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Integrated nutrient management: An sustainable approach for soil productivity

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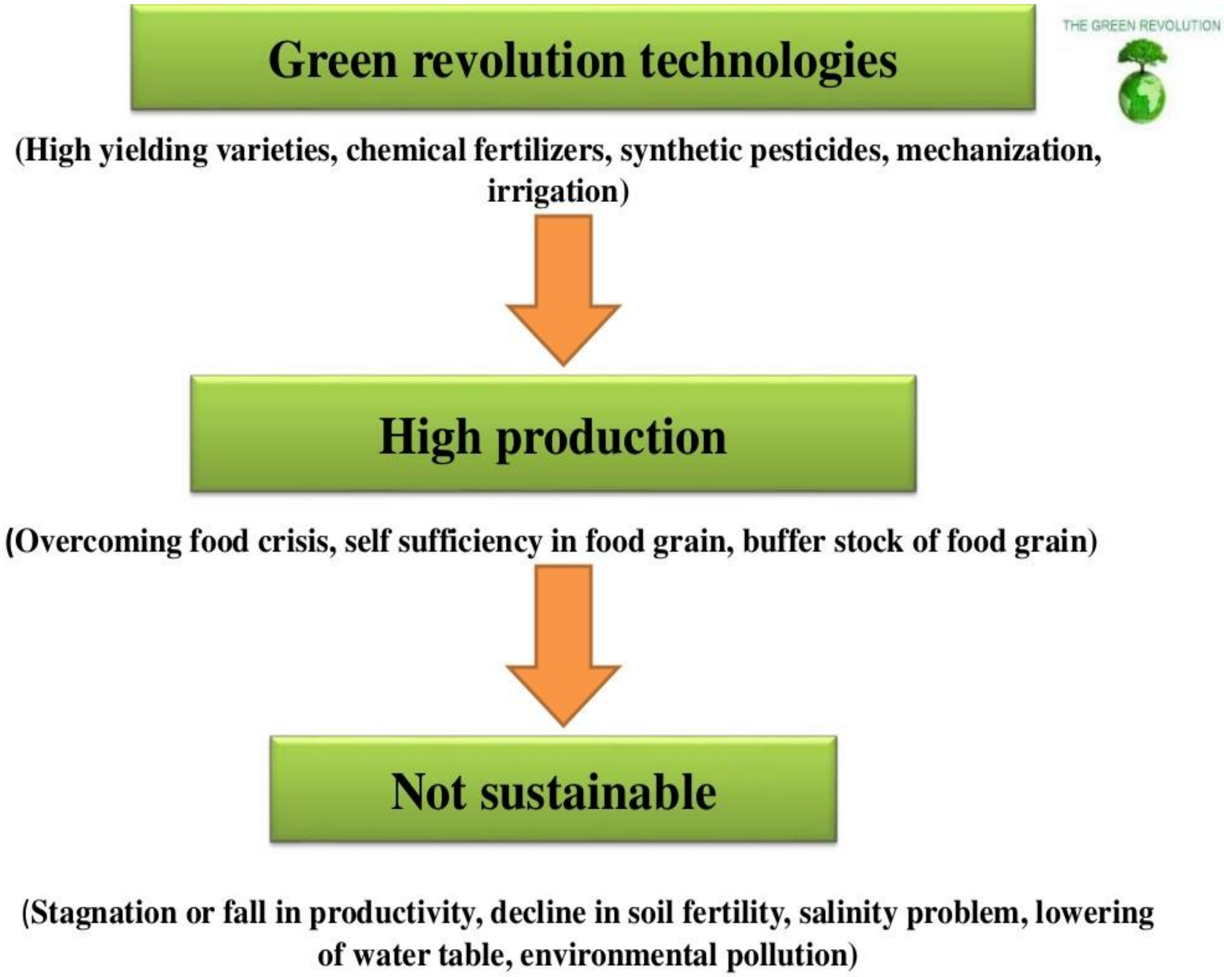
Integrated Nutrient Management approach to the management of plant nutrients for maintaining and enhancing soil, Soil fertility maintenance requires a balanced application of inorganic and organic nutrient sources. Sustainable agricultural productivity might be achieved through a wise use of integrated nutrient management. Integrated use of organic and inorganic source of plant nutrients on growth and yield attributes is very crucial for assurance of food security. The integrated plant nutrient supply/management is important approach for maintenance or adjustment of soil fertility and plant nutrient supply to an optimum level for sustainable crop productivity through optimization of benefit from all possible sources of plant nutrients in an integrated manner which includes; Maintain or enhance soil productivity through a balanced use of fertilizers combined with organic and biological sources of plant nutrients and also to reduce inorganic (fertilizer) input cost. Organic sources such as FYM, bio compost, vermicompost, decompose, green manures, crop residues and industrial wastes have been used in various cropping systems. Soil as a source of nutrients, must be protected from all kinds of external factors, especially from the addition of fertilizers in excessive rates. Any degradation in the quality of soil can significantly produce many undesirable changes in the environment and also reduces the overall crop yield. The amount and availability of nutrients in organic materials vary widely, which makes interpretation of the value of nutrients supplied.

