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Soil Organic Nutrients Management Through Integrated Approach: A Policy for Environment & Ecology

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Abstract

Integrated Organic Nutrient Management refers to the maintenance of soil fertility and plant nutrient supply at an optimum level for sustaining the desired productivity through optimization of the benefits from all possible sources of organic and biological components except inorganic in an integrated manner. Organic agriculture is holistic food production system which promotes and enhances agro ecosystem health including quality and healthy food. A good farm design should incorporate rain water harvesting, soil and water conservation measure, in-situ residue management for soil health, hedge row on fences, fodder crops, multiple tree, fruits vegetables and food crops at appropriate location, with livestock, fisheries, vermicomposting etc. integration for enhancing income and effective recycling of on farm residue. Integrated Organic Nutrient Management refers to the maintenance of soil fertility and plant nutrient supply at an optimum level for sustaining the desired productivity through optimization of the benefits from all possible sources of organic and biological components.

Keywords: In-situ residue management; Soil health; Integrated organic nutrient management

Introduction

The term "Organic" means origin from a living thing and farming with the philosophy of Organic is to make production system alive with long life. The basic concept of Integrated Nutrient Management or Integrated Plant Nutrient Management is the adjustment of plant nutrient supply through various sources to an optimum level for sustaining the desired crop productivity. It involves proper combination of organic manure, crop residues, N_2 fixing crops like pulses, oilseeds and biofertilizers suitable to the system of land use and ecological, social and economic conditions [1]. The cropping system rather than an individual crop, and farming system rather than an individual field, is the focus of attention in this approach for development INM practices for various categories. Plant nutrients, soil nutrients, organic manure, soil amendments, crop residues, green manure, biological nitrogen fixation, biofertilizers are the major components of INM through organic sources. It involves proper combination of chemical fertilizers, organic manure, crop residues, N_2~fixing crops (like pulses such as rice bean, Black gram (Paheli dal), other pulses and oilseeds such as soybean and biofertilizers suitable to the system of land use and ecological, social and economic conditions.

Organic rice production involves recycling of crops residues, crop rotation, inclusion of legumes in system both in sequence or as an intercrop, green manuring, off-farm waste recycling, use of mineral rocks like rock phosphate, mechanical cultivation, biological pest control and avoid use of synthetic agrochemicals with overall objective of sustainable production, maintaining resources and environmental quality. Weed control, soil fertility and management of pest and diseases are the principal challenges associated with organic production. Relevant/appropriate measures should be taken to ameliorate acid soil. Clearing of primary forest not permitted and burning of organic matters to clear land to the minimum level. Across the slope cultivation should be practiced. The major challenge in Organic Agriculture is the availability of huge quantities of organic inputs for satisfying the farm demand. Use of animal excreta-based manure alone is not sufficient for meeting the nutrient needs of the crops. It is therefore, necessary to utilize all the sources available on and off farm effectively [2].

The resource components available for nutrient management in organic farming are: farmyard manure, crop residue, weed biomass, green manures, biofertilizers, composts/phospho-compost, vermicomposting, oil cakes, mulching/cover crop, liquid manures, biodynamic preparation, botanicals, legumes in cropping sequence, crop rotation/intercropping/ sequential cropping, hedge row/alley cropping, indigenous nutrient solution, conservation tillage, by-product from integrated farming systems, industrial/agricultural/ household waste and certified commercial products. Major and minor micronutrient content in different organic product has been presented in Table 1 & 2.

Table 1: Major nutrient content of different organic product [17].

Sources	Nitrogen (%)	Phosphorus (%)	Potassium (%)
FYM	0.93	0.36	0.92
Vermicompost	2	1	2
Pig manure	1.19	0.38	0.98
Poultry manure	1.82	0.51	2.1
Cattle urine	1.2	-	1.2
Crotolaria juncea	3.5	0.33	2.38
Tephrosia purpurea	3.11	0.23	1.24
Eupatorium odoratum	2.38	0.07	2.84
Ambrossia artimisifolia	3.19	0.22	4.38
Rape seed cake	4.8	2	1.3
Neem cake	5.2	1.1	1.5

*FYM=Farm Yard Manure

Table 2: Micronutrient content of different organic product (ppm) [17].

