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# Review on Integrated Nutrient Management on Growth and Yield of Wheat (Triticum spp) in Ethiopia

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**Abstract**
Soil fertility maintenance requires a balanced application of inorganic and organic nutrient sources. Wheat (Triticumaestivum L.) is a dominant cereal crop of north-western zone of India and it is second most common crop of the country. Ethiopia is the second largest wheat producer, after South Africa, in Sub-Saharan Africa. Wheat is one of the major staple crops in the country in terms of both production and consumption. In terms of caloric intake, it is the second--most important food in the country behind maize. Sustainable agricultural productivity might be achieved through a wise use of integrated nutrient management. Integrated use of chemical and organic fertilizer on yield and yield components of wheat is very crucial for assurance of food security. Integrated nutrient supply/management (INS) aims at maintenance or adjustment of soil fertility and plant nutrient supply to an optimum level for sustaining the desired crop productivity through optimization of benefit from all possible sources of plant nutrients in an integrated manner which includes; Maintain or enhance soil productivity through a balanced use of fertilizers combined with organic and biological sources of plant nutrients. Improve the stock of plant nutrients in the soils, and the efficiency of plant nutrients, thus, limiting losses to the environment. The integrated nutrient management system (INMS), nevertheless, remains the maintenance and possible improvement of soil fertility for sustained crop productivity on long term-basis and also to reduce inorganic (fertilizer) input cost. Different kinds of organic materials such as FYM, animal manures, green manures, crop residues, composts, and industrial wastes have been used in wheat systems. The amount and availability of nutrients in organic materials vary widely, which makes interpretation of the value of nutrients supplied. The literatures lines of research in wheat are presented in an elaborative method were reviewed in this paper.
**Keywords**: Integrated nutrient management, organic fertilizer, Chemical fertilizer Bio-fertilizer

## 1. Introduction

Wheat (*Triticum aestivum* L.) is the most important cereal crop in the World and stands next to rice in India. Wheat is one of the most important cereals cultivated in Ethiopia. It ranks fourth after Teff (*Eragrostis tef*), Maize (*Zea mays*) and Sorghum (*Sorghum bicolor*) in area coverage and third in total production (8). The share of wheat to total food grain production in India is around 37% and occupies about 24% of the total area under food grains .Wheat is the most important cereal and staple food crop of Pakistan sharing 13.7% to the value added in agriculture and 3% to GDP. It is cultivated over an area of 8303 thousand hectares (1). Over the past three decades, increased agricultural productivity occurred largely due to the deployment of high-yielding cultivars and increased fertilizer use. Due to food crises all over the world and increasing population pressure there is an urgent need to increase the quantity and improve the quality of grains. To increase the yield per unit area a variety of factors can contribute like proper and balanced dose of fertilization, irrigation, time of sowing, use of quality seed etc. The calcareous nature of soils, high pH, low organic matter, salt stress, continual drought, high bicarbonate content in irrigation water and imbalanced application of fertilizers (20; 160; 28) conducted broad study in several countries and revealed that crop yield, or soil and plant analytical data, or a combination of both indicated some degree of micronutrient deficiency, especially Zn, at all Iraqi and Pakistani study sites(15, 26).

Integrated Nutrient Management (INM) promotes the use of balanced and judicious use of chemical fertilizers in conjunction with manures like compost, far m yard manure, vermicomposting, green manures and use of fertilizers fortified with micro-nutrients, use of bio-fertilizers (e.g. phosphate solubilizing bacteria, Azospirillum, Azotobacter,Rhizobium, and Potash mobilizing bio-fertilizers) that can supplement a part of NPK fertilizers (13).

Integrated use of manures and chemical fertilizers is known to have a promising effect in arresting the decline in productivity through correction of marginal nutrient deficiencies and their positive inf1uence on the physical and biological soil proper ties. This system can bring about equilibrium between degenerative and restorative activities in the soil environment (30). Many researchers have shown that micronutrients have a promising effect on the growth and development of the crop plants. Use of micronutrients improves the quality and quantity of the agricultural produce. (23) Reported that in Pakistan Zn requirement for wheat is low (i.e., 2.0 kg Zn/ha) and Zn use enhances wheat productivity in a highly cost effective manner. They further added that contrary to the general belief, Zn content in mature wheat grain is a good indicator of soil Zn availability status. Wheat critical Zn concentration in young whole shoots ranges from 16 to 20 mg/kg; flag leaves 12 to 16 mg /kg and mature grains 20 to 24 mg/kg. Zinc deficiency is a common micronutrient disorder in arid and semiarid regions of Pakistan because of low-Zn solubility and high-Zn fixation under such soil conditions. (14) Reported that animal manures are an excellent source of plant nutrients. Approximately 70- 80 % of the nitrogen, 60-85% of the phosphorus and 80- 90 % of the potassium in feeds is excreted in the manure. He further added that manure contains all the plant nutrients needed for crop growth including trace elements. The availability or efficiency of manure utilization by a crop is determined by the method of application, time to incorporation and the rate of manure decomposition by microorganisms in soil. The objective of this paper is to review integrated nutrient management on the productivity and yield of wheat.