Keywords: Integrated nutrient management, organic and inorganic fertilizer, bio-fertilizer, sustainability, soil productivity.

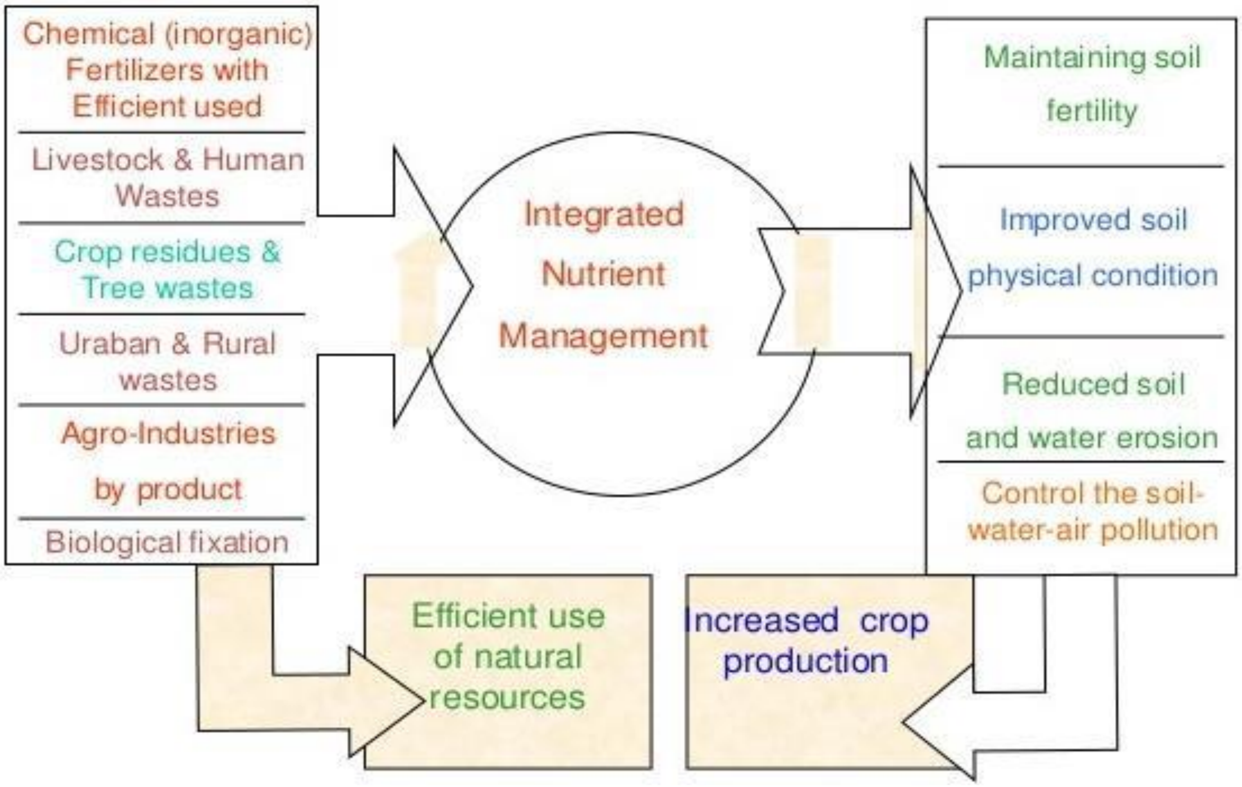
India is predominantly an agriculture-based country and more than two-third of the population depends on agriculture for their livelihood. India with geographical area of 329 M ha presently supports 17% of the world's population on merely 2.5% world's land area and 4% world's fresh water resources. India made a spectacular achievement in attaining the self-sufficiency in food production by the introduction of high yielding dwarf and fertilizer responsive varieties of cereals, particularly wheat and rice in the mid- 1960s .

Integrated Nutrient Management is a practice where all sources of nutrients namely organic, inorganic (chemical fertilizer), biofertilizer can be combined and applied to soils so that crop growth is enhanced and we can get good yield with quality product. Integrated Nutrient Management (INM) has to be considered an integral part of any sustainable agricultural system.

