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Integrated Nutrient Management & Its Impact on Soil Health

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SUBMITTED TO:

Course Instructors	Major Professor
1. Dr. Md. Mizanur Rahman Professor BSMRAU 2. Dr. A. K. M. Aminul Islam Professor BSMRAU 3. Dr. Md. Rafiqul Islam Professor BSMRAU 4. Dr. Dinesh Chandra Shaha Assistant Professor BSMRAU	Dr. G.K.M. Mustafizur Rahman Professor , Dept. of Soil Science BSMRAU

SUBMITTED BY:

Falguni Khan

MS Student

Reg. No.: 13-05-2942

Department of Soil Science

BANGABANDHU SHEIKH MUJIBUR RAHMAN AGRICULTURAL UNIVERSITY

SALNA, GAZIPUR 1706

Integrated Nutrient Management and Its Impact on Soil Health[1]

Falguni Khan[2]

Abstract

Soil fertility maintenance requires a balanced application of inorganic and organic sources. Sustainable agricultural productivity might be achieved through a wise use of integrated nutria management. Integrated use of chemical and organic fertilizer on yield and yield components of different crops is very crucial for assurance of food security. Integrated Nutrient Management/ Supply (INM/INS) aims at maintain or enhance soil productivity through a balances use of fertilizers combined with organic and biological sources of plant nutrients. Improve the stock of plant nutrients in the soils and the efficiency of plant nutrients that limiting losses to the environment. Animal manures, FYM, green manures, residues of different crops, vermicomposts and industrial wastes are the important sources of organic materials. The amount and availability of nutrients in organic materials vary widely. So that production and nutrient status of food increases in an efficient and environmentally benefited manner.

Keywords: Integrated Nutrient Management (INM), Sustainable agriculture, Components of INM, Soil health

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[1]A seminar paper presented at the graduate seminar course on 03 may 2017

[2]Ms Student, Department of Soil Science, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur-1706

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CHAPTER I

INTRODUCTION

Agriculture is a soil-based industry which extracts nutrients from the soil. Over- and under-application of fertilizers and the poor management of resources both deteriorated soil health andraised environmental concerns. In developing countries, changing climatic conditions, increasing population pressure, reducing cultivable land area and ignoring traditional soil management practices have often reduced soil fertility (Kumwenda et al. 1996).

The most effective and usefulapproaches to slowing the rate of nutrient mining by returning the nutrients to the soil will be required in order to increase and maintain crop productivity and sustain agriculture. The overall strategy for increasing crop yields and sustaining them at a high level must include an integrated approach to the management of soil nutrients. An integrated management recognizes that soils are the storehouse of most of the essential nutrients for plant growth. Farmers, researchers, fertilizer industry and governments all must need to play an important role in this topic.

Integrated nutrient management (INM) is an old concept. It was performed when almost all the nutrient needs were met through organic sources to supply secondary and micronutrients along with primary nutrients. The advantages of INM can be broadly considered as i) restoration of soil fertility and crop productivity, ii) prevention of secondary and micronutrient deficiencies, iii) reduction of fertilizer use and improvement in nutrient use efficiency and iv) favorable effect on the physical, chemical and biological health of soils(Singh, Dwivedi and Datta, 2001).

1.1 INM/IPNS Definitions

INM or IPNS has been defined by different researchers as follows:

- IPNS is defined as adjustment of soil fertility and supply of plant nutrient to optimum level crop productivity through optimization of benefit from all possible plant nutrient sources in an integrated manner (Roy and Ange, 1991).
- INM is actually the technical and managerial component of achieving the objective of IPNS under farm situations. It takes into consideration all factors of soil and crop management including management of all other inputs such as water, agrochemicals, amendments, *etc*., besides nutrient management(Goswami, 1998).

- IPNS is practiced to maintain soil fertility and enhance plant nutrient availability to achieve a given level of crop production. This is done by optimizing the benefits from all possible sources of plant nutrients (FAO, 1998).

The thumb rule of INM is toimprove of soil fertility by integrating various nutrient sources along with fertilizers for ensuring long-term crop productivity. These concepts encircled main areas like, maintenance of soil fertility, optimum supply of nutrient to plant, sustaining desired level of productivity, optimization of benefits from all possible sources of nutrients and considering environmental issues. This may be obtained through combined use of allpossible sources of nutrients and their scientific management for optimum growth, yield and quality of different crops and cropping systems.

This concept of nutrient management possessed greater significance in recent years because of two reasons. First, the present level of fertilizer production is not enough to meet the entire plant nutrient requirement due to increasing in agricultural production and this productivity requires more application of nutrients. Second, a large number of experiments on INM especially long-term experiments (LTEs) conducted all over the worldto reveal that only the fertilizers or the organic sources can not bring about sustainable production under intensive cropping (Hegde and Dwivedi, 1993).

