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NUTRIENT MANAGEMENT IN ORGANIC RICE (*ORYZA SATIVA* L.) — AN OVERVIEW

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Rice is the major staple food crop in India occupying around 44 million hectares and contributing about 100 million tonnes to the total food grain production. Introduction of high yielding and fertilizer responsive rice varieties with the advent of green revolution resulted in intensive rice farming leading to increased use of chemical fertilizers, pesticides and other inputs. Continuous use of sole chemical fertilizers has been reported to cause harmful effects on the soil environment, ground and surface water and even atmospheric pollution reducing the productivity of the soil by affecting soil physical, chemical and biological properties (Altieri, 2000). The reported occurrence of widespread soil fatigue in intensively cultivated irrigated rice lands has led to the use of 40 per cent more N to increase rice yield obtained 10 years ago has further accentuated the problem (Lampe, 1993). Likewise, indiscriminate and increased use of pesticides is leading to soil pollution, entry of toxic compounds into food chain, death of natural enemies of insect pests and development of resurgence and resistance to pesticides (Chandra Mohan, 2001). Outbreaks of insect pests have occurred frequently due to over use of insecticides. Numerous reports have indicated that spraying insecticides could cause serious decrease in natural enemies of insect pests and consequently lead to the outbreak of brown planthopper, *Nilaparvatalugens* (Wang *et al.* 1994 and Gu *et al.* 1997). Continuous monoculture of rice has also led to the degradation of soil resource base. Hence, enhancement and maintenance of system productivity and resource quality is essential for sustainable agriculture.

It was felt that organic farming can solve the above mentioned problems as this system is believed to maintain soil productivity and pest control by enhancing natural processes and cycles in harmony with nature. Organic farming may promote natural control of some pests and diseases reduce soil quality deterioration by improving soil organic matter (SOM) and soil microbial activity. Organic farming reduces the entry of toxicants in the form of pesticides in food chain and minimizes the accumulation of toxic residues in the soil thus leading to production of “clean” foods. There is a growing demand worldwide, especially in the European region and other parts of Western world for organically grown food products. There is a scope for minimizing the economic and environmental costs under organic farming system as compared to conventional farming in the long run by preventing environmental damage and protection of natural eco-systems. Organic farming is considered as one of the keys for sustainable agriculture.

Organic rice cultivation : India has tremendous potential to become a major exporter of organic rice in the International market. Agricultural and Processed Food Products Export Development Authority (APEDA) made efforts to produce and export basmati rice, aromatic rice and other rice varieties by establishing model farms in states like Punjab, Haryana and Uttar Pradesh. Rice is the major crop that receives maximum quantity of fertilizers (40%) and pesticides (17-18%) and these practices pose major challenges in organic rice farming for nutrient and pest management. All possible organic nutrient sources and how these sources can effectively and efficiently be managed for achieving higher productivity are discussed in detail in this section.

Nutrient management in organic rice production : The success of organic farming depends on the availability of organic resources for recycling of plant nutrients. The animal dung, crop residues, green manures, bio-fertilizers, poultry manure, vermi compost, agro-industrial wastes, food processing waste and urban solid waste are some potential organic sources of nutrients. In addition, the organic farmers are using a wide range of other local products of plant extracts and animal wastes not only to supplement the crop nutritional requirement but also to protect them against pests, with a good measure of success.

The organic nutrient management techniques that can be followed in nursery and main field are described in detail giving several options to the farmers who are willing to practice organic rice cultivation.

1. Nursery management : Seed bed preparation: During seed bed preparation, organic manures such as FYM, Compost, vermi-compost can be used @ 5t/ha

2. Seed treatment: Seed treatment is very important as it helps to improve the germination potential, vigour, hardening against drought, environmental shocks and resistance to pests and diseases. The recommended seed treatment techniques using bio-fertilizers are :

Seed treatment with *Azospirillum* and/or phosphorus solubilizing bacteria (PSB) or phosphorus solubilizing microorganisms (PSM) @ 10 g each/kg seed.

Seedling root dipping in *Azospirillum* and/or PSB/PSM suspension prepared with 600 g of culture for seedlings sufficient to transplant in a hectare of land. Some other popular seed treatment methods followed by farmers are treating with cow urine, cow milk, wood ash and hot water treatment.