## 2. Literature review

In the coming decades, a major issue in designing sustainable agricultural systems will be the management of soil organic matter and the rational Use of organic inputs such as animal manures, crop residues, green manures, sewage sludge, and food industry wastes. The basic concept underlying the integrated nutrient management remains the maintenance and possible improvement of soil fertility for sustained crop productivity on long-term basis and also reduction of fertilizer inputs. In South Asia, use of organics along with fertilizers is less popular in wheat than in summer season crops like rice and maize because during winter when wheat is in the fields, mineralization of organic materials is slow. However, in wheat-based cropping systems, substantial residual effect of organic materials applied to preceding summer season crops can be observed in wheat. Different kinds of organic materials such as FYM, animal manures, green manures, crop residues, composts, and industrial wastes have been used in wheat systems. The amount and availability of nutrients in organic materials vary widely, which makes interpretation of the value of nutrients supplied by these materials a difficult task.

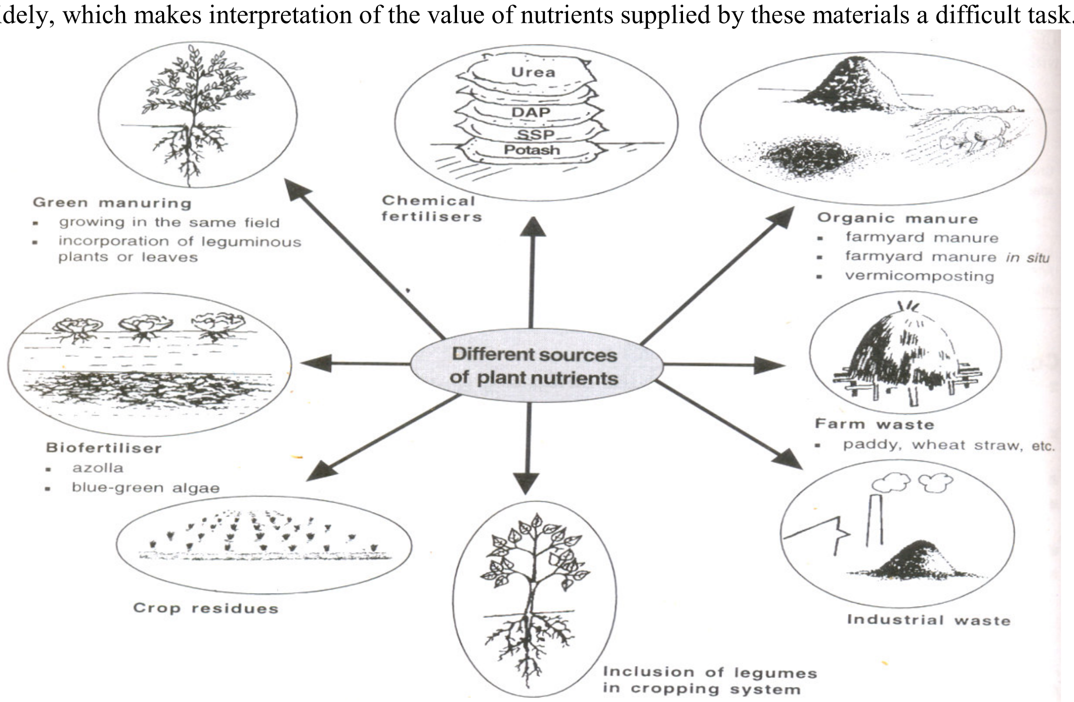


Fig. Basic components of INM in wheat

### 2.1 Farmyard manure

FYM is the most commonly used organic manure in wheat-based cropping systems in South Asia. It is generally applied to rice or maize grown in summer, but it leaves considerable residual effect in the following crop of wheat in winter. Some researchers have also attempted to find the value of FYM when it is directly applied to wheat. (4) Recorded about 27% higher wheat yield in NPK (120 kg N/ haþ26 kg P/ ha þ33 kg K/ ha) þ FYM (10 t /ha)-treated plots than in NPK plots (2.4 t /ha). Similar observations were recorded by (15), (29) applied 25% of the recommended fertilizer N to wheat through FYM and recorded yield of wheat equivalent to that produced by 100% inorganic fertilizers. In Nashipur (Bangladesh), (6) observed that application of 10 t FYM/ha along with 75% of the local fertilizer recommendation produced grain yield of wheat equivalent to 100% of the inorganic fertilizer treatment (100 kg N /haþ26 kg P/ ha þ33 kg K /ha). The application of 10 t/ ha FYM along with 100%local recommendation of NPK (120 kg N /ha þ26 kg P /ha þ25 kg K /ha) produced wheat grain yield as high as produced by 150% NPK. FYM applied to rice or maize during summer season rapidly releases nutrients, but it also has more resistant portion that is released slowly to provide a residual benefit to wheat that follows. In a rice–wheat system, the residual effect of FYM applied to rice was equivalent to 40% of N and 35% of P in the following wheat (11). Several researchers from South Asia have observed residual effects of FYM applied to rice and maize on the succeeding wheat. The application of 10 t/ha FYM along with 100% NPK (local recommendation) to maize, followed by 100% NPK to wheat recorded the highest yield of both maize and wheat in a maize–wheat sequence. The application of FYM on a calcareous soil could substitute 50% of the P requirement of rice and left a residual effect equivalent of 13.1 kg P /ha in the following crop of wheat. The grain yield of wheat grown after rice on soils amended with FYM at 12 t/ha along with 80 kg /N ha and 17.5 kg P/ ha was significantly higher than that obtained in plots where only 120 kg N/ ha and no FYM were applied to rice. In contrast to rice–wheat system, grain yield of wheat in a maize–wheat system was not influenced by application of FYM to maize. Table 1 different composition of FY manure