Considering the above fact the following objectives were undertaken:

- To understand about Integrated Nutrient Management practice
- To know about how INM helps to improve soil health and crop productivity

CHAPTER 2

MATERIALS AND METHODS

This seminar paper is exclusively a review paper. Therefore, all of the information has been collected from secondary sources with a view to prepare this paper. During the preparation of this paper, I went through various relevant books, journals, proceedings, reports, publications etc. Findings related to my topic have been reviewed with the help of the library facilities of Bangabandhu Sheikh Mujibur Rahman Agricultural University. For collecting recent information internet browsing was also be practiced. Good suggestions, valuable information and kind consideration from my honorable major professor and course instructors were taken to enrich this paper. After collecting necessary information, it has compiled and arranged chronologically for better understanding and clarification.

CHAPTER III

REVIEW OF FINDINGS

3.1. Ingredients of INM

Fertilizers, organic manures, legumes, crop residues, industrial by-products and bio-fertilizers are the main ingredients of INM.

3.1.1 Fertilizers

Fertilizers continued to be the most important ingredient of INM. The dependence on fertilizers has been increasing constantly because of the need to supply large amounts of nutrients in intensive cropping with high productivity. Some problem also arises such as:

i. Consumption of fertilizer is inadequate and imbalanced too. Application of K, S and other micronutrients is generally ignored where the $N:P_2O_5:K_2O$ use ratio is quite wide.

ii. In our country domestic fertilizer production is not adequate to meet the requirements and this situation will not be improved in the near future.

iii. On the other hand, fertilizer import in large quantities would not permit due to increase of global price of fertilizers and raw materials. This leads to a big gap between fertilizer supply and consumption which act as major constraints. While organics and bio-fertilizers are expected to bridge a part of this gap, efficient use of fertilizers in narrowing the nutrient supply gap also needs greater emphasis. Utilization of fertilizer nutrients by the crops vary from 30-50% in case of N, 15- 20% in case of P and less than 5% in case of micronutrients.

Fig-1: Images of N, P, K fertilizers

(Sources: www.google.com)

3.2. Organic Manures

Organic manures such as urban compost, FYM, crop residues/wastes, human excreta, city refuse, vermicompost, sewage-sludge, sugarcane press mud and other agro industrial wastes have large nutrient potential. For maintaining soil fertility, compost and FYM have traditionally been used as important manures which ensure yield stability. Other potential organic nutrient sources are non-edible oilcakes and wastes from food processing industry. Nutrient composition of some important organic sources/manures is given in **Table 1.**

Moreover, several industrial by products and municipal wastes are potential nutrient sources. But, those nutrient-carriers have not been properly evaluated for establishing as fertilizer equivalents.

Table 1- Nutrient content of some organic manures and recyclable wastes

Category	Source	Nutrient content (%)		
		N	P_2O_5	K_2O
FYM/Compost	Framyard manure	0.5-1.0	0.15-0.20	0.5-0.6
	Poultry manure	2.9	2.9	2.3
	Urban compost	1.5-2.0	1.0	1.5
	Rural compost	0.5-1.0	0.2	0.5
Animal wastes	Cattle dung	0.3-0.4	0.10-0.15	0.15-0.20
	Cattle urine	0.80	0.01-0.02	0.5-0.7
	Sheep & goat dung	0.65	0.5	0.03
	Night soil	1.2-1.5	0.8	0.5
Oil cakes	Castor	5.5-5.8	1.8	1.0
	Coconut	3.0-3.2	1.8	1.7
	Neem	5.2	1.0	1.4
Animal meals	Horn & hoof	13.0	0.3-0.5	-
	Fish	4-10	3-9	1.8
	Raw bone	3-4	20-25	-

(Source: Tandon, 1995)

Sulphitation press mud (SPM) is a potential source that supplies nutrients in addition to favorable effects on soil properties. Studies revealed that use of decomposed SPM also had positive effect on yield stabilization of rice-wheat system **(Fig 1).**