2. Main field management : In the main field, only organic manures/crop residues/green manures are to be utilized to supply plant nutrients based on soil test recommendations of the location. Nutrient concentrations and moisture content of organic manures, their contribution to plant uptake and crop nutrient requirement are to be evaluated to estimate the quantity of organic sources. Rice requires 16 - 21 kg N, 5 – 9 kg P_2O_5 and 20 – 25 kg K_2O to yield a ton of paddy. During land preparation and puddling, 10 tons of FYM/ha along with 5 tons paddy straw and 10 tons of insitu grown dhaincha/sunhemp green manure/ha needs to be incorporated. In the last puddle, vermi-compost @ 2 t/ha may be applied (optional). Through these organics, approximately 150 kg N, 40 -50 kg P_2O_5 and 100 – 120 kg K_2O can be supplied which take care of crop NPK needs to a large extent depending on their mineralization and release of nutrients. In addition to NPK, these organics supply micronutrients also in required quantities.

Bio-fertilizers such as *Azospirillum*or PSB/PSM @ 2 – 3 kg culture/ha can be mixed with 25 kg FYM or vermi-compost and applied to the soil just before planting. Blue green algae @ 10 kg/ha, 10 days after planting is also recommended. If possible, Azolla @ 1 t/ha can be added 7 – 10 days after transplanting and incorporated after 3 weeks. Azolla can also be used as a green manure @ 6 t/ha and incorporated before transplanting. All these bio-fertilizers may add 30 – 40 kg N on an average. Bio-fertilizers, in addition to improving the availability of major nutrients like N and P are also known to produce various growth promoting substances and the nutrients release will be staggered and made available slowly to the plants over an extended period of time thus minimizing nutrient losses through leaching, volatilization and competition from weeds.

Important organic sources for nutrient management

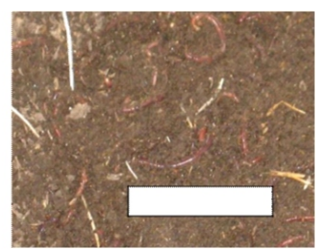
1. Organic manures
2. Crop residues
3. Green manures
4. Bio-fertilizers
5. Inclusion of Legumes
6. Agro industrial wastes
7. Multi variety seed sowing Dabholkar method).
8. Organic solutions and preparations.

1. Organic *manures :* Organic manures constitute an important component of organic farming. The benefits of organic manures include: slow release of N and other nutrients; they are sources of almost all the plant nutrients and also effectively solubilize nutrients from mineral components in soil; improve the soil structure and other soil physical properties. They generate high levels of biological activity of soil microorganisms and also reduce the toxic effects of Agri-chemicals and other heavy metals. Organic manures include: Farm yard manure (FYM), compost, vermi-compost, coirpith compost, other organic wastes like urban solid and human wastes (bio solids), poultry litter, sheep and goat manure, slaughter house waste, animal and fish wastes and several edible and non-edible oil seed cakes. Efficient livestock waste management would not only cut down the pollution, but also provide farmers with a useful source of less costly organic fertilizers. Many long term fertilizer experiments have revealed the beneficial role of FYM by increasing crop yields over the years besides improving soil physical and chemical properties.

Method of application : To derive maximum benefit, the organic manures should beimmediately spread and mixed into the soil without leaving them in small piles in the fields for a long period. Under tropical climatic conditions existing in India, organic matter is quickly lost and hence fresh applications are necessary to obtain increased yields and maintain soil fertility.

FYM

Vermicompost



Poultry manure

Coir pith compost

2. Crop residues : Crop residues can be recycled into the soil by different methods such as incorporation, mulching, composting and partial burning which will eventually improve the chemical, physical and biological properties of the soil resulting in higher crop productivity. Substantial quantities of crop residues (about 330 m.t.) are produced in India every year. Half of these are used as cattle feed and the rest 50% can be recycled for their beneficial effects on soils and plants. Cereal straws/residues on an average contain 40-45% C, 0.5-0.8% N, 0.1-0.2% P, 1.0-1.5% K and 5-10% Si. Thus, 1 ton of rice straw contains approximately 400-450 kg C, 5-8 kg N, 1-2 kg P, 10-15 kg K and 50-100 kg Si. Legume residues have much higher potential qualitatively as they are readily decomposed.