Sources	Iron (Fe)	Copper (Cu)	Zinc (Zn)	Manganese (Mn)	Boron (B)	Molybdenum (Mo)
FYM	2600	2.5	57	250	2.1	0.13
Compost	-	450	9.4	12.4	5.8	0.1
Pig manure	1200	8.9	50	70	-	-
Poultry manure	1400	7.1	90	210	5	-
Goat manure	-	61	2570	150	4600	-

*FYM=Farm Yard Manure

Nutrient management strategy

Maintenance of soil fertility may be achieved through organic matter recycling, enrichment of compost, vermicomposting, animal manures, urine, farm yard manure, litter composting, use of botanicals, green manuring etc. Use of bio-fertilizers like Azolla, Azospirillum, Azotobacter, Rhizobium culture, PSB etc. to be used. Saw dust from untreated wood, calcified seaweed, limestone, gypsum, chalk, magnesium rock and rock phosphate can be used. Various sprays like vermiwash and liquid manure etc. can be used in crops for nourishing the soil and plant.

Modern strategy for manures management

Plant nutrients are lost from the soil in different ways. Large quantities are removed from the soil due to harvest of crops. Weeds remove considerable quantities of plant nutrients from the soil. Nutrients are also lost by leaching and erosion [3]. Nitrogen is also lost by volatilization and de-nitrification. Soil is the important source of plant nutrients. When the crop requirements are higher than the soil supplying power, nutrients are applied as manures. Manures are plant and animal wastes that are used as sources of plant nutrients. They release nutrients after their decomposition. Manures can be grouped into bulky organic manures and concentrated organic manures based on concentration of the nutrients. 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 have several advantages viz. supply macro nutrients including micronutrients, improve soil physical properties like structure, water holding capacity etc., increase the availability of nutrients to plants, plant parasitic nematodes and fungi are controlled to some extent by altering the balance if microbes are present in the soil. 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 0.93 per cent N, 0.36 per cent P_2O_5 and 0.92 percent K_2O. 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 reduce by following improved method of preparation of farmyard manure. Trenches of size 6m to 7.5m length, 1.5m to 2.0m width and 1.0m deep are dug. All available litter and refuse are mixed with soil and spread in the shed so as to absorb urine [1-3].

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The next morning, urine soaked reduce 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 45cm to 60cm 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 filled, second trench is prepared. The manure becomes ready for use in about three to four months after plastering. If urine is not collected in the bedding, it can be collected along with washing 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 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 20t/ha is applied, but more than 20t/ha is applied to fodder grasses and vegetables [4].

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

Compost management guideline

A mass of rotted organic matter made from waste is called compost. The compost made from farm waste like sugarcane trash, paddy straw, weeds and other plants and other waste is called farm compost. The average nutrient contents of farm compost are 0.5 percent N, 0.15 percent P_2O_5 and 0.5 percent K_2O. The nutrient value of farm compost can be increased by application of superphosphate or rock phosphate at 10 to 15 kg/t of raw material at the initial stage of filling the compost pit. The compost made from town refuses like night soil. Street sweepings and dustbin refuse is called town compost. It contains 1.4 percent N, 1.00 per cent P_2O_5 and 1.4 percent K_2O. Farm compost is made by placing farm wastes in trenches of suitable size, say, 4.5 to 5.0m long, 1.5m to 2.0m wide and 1.0m to 2.0m deep. Farm waste is placed in the trenches layer by layer. Each layer is well moistened by sprinkling cow dung slurry or water. Trenches are filled up to a height of 0.5mm above the ground [6].

The compost is ready for application within five to six months. Phospho-compost or P-enriched compost can be made by mixing rock phosphate @5% P_2O_5 with the composting mass. To produce 1000tones phosphocompost on dry weight basis following materials are required; 800t organic refuse, crop residues, leaves, grasses+100t cattle dung or biogas slurry+100t soil+50t well-decomposed FYM/compost/sewage sludge+265t rock phosphate. The addition of insoluble source of P to enrich compost is a more rational and practically useful approach since solubilization of insoluble P occurs during composting [7]. Following compostable materials consisting crop residues, grasses, weeds, tree leaves, animals feed wastes or their mixtures and cattle dung are used along with P sources.