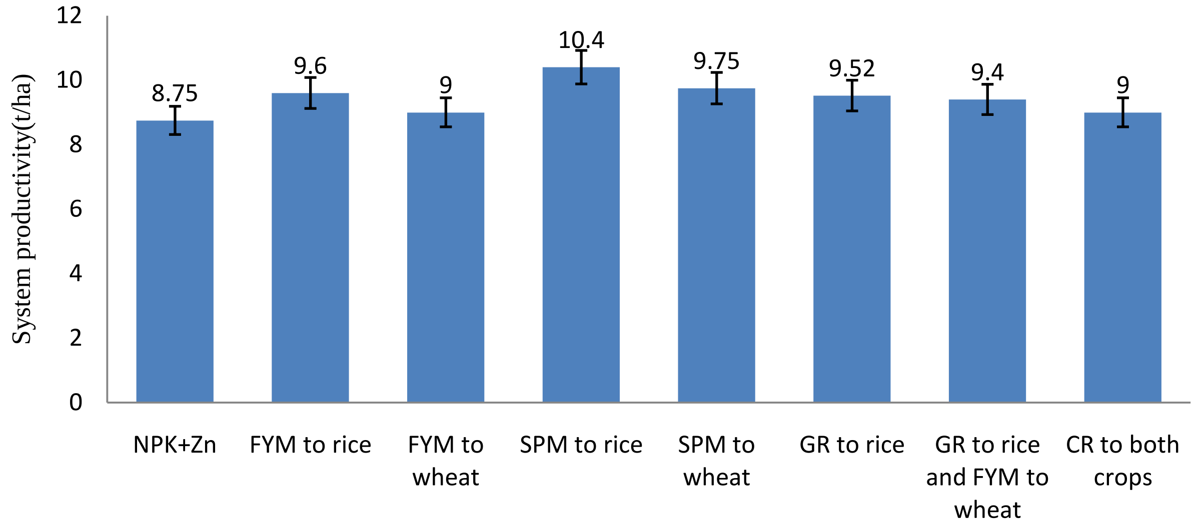

Fig 2- Rice-Wheat system productivity as influenced by different organic sources

(Source: Singh and Mishra, 2010)

These nutrient sources have low nutrient content and short in supply but bulky in nature. Those are lost their relative importance over time in crop production. However, fertilizers cost and their limited supply made those necessary for alternative and renewable sources of plant nutrients.

Fig-3: Image of Farmyard manure

(Source: www.google.com)

Organic manures supply macro as well as micronutrients. Those sources help improving the physical, chemical and biological properties of the soils. These manures, not only supply nutrients to the first crop, but also leave substantial residual effect on succeeding crops in the system.

3.3. Legumes

Legumes has the ability to obtain N from the atmosphere in symbiosis with Rhizobia and restorers soil fertility. It can be proved as an important component for INM. Legumes can be grown as green manure, forage or grain crops improved the crop productivity and increases soil fertility (Yadav et al. 2000).

3.3.1. Legumes Grown in Rotation

Almost all legumes have the different capacity to leave behind different amounts of N for the following crop utilization. Further, grain legumes contribute less N than fodder legumes. A number of leguminous crops have been evaluated for the contribution which they make in meeting the N requirement of the succeeding crop. Grain yield of following crop increased markedly with former legume than a former cereal crop. In general, for utilization of the following crop, pulse crops do leave a residual amount of as much as 30 to 50 kg N/ha (**Table 2**).

Table 2: Effect of pulse crop on the N economy in succeeding wheat

Preceding Winter Crop	Fertilizer N (kg/ha)				
	0	40	80	120	Mean
	Grain yield (t/ha) of Wheat				
Gram	2.01	2.35	2.62	2.80	2.44
Lentil	1.97	2.39	2.53	2.66	2.41
Peas	2.13	2.56	2.63	2.73	2.03
Wheat 80 kg N/ha	1.55	1.97	2.21	2.41	2.03
Wheat 120 kg N/ha	1.61	1.92	2.44	2.61	2.14

(Source: Tauro, 1983)

By inoculation with proper species of *Rhizobia* the conveniences of legumes could be improved. Legumes can grow well in that soil where N supply is not enough to support other crops. After harvest, roots of legumes plant left in the soil, releasing fixed N for uptake by the next crop. By rotating a legume crop with a non legume,farmers can take benefit of this natural fertilization. Use of chemical fertilizers reduced when nitrogen fixation occurs naturally. This also saves money and helps from preventing many problems brought due to excessive use of N fertilizers.

3.3.2. Legumes as Green Manures

Applications of green manure with legumes enrich soil N due to fixation of atmospheric N. The decomposing green manure has a solubilizing effect on N, P, K and micronutrients in the soil. Leaching and gaseous losses of N can be reduced by using green manures with legumes. Besides, it also improves the soil physical, chemical and biological properties. The most important and common green manure crops are Sun hemp (*Crotolaria juncea*) and Dhaincha (*Sesbania aculeata*).

Figs-4: Image of Sun hemp

(Source: www.google.com)

3.3.3. Induced Defoliation in Pigeon pea

Recent studies revealed that the green foliage retained at maturity by extra-short duration (ESD) varieties of pigeon pea could be recycled, as a non-conventional avenue of INM. Induced defoliationby foliar spray of 10% urea solution (w/v in water) at maturity of ESD pigeon pea resulted in addition of 1-1.2 t ha-1 leaf litter, recycling more than 40 kg N per ha (Chauhan et al. 2004 and Mandal et al. 2013).