Method of application : Crop residues can be recycled by methods such as incorporation,mulching, composting and burning. Incorporation is better way of application. Immobilization of N is usually associated with high C/N cereal straws and by mixing them with green manures of narrow C/N ratio (in 1:2 proportions), temporary immobilization can be avoided and N release can be accelerated. Another way is by delayed planting (1-2 weeks) after incorporation. In mulching, though decomposition is a slow process, its biomass and C/N ratio during the course of one crop season is appreciably reduced and this facilitates its easy incorporation in next season. Mulch helps in controlling weeds and conserving moisture. Though burning facilitates easy and quick disposal of residues and promotes partial sterilization of soil, the drawback is, it causes energy and nutrient losses and atmospheric pollution besides killing soil biota which is not a desired practice in organic farming.

Paddy straw and its incorporation along with green manure

3. Green manures : Green manures (GM) play a major role in integrated nutrient management (INM) especially if they are grown in off season utilizing either early monsoon showers or where good irrigation facilities are available. Dual purpose grain legumes like green gram and cow pea are most promising as they offer immediate economic benefit through their grain (4-5 q/ha) and can be incorporated in to the soil before transplanting *kharif* rice. Among the sole green manure crops, dhaincha (*Sesbaniaaculeata*) and sunnhemp (*Crotalaria juncea*) are most suitable as they put up sufficient biomass (22-40 t/ha) in a minimum required period of 45-60 days. They add on an average 60-80 kg N/ha in addition to other nutrients. They also recycle sub soil nutrients and improve soil physical condition. Further, they contribute to the active pool of soil organic matter consisting of microbial biomass/enzymes and other secretory products from soil biota contributing to soil quality improvement.

Method of incorporation : The GM crops are grown up to 8 weeks in the field and thenincorporated into the soil before they start seeding. In case of grain legumes, after taking the economic end product that is grain, the residues can be incorporated into the soil. The important caution to be exercised is that transplanting of rice should be done with in 1 or 2 days of incorporation since 50% of N is known to be released within 3 weeks which may be prone to severe losses in the absence of absorbing roots in case of delayed planting practiced traditionally across the country.

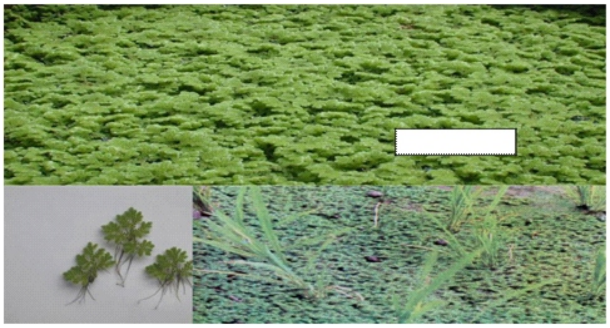
Sun hemp **Cowpea**

Dhaincha **Incorporation of green manures**

Different green manure crops and their incorporation

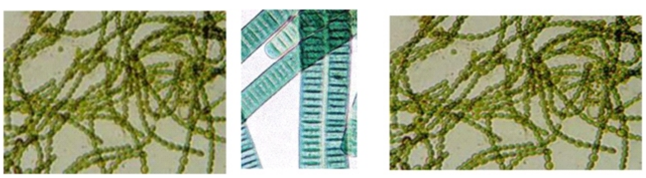
4. Bio-fertilizers : Bio-fertilizers, also known as microbial inoculants, contain actively living cells of microorganisms which are proven as efficient nitrogen fixers or perform other functions such as phosphate and other mineral solubilisation which beneficially affect plant growth and yield of crops. N and P are the main nutrients that can be supplemented by bio fertilizers to rice. Azolla, blue green algae (BGA) and Azospirillum for N and phosphate solubilising microorganisms for P are important to rice.

(a) Azolla : Azolla is an aquatic fern (non- seeding plant) widely distributed in waterbodies and harbours blue green algae, *Anabaena*. N fixed by azolla in association with anabaena becomes available to the rice plant after the decomposition of azolla, which is therefore comparable to green manuring. Inoculation of Azolla either as a green manure @ 3-4 t/ha 15 days before transplanting or as a dual crop 1-2 weeks after transplanting and incorporating after 2-3 weeks is reported to contribute 10-50 kg N/ha/crop.



Azolla

(b) Blue green algae (BGA) : BGA occur abundantly in soils and can fix atmospheric N bynon-symbiotic N fixation. Besides N fixation, BGA synthesise and excrete several growth promoting substances like auxins and ascorbic acid. Inoculation of BGA @ 10 kg/ha adds about 30 kg N/ha.



