



IMPACT OF INTEGRATED NUTRIENT MANAGEMENT ON WHEAT PRODUCTIVITY AND SUSTAINING SOIL FERTILITY: A REVIEW

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ABSTRACT

Soil fertility and nutrient management is one of key factor of crop production, which directly affects the crop yield and quality. Wheat is one of the most important leading crops in India and Afghanistan. The grain revolution through adoption of modern methods and technology such as the use of high yielding variety, tractors, irrigation facilities, pesticides, and fertilizers resulted higher crop productivity. But in long run due to intensive cropping, use of heavy machineries, synthetic herbicides, pesticides and chemical fertilizers negatively affected the soil fertility and crop productivity through problems of soil erosion, loss of top fertile soil, soil compaction, soil toxicity, salinity of underground water, which further caused human and animals diseases, global warming, etc. organic manures such as FYM, compost, vermicompost, poultry manure, sheep and good manure, etc. as a natural product serves as a good reservoir of nutrient and water in soil which reduces the soil compaction, surface crusting, increase soil infiltration, reduce soil erosion, improves soil structure, encourages the growth and population of beneficial soil microorganisms, increase nutrient availability for crop growth and detoxify the hazardous chemicals in soil. Overall these manures are rich in micro and macro nutrients, vitamins, enzymes, antibiotics and growth hormones. Further all these traits contribute to soil, plant, animal and human health. Since organic manures contains small percentages of nutrients in bulk and cannot be found in sufficient amount to fully respond nutrient requirement of crop. Thus integrated use of organic and inorganic fertilizer not only sustains the crop yield and increases the soil fertility in long term, but it also enhances the nutrient use efficiency. Therefore to maintain the soil sustainability and increase wheat productivity in long term, a balanced and integrated use of organic and inorganic fertilizer is the best option.

KEY WORDS: *Integrated Nutrient Management, Soil Fertility, Wheat.*

INTRODUCTION

Cereals are the most important sources of protein and energy supply in most of the countries. Wheat (*Triticum aestivum* L.) with its main unique protein is one of the main winter cereal crops in India and Afghanistan. India produces 97.44 million tons of wheat from an area of 30.72 million hectare with an average productivity of 3172 kg ha (Anonymous, 2017). Wheat is one of the staple foods of Afghanistan which a large part of this crop is grown in the Northern provinces with