Green manuring win-win strategy

Green manuring can be defined as a practice of ploughing or turning into the soil un-decomposed fresh green plant tissue for the purpose of improving fertility status and physical structure of the soil. The increase in yield after green manuring is usually 30-50%. The fertilizing value of the legume crops can be increased greatly by manuring it with super phosphate. This practice not only increases the P content of the green manure but also encourages their plant growth overall, thus converting inorganic fertilizer into organic manure [8]. A leguminous crop of 45 to 60days can add up to more than 200kg/ha when ploughed under; generally, it is around 100kg/ha green manure N, which corresponding to the average amount of mineral fertilizer N applied to most agricultural crops, is as efficient as fertilizers N. Integrated use of green manure and organic fertilizers can save 50-75% N in rice.

The ideal green manure should capable of establishing and growing quickly, tolerant to adverse climatic conditions such as drought, water logging, high and low temperatures etc. and tolerant to pest and diseases, should possess adequate rhizobium nodulation potential and must be effective nitrogen fixer, should be capable of growing very fast and capable of accumulating sufficient fixed N_2 in 4-6weeks, easy to incorporate and quickly decomposable. Depending upon the agro climatic conditions following two types of green manuring practices can be adopted. Green manuring crops are grown and buried in the same field which is to be green manured, either as a pure crop or as an intercrop with the main crop. The most common green manure crops in this system are Sunnhemp (Crotolaria juncea), Dhaincha (Sesbania aculeata, Sesbania rostrata) and cluster bean (Cymopsis tetragonoloba).

Some common grain legumes such as cowpea, lupine and horse gram are also widely used as green manures. To make the green manuring more economical and affordable, it is also being recommended to grow legumes such as cowpea, French beans and rice beans and incorporate them after collecting the two harvest of green pods for vegetable purposes. Dhaincha, sunhemp and cowpea are the major green manure crops capable of accumulation of 4-5 tonnes/ha of dry biomass and 100N kg/ha in 50-60 days when well managed. In Sikkim's conditions rice bean and buck wheat can be recommended as green manuring crops. It refers to the collection leaves and tender twigs from shrubs and trees grow on bunds, wasteland and nearby forest areas and then incorporate them into cultivable field. The common shrubs and trees used for introduced green leaf manuring are Gliricidia sepium, Sesbania speciosa, karanj (Pongamia glabra), Ipomea, Jatropha gossipifolia.

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Some of the trees that are being widely planted for fodder fuel, timber and green manuring purposes are Albizzia falactoria, A. Lebbak, Calinadra calothyrsus, Sesbania grandiflora, Flegmingo macrophylla, Leucaemea leucocephala and many species of Acacia. Sesbania speciosa seedlings planted 10cm apart on paddy borders produce 1,000 to 2,500kg green leaf for manuring 0.4ha paddy field. Farmers can choose the green manure crop according to the local availability and agro climatic conditions. Dhaincha (Sesbania aculeata) is commonly used and is an ideal green manure crop for rice fields. Usually after the harvest of rabi crop, dhaincha is sown with the receipt of summer showers and it is ploughed and incorporated 8-10 weeks after sowing. Among the green manure crops, Sesbania aculeata is the one, which can supply highest amount of biomass and nitrogen. It is fairly drought tolerant and resistant to water logging. It is suitable for loamy and clayey soils. One crop of dhaincha can add 10-20 tonnes of biomass per ha. For sowing one ha area, 20-25 kg of seed is required. It can fix about 75-80kg N per ha depending on the environmental conditions.

New generation organic nutrient management strategy

Night soil is human excreta, both solid and liquid. It is richer in N, P and K than farmyard manure and compost. Night soil contains on a average 5.5 percent N, 4.0 percent P_2O_5 and 2.0 percent K_2O. In the modern system of sanitation adopted in cities and towns, Human excreta is flushed out with water which is called sewage. The solid portion in the sewage is called sludge and liquid portion is sewage water. Both the components of sewage are separated and are given a preliminary fermentation and oxidation treatments to reduce bacterial contamination and offensive smell. The droppings of sheep and goats contain higher nutrients than farmyard manure and compost. On an average, the manure contains 3 percent N, 1 percent P_2O_5 and 2 percent K_2O. It is applied to the field in two ways.