Besides, it keeps the soil in healthy condition. In INM it integrates/combines the objectives of production with ecology and environment, that is, optimum crop nutrition, optimum functioning of the soil health, and minimum nutrient losses or other adverse effect on the environment. With the use of improved varieties coupled with increased fertilizer and agro-chemicals use, price support and other policy initiatives, the food grain production increased from 50.8 mt in 1951 to 308.65 million tonnes during 2020 – 21.



In the early 1990s, however, fertilizer became the target of criticism, mainly because of heavy use in the developed countries, where it was suspected of having an adverse effect on the environment through nitrate leaching, eutrophication, greenhouse gas emissions and heavy metal uptakes by plants. Consequently, fertilizer use per se was mistakenly identified as harmful to the environment. But, if for any reason fertilizer use were discontinued today, world food output would drop by an estimated amount of 40 per cent. While fertilizer misuse can contribute to environmental contamination, it is often an indispensable source of the nutrients required for plant growth and food production. Unless all the soil nutrients removed with the harvested crops are replaced in proper amounts from both organic and sustained; soil fertility will decline. If in the past, the emphasis was on increased use of fertilizer; the current approach should aim on educating farmers to optimize use of organic, inorganic and biological fertilizer in an integrated way. Plant nutrition today requires judicious and integrated management of all sources of nutrients for sustainable agriculture.



The basic principle underlying INM in the maintenance and possible increase of soil fertility for sustaining increased crop productivity through the use of all possible sources, organic and inorganic, of plant nutrients required for crop growth and quality in all integrated manner appropriate to each cropping system and farming situation within the given ecological, social and economic boundaries. Attempts have been in our country to complement the use of mineral with organic sources of plant nutrients generated useful, though information on the complementary and synergistic effects of these materials on the yield of crops. Because organic sources of nitrogen are also improving soil structure and soil bioactivity which are not directly improved by mineral sources of N. The productivity of the crop for each kg of N may be better with organic sources than sources of N. If the objective of INM is the balanced and effective use of various sources of plant nutrients then the strategy should be the mobilization of all available, accessible and affordable plant nutrient sources in order to optimize the environmentally safe productivity of the whole cropping system and to increase the monetary return to the farmer.

Thus, there is need for information on: Integrated nutrient recommendations for cropping systems as a whole taking into account the complementary and the synergistic effects of combined use of both mineral and organic/biological sources for sustained crop production. Recommendations for different agro-ecological situations taking into account available organic/biological resources. Transfer of this technology for the benefit of small farmers through the national agricultural extension services. Integrated nutrient management is a judicious use of organic and inorganic sources of nutrients for sustaining and maintaining soil productivity. Imbalance fertilization has key role to play in obtaining low productivity, so in order to achieve optimum crop productivity management of nutrients through judicious application of organic sources, bio-fertilizers and micro-nutrients are required. Furthermore, the fertilizer management is one of the most important factors that influence the growth and yield of maize crop. The use of chemical fertilizers in conjunction with organic manures like compost, farm yard manure, vermicompost, green manures, fortified micro-nutrients fertilizers, bio-fertilizers (e.g. phosphate solubilizing bacteria, *Azospirillum*, *Azotobacter*, *Rhizobium*, and Potash mobilizing bio-fertilizers) that can supplement a part of NPK fertilizers. Therefore, there is a need to improve nutrient supply system in terms of integrated nutrient management involving the use of chemical fertilizers in conjunction with organic manures coupled with input through biological processes. However, the role of major nutrients on crop physiology and the effect of these nutrients on growth, quality, yield and yield components of cereal crops. Above all, the role of balanced fertilizer is the application of essential plant nutrients in light proportion and in optimum quantity for a specific soil crop condition in alleviating the yield, quality and its attributes. Appropriate and conjunctive use of application of suitable nutrients through organic and inorganic solely or in combination can provide the solutions to the problems such as increase in the price of inorganic fertilizers and deterioration effect of soil fertility and productivity. Hence, judicious application of these combinations can sustain the soil fertility and productivity. Integrated use of nutrient is very essential approach, which not only sustains high crop production over the years but also improves soil health and ensures safer environment. Biofertilizers can prove to be an effective low-cost technology for the farmers. Thus, there is a need to improve the nutrient supply systems in terms of integrated nutrient management involving the use of fertilizers in conjunction with organic manures and fertilizers. Integrated nutrient management is the only possible approach in enhancing the soil productivity through a balanced use of mineral fertilizers combined with organic and biological sources of plant nutrients. It plays a vital role in improving the stock of plant nutrients in soil by increasing the efficiency of plant nutrients, thus limiting losses to the environment. It optimizes the function of the soil biosphere and ultimately sustaining the physical, chemical and biological functioning of soil etc. Integrated nutrient management is balanced and judicious use of manures and chemical fertilizers is known to have a promising effect in arresting the decline in productivity through correction of marginal nutrient deficiencies and their positive inf1uence on the physical and biological soil properties. This system can bring about equilibrium between degenerative and restorative activities in the soil environment. Micronutrients have a promising effect on the growth and development of the crop plants. Use of micronutrients improves the quality and quantity of the agricultural produce. Approximately 70- 80 % of the nitrogen, 60-85 % of the phosphorus and 80- 90 % of the potassium in feeds is excreted in the manure. He further added that manure contains all the plant nutrients needed for crop growth including trace elements. The availability or efficiency of manure utilization by a crop is determined by the method of application, time to incorporation and the rate of manure decomposition by microorganisms in soil. A long-term imbalanced use of fertilizers like NPK and some micronutrients is adversely affecting the sustainability of agricultural production eventually causing environmental pollution. Soils which receive plant nutrients only through chemical fertilizers are showing declining productivity despite being supplied with sufficient nutrients. This can be attributed to the appearance of deficiency in secondary and micronutrients. The physical condition of the soil is deteriorated as a result of long-term use of chemical fertilizers. It also aggravates the problem of poor fertilizer nutrient use efficiency (NUE).