3.4. Crop Residues

Crop residues are not always available as a component of INM, though it has several competitive uses. Other crops except cereal crops like, potato, sugarcane, vegetables, *etc*. produce large amounts of residues, which are practically wasted in most of the cases. Cereal crop residues are used as cattle-feed. If these are available in excess of the local needs then it could be used to supplement the fertilizers.

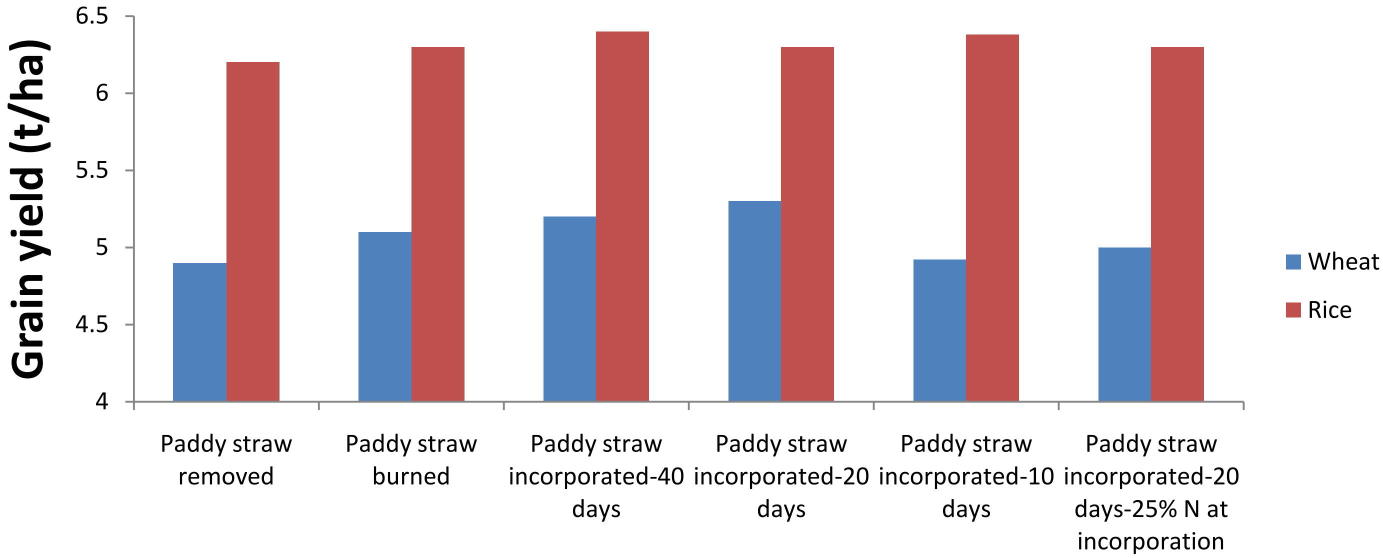

Fig-5: Effect of long term rice straw management on yield of Wheat & Rice

(Source: Gupta, et al. 2004)

3.4.1. Crop Residue Management

In resource conservation technologies (RCTs) crop residue retention is one of the important techniques that advocated Conservation Agriculture (CA). Some studies showed that surface retention of residues under CA (instead of incorporation in conventional farming) minimizes immobilization owing low relatively less soil-residue contact, in addition to reveal other advantages. With the retention of residues on soil surface Greenhouse gas (GHG) emissions are also reduced.

Fig-6: Image of crop residue

(Source: www.google.com)

3.5. Bio fertilizers

Fertilizers that contain living or latent cells of microorganisms are known as bio fertilizers. These fertilizers are agriculturally beneficial because it plays an important role in improving soil fertility and crop productivity by fixing N present in the atmosphere, solubilize P and decompose farm waste and release nutrients for plant uptake. It also can be used to reduce the use of chemical fertilizers. Bio fertilizes are eco friendly organic agro-inputs. Some bio fertilizers are- *Rhizobium, Azospirillum, Azotobacter* can fix atmospheric N, *Pseudomonas, Bacillus, Aspergillus* help to solubilize P and improve P availability, Vesicular Arbuscular Mycorrhizae (VAM) increase nutrient uptake by increasing root contact with large soil volume.

Rhizobium is the most popular bacterial species that fix atmospheric N. In leguminous plant, *Rhizobium* infects the roots and produce nodule where N fixation takes place. From all leguminous plant around 90% legumes bear nodule and have the capacity to fix N. Around 100-300 kg N/ha can be fixed in one crop season by Rhizobium legume association and leave residual N for the succeeding crop. More than 80% of the N requirement can be met up from this symbiosis.

