



The Effect of Organic and Inorganic Fertilizers on Growth and Yield of Bread Wheat (*Triticum aestivum* L.)

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Abstract

Wheat (*Triticum aestivum* L.) is a dominant cereal crop of north-western zone of India and it is second most common crop of the country. It is also one of the major staple crops in many the country in terms of both production and consumption. Soil fertility maintenance requires a balanced application of inorganic and organic nutrient sources. Sustainable agricultural productivity might be achieved through a wise use of integrated nutrient management. Integrated use of 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: Bio-fertilizer; Integrated nutrient management; organic fertilizer; Inorganic fertilizer

Introduction

Wheat (*Triticum aestivum* L.) is the most important cereal crop in the World and stands next to rice in India. Production of wheat in Ethiopia ranks fourth after Teff, Maize and Sorghum, and third in total production CSA [1]. Increased agricultural productivity occurred largely due to the development of high-yielding cultivars and increased fertilizer use. The food crises all over the world and increasing population pressure demand urgent need to increase the quantity and improve the quality of grains. To meet the demand yield increase per unit area can be achieved by 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 micronutrient

deficiency, especially Zn, at all Khan et al. [15] could affect wheat yield and quality.

Moreover, integrated Nutrient Management (INM) promotes the use of balanced and judicious use of chemical fertilizers in conjunction with manures like compost, farmyard manure, vermicomposting, green manures and use of fertilizers fortified with micro-nutrients, use of bio-fertilizers that can supplement a part of NPK fertilizers Herbert [2] as referred to by Habtamu Deribe et al. [3] Judicious use of FYM with chemical fertilizers improves soil physical, chemical and biological properties and improves the crop productivity Sharma et al. [4]. Application of organic manures may also improve availability of native nutrients in soil as well as the efficiency of applied fertilizers Sawrup 2010). Organic materials,

such as green manure (GM), crop residues and animal manure, and their continuous use have a strong influence on soil productivity and agronomic efficiency of wheat crop and N dynamics in the soil-plant system Schmidt 2004). Among different sources of organic manures, vermi-compost is most important source and used since long as a nutrients supplement to crop production. Use of micronutrients improves the quality and quantity of wheat. Rafique et al. [5] 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. Zn content in mature wheat grain is a good indicator of soil Zn availability status to plants.

Objective

To review the effect of integrated nutrient management on growth and yield of wheat.

Literature Review

Sustainable agricultural systems wheat requires management of soil organic matter, crop rotation, 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 for wheat remains the maintenance and possible improvement of soil fertility for sustained wheat productivity on long-term basis and also reduction of fertilizer inputs. 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 Yadav et al. [6]. 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 Habtamu Deribe et al. [3].

The Effect of Farmyard Manure on Growth and Yield Of Wheat

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. Similar observations were recorded by Khan et al. [7] 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 Bangladesh Bodruzzaman et al. [1] 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 / ha, 26 kg P / ha, 33 kg K / ha). The application of 10 t/ha FYM along with 100% local recommendation of NPK (120 kg N /ha, 26 kg P /ha and 25 kg K /ha) produced wheat grain yield as high as produced by 150% NPK. 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 Bodruzzaman et al. [8].

Effect of Poultry Manure on Growth and Yield Wheat

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 $\text{NH}_4\text{-N}$. In a laboratory study, about 45% of total in poultry manure was mineralized in 4 weeks as compared to 12% from FYM. Bijay-Singhet al. [9] showed that poultry manure-N was not only as efficient as urea-N in increasing yield and N uptake of rice but also showed significant residual effect equivalent 40 kg N/ha in wheat. 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 Shah et al. [10] 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, Bodruzzaman et al. [8] 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. A residual effect of poultry manure equivalent to 30 kg N/ha and 13 kg P/ha was observed in the following wheat.

Effect of Green Manure on Growth and Yield of Wheat

Green manures applied directly to wheat are generally the leaves of *Leucaena* left as mulch or incorporated into the field. Application of *Leucaena leucocephala* increased wheat yield by

11.7%. About 3.14 t/ha green *Leucaena* leaves containing 3% N on dry weight basis when incorporated into the soil 15 days before planting increased wheat 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%N was applied to provide 60 kg N/ha before planting of wheat. 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 Shehata et al. [11]. 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* Behera et al. [12].

The Effect of Crop Residues on Growth and Yield Wheat

The long-term effects of crop residue incorporation are generally expected to be beneficial; the short-term effects are often unpredictable. 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 Verma et al. [13]. 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. Although in some studies the negative effects of residue incorporation in a rice-wheat cropping system diminished after a few initial years Dhiman et al. [14]. 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 Yadav et al. [6].