| Manure composition Kg/ton | | | | | | |
|---|---|---|---|---|---|---|
| Animal | Faces/urine ratio | Water % | Nitrogen | | Phosphorous $P_2O_5$ | Potassium $K_2O$ |
| Cattle | 80:20 | 85 | Faces | 2.5 | 1.3 | 0.6 |
| | | | Urine | 2.7 | | 3.7 |
| Donkey | 80:20 | 66 | Faces | 3.3 | 1.8 | 2.4 |
| | | | Urine | 2.0 | | 1.9 |
| Sheep/goat | 67:33 | 66 | Faces | 4.5 | 3.0 | 2.7 |
| | | | Urine | 4.0 | 0.2 | 6.2 |
| Chicken | 100:0 | 62 | Faces | 13.5 | 6.5 | 3.2 |
| | | | Urine | | | |
| Pig | 60:40 | 85 | Faces | 2.7 | 2.5 | 1.9 |
| | | | Urine | 2.0 | 0.3 | 1.5 |

**Source: Organic field crop handbook**

### 2.2 Poultry manure

Rate of N mineralization from poultry manure is faster than from FYM because it contains high amount of uric acid and urea substances which readily release NH4þ_N. In a laboratory study, about 45% of total in poultry manure was mineralized in 4 weeks as compared to 12% from FYM. Studies conducted (5) showed that poultry manure-N was not only as efficient as urea-Nin increasing yield and N uptake of rice but also showed significant residual effect equivalent 40 kg N/ha in wheat that followed rice. At Indore in India, (2) observed that application of 2.5 t/ha poultry manure along with 50% and 100% of the recommended dose of NPK (120 kg N/ha þ26.2 kg P/ha þ33.3 kg K/ha) continuously for five seasons in a wheat–soybean system produced on an average 4.91 and5.61 t/ha of wheat grain yield as compared to 4.74 t/ha in the 100% NPK treatment. Application of poultry manure was also found to leave a positive impact on soil health and sustainability of wheat–soybean system. In experiments conducted by (27) at Peshawar (Pakistan), maximum grain yield of wheat was recorded from the treatment in which 25% N was applied from poultry manure and 75% from fertilizer. In Bangladesh, (6) recorded significantly higher wheat yield by applying poultry manure at 10 t/ha along with 75% of the recommended NPK dose over the 100% NPK treatment. In a rice–wheat cropping system, (30) observed that application of poultry manure at 5 t/ha along with 40 kg N/ha increased rice yield and nutrient uptake similar to what was obtained with the recommended fertilizer N level of 120 kg/ha. A residual effect of poultry manure equivalent to 30 kg N/ha and 13 kg P/ha was observed in the following wheat.

### 2.3 Green manure

Green manures applied directly to wheat are generally the leaves of Leucaena left as mulch or incorporated into the field. In cropping systems such as rice– wheat and maize–wheat, green manure crops like S. aculeata, Crotolariajuncea, and Vigna unguiculata grown and incorporated into the fields before planting rice and maize leave substantial residual effect on wheat. It reported that application of subabul (Leucaenaleucocephala) leaf green manure increased wheat yield by 11.7%. (24) Observed that air-dried Leukaemia leaves applied as surface mulch at 2 t /ha and incorporated into the soil 30 days after harvest of maize significantly increased wheat grain yield. It 3.14 t/ha green Leucaena leaves containing 3% N on dry weight basis when incorporated into the soil 15 days before planting wheat increased grain yield at par with 100 kg N/ ha applied through urea. In a maize–wheat cropping system, Leucaena green leaf manure containing 3.83–4.25%Nwas applied to provide 60 kg N /ha before planting of wheat.

Wheat yields were near maximum when equal amount of N was applied through Leucaena and urea (26).