The sweeping of sheep or goat sheds are placed in pits for decomposition and it is applied later to the field. The nutrients present in the urine are wasted in this method. The second method is sheep penning, where in sheep and goats are kept overnight in the field and urine and fecal matter added to the soil is incorporated to a shallow depth by working blade harrow or cultivator. The excreta of birds ferment very quickly. If left exposed, 50 percent of its nitrogen is lost within 30 days. Poultry manure contains higher nitrogen and phosphorus compared to other bulky organic manures. The average nutrient content in poultry manure is 3.02% N_2; 2.63% P_2O_5 and 1.4% K_2O. Except for nitrogen, the availability of most nutrients in poultry manures is fairly consistent. Nitrogen can occur in several forms, each of which can be lost when subjected to different management or environmental conditions. Nitrogen in poultry wastes comes from uric acid, ammonia salts, and organic (fecal) matter [9]. The predominant form is uric acid, which readily transforms to ammonia (NH_3), a gaseous form of nitrogen that can evaporate if not mixed into the soil. When it is thoroughly mixed, the ammonia changes to ammonium (NH_4^+), which can be temporarily held on clay particles and organic matter. Thus, soil mixing can reduce nitrogen losses and increase the amount available to plants.

Concentrated organic nutrients

Concentrated organic manures have higher nutrient content than bulky organic manure. The important concentrated organic manures are oilcakes, blood meal and fish manure. These are also known as organic nitrogen fertilizer. Before their organic nitrogen is used by the crops, it is converted through bacterial action into readily usable ammonia cal nitrogen and nitrate nitrogen. These organic fertilizers are, therefore, relatively slow acting, but they supply available nitrogen for a longer period. 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. Both edible and non-edible oil cakes can be used as manures. However, edible oil cakes are feed to the cattle and non-edible oil cakes are used as manures especially for horticultural crops.

Microbial strain as bio-fertilizers

Bio-fertilizers (BF) is the product containing cells of different types of microorganisms that have an ability to mobilize nutritionally important elements from non-usable to usable form through biological process. BF refers to living organisms that augment plant nutrient supplies in one way or the other. They are the renewable energy source. They are environment friendly and cost-effective supplement to the chemical fertilizers, laying a significant role in improving nutrients availability to the crop plants. Although the potentiality of biofertilizers has increased in India in the recent years, there exists a large gap between its demand and supply [9]. Since it is not a plant food it requires careful management and nutrients like other organisms for proper functioning. Their success in fixing atmospheric N and solubilizing insoluble P into plant utilizable P in field conditions depend mainly on the development of raw material as carrier which is the most important ingredient in biofertilizer. Some biofertilizers are Azolla, blue-Green algae (BGA), Rhiziobium, Azotobacter, Azospirillum and others. Generally, 200g biofertilizer is suspended in 200 to 400ml water to make a slurry, which is poured on 10-10kg seeds slowly and mixed thoroughly with culture. Inoculation of seeds with efficient strains of Azospirillum and Azotobacter contributes about 15-20kg N/ha in different crops. Some symbiotics are leguminous plant and Rhizobium and Blue-green algae and water fern (Azolla) in rice fields. Some non-symbiotics are Blue-green algae: Nostoc, Anabaena and bacteria under aerobic condition like Azotobacter, Azospirillum, Bacillus, Polymyxa and anaerobic Clostridium, Rhodosprillum, Chlorobium. Symbiosis N_2 fixation involves different hosts and micro-symbionts between legumes and bacteria belonging to the genera Rhizobium, Bradyrhizobium and Azorhizobium. Nodulation and N_2 fixation are observed under wide range of temperatures with optima between 20-30 °C.

The seven recognized species are Rhizobium leguminosarum (pea group), Rhizobium phaseoli (bean group), Rhizobium trifolii (clover group), Rhizobium meliloti (alfalfa group), Rhizobium

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lupin (lupini group), Rhizobium japonicum (soybean group) and Rhizobium sp. (cowpea group). Yield increases of crops planted after harvesting of legumes are often equivalent to those expected from application of 30 to 80kg of fertilizer N/ha. Alfalfa, red clover, pea, soybean, cowpea, and vetch were estimated to fix about 23 to 300kg of N ha/year. The carryover of 35-65kg N/ha from cowpea, black gram, groundnut to succeeding cropping cropping sequences has been observed by many workers. A dominant non-symbiotic free-living heterotrophic nitrogen fixing bacteria. It not only provides the nitrogen but produce a variety of growth promoting substances. Azotobacter chroococcum is dominant in arable soils and capable of fixing N_2 10-15kg N/ha. The inoculants can be mixed with FYM and broadcast near the root zone.