Manuring and soil enrichment

India has great potential of using residues of crops and straw of cereals and pulses in recycling of nutrients during organic farming. Crop residues when inoculated with fungal species improve physicochemical properties of soil and crop yields. During conversion period, soil fertility can be improved and maintained initially through use of organic inputs like well decomposed organic manure/ vermicompost, green manure and biofertilizers in appropriate quantity. Plant biomass, FYM, Cattle dung manure, enriched compost, bio dynamic compost, cow-pat-pit compost and vermicompost are key sources of on-farm inputs. Among off-farm inputs, important components are non-edible oil cakes, poultry manure, biofertilizers, mineral grade rock phosphate and lime etc.

Organic manure: The organic manure is obtained from biological sources (plant, animal and human residues). Organic manure helps in increasing crop growth directly by improving the uptake of humic substances and indirectly promoting soil productivity by increasing availability of major and minor plant nutrients through soil microorganisms.

Bulky organic manure: Bulky organic manure includes compost, FYM and green manure having less nutrients in comparison to concentrated organic manure.

Farm yard manure (FYM): Farm Yard Manure (FYM) refers to the well decomposed combination of dung, urine, farm litter and leftover materials (roughages or fodder).

Compost: Large quantities of waste material (vegetable refuse, weeds, stubble, straw, sugarcane trash, sewage, sludge, animal waste, human and industrial refuse) can be converted into compost manure by an aerobic decomposition.

Vermicompost: Vermicompost is organic manure or compost produced by the use of earthworms that generally live in soil, eat organic matter and excrete it in digested form. These are rich in macro and micronutrients, vitamins, growth hormones and immobilized micro flora essential for plant growth.

Green manuring: green manuring is practice of adding organic matter to the soil by incorporating undecomposed green plant tissues for improving soil health. The green manure crop (legume crops) supplies organic matter and additional nitrogen. Commonly used green manure crops are sun hemp (*Crotalaria juncea*), dhaincha (*Sesbania aculeata*), cowpea, cluster bean, senji (*Melilotus parviflor, Vigna sinensis*), berseem (*Trifolium alexandrium*) etc.

Concentrated Organic Manure: Oilcakes, blood meal, fishmeal, meat meal and horn and hoof meal that are organic in nature made from raw materials of animal or plant origin and contain higher percentage of vital plant nutrients as compared to bulky organic manures.

Biofertilizers: Biofertilizers are microorganisms that have the capability of increasing the fertility of soil by fixing atmospheric nitrogen and through phosphate solubilization. Biofertilizers have biological nitrogen fixing organism which help them in establishment and growth of crop plants and trees, enhance biomass production and grain yields. Biofertilizers viz: *Rhizobium, Azotobacter, Azospirillum,* PSB and *Pseudomonas* etc. have been found to be very effective tools of fertility management and biological nutrient mobilization. Recently customized consortia of such biofertilizer organisms, better adapted to local climatic conditions have also been developed and are available commercially. Efficiency of such microbial formulations is much higher under no-chemical use situations; therefore, application of such inputs needs to be ensured under all cropping situations. There are some important and widely used bio-fertilizers.