Composts

The effect of composts on growth and yield of wheat

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 Mostafa et al. [15]. P-enriched phosphor compost from crop residues, animal feed wastes, grasses, weeds, tree leaves cattle dung, biogas slurry, and Missouri rock phosphate the wheat yield. Phosphorus compost was found to be comparable to superphosphate in increasing grain yield of wheat Mostafa et al. [15]. The compost from paddy straw using urea and Missouri 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 Mostafa et al. [15].

The effect of cereal-legume intercropping on growth and yield wheat

Inclusion of legumes intercropping or rotation offers considerable benefits because of their ability to fix atmospheric nitrogen biologically in symbiosis with *Rhizobium*. There are two main types of mechanisms postulated for the beneficial effects of legumes in multiple cropping systems Anonymous [16] through immediate transfer, which nitrogen travels from the legume directly to the associated crop, and Behera et al. [12] 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 maize/cowpea intercrop it is believed that N benefits 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 deficiencies, Al and Mn toxicities, and drought stress are limiting factors for N₂ fixation Habtamu Deribe et al. [3].

The effect of Bio Fertilizers on growth and yield of wheat

The quantity of organic matter in the soil is a major soil quality indicator. To achieve higher grain yield, we should apply chemical, bio and organic fertilizers. For sustainability, it is important to incorporate bio organisms and organic matters into the soil Koopmans et al. [17]. To improve soil quality we should treat our organic matter like a bank account. 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. Poulton [18] 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 bio-inoculants 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 Mishustin et al. [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 NH₄ and/or leaching NO₃). Hence, increasing attention is being paid to biological N₂ fixation meet the N requirements Canbolat et al. [5] and improve the soil fertility status to sustain crop yield Mostafa et al. [15].

The effect of chemical fertilizers on growth and yield of wheat

For late-planted wheat, application of all the fertilizers at planting is recommended. Potassium should be applied as per soil analysis (FAO, 2004). 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 kaolintic and oxide Solis are needed to sustain high crop yield and maintain an optimum balance of nutrient in agro ecosystems(FAO, 2004).

The effect of nitrogen fertilizer on growth and yield of wheat

Ayoub et al. [20] reported the increase in yield and yield parameters of wheat with the increase in successive N levels from 0, 60, 120 and 180 kg N ha⁻¹. Increase in grain yield was from 27 to 81 % at N rates of 120 and 180 kg ha⁻¹, respectively. Gelato et al. [21] reported that grain and biomass yield and most grain yield components increased by increasing N rate. Frederick et al. [22] reported the influence of N rates on yield and yield associated traits of wheat on irrigated fields. They reported significant increase in grain yield with 135 kg N ha⁻¹. Singh et al. [23] reported that the application of N recorded more grain and straw yield of and wheat over control. Rajender et al. [23] reported that there was a linear rise in grain yield and straw yield with every additive dose of NPK fertilizer up to 120-60-40 kg NPK/ha.

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. 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. Beri et al. [24] 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).

The effect of phosphorus fertilizer on growth and yield wheat

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 Bijay-Singhet al. [9]. Mono ammonium phosphate and DAP the two fully water-soluble P sources-were found to be equally efficient in supplying P to wheat. 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 Bijay-Singh et al. [9].

The effect of potassium fertilizer on growth and yield wheat

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 Bijay-Singh et al. [9]. 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 Bijay-Singh et al. [9].

The effect of micronutrients on growth and yield wheat

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 Shehata et al. [11]. 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 behavior and the foliar application timing Shehata et al. [11].

Effect of integrated nutrient management on growth and yield wheat

In experiments conducted by Shah et al. [25-29] 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, Bodruzzaman et al. [8] 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. A residual effect of poultry manure equivalent to 30 kg N/ha and 13 kg P/ha was observed in the following wheat [30-37].

In Bangladesh, Bodruzzaman et al. [8] the application of 10 t/ha FYM along with 100% local recommendation of NPK (120 kg N /ha, 26 kg P /ha and 25 kg K /ha) produced wheat grain yield as high as produced by 150% NPK. 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.

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 many research results showed that the integrated application of organic and inorganic fertilizers improved productivity of yield as well as the fertility status of the soil. Application of Organic manures along with mineral fertilizers led to the greatest increase in NPK and nutrients uptake and wheat yield. These results imply that the integrated use of mineral fertilizers and organic manures represents a sound practice for sustaining NPK reserves in soil and hence enhancing NPK availability in wheat. The application of organic and inorganic fertilizers can increase average wheat yields to 6-7 tons ha⁻¹. Wheat yields are highest 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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