From the field experiments carried out in different part of India Azotobacter inoculants have shown to increase the yield by 3-34% of many crops. High nitrogen fixation capacity, low energy requirement and abundant establishment in the root of cereals. Azospirillum inoculum is used for sorghum. Positive interaction between Azospirillum and applied N has been observed in several cereal crops with the effect of Azospirillum being equivalent to 20-30 kg/ha of applied N. A. brasilense produced high amount of IAA in culture medium, caused an increase in number and length of lateral roots. In Indian condition many scientists reported that Azospirillum inoculation enhanced the grain yield of rice 5-25 percent. It can be used both as a green manure before transplanting and as a dual crop after transplanting of rice. Both practices are feasible in India, but dual cropping is more practicable, although growth an N fixation of azolla as well as yield of rice are generally more than dual cropping. Adoption of azolla green manuring is restricted to areas having water availability before transplanting.

The cultivation of azolla is labour intensive. Incorporation of one crop of azolla increased the grain yield equivalent to that obtained with 25-30kg N/ha urea whereas 2 to 3 crops of azolla, equivalent to 60 to 90kg fertilizer N/ha. Azolla provided N to rice after its decomposition just like any other organic matter. Incorporated azolla takes about 8-10 days to decompose and release about 67 percent of its N within 35 days. The decomposition and N release vary among azolla species/strains. Fresh azolla is superior to dry azolla as regards N release. Studies carried out for 15 years at CRRI, Cuttack showed that azolla green manuring produces 10-20t ha^{-1} of green matter containing 20-40kg N, whereas it dual cropping provides 20-30kg N ha^{-1}.

They are a free living N fixer that is distributed worldwide and contributes to the soil fertility in many agricultural ecosystems mainly in rice. The rice ecosystem is an ideal environment for BGA. Judicious use of BGA could provide N to the country's entire rice acreage as much as that obtained from 15-17 lakh tonnes of urea. Study at CRRI indicated that BGA increase grain yield by 6-35%. Application of BGA (10kg/ha) is recommended for flooded paddy as it can survive and multiply easily in standing water. The BGA cyanobacteria (anabaena azollae) present as symbiont with this fern in the lower cavities fixes atmospheric nitrogen around 25kg/ha. Under good management conditions their contribution seldom exceeds 20-40N kg/ha. Phosphorus is the second most important nutrient after nitrogen that is required by the plants for normal growth. Larger percentage of soil phosphorus is in the unavailable form and not more than 1-2 percent if it is incorporated into the above ground parts of the plants.

Generally, phosphorus is supplied in the form of chemical fertilizers or organic sources such as decomposed plant and animal wastes. Phosphorus solubilizing microorganism includes various bacterial, fungal and actinomycetes forms that help convert insoluble inorganic phosphate into simple and soluble forms. Members of Pseudomonas, Micrococcus, Bacillus, Flavobacterium, Penicillium, Fusarium, Sclerotium and Aspergillus are some of the phosphate solubilizing microorganisms. Integrated use of P solubilizing bacteria with rock phosphate contributes about 30-35kg P_2O_5/ha. The efficient cultures have shown capacity to solubilise insoluble inorganic phosphate such as rock phosphate, tri calcium phosphate, iron, and aluminium phosphates by production of organic acids. They can also mineralize organic phosphatic compounds present in organic manure and soils.

These cultures have been tested in multi-locational field trials on wheat, rice, gram, lentil and potato. The results invariably showed that inoculation of seeds or seedlings increased the grain yield of crops indicating the solubilization of fixed soil phosphorus. The use of cultures increased the efficiency of rock phosphate and super phosphate applied to neutral to alkaline soils. One packet of 200g of biofertilizer is mixed in 500ml of water to prepare slurry and the slurry is mixed with about 10-12kg seeds and is air dried under shade. Soon after drying the biofertilizer coated seeds are broadcast. In seedlings dipping method 1kg biofertilizer that is sufficient for one acre is mixed in 5 lire water in a bucket and mixed thoroughly. The roots of seedlings bundles are dipped in the biofertilizer suspension for about 30min. and these biofertilizer-coated seedlings are transplanted immediately.

In soil application 4 to 5kg of desired biofertilizer is mixed with 100kg of well-decomposed FYM and mixed thoroughly to get a uniform mixture. The biofertilizer mixed FYM is applied to the soil 15 to 20 days of transplanting rice crops or one month after broadcasting of seeds of FYM is applied in the pits before transplantation or in dragged ring so as to ensure the placement near the root zone of the crop.