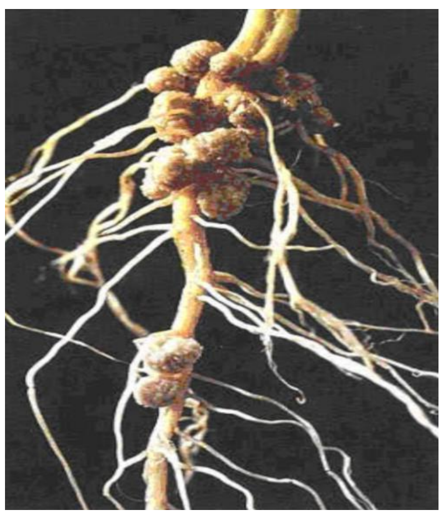

Fig-7: Image of Rhizobium in root nodule

(Source: www.google.com)

Azotobacter is another free living N fixing bacteria. It generally contribute around 20-25 kg N per ha. *Azospirillum* also act as N fixer. It colonizes in the root and fix N in loose association with plans. Average 15-20 kg N per ha can be get from *Azospirillum*.

Some bacteria like *Pseudomonas*, *Aspergillus* helps in converting insoluble P into plant useable form. Soil inoculation of *Pseudomonas* with low grade rock phosphate might add 30-35 kg P_2O_5

per ha. Inoculation of *Aspergillus* in wheat seed also increases crop response to P and soil availability.(Singh and Dwivedi, 2004).

Now a days K mobilizing Bio fertilizer (KMB) and Zn Solubilizing Bio fertilizer (ZnSB) have been introduced to increase the availability of K and Zn. At present liquid bio fertilizers also proved as effective bio fertilizers for increasing soil fertility.

For wetland rice cultivation Blue green algae is another important source of N. 20-30 kg N per ha can be fixed by BGA. *Azolla* also allowed to reduce N application by at least 30-40 kg per ha.

3.6 Impact of INM on Soil Health

3.6.1. INM Improves Soil Physical Properties

Bulk density (BD) is the most important and widely considered parameter for assessing soil health. It has strong relationships with soil strength, porosity, rate of moisture retention capacity and water flow. When excessive tillage with heavy farm machinery is done, erosion and soil organic matter loss may lead to increase soil BD and which leads to lower yields (Das, 2012). Soil BD is influenced by the quantity and quality of organic materials. If higher rates of organic materials are added to the soil, BD reduced and increased crop yield. Organic inputs effect on soil BD was larger in 0- 15 cm layer which may be extended up to 30 cm.

Upper soil layer normally indicates higher water holding capacity (WHC) compared with deeper soil layers due to greater amount of organic matter is generally found in the surface layer (0-15 cm) (Bandyopadhyay, Saha, and Mallick, 2011).For example, in Alfisols, the amount of soil water retention capacity at saturation condition was significantly higher in NPK + manure and NPK + lime than in control, N or N+P fertilization at both 0-15 and 15-30 cm depths, due to improvement in soil structure through addition of manure or lime. (Hati et al. 2008).

Another physical property related to soil structure is soilaggregation, which is greatly influenced by the application of organic materials. Das et al.(2014) based on 18 years of study with rice-wheat cropping system reported that soil aggregation and structural stability is improved and C content in macro-aggregates showed higher amount due to the application of NPK fertilizer along with organics (FYM or greengram residue+ FYM or cereal residue). Lee et al.(2009) observed that continuous application of compost is significantly increased the proportion of large size aggregates but decreased that of small aggregates, compared with non-compost plots (NPK only and the control. Reports showing the application of organic inputs have the positive effects on Soil Organic Matter (SOM) content (Karami et al. 2012)

3.6.2. INM Affecting Soil Chemical Properties

3.6.2.1. Effect on SOC Content

SOC stocks decreases due to the conversion of forest lands to permanent cropping lands rapidly in the recent years. Some report showed that organic matter content of tropical soils is declined due to continuous cultivation (Nieder and Benbi, 2008). To increase Carbon content in soil, we need to use organic sources along with chemical fertilizers. In that case, NPK fertilizers with crop residues, bio fertilizers or green manures can be used as organic sources.

3.6.2.2. Effect on SOC Fractions

Labile pool of SOC is influenced nutrient cycling and soil fertility, which upon quick decomposition contribute to CO_2 flux (Chan et al. 2001, Majumder et al. 2008 and McLauchlan and Hobbie, 2004). So, the SOC status is served well by labile C pool under different soil management practices. C inputs to the soil are highly responsible on labile fractions to provide a measurable change in the amount of total organic matter. In contrast, For C sequestration characterization the more stable (humified) pools are probably the more appropriate fractions (Cheng, 2001).Sleutel et al. (2006) reported that the amount of OC can be increased by manure and fertilizer application for long time application. Mandal et al. (2013) found that application of organic manures like FYM was beneficial for improving SOC and mineral-N levels. It was also found that organic C composition was more affected by land use or management practice than organic N forms (Abe et al. 2009).