In South Asia, several workers have observed significant residual effect of green manure incorporated before planting summer season crops on the productivity of wheat grown in winter (25). In a maize–wheat rotation when different green manures were applied to maize, wheat was benefitted due to the residual effect of summer legumes to the extent of 18–23 kg N/ha after cowpea and green gram and 27 kg N/ha after Sesbania (2).

The incorporation of Sesbania green manure and mungbean residue in rice increased grain yield of succeeding wheat by 0.3–0.7 t/ ha. The assessed the effect of six legume green manures legumes in a rice–wheat system at Peshawar in Pakistan and found that average increase due to green manuring was 18.1% for grain yield and 59.7% for total N uptake by wheat crop. Sesbania green manure produced the greatest and guar (Cyamopsis tetragonoloba) the lowest increases in the grain yield of wheat.

**2.4 Crop residues**

It is being increasingly realized that crop residues are a tremendous natural resource and not waste materials that require disposal. The long-term effects of crop residue incorporation are generally expected to be beneficial, the short-term effects are often unpredictable (5) conducted a field experiment using 15N-labeled urea and found that wheat grain yield and AEN were not influenced by incorporation of rice straw at least 20 days before planting of wheat. However, N uptake and REN (difference method) were lower with rice straw incorporation than with burning of straw. Nitrogen-15 recovery by wheat was the highest (41%) when rice straw was removed or burned and the lowest (30.4%) when 30 of the 120 kg N/ha was applied at the time of straw incorporation at 20 days before planting of wheat. In the later case, 15N losses were the highest (45.2%). In a 7-year experiment conducted on a sandy loam soil, examined the effect of time of residue incorporation before planting wheat and found that residue incorporation for 10–40 days had no effect on wheat yields. Starter N applied at residue incorporation did not influence wheat yields but decreased REN. It also reported similar residue management effects on wheat yield and observed that incorporation of rice straw 3 weeks before wheat planting significantly increased wheat yield on clay loam soil but not on sandy loam soil. (5) Reviewed the literature on crop residue management and found that incorporation of 3–7.9 t /ha rice residue 10–40 days before planting wheat significantly increased yield of wheat only in 1 of 14 data sets examined from South Asia. As most of the studies on rice straw management were conducted at recommended N levels, it was not easy to quantify the contribution of rice straw in supplying N to plants in the cropping system. (29) Incorporated rice straw (5 t/ ha dry weight) 30 days before the planting of wheat and could record significantly lower grain yield than the removal or burning of straw in the first 2 years. The treatment with no rice straw incorporation and application of recommended doses of fertilizer (120 kg N /ha, 26kgP/ha, and 50 kg K/ha) produced the highest yield of wheat. Treatments with the incorporation of rice straw at 5 t /ha with additional 60 kg N/ha produced grain yield similar to that in the treatment with no straw incorporation. The incorporation of crop residue can have adverse effects on the following crop (3), although in some studies the negative effects of residue incorporation in a rice–wheat cropping system diminished after a few initial years (9). In the study carried out by (3), the negative effects due to immobilization of N by the decomposing residue were not reversed even after 11 years. As immobilization of N is temporary, and N can be released during the cropping season through mineralization, the optimal distribution of fertilizer N during the growing season to synchronize N supply with N need by the crop can differ when crop residue is incorporated (30).

**2.5 Composts and press mud cake**

Composting of organic manures increases the nutrient content, reduces the bulk to be handled per unit of nutrients, and offers a potential for the utilization of low solubility materials such as phosphate rocks. (21) Prepared P-enriched phosphor compost from crop residues, animal feed wastes, grasses, weeds, tree leaves cattle dung, biogas slurry, and Mussoorierock phosphate. It contained between 2.6% and 3.5% P. The N content was relatively low (0.82%) due to dilution effect. In field trials, phosphor compost was found to be comparable to superphosphate in increasing grain yield of wheat (21). The compost from paddy straw using urea and Mussoorie rock phosphate for N and P enrichment is important. Inorganic N was partly conserved in the compost by the addition of pyrite. Compost containing about 1.6% total N and 3.3% total P was found to be a good source of P for a wheat crop and could supply significant amount of N to the plants. Significant amount of press mud cake is produced from the sugar industries in South Asia. Press mud cake produced from the sugar industries employing suffixation process contains about 1.8–2.25% N, 0.8–1.2% P, and 0.4–0.6% K in addition to several micronutrients. Experiments conducted in the Indian Punjab showed that application of press mud cake (5 t/ha, dry weight basis) along with 60 kg N/ha produced rice grain yield equivalent to that produced in the recommended fertilizer treatment of 120 kg N/ha.

**2.6 Cereal-legume intercropping or rotation**

Inclusion of legumes intercropping or m rotation offers considerable benefits because of their ability to fix atmospheric nitrogen biologically m symbiosis With Rhizobium. There are two main types of mechanisms postulated for the beneficial effects of legumes m multiple cropping systems (1) through Immediate transfer, m which nitrogen travels from the legume directly to the associated crop, and (2) through residual effects Which nitrogen fixed by the legume is available to an associated sequentially cropped non-legume after senescence of the legume and decomposition of Its organic residue. Although some research workers have reported evidence of direct transfer of N m a maize/cowpea intercrop it is believed that N benef1ts of these systems may accrue more to subsequent crops after root and nodule senescence and decomposition of fallen leaves. It is generally known that soil conditions, such as P, Ca and Mo deficIenc1es, Al and Mn tox1c1tles, and drought stress are limiting factors for N2 fixation.