Symbiotic nitrogen-fixation: *Rhizobium, Frankia* and *Anabaena azollae* bacteria fixes atmospheric nitrogen in roots of leguminous plants, form tumours like growth known as root nodules. These are widely used biofertilizer which can fix around 100-300 kg N ha^{-1} in one crop season.

Asymbiotic/ Associative symbiotic nitrogen-fixation: Blue Green Algae, *Azolla, Azotobacter, Azospirillium, Beijerinkia, Clostridium, Klebsiella, Anabaena* and *Nostoc,* grow on decomposing soil organic matter and fixes atmospheric nitrogen in suitable soil medium. *Azotobactor* has beneficial effect on vegetables, millets, cereals, sugarcane and cotton. Organism is capable of producing nitrogen as well as antifungal, antibacterial compounds, siderophores and harmones. *Azospirillium* has beneficial effect on oats, barley, maize, sorghum, forage crop and pearl millet. It fixes nitrogen by colonising root zones.

Phosphorus solubilizing bacteria (PSB): *Bacillus megaterium* var. *phosphaticum, Bacillus subtilis, Bacillus circulans* and *Pseudomonas striata,* are beneficial bacteria capable of solubilizing inorganic phosphorus from insoluble compounds. Phosphorus solubilization ability of rhizosphere microorganisms is considered to be one of the most important in plant phosphate nutrition.

Phosphorus solubilizing fungi (PSF): *Penicillium sp, Aspergillus awamori and* Fusarium play a noteworthy role in increasing the bioavailability of soil phosphates for plant nutrition.

Phosphorus solubilizing microorganisms (PSM): *Arbuscular mycorrhiza-Glomus sp.,Gigasporasp., Acaulospora sp., Scutellospora sp.* and *Sclerocystis sp.;* *Ericoid mycorrhizae-Pezizellaericae;* *Ectomycorrhiza-Laccaria sp., Pisolithus sp., Boletus sp., Amanita sp.* and Orchid mycorrhiza-*Rhizoctonia solani.* phosphate solubilizing microorganisms (PSM) could play an important role in phosphorus nutrition in many natural and agro-ecosystems.

Biofertilizers for micro nutrients: Silicate and zinc solubilizers- *Bacillus* sp. micro nutrient and biofertilizers along with recommended dose of major nutrients increases the availability of the essential nutrients in the rhizosphere zone.

Plant growth promoting Rhizobacteria: Pseudomonas-*Pseudomonas fluorescens* are known to enhance plant growth promotion and reduce severity of various diseases. The efficacy of bacterial antagonists in controlling fungal diseases was often better as alone, and sometimes in combination with fungicides.

Blue green algae (BGA): Blue-green algae reduce soil alkalinity and it is good for rice cultivation and bio-reclamation of land.

Azolla: Small floating fern, *Azolla harbours,* blue-green algae, anabaena, commonly seen in shallow fresh water bodies and in low land fields. They fix nitrogen in association.

Mycorrhizae: *Mycorrhizae* is symbiotic association of fungi with roots of vascular plants. This helps in increasing phosphorous uptake and improves the growth of plants.

Nutrients fixing bio-fertilizers:

S. No.	Groups	Examples
N_2 fixing biofertilizers		
1.	Free-living	*Azotobacter, Beijerinkia, Clostridium, Klebsiella, Anabaena, Nostoc,*
2.	Symbiotic	*Rhizobium, Frankia, Anabaena azollae*
3.	Associative Symbiotic	*Azospirillum*
P solubilizing biofertilizers		
1.	Bacteria	*Bacillus megaterium* var. *phosphaticum, Bacillus subtilis, Bacillus circulans, Pseudomonas striata*
2.	Fungi	*Penicillium sp, Aspergillus awamori*

P mobilizing biofertilizers		
1.	Arbuscular mycorrhiza	*Glomus sp.,Gigaspora sp.,Acaulospora sp., Scutellospora sp.* & *Sclerocystis sp.*
2.	Ectomycorrhiza	*Laccaria sp., Pisolithus sp., Boletus sp., Amanita sp.*
3.	Ericoid mycorrhizae	*Pezizella ericae*
4.	Orchid mycorrhiza	*Rhizoctonia solani*
Micro nutrients biofertilizers		
1.	Silicate and Zinc solubilizers	*Bacillus* sp.