3.6.2.3. Effect of INM on Available Nutrient Content

(i) INM affects mineralization and uptake of N:SOCcontent and soil mineralizable N is linearly related. TheNH_4-N and NO_3-N contents are significantly increased due to continuous useof FYM over seven years,though green leafmanures addition did not leave anyprofound effect. On the other hand, Puranik et al.(1978) and Prasad and Rokima (1991) observed the mitigation of NO_3-N content of the soil with the application of FYM alone. But when NPK and FYM are used together, the highest N content was observed. The soil NO_3-N content at any given time depends upon the following factors-therate of formation, crop removal, leaching, volatilization, denitrification, addition of NO_3-Nthrough fertilizers and organic manures and mineralization rate. Soil NH_4-N content was low where N was appliedonly through fertilizers. N substitution through FYM or vermicomposting show a positive effect of 50% to 75% NH4-N contents in the soil due to slow release and retention by soil (Duraisami et al. 2001 and Mandal et al. 2007).

(ii) INM Helps Curtailing Fertilizer P Demand:The reduction of Fe and P solubilization depends on Increasing SOC levels (Timsina and Connor, 2001). Verma et al.(2010) studied that the improvement in extractable P content in soil was directly proportional to the amount of FYM applied. The mineralization of organic P plays important role in its availability in soils, especially in relatively high SOC soils. The level of SOM is influenced the transformation of added P fertilizers. Significant increase in available P content was also observed with the application of fertilizer in combination with FYM. Incorporation of green manure (*Sesbania*) generally increased available P content of soils.

(iii) INM Helps Mitigating S Deficiency in Soil: S deficiencies are widespread, and around 41% of S is deficient in the soil samples (Tiwari et al.2006).One of the major factors of S deficiency is low SOC content along with low S content of the soil, ignoring S application, coarse texture, imbalanced fertilizer useand leaching losses of available S (Shukla et al. 2012). If organic manure along with fertilizers can be applied than lesser deficiencies are expected.

(iv) INM Helps Improving Micronutrient Contents:NPK+FYM bound with organic B are possible due to greater chelation of B by organic matter. Substantial increase in readily soluble B under NPK+FYM also appears to be associated with high organically bound fraction. (Fig-3).

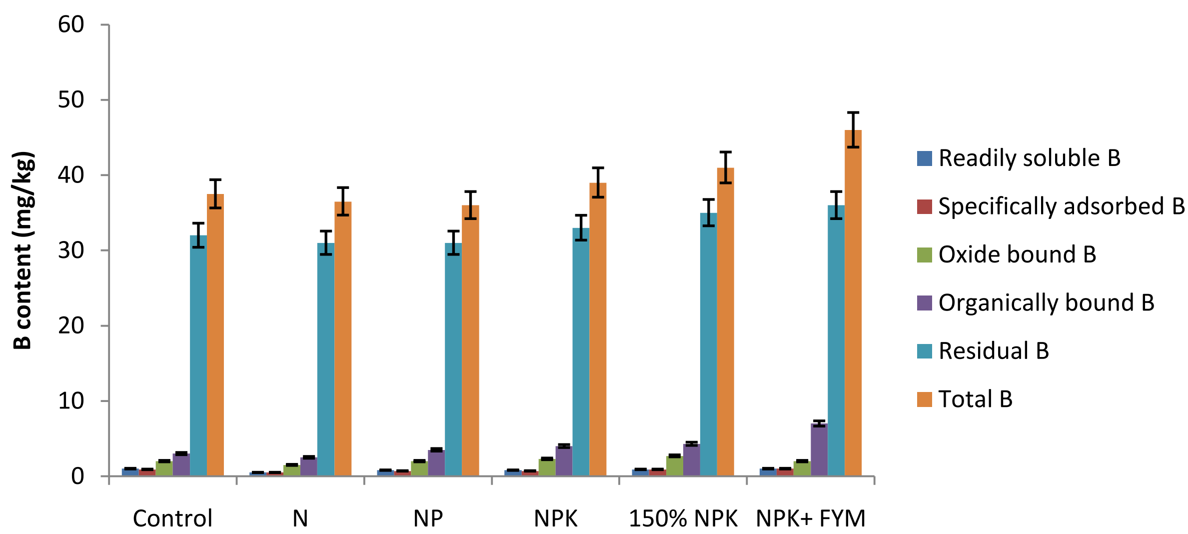

Fig-8: Fractions of soil B as affected by long-term fertilization and manuring

(Source: AICRP-LTFE Progress Report, IARI, 2012)

3.7 Impact of INM on Soil Biological Properties

3.7.1. Soil Microbial Biomass C (MBC)

Soil microbial biomass C (MBC) is consists of bacteria and fungi which are about 1-5% of SOC. Increase in MBC can provide an early sign of longer-term total organic C (TOC) in soils. The ratio of MBC to TOCis known as the 'microbial quotient' (MQ). Change of MQ ratio show greater impact on organic matter inputs, the efficiency of conversion to microbial C, losses of C from the soil and the stabilization of organic C by the soil mineral fractions. Moharana et al. (2012) reported 76.5% increase in MBC under NPK+FYM treatments over control and 43% increase over NPK fertilizer treatment. MBC content shows positive effect on INM (Fig-5) (Ghosh et al. 2010, Mandal et al. 2007 and Nayak et al. 2012).