Fig. intercropping wheat with leguminous crops

**2.7 Bio fertilizers**

The quantity of organic matter in the soil is a major indicator of latter's quality. To achieve higher grain yield, we should apply chemical, bio and organic fertilizers. For sustainability, it is important to incorporate bio-organisms and organic matter into the soil. (16)The improve soil quality we should treat our organic matter like a bank account. A bank account lets us deposit, save, and withdraw something we value. For sustainability, it is important to deposit in the account active bio-fertilizers along with organic matter in the soil on a regular basis, thereby, building cultural fertility. (22) Summarized that long term experiments are essential in determining the factors affecting soil fertility and sustainable production. The use of non-symbiotic nitrogen fixer, Azotobacter spp, as a bio-inoculant is known to benefit a wide variety of crops due to its properties like nitrogen fixation, secretion of growth promoting substances, vitamins and antifungal metabolites and phosphate solubilisation (19). Bio fertilizers are considered as the most important factor in reducing the application of chemical nitrogen fertilizers and minimizing the induced environmental pollution such as those resulted from nitrogen losses (volatilized NHþ4 and/or leaching $NO_{-}^{3}$). Hence, an increasing attention is being paid to biological N2 fixation to meet the N requirements (7) and improve the soil fertility status to sustain crop yield (21)

**2.8 Chemical fertilizers**

A fertilizer is any material, organic or inorganic, natural or synthetic, that supplies plants with the necessary nutrients for plant growth and optimum yield. Inorganic fertilizers are mined from mineral deposits with little processing (e.g., lime, potash, or phosphate rock), or industrially manufactured through chemical processes. Inorganic fertilizers vary in appearance depending on the process of manufacture. The particles can be of many different sizes and shapes (crystals, pellets, granules, or dust) and the fertilizer grades can include straight fertilizers (containing one nutrient element only), compound fertilizers (containing two or more nutrients usually combined in a homogeneous mixture by chemical interaction) and fertilizer blends (formed by physically blending mineral fertilizers to obtain desired nutrient ratios).

The general recommendations are given as a range: low rates for fertile soils and high rates for fields with poor soil fertility. It is recommended to broadcast and mix with the soil half N and all P and K before planting wheat. Phosphorus can be applied at the first irrigation if not applied at planting. The remaining half N is top dressed with the first or second irrigation. On light-textured soils, it is recommended to apply N in three splits. For late-planted wheat, application of all the fertilizers at planting is recommended. Potassium should be applied as per soil analysis (10). Increase in fertilizer use mirrors the gains in productivity, but to maintain production in the years to come, efficient management of nutrients supplied by fertilizers will assume more importance than the quantity of nutrients applied to wheat. Lower rates, split application, banding) of inorganic fertilizers on the infertile kaolinitic and oxide Solis are needed to sustain high crop Yield and maintain an optimum balance of nutrient in agro ecosystems Published results have shown that continuous use of relatively high rates of nitrogen fertilizers on kaolinitic Alfisols, especially under cereal monoculture, can reduce soil pH (acidification) and seriously degrade soil fertility. Acidification occurs manly through the leaching loss of exchangeable bases (Ca, Mg, and K) and acid production during Al hydrolysis and nitrification. The primary macro nutrients are NPK discussed below.

**2.8.1 Nitrogen**

Among forms of N, nitrate is the most susceptible to leaching, ammonium the least, while urea is moderately susceptible. Ammonium and urea are more susceptible to volatilization loss of N as ammonia than the fertilizer materials containing nitrate. Urea is the major source of fertilizer N for wheat systems in the South Asia. Small quantities of calcium ammonium nitrate (CAN), ammonium chloride and ammonium sulphate are also available to farmers growing wheat. One of the major reasons for low N use efficiency in wheat is inefficient splitting of N doses. Fertilizer N needs to be applied at growth stages when N demand of the crop is the highest. To be able to match supply with demand, it is important to identify the periods of high N requirement. Nitrogen uptake of irrigated wheat proceeds very slowly until tillering begins; the N flux (kg N/ha/day) increases to maximum during the jointing stage. Thus, rapid N uptake by wheat starts from beginning of stem elongation or Zadoks stage. Time of fertilizer N application in irrigated wheat depends not only upon N demand but also on the specific irrigation schedule that is followed. As efficient N use is central to eco-efficiency in agriculture, it is important to work out fertilizer N doses that will not only produce high yields of wheat per unit area but also result in minimal environmental impacts while remaining economically attractive to farmers. (3) Observed greater decline in wheat yield at a low rate of N application (0.5 t/ ha decline at 60 kg N /ha) than at a high rate of N application (0.08 t/ ha decline at 180 kg N /ha).