Blue green algae

(c) *Azospirillum* : This organism, a bacterium fixes atmospheric N by the process,associative symbiosis in association with the root tissues using the root exudates. It is also known to produce growth promoting substances such as Indole acetic acid (IAA), Gibberellic acid (GA) etc. Azospirillum inoculation @ 600 g/ha in nursery and 2 kg/ha in the main field are reported to contribute on an average 20-30 kg N/ha

Azospirillum

(d) Phosphate solubilizing microorganisms : They are a group of heterotrophic microorganisms (bacteria and fungi) which have the ability to solubilize/mineralize insoluble inorganic/organic P sources to forms available to the plant. Inorganic P is solubilized by the production of organic acids like citric, fumaric, malic etc. by the microorganisms whereas organic P is mineralized through production of phosphatases. Inoculation of 5-6 kg PSB/ha as soil application is generally recommended.

Phosphate solubilizing bacteria (PSB).

5. Inclusion of Legumes : Rice mono-cropping is not a sound nutrient management practice as it leads to mining of same soil horizons repeatedly. Rice-rice system (anaerobic-anaerobic) is known to build up phenol rich difficultly decomposable organic matter and in the process, a lot of N is locked in through immobilization. Legumes are considered as soil builders and rice-legume cultivation system is more ideal in terms of nutrient addition, especially N and also helps regenerate disturbed rice soil structure (on account of puddling) through their favourablerhizosphere effects. Similarly, in upland rice-chick pea system, the legume component improves P availability by acidifying its rhizosphere due to its acidic root exudates like citric acid. This supplies P in addition to N to the succeeding upland rice which lacks advantage of flooding. Inclusion of legumes in the cropping sequence gives a lot of scope to economize on certain nutrients.

Field Bean + red gram **Redgram**

Chickpea **Greengram** **Groundnut**

6. Agro–Industrial wastes : Agro-industries are based not only on crops such as rice, sugarcane, jute, tea, coffee, fruits and vegetables but also based on forest products (non edible oil seeds, wood, lac etc.), marine products (prawns, fish, frogs and sea weeds) and slaughter house wastes and dead animal carcases**.** Recyclable agro-industrial products like rice husk, bran, bagasse, pressmud, coir pith, sewage sludge, seed cakes and wastes from marine industry are not put to use and if properly used, they help in reducing the off-farm inputs needed. However, much work has not been done on the use of these wastes in improving the yields and soil quality particularly with respect to spread of parasites and pathogens adversely affecting human and animal health.

Pressmud **Bagasse** **Cotton cake** **Groundnut cake**

7. Multi variety seed sowing (Dabholkar method) : This method has been developed by a mathematician by training Mr. Dabholkar from Maharashtra state who did a lot of experiments on soil fertility and organic farming (Dabholkar 2001). This method is similar to green manuring. But, in this method, 20-30 diverse, short duration crops involving cereals (jowar, bajra, ragi, korra etc.), pulses (black gram, green gram, Bengal gram, cowpea etc.), oil seeds (sesame, sunflower, groundnut, castor etc.), legumes (pillipesara, dhaincha, sunnhemp, subabul etc.), and spices (coriander, jeera, mustard, fenugreek etc.) will be grown *in situ* and incorporated into the soil after 30-40 days. The seed rate recommended is 50-60 kg/ha. For normal soils of moderate or optimal fertility, this process is recommended once in between two main crops. If the soil fertility is very poor and in case of problem soils, same process has to be repeated for a period of 60 days and then the crops have to be incorporated.

This process has to be repeated for the third time for a period of four months (120 days) and then the crops have to be incorporated. By this way, the degraded soil will regain its fertility and sustain the productivity of the main crop.

The philosophy behind this method is that different crops take up varying quantities ofnutrients from various depths due to their rooting depth differences and their need and deposit them on the top layers when they are incorporated into the same soil. In this process, the soils become highly fertile and all the plant nutrients, including micro nutrients will be made available to the succeeding rice crop.

8. Organic solutions : "Panchagavya" and "Amruthajalam" are organic solutions and alternatives tochemical fertilizers (Vijayalakshmi*et al.* 2004 and MOFF 2006). Some of the farmers practicing organic farming and system of rice intensification (SRI) cultivation used these organic solutions in their crop and reported good results.