N_2 fixing capacity of Azospirillum in the roots of several plants:

S. No.	Crop plants	Mg N_2 fixed /g of substrate
1.	*Oryza sativa* (Rice)	28
2.	*Sorghum bicolour* (Sorghum)	20
3.	*Zea mays* (Maize)	20
4.	*Panicum species*	24
5.	*Cynodon dactylon*	36
6.	*Setaria species*	12
7.	*Amaranthus spinosa*	16

Quantity of biological N fixed by liqiud *Rhizobium* in different crops:

S. No.	Host group	***Rhizobium*** **Species**	Crops	N fix kg/ha
1.	Pea group	*Rhizobium leguminosarum*	Green pea, Lentil	62- 132
2.	Soybean group	*Rhizobium .japonicum*	Soybean	57- 105
3.	Lupini Group	*Rhizobium lupine orinthopus*	Lupinus	70- 90
4.	Alfafa grp.Group	*Rhizobium mellilotiMedicago Trigonella*	Melilotus	100- 150
5.	Beans group	*Rhizobium phaseoli*	Phaseoli	80- 110
6.	Clover group	*Rhizobium Trifoli*	Trifolium	130
7.	Cowpea group	*Rhizobium Species*	Moong, Redgram, Cowpea, Groundnut	57- 105
	Cicer group	*R. species*	Bengal gram	75- 117

Recommended liquid bio-fertilizers:

S. No.	Field crops	Recommended bio-fertilizer	Application method	Quantity to be used
1.	**Pulses**: Chickpea, pea, groundnut, soybean, beans, lentil, lucern, berseem, green gram, black gram, cowpea and pigeon pea.	*Rhizobium*	Seed treatment	200ml/acre
2.	**Cereals**: Wheat, oat, barley, rice, maize, sorghum.	*Azotobacter/ Azospirillum*	Seed treatment	200ml/acre
3.	**Oil seeds**: Mustard, seasum, linseeds, sunflower, castor.	*Azotobacter*	Seed treatment	200ml/acre
4.	**Millets**: Pearl millets, finger millets, kodo millet	*Azotobacter*	Seed treatment	200ml/acre
5.	**Forage crops and Grasses**: Bermuda grass, sudan grass, napier grass , paragrass, star grass etc.	*Azotobacter*	Seed treatment	200ml/acre
6.	Other misc. Plantation crops, tobacco etc.	*Azotobacter*	Seedling treatment	500ml/acre
7.	Tea, coffee	*Azotobacter*	Soil treatment	400ml/acre
8.	Rubber, coconuts	*Azotobacter*	Soil treatment	2-3 ml/plant
9.	**Agro-Forestry/Fruit Plants**: All fruit/agro-forestry (herb, shrubs, annuals and perennial) plants for fuel wood fodder, fruits, gum, spice, leaves, flowers, nuts and seeds purpose.	*Azotobacter*	Soil treatment	2-3 ml/plant at nursery
10.	Leguminous plants/ trees	*Rhizobium*	Soil treatment	1-2 ml/plant

Effect on growth and yield attributes:

Organic and inorganic sources of plant nutrients play a pivotal role in growth parameters and yield attributes. The plant height and number of tillers per plant was observed with (120: 60: 40: 25

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NPK Zn kg ha^{-1} , 10 t ha^{-1} FYM). Integrated nutrient management (INM) treatments might be due to addition of nitrogen as well as other nutrients and growth promoting substances through organic manure. Dry matter accumulation, number of effective tillers, grains spike^{-1} and the test weight increased with the integrated use of fertilizers with vermicompost and phosphate solubilizing bacteria. Addition of vermicompost with or without PSB together with different fertilizer levels produced higher grain and biological yields than the application of fertilizers alone. Injudicious fertilization has key role to play of major nutrients on crop physiology and the effect of these nutrients on growth, quality, yield and yield components. Application of FYM improving soil physical, chemical and biological properties and had synergistic relationship with N, P, thereby helping in mineralization of applied N and P helped in increasing the growth and mean while grain yield. Organic and inorganic sources of nutrients combinations with application of 25 % RDF (30: 15: 15, NPK, kg ha^{-1}), biofertilizers (*Azotobacter*+ PSB), green manuring of sun hemp and compost resulted maximum total plant dry matter accumulation and to increase the productivity of crops. Highest plant height and number of leaves per plant observed under application of 75 % N from urea + 25 % N from poultry manure which was at par with 100 % N from urea in maize. Application of 150: 75: 00 NPK kg ha^{-1} + FYM @ 5 t ha^{-1} + *Azotobacter*+ PSB + Sulphur @ 40 kg ha^{-1}ha (gypsum) produced a beneficial effect. The combined effect of organic manure (FYM), biofertilizers and chemical fertilizers with sulphur in balanced proportion played a very vital role in decomposition and easy release of different nutrients and their uptake by the crop which led to higher dry matter accumulation and its translocation in different plant parts of growth and yield parameters. Farm yard manure helps to increase the dry matter production, yield and nutrient uptake by wheat. The combination of organic and inorganic N sources resulted in comparable rice yield to the application of inorganic nitrogen alone. Application of phosphate solubilizing micro-organism (PSM) in combination with phosphorus fertilizer and organic manure significantly improved grain and biological yield of wheat. The yield increase may be due to addition of individual FYM, sulphur or boron with 100 % NPK (150; 60: 60 NPK), influenced plant growth compared to sole NPK source. Increase grain and straw yield due to integrated use of FYM, sulphur and boron with 75 % NPK may be due to synergistic effect of all inputs when combined together with 75% NPK. Balanced fertilizer is the application of essential plant nutrients in light proportion and in optimum quantity for a specific soil crop condition in alleviating the yield, quality and its attributes. **Effect on nutrient composition, nutrient uptake and soil status:**