**2.8.2 Phosphorus**

Presently, DAP is the major source of P used in wheat in South Asia; it accounts for nearly 65% of the P used in India. The other sources of P are SSP, ammonium nitro phosphates (ANP), and compound fertilizers. The efficiency of a P source varies depending upon proportion of water soluble P and soil properties such as pH. In neutral to alkaline soils, materials containing water-soluble P have proved more efficient than materials containing citric acid-soluble or citric acid-insoluble P (5). Mono ammonium phosphate and DAP—the two fully water-soluble P sources—were found to be equally efficient in supplying P to wheat. On highly calcareous soils of north India, the efficiency of P sources decreased with decreasing water-soluble P content in the fertilizer (20). In South Asia, fertilizer P is generally broadcasted on soil surface followed by soil incorporation before planting of wheat. It results in conversion of soluble P to insoluble forms and thus reduces its use efficiency. Fixation of broadcasted P is greater than when fertilizer is applied in bands because of reduced contact with soil.

Table 2: mean yield and yield components of wheat variety Inqlab-91 as affected by different levels of phosphorous

| Treatments | NP kg/ha | Germination count m2 | Fertile tillers m | Grain per spike | 1000grains wt(g) | Yield (kg/ha) |
|---|---|---|---|---|---|---|
| T1 | 128-32 | 148.5 | 292.5 | 24 | 40.03 | 3142c |
| T2 | 128-42 | 156.00 | 304.00 | 25.50 | 40.78 | 3286b |
| T5 | 128-84 | 176.50 | 328.00 | 22.5 | 42.49 | 3251b |
| T4 | 128-96 | 155.00 | 302.50 | 25.5 | 40.31 | 3204b |
| T5 | 128-128 | 162.50 | 319.50 | 26 | 44.01 | 3558a |
| | | NS | NS | NS | NS | |

Sources; Kaleem *et al,* 2009

**2.8.3 Potassium**

Muriate of potash (KCl) is the major fertilizer K source for wheat because of its low cost and high K analysis. At planting of wheat, fertilizer K is generally applied by drilling, placement or broadcast followed by incorporation (5). Application of full dose of K at planting of wheat is the commonly followed practice in South Asian wheat-growing regions. As sustained supply of K is necessary up to heading stage, split application of fertilizer potassium in wheat in coarse-textured soils may give higher K use efficiency than its single application due to reduction in leaching losses and luxury consumption of K have cited several references showing a distinct benefit of applying fertilizer K in split doses. In a sandy loam soil, obtained a wheat yield advantage of 440–490 kg grain/ ha by split application of fertilizer K over single application.

**2.8.4 Micronutrients**

For high yields, Mn and Zn may be in short supply in neutral to alkaline soils and Cu on sandy soils. Zn deficiency is generally a problem in coarse-textured soils under intensive cropping. Here, an application of zinc sulphate of 62.5 kg/ha once every 2–3 years is suggested. Zn deficiency can also be corrected by spraying 0.5-percent zinc sulphate (at a per-hectare rate of 2.5 kg zinc sulphate and 1.25 kg unslaked lime dissolved in 500 litres water). Generally, 2–3 sprays at 15–day intervals may be needed. In Mn-deficient soils, foliar spray with 0.5- percent manganese sulphate solution 2–4 days before the first irrigation and again 2–3 times at weekly intervals can be done on sunny days.

However, microelements such as Fe, Zn, Mn and Cu are also added to foliar fertilizers used throughout the world as effective measure to compensate their deficiency. This has special importance in arid and semi-arid regions where osmotic pressure promotes the absorption and activity of these elements influenced by the plant behaviour and the foliar application timing (25).