Panchagavya : For this, 5 kg cow dung+ 5 litres cow urine+ 2 litres cow milk+ 2 litrescow butter milk+ 500 g cow ghee + 500 g jaggery are required. Initially, dung and ghee are mixed and kept in a pot for 4 days and on the 5th day; the remaining ingredients are added and allowed to ferment for 15 days. The contents are stirred three times daily in the morning, afternoon and evening.

Method of application : 250 ml panchagavya mixed with 10 litres water can be sprayedon the crop. Depending on the crop growth, 200-300 litres/acre can be sprayed 2 – 3 times during active growth period of the crop.

Amruthajalam : 1 litre cow urine + 1 kg cow dung+250 g jaggery+ 10 litres water arerequired for preparing this. All these contents are mixed and allowed to ferment for one day.

Method of application *:* To 1 litre of amruthajalam, 10 litres water is mixed, filtered andthe filtered solution can be sprayed on the crop @200-300 litres/acre, 2 – 3 times during active growth period of the crop.

Any easily available and local organic source (preferably on-farm) should be efficiently utilized rather than going for scarce organic manures at higher price. Based on the nutrient concentration, moisture content and C/N ratio, a combination of different organic sources can be used in a balanced proportion to avoid excess buildup of only certain elements

Indigenous Technical Knowledge (ITK) : Indigenous Technical Knowledge (ITK) is the knowledge that people of a particular community have acquired from their ancestors or developed from their personal experience. It is based on experience, often tested over long period of use, adapted to local culture and environment, dynamic and changing, and lay emphasis on minimizing risks rather than maximizing profits. This traditional knowledge evolved from the experiences of farmers is found to possess practical utility in solving some of the farmer?s problems under their own conditions. Most of these ITKs can be efficiently utilized in organic rice farming as they have been verified scientifically and found effective in improving soil fertility and managing pests. Some important ITKs (Muthuraman*et al.* 2009) that can be adopted in organic rice farming for soil fertility management are listed here :

Soil Fertility management

Mixing of rice husk with excreta of poultry birds, cattle, pigs and ash and its application to soil

Collection of soil from the base of the pond and its application to the main field during summer

Sheep and goat penning in the field

Water hyacinth compost

Walking in the rice field and/or using a weeder for better aeration to control iron toxicity

Application of wild indigo (*Wrightiatinctoria*) and *Pongamiapinnata* leaves

Left over material of animal feed on the bedding along with urine and excreta of animals

ITKs that are locally and easily available, proved effective without having any side effects and have been in practice for hundreds of years of adoption may prove a low cost ideal tool for sustainable organic rice farming.

Major problems/challenges in organic rice farming

Lack of availability of organics in large quantities to meet exact crop nutrient requirements at appropriate time.

Lack of knowledge/know how on organic rice cultivation and limited access to advanced knowledge and technology for efficient use of organic inputs.

Lack of knowledge for preparation of good quality organic inputs as standardized procedures for their preparation are not available

Non availability of good quality organic manures, bio fertilizers, botanicals and bio pesticides and lack of artificial rearing methods for inundative release of biological control agents.

High cost of organic manures and bio pesticides, more transportation and labour costs for procuring and spreading the manure if purchased from outside leads to high cost of cultivation

Standardisation of package of practices is difficult because the practices successful at one farm under certain situations may not be applicable elsewhere and location specific practices for efficient use of various organic sources are not available.

Decomposition of organic manures/crop residues may be a problem under very low temperatures

Under certain situations, use of huge quantities of organics in rice production may increase the emission of green house gases from the wet land soils

Wrong perceptions among the farmers that yields are low in organic cultivation which is not true under all situations though initial yield reduction is possible under certain conditions

Difficulties in the certification procedures in terms of cost, accessibility, cumbersome nature and lack of guidance

Lack of marketing facilities for selling organic produce in most of the areas

Lack of interest among the farmers when no price premium is offered for un-certified produce

Future thrust and suggestions for promoting organic rice farming

Promotion of research on various organic nutrient sources, bio control of pests anddiseases etc. to arrive at crop specific recommendations

Production and promotion of standard quality manures and organic pesticides in sufficient quantities and at reasonable prices

Creation of awareness among farmers about organic farming

Provision of subsidies and financial support to help marginal and small farmers for initial expenses of converting to certified organic farms

Reduction of certification costs to make them accessible to small farmers without diluting standards

Improvement of infra-structure such as roads, transportation, storage facilities etc.

Encouragement to develop domestic market for organic products

Development of strong linkages between growers and consumers, with minimum influence of middlemen.

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