosphatase, responsible for enhanced N, P and K contents in vermicomposts.
- Earthworms get their nourishment from microbes, whereas microbial activity is influenced by the casts produced by worms.

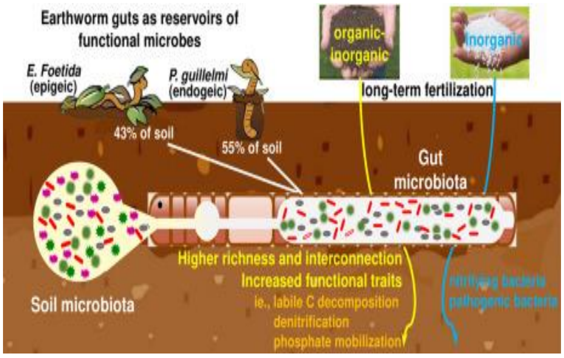


**Fig: Mutualistic relationship shown by earthworm and microbes**.

***Roles of vermicompost:*** Beneficial roles of vermicompost (Adhikary, 2012): (1) Red worm castings contain a high percentage of humus. Humus helps soil particles form into clusters, which create channels for the passage of air and improve its capacity to hold water. (2) Humus is believed to aid in the prevention of harmful plant pathogens, fungi, nematodes and bacteria. (3) A worm casting (also known as worm cast or vermicast) is a biologically active mound containing thousands of bacteria, enzymes, and residues of plant materials that were not digested by the worms. (4) Castings contain nutrients that are readily available to plants. (5) The activity of the worm gut is like a miniature composting tube that mixes conditions and inoculates the residues. (6) Worm castings are the best imaginable potting soil for greenhouses or houseplants, as well as gardening and farming. (7) Plant Growth Regulating Activity: Some studies speculated that the growth responses of plants from vermicompost appeared more like "hormone induced activity" associated with the high levels of nutrients, humic acids and humates in vermicompost. (8) Ability to Develop Biological Resistance

*The beneficial impacts of vermicompost on soil (*Sinha, 2014*):*

1. Increase the 'Soil Organic Matter' (SOM), soil structure and prevent soil erosion. 2. Increase beneficial soil microbes, microbial activity and nutrients. 3. Improve cation exchange capacity. 4. Reduces bulk density of soil, prevents soil compaction and erosion. 5. Suppression of soil-born plant diseases. 6. Increase water-holding capacity of soil. 7. Remove soil salinity and sodicity. 8. Maintain optimal pH value of soil

***Vermicompost is ideal organic manure for better growth and yield of many plants due to following reasons (*Joshi et al. 2015*):***

1. Vermicompost has higher nutritional value than traditional composts. 2. This is due to increased rate of mineralization and degree of humification by the action of earthworms. 3. Vermicompost has high porosity, aeration, drainage, and water-holding capacity. 4. Presence of microbiota particularly fungi, bacteria and actinomycetes makes it suitable for plant growth. Nutrients such as nitrates, phosphates and exchangeable calcium and soluble potassium in plant-available forms are present in vermicompost. 5. Plant growth regulators and other plant growth influencing materials produced by microorganisms are also present in vermicompost. 6. Production of cytokinins and auxins was found in organic wastes that were processed by earthworms. 7. Earthworms release certain metabolites, such as vitamin B, vitamin D and similar substances into the soil. 8. In addition to increased N availability, P, K, Ca and Mg availability in the casts are found.

***Fortified vermicompost in relation to growth and development as well as enhancing physico-chemical properties***

## CONCLUSIONS:

Vermicompost produced by the activity of earthworms is rich in macro and micronutrients, vitamins, growth hormones, enzymes such as proteases, amylases, lipase, cellulose and chitinase and immobilized microflora. Vermicompost is optimal organic manure for better growth and yield of many plants. It can increase the production of crops and prevent them from harmful pests without polluting the environment. Application of vermicompost increased growth, improved plants nutrient content, and improved the quality of the fruits and seeds.

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