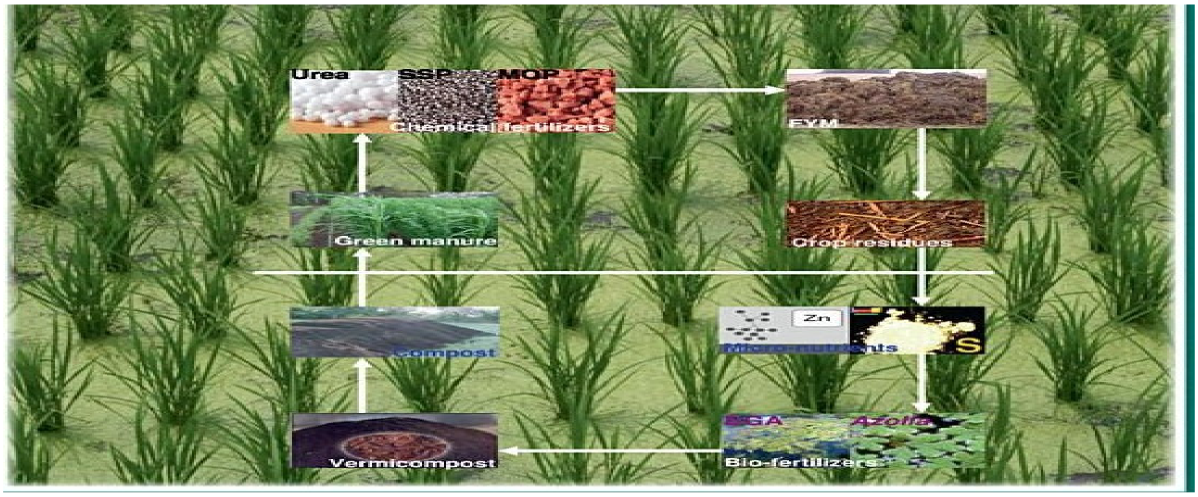


Fig different combination and application forms of components of INM in wheat

## 3. Summary and Conclusion

Integrated soil fertility management plays a critical role in both short-term nutrient availability and longer-term maintenance of soil organic matter and sustainability of crop productivity in most smallholder farming systems in the tropics. The two year result showed that the integrated application of organic and inorganic fertilizers improved productivity of wheat and teff as well as the fertility status of the soil. Nevertheless, though ISFM is the notably preferred option in replenishing soil fertility and enhancing productivity, it is not yet widely taken up by farmers. The reasons for this are many, which include access or availability of inputs, use of organic resources for other purposes in place of soil fertility, nutrient balancing, collecting, transporting and management of organic inputs and economic returns of investments. These are the key challenges of adoption in the scaling up of such alternative soil fertility management practices to millions of small-scale farmers in the highlands of the country. There is a need, therefore, for research and extension to sort out issues of adoption and scaling up of the available options. In order to address soil fertility problems, potential synergies can be gained by combining technical options with farmers' knowledge as well as training of farmers and development agent on new soil fertility management approaches. The application of organic and inorganic fertilizers can increase average wheat yields to 6-7 tons $ha^{-1}$. Wheat yields are highest (9.4 tons $ha^{-1}$) when farmyard manure is applied, wheat is grown in rotation and inorganic fertilizers are used to top-up N availability.

Therefore, integrated ways of nutrient management on wheat crop have multipurpose on the improvement of soil fertility and crop productivity in the sustainable manners. It is also important for the improvement of soil chemistry, physics and soil biology before application for a long period of crop season. It is commonly believed that the combination of organic and inorganic fertilizer will increase synchrony, enhancing the efficiency of the fertilizers, and reduce losses by converting inorganic nitrogen (N) into organic forms but also reducing environmental problems that may arise from their use.

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## 4. Reference


1. Anonymous. 2005. *Agriculture Statistics of Pakistan* Govt. of Pakistan, Ministry of Food, Agric. and Livest, Econ.Wing, Islamabad
2. Behera, U.K., Sharma, A.R., Pandey, H.N., 2007 Sustaining productivity of wheat–soybean cropping system through integrated nutrient management practices on the Vertisols of central India Plant Soil 297, 185–199
3. Beri, V., Sidhu, B.S., Bahl, G.S., Bhat, A.K., 1995 Nitrogen and phosphorus transformations as affected by crop residue management practices and their influence on crop yield. Soil Use Manage. 11, 51–54.
4. Bhattacharyya, R., Pandey, S.C., Chandra, S., Kundu, S., Saha, S., Mina, B.L., Srivastva, A.K., Gupta, H.S., 2010. Fertilization effects on yield sustainability and soil properties under irrigated wheat–soybean rotation of an Indian Himalayan upper valley. Nutr. Cycl. Agroecosyst. 86, 255–268.
5. Bijay-Singh, Varinderpal-Singh, Yadvinder-Singh, Thind, H.S., Ajay-Kumar, Satinderpal-Singh, Choudhary, O.P., Gupta, R.K., Vashistha, M., 2013. Supplementing fertilizer nitrogen application to irrigated wheat at maximum tillering stage using chlorophyll meter and optical sensor Agric. Res. 2, 81–89
6. Bodruzzaman, M., Meisner, C.A., Sadat, M.A., Hossain, M.I., 2010. Long-term effects of applied organic manures and inorganic fertilizers on yield and soil fertility in a wheat-rice cropping pattern. In: Proceedings of the 19th World Congress of Soil Science, Brisbane, Australia, pp. 142–145.