Immediately after biofertilizer is applied it should be covered with soil to avoid exposure to direct sunlight. Since the microbes like to grow and proliferate at the rhizosphere zone of the crop, the added inoculants should be placed close to the root zone so that the mutual requirement of microns and the beneficiary crop can meet and the inoculated microbe could easily established in the root rhizosphere. The biofertilizer should be stored in a cool place and should not be mixed with chemical fertilizers or pesticides and should not be exposed to direct sunlight. After the biofertilizer is applied it is immediately covered with soil under moderate moisture. The chemical fertilizer schedule to the crop

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along with biofertilizer application should be avoided to prevent direct contact of microbial organisms with the chemical fertilizers. These precautions are to be taken in the field conditions. The VAM is Vesicular Arbascular Mycorrhizae, called fungi which possess special structures known as vesicles and arbuscules. They help in the transformation of nutrients from soil to root system. They often increased uptake of nutrients and water. These fungi (VAM) are very suitable for groundnut, soybean, millets, coffee, citrus, pepper and cloves. Mycorrhizae help in mobilizing insoluble soil phosphates. They further help increasing nutrient uptake. The fungal hyphae growing out from the plant root reach to the additional soil areas and help to absorb many nutrients for transmission to the plant, particularly less mobile nutrients such as phosphate (PO_4^{3-}), Zn^{+2}, Cu^{+2} and MoO_4^{-2}. Because they provide a protective cover, mycorrhizae increase the plant seedlings tolerance to drought to high temperature, to infection by disease fungi, and even to extreme soil acidity. Under drought conditions the uptake of highly mobile nutrients such as NO^{3-} can also be enhanced by them. Mycorrhizal fungi can also improve absorption of N from NH^{4+} -N mineral fertilizers, transporting it to the host plant. They can protect host plants against detrimental effects caused by drought stress.

Conservation practices for nutrient recycling

Crop rotation including legumes and other green manuring to be practiced. Cover crops catch crops and mulching should be done for conserving soil fertility and reduce soil loss in hilly area. Sufficient diversification should be obtained to take care of the pest and disease pressure and to improve soil fertility, microbial activity and general soil health. This also reduces farmers risk and provide some insurance against failure or poor performance of one or other component in the farm. Legumes in rotation restore soil fertility in more than one way viz, some of the N fixed is left in the soil after harvest, improvement in soil properties, lesser disease and pest problem and better weed control. Legumes rotation can fix atmospheric N_2 to an extent of 135-488kg ha^{-1}. It is estimated that cotton following a non-legume rotation crop required an application of 179 kg N ha^{-1}, while following the grain- and GM-legume system it required only 90 and 52kg N ha^{-1}.respectively. Therefore, legumes in a cropping system certainly provide a link towards INM. Improvement in cereal yield upto 0.5-3.0 tonnes/ha following monocropped legumes are reported [10]. Crop residues need to be converted to bio-composts for its effective conversion and utilization by crop plants.

Study revealed that incorporation of residues improved the productivity of crops. Improvements in the soil fertility might stabilize long-term yields. Since limited application (due to low crop response) of K leads to an accelerated depletion of other nutrients in addition to K, crop residue incorporation (with high in K) can alleviate these problems here besides improving long-term nutrient balances of cations and restoring Soil Organic Carbon. On an average 25% of N and P, 50% of S and 75% of K is retained un the cereal residues making them valuable nutrient sources. Recently it is shown that 2-4mg N could be fixed by heterotrophic microorganism per gram of straw added in flooded soil. A better example of nutrient recycling in INM for sustainable farming involves application of a set of organic materials/complexes for higher production efficiency with lower nutrient loss from soil (nutrient recharge) [11-13]. It is evident that application of FYM, green gram mulching, Glyricidia green foliage loppings and sunnhemp as GM increase yield over control and considerable build-up of soil available nutrients following these. Besides, direct addition of N to the available soil pool, organics facilitates in the greater multiplication of soil microbes that could convert organically bound N to inorganic form there by help maintaining/ restoring soil N status. Similarly, microbial decomposition of organics could form organic complexes with sesquioxides and thus, reducing the P fixing capacity of this soil. Moreover, enhancement in K availability is fortified following mineralization of organics and release of K to soil pool due to organic matter-clay interaction and reduction in K fixation.