Nutrient management is playing a vital role in enhancing the soil productivity through judicious balanced use of inorganic fertilizers combined with organic and biological sources of plant nutrients. It is improving the plant nutrients status in soil by increasing the efficiency of plant nutrients, thus limiting losses to the environment. It optimizes the function of the soil biosphere and ultimately sustaining the physical, chemical and biological functioning of soil etc. Application of vermicompost + PSB along with fertilizer levels increased the available nitrogen, phosphorus and potash status of the soil. Addition of organic manure (l0 t ha^{-1} FYM) with fertilizer levels increased the nutrient uptake by wheat, improved the organic carbon content N, P and K status as compared to chemical fertilizer alone. The increase in nitrogen, phosphorus and potash status of the soil is due to the application of vermicompost and PSB which enhances the activity of some microbial populations. Use of green manure crop (*Erythrina bruice*) either its biomass alone or in combination with mineral fertilizer is found to increase soil productivity. *Erythrina bruice* is a nitrogen fixing plant, which fix's the nitrogen through its leaves; this is a fast-growing nutrient rich plant particularly high with nutrient contents on NPK. An integrated use of chemical and organic fertilizer has proved to be highly beneficial for sustainable crop production. It is commonly believed that the combination of organic and inorganic fertilizer will increase synchrony, enhancing the efficiency of the fertilizers, and reduce losses by converting inorganic nitrogen (N) into organic forms but also reducing environmental problems that may arise from their use. Thus, the study reflects those integrated use of chemical fertilizers, organic manures including green manure and recycling of crop residues, assume greater significance of improving efficiency of chemical fertilizers in soil.

Appropriate and conjunctive use of application of suitable nutrients through organic and inorganic solely or in combination can provide the solutions to the problems such as increase in the price of inorganic fertilizers and deterioration effect of soil fertility and productivity. Hence, judicious application of these combinations can sustain the soil fertility and productivity. Integrated use of nutrient is very essential approach, which not only sustains high crop production over the years but also improves soil health and ensures safer environment. An application of 120 kg N ha^{-1} + 1.5 t ha^{-1} vermicompost resulted in higher nutrient content and uptake compared with 80 kg N ha^{-1}+ 1.5 t ha^{-1} vermicompost in maize. Nutrients combinations with application of bio compost @ 5 t ha^{-1} with 75 % N and P through fertilizer (100 % RDF 120: 60: 60 NPK kg ha^{-1}) recorded higher available organic carbon and N in soil after crop harvest . Organic carbon, available N, P_2O_5 and K_2O content in soil were recorded with application of 25 % RDF (30: 15: 15 NPK kg ha^{-1}) + biofertilizers (*Azotobacter* + PSB) + green manuring with sun hemp + compost. Organic carbon content, N and P status of soil improved with application of vermicompost @ 5 t ha^{-1} with 100 % RDF (90: 40 NP kg ha^{-1}. Soil organic matter imparts desirable physical environments to soils by favourably affected soil structure expressed through soil porosity, aggregation, bulk density and soil water storage. Animal manure supplies all the macronutrients as well as micronutrients necessary for plant growth, hence it acts as a