7. Canbolat, M.Y., Kenan, B., Ramazan, C. & Fikkrettin, S. (2006) Effect of mineral and bio-fertilizers on barley growth on compacted soil. J. Soil Plant Sci. 56, 324–332.
8. CSA, 2007. Agricultural sample survey: Report on area and production for major crops. Statistical Bulletin 388.Addis Ababa, Ethiopia.
9. Dhiman, S.D., Nandal, D.P., Om, H., 2000 Productivity of rice (Oryza sativa)-wheat (Triticum aestivum) cropping system as affected by its residue management and fertility levels. Indian J Agron 45, 1–5.
10. FAO 2004b Use of phosphate rocks for sustainable agriculture. FAO Fertilizer and Plant Nutrition Bulletin No. 13. Rome.148 pp
11. Gill, H.S., Meelu, O.P., 1982 Studies on the substitution of inorganic fertilizers with organic manure and their effect on soil fertility in rice-wheat rotation. Fertil. Res. 3, 303–314.
12. GOIMoA (Government of India Ministry of Agriculture). (2013) State of Indian Agriculture 2012-13(Ed M-G of India). Indian Offset Press, New Delhi
13. Herbert, S.J. 1998. Deptt. Of Plant and Soil Sci., Univ. of Massachusetts Amherst Crops, Dairy, Livestock News. 3:1.
14. Jabbar, S.M.A., Begum, M.M., Cruz, P.C.Sta., Harun-ur-Rashid, M., 2008. Evaluation of Different nutrient management practices for wheat-rice cropping system under agro ecological zone 1 in Bangladesh. Philippine Agric. Sci. 91, 269–277.
15. Khan, M.Z., M.E. Akhtar, M.N. Safdar, M.M. Mahmood, S. Ahmad and N. Ahmed 2010 Effect of source and level of potash on yield and quality of potato tubers. *Pak. J. Bot.*, 42(5): 3137-3145. Lindsay, W.L. 1979. *Chemical Equilibrium in Soils* John Wiley and Sons: New York. p. 449
16. Koopmans C. and Goldstein W 2001 Soil organic matter budgeting in sustainable farming with applications to southeastern Wisconsin and northern Illinois Bulletin No 7, Michael Fields Agricultural Institute, 39p
17. Kumar, A., and Yadav, D.S., 1995. Use of organic manure and fertilizer in rice (Oryza sativa) Wheat (Triticum aestivum) cropping system for sustain ability. Indian J. Agric. Sci 65, 703–707.
18. Malakouti, M.J. 2008 The effect of micronutrients in ensuring efficient use of macronutrients. *Turk. J. Agric. For*., 32:215-220.
19. Mishustin EN and Shkinova VK 1971. Biological nitrogen Fixation of Atmospheric Nitrogen, Macmillan Press Ltd, London
20. Mishra, M.M., 1992. Enrichment of organic manures with fertilizers In: Tandon, H.L.S. (Ed.), Non-Traditional sectors for Fertilizer Use. Fertilizer Development and Consultancy Organization, New Delhi, India, pp. 48–60.
21. Mostafa, G. & Abo-Baker, A.A. (2010) Effect of bio and chemical fertilization on growth of sunflower (Helianthus annuus L.) at south valley area Asian J. Crop Sci. 2, 137–146.
22. Poulton PR 1995. The importance of long-term trials in understanding sustainable farming systems: the Roth Amsted experience. Australian Journal of Experimental Agriculture 35:825-834
23. Rafique, E. and A. Rashid 2006. Zinc deficiency in rain-fed wheat in Pakistan: magnitude, spatial variability, management and plant. Analysis diagnostic norms *Comm. in Soil Sci. & Plant Analysis*, 37: 181-197
24. Sharma, A.R., Behera, U.K., 2010 Green leaf manuring with prunings of Leucaena leucocepala for nitrogen economy and improved productivity of maize (Zea mays)– wheat (Triticum aestivum) cropping system. Nutr. Cycl. Agroecosyst. 86, 39–52.
25. Shehata, S.M., Abdel-Azem, H.S., Abou El-Yazied, A. & El-Gizawy, A.M. (2010) interactive effect of mineral nitrogen and biofertilization on the growth, chemical composition and yield of Celeriac plant. Eur. J. Sci. Res. 47, 248–255.
26. Sillanpaa, M. 1990. Micronutrient assessment at the country level: An international study. The Government of Finland (FINNDA) Food & Agric. Org. of the United Nations, Rome, Italy.
27. Shah, A.Z., Shah, S.M., Mohammad, W., Shafi, M., Haqnawaz, Shehzadi, S., Amir, M. 2010. Effect of integrated use of organic and inorganic nitrogen sources on wheat yield.Sarhad J. Agric. 26, 559–563
28. Thuy, N.H., Shan, Y., Bijay-Singh Wang, K., Cai, Z., Yadvinder-Singh, Z., Buresh, R.J., 2008. Nitrogen supply in rice-based cropping systems as affected by crop residue management. Soil Sci. Soc. Am. J. 72, 514–523.
29. Verma, T.S., Bhagat, R.M., 1992. Impact of rice straw management practices on yield, nitrogen uptake and soil properties in a wheat–rice rotation in northern India. Fertil. Res. 33, 97–106.
30. Yadav, D.S. & Kumar, A. (2009) Long-term effect of nutrient management on soil health and productivity of rice (Oryza sativa)-wheat (*Triticum aestivum*) system. Indian Journal of Agronomy, 54, 15–23.