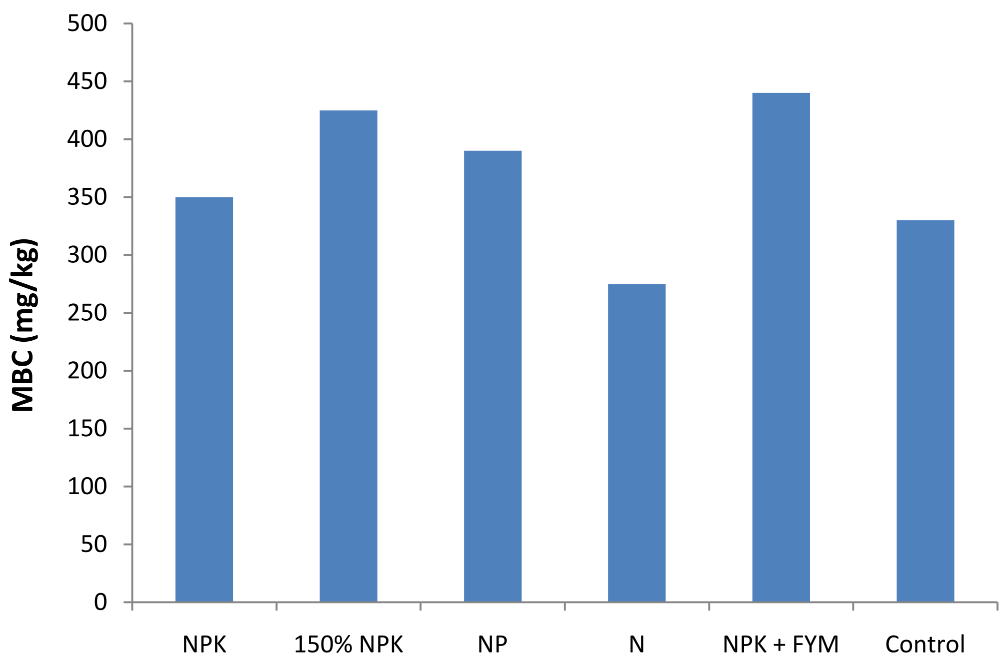

Fig-9: Soil MBC influenced by long-term use of fertilizer and manure
(Source: AICRP-LTFE Progress Report, IARI, 2012)

3.7.2. Soil Dehydrogenase Activity (DHA)

Generally, the organic matter content is closely related to the enzyme activities in the soil (Chu et al. 2007). Application of balanced amounts of nutrients and manures improved the organic matter and MBC content of soils (Mandal et al. 2007) (Fig-6). Application of organic sources may be linked with Dehydrogenase activity in the soil. DHA and microbial biomass increases with the number and amount of nutrients addition (Manjaiah et al. 2001).