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diverse fertilizer. Its fertilizing effect on crops can be compared to that of mineral fertilizers. Therefore, application of farm yard manure is synergistic to mineral fertilizers for various nutrients. This illustrates that nutrients from farmyard manure can be substituted for mineral fertilizers and this also improves soil environment. The porosity, CEC, organic carbon, available N, P_2O_5 and Zn in soil recorded highest with the application of RDF (120: 60: 40 NPK kg ha^{-1}) + FYM 10 t ha^{-1}. Use of inorganic fertilizers in combination with FYM / green manure (GM) /crop residue (CR) plays an important role in improving the damaged soil structure by reducing bulk density and increasing infiltration rate and the mean weight diameter of the aggregates. Besides, there is plenty evidence that application of organic fertilizer also enhances the effectiveness of commercial fertilizer through favourable soil microbial activity and augmentation of organic soil colloids (humus) that possess large nutrient retaining surface area. The country in general is rich in livestock and lot of biomasses that can be used as compost these integrated fertility management would help to change the existing situation. Addition of organic nutrient source might have created environment conducive for formation of humic acid, stimulated the activity of soil microorganism resulted in an increase in the organic carbon content of the soil. Integrated nutrient management is balanced and judicious use of manures and chemical fertilizers is known to have a promising effect in arresting the decline in productivity through correction of marginal nutrient deficiencies and their positive inf1uence on the physical and biological soil properties. This system can bring about equilibrium between degenerative and restorative activities in the soil environment. Micronutrients have a promising effect on the growth and development of the crop plants. Use of micronutrients improves the quantity of the agricultural produce.

The integrated use of chemical fertilizers and organic manures including green manure and biological sources of plant nutrients, assume greater significance of improving efficiency of chemical fertilizers in soils by increasing the efficiency of plant nutrient. Soil as a source of nutrients, must be protected from all kinds of external factors, especially from the addition of fertilizers in excessive price. Integrated ways of nutrient management is judicious approach for maintaining the soil fertility, soil health and sustaining the environment. Any degradation in the quality of soil can significantly produce many undesirable changes in the environment and also reduces the overall crop yield. The amount and availability of nutrients in organic materials vary widely, which makes interpretation of the value of nutrients supplied.

Constraint in adoption of integrated nutrient management (INM):

1. Insufficient availability of organic manure:

- Reduction in cattle population in India.
- Use of cattle dung for fuel purposes and hence less availability for application.

Availability of organic manure is reducing for various reasons as stated below:

- Availability of farmyard manure is limited. Increasing mechanization (tractors) is replacing draught animals for which dung is reducing.
- Off-farm transported organic manure is often too expensive and its application is labour consuming.
- Burning of crop residues (straw), instead of recycling or composting leads to low availability of organic materials.
- Labour shortage or short period between two crops could further limit INM application.

2. Lack of facilities to collect and market agricultural wastes:

- Facilities to collect, store and market huge amounts of animal wastes (dung, slurry, droppings) from livestock farms are limited or non-existent.
- Disposal can be harmful to the environment. Mineral fertilizers are easily available and literature (pamphlets) on their proper use is more comprehensive.

3. Reduce in importance of organic manures, crop residues and biofertilizers:

- Rapid Composting Technology is still unknown to most farmers.
- Crop residues such as rice stubble, straw and other plant materials, have high C:N ratio taking a larger time to decompose and mineralize.
- Direct application will cause temporary immobilization of soil N. Composted organic material is well suited for direct application. But exposure of compost or FYM to the elements (sun, wind and rain) results in nutrient losses through leaching and volatilization.
- Animal wastes have more N than plant parts. They decompose faster than plant material. Application of large quantities of slaughterhouse waste e.g., blood meal will result in losses of N through volatilization.

4. Urban wastes:

Care needs to be taken in using urban waste compost made of city garbage sewage and particular industrial wastes. Such materials could contain both pathogenic microbes and heavy metals.

- Heavy metals such as cadmium, arsenic, lead, copper and mercury are toxic to the human environment, and need monitoring.
- Use of FYM, poultry litter and other animal wastes may be quite acceptable to farmers but urban compost, sewage and sludges and night soil are not popular.

5. Growing green manure crops:

Seeds are not available everywhere in sufficient quantity

- Needs additional labours/inputs

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- Not feasible in all ecosystems
- Difficulty in incorporation and decomposition due to uncertain rainfall
- Lack of farmers' knowledge

6. Use of Biofertilizer:

Non-availability of proper inoculums

- Lack of farmers' knowledge
- Prediction and performance of biofertilizer is uncertain
- Problem of inoculum transportation and storage
- Awareness programme for popularization of biofertilizer is lacking

7. Financial aid and quality control:

Quality control of commercially produced organic fertilizer, standard definition for a product produced on basis of raw materials from various origins is difficult (city garbage, solid waste, sewage sludge, chicken droppings, etc.).

- Lack of government support for promotion, pricing and quality control of commercial organic fertilizer.
- Financial commercial credit is available mostly for mineral fertilizer; however, there is no organized credit system to help farmers to use organic manures.
- Quality standards and regulations for marketing of mineral fertilizers are well established contrary to organic fertilizer manures and commercial composts.

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