Modern earthworm technology

Compost that is prepared with the help of earth worm (may be local species or more vigorous exotic ones) is called vermicompost. Vermicompost is popularly known as Black Gold due to its colour and quality in supplying nutrients to plants, enriching soils by improving physicochemical and biological properties. Earthworm consumes large quantities of organic matter and excretes soil as casts. Casts of the earthworm have several enzymes and are rich in plant nutrients, beneficial bacteria and mycorrhizae. It is made in small pits of suitable size (2m × 1m × 0.5m) in a shady are in farm [14]. The waste material collected from farm and are placed in the pit layer wise and soil is added for each layer. Earthworms are released for each layer and water is applied. Compost is ready within 2-3 months. The nutrients value in casts depends upon the source of raw materials and the species of earthworm used. A fine worm cast is generally rich in N, P, K other nutrients in trace amount. Nutrient analysis of biofertilizer enriched vermicompost made from Eisenia foetida is pH 6.8, OC 11.88%, OM 20.46%, N 2.0%, P 1.0% and K 2.0%. The rate of application of vermicompost depends upon the nature and requirement of crops. General recommended dose is for field crops (6-8t/ha), fruit crops (3-5kg/ha) and pots (100-200g/pot).

Vermicompost improves soil aeration, enriches soil with micro-organisms (adding enzymes such as phosphatase and cellulase), microbial activity in worm castings is 10 to 20 times higher than in the soil and organic matter that the worm ingests, attracts deep-burrowing earthworms already present in the soil, improves water holding capacity. Application of vermicompost increases the total microbial population of nitrogen fixing bacteria and actinomycetes. The symbiotic association of mycorrhizae on plant root system increase [15,16]. Earthworm casts harbor large number vesicular micorrhiza (VAM) propagules. It neutralizes highly acidic or basic soils. Worm casts are capable of degrading toxic contaminants for reclamation of the polluted sites. It boosts up soil health by decreasing soil health. Enhances germination,

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plant growth, and crop yield, improves root growth and structure. enriches soil with micro-organisms (adding plant hormones such as auxins and gibberellic acid).

It reduces plant pest attack and improves disease resistance. It gives the seedling a good start in life. Unlike mineral fertilizers, vermicompost does not burn plants when applied even in higher amounts. Vermicompost can be mixed directly into the soil. The resulting liquid is used as a fertilizer or sprayed on the plants. The pH, nutrient, and microbial content of these fertilizers varies upon the inputs fed to worms. Pulverized limestone or calcium carbonate can be added to the system to raise the pH. It supplies balanced nutrition to growing plants [17]. As nutrients content analysis shows it has all the major, secondary and micronutrients. It increases humic substances by 40-60% which is higher than the value obtained by any composting. Worm casting decrease bio-available metals by 35-55% within two months of its application.

Prospective about Future Research

In organic farming the use of chemical fertilizers is not allowed, and the additional nutrient demands of crop plants have to be met with organic manures which are not only low in essential plant nutrients but also release them slowly. This makes the synchronization of nutrient release from organic manures and their uptake by crop plants a difficult task. Thus, supply of plant nutrients through organic manures requires much more skill on the part of the farmers [18]. There is ample scope of increasing production by use of good agronomic practices as well as proper crop management. Since, nutrients applied to preceding crops exhibit residual effect on succeeding crops, fertilization must be done keeping the whole cropping system in view rather than the individual crops. Getting maximum profitability lies not only in reducing use of input per unit area but also in lowering costs per unit crop production through higher yields. Therefore, economic analysis is required for making recommendation for farmers from agronomic experiments [19].

Conclusion

They do not cause any serious soil health problems. Nutrients held in organic combinations becomes available to plants only slowly in many cropping seasons as a result of natural control over nitrification effected by the heterotrophic organisms through nutrient immobilization of secondary. Prevent conditions leading to the deficiency of secondary and micronutrients in the soil. An organic residues, grasses and others when incorporated into the soil not only improve the soil physical properties but also improve the soil microbial life. The addition of organic residues like straw not only retards humus depletion but also enriches the nitrogen status of soil by fixing atmospheric nitrogen through the process of photochemical fixation. When organic residues are blended with different calcium phosphates such as basic slags and rock phosphates, the fixation of atmosphere nitrogen by humus is accelerated. As soil organic matter is a steady suppler of available nitrogen, phosphorus, potash, calcium and other plant nutrients, lands rich in human population can support increased production without the use of chemical fertilizer.

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