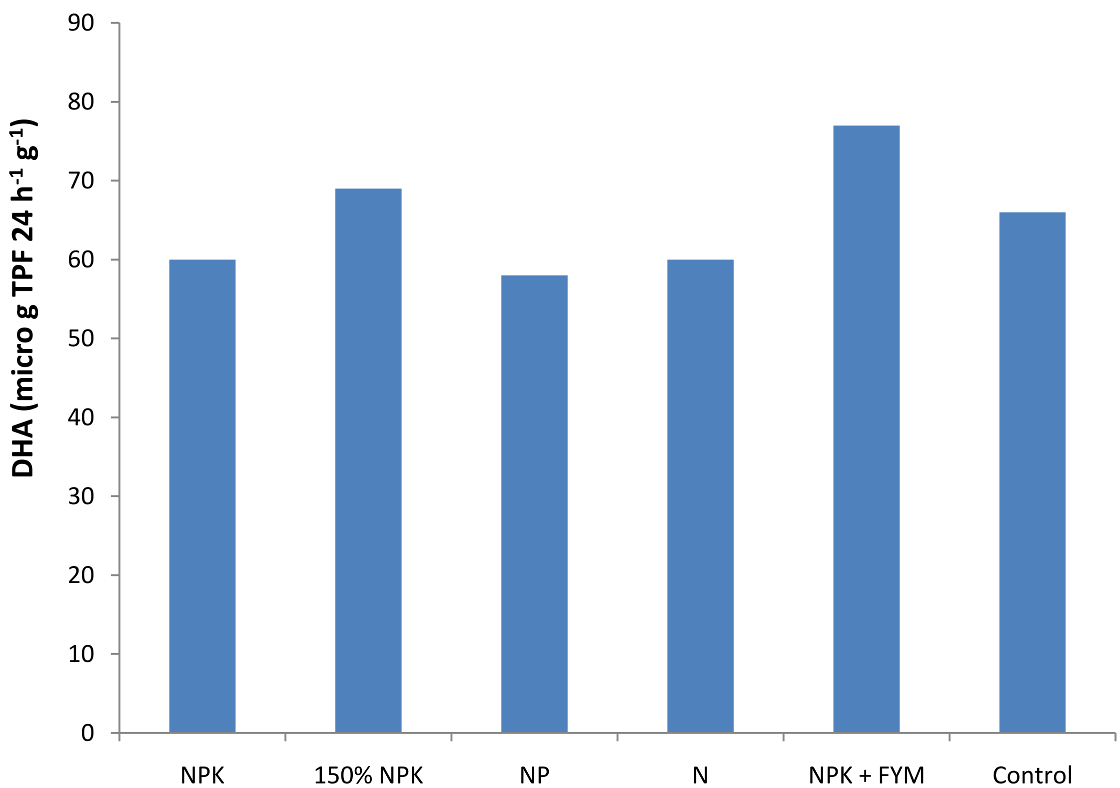

Fig 10 – Soil dehydrogenase activity during Wheat as influenced by long-term use of fertilizer and manure

(Source: AICRP-LTFE Progress Report, IARI, 2012)

3.8. Impact of INM on productivity of major crop or cropping systems

INM strategies for major crop or cropping systems are summarized in **Table3**.

Table-3: INM strategies for important crop or cropping pattern

Crop /Cropping System	IPNS strategy
Rice-Rice	Application of 75% NPK+ 25% NPK through green manure or FYM at 6 t/ha to Kharif rice and 75% NPK to Robi rice
Rice-Wheat	Application of 75% NPK+ 25% NPK through green manure or FYM at 6 t/ha to Rice and 75% NPK to Wheat
Rice-Potato	Use 75% NPK with 10 t FYM/ha in Rice and potato.
Sugarcane	Combined use of 10 t FYM/ha and recommended NPK increases the cane productivity
Pulses	FYM at 2.5 t/ha and 50% recommended NPK fertilizers +*Rhizobium* inoculation.
Oil seeds (Mustard, sunflower etc.)	Substitute 25-50% of fertilizer through 10 t FYM/ha to get higher yield
Mandarin	100% Recommended dose of chemical fertilizer along with Cow Dung show better result
Potato	75% Recommended dose of chemical fertilizer + 8 t/ha Vermicompost + *Azotobacter* and PSB
Tomato	Recommended dose of chemical fertilizer + Poultry manure/ FYM or Wheat straw
Onion	Recommended dose of chemical fertilizer + Poultry manure/ Sheep manure or Cow Dung

(Sources: Sarker, et al. 2016, Narayan, et al. 2013, Javaria, and Khan, 2011, Saddiq, et al. 2017)

3.9. Constrains in adoption of INM technology

As per expectation, this technology has not been widely adopted yet to the farmers. Due to topographic variation, circumstances, nutrient sources and markets they have different priorities. Cost of mineral fertilizers is high and those contained low amount of nutrients which act as major constrains to adopt INM among the farmers. On the other hand, low price of inorganic fertilizers, easy to apply, fast nutrient releasing capacity grow interest among the farmers to use chemical fertilizers.

The low efficiency of the extension services is also a major constrains in INM practices. In recent years, the development of non-governmental agro technological services occurs rapidly. The agro technological extension technicians generally give less time to the farmers. It is too difficult to know about INM.

Low levels of education and insufficient trainings are another constrains for transfer technologies among the farmers. To improve soil health, improvement of education level and developing awareness to the farmers can play major role to adopt INM.

CHAPTER 4
CONCLUSION

- A comprehensive effort to utilize locally available component of INM can provide a sustainable crop nutrition management. Nutrient use efficiency can be increased if we can practice INM. It also helps in maintaining environment from pollution.

- As we know that soil is the natural media for plant growth, inadequate use of inorganic fertilizers may adversely affect on soil fertility and crop production. INM shows the way to control soil health by maintaining plant nutrient organic and inorganic sources and to provide optimum and sustainable crop production.Moreover, government should take necessary steps to promote the necessity of INM to enhance the yield of good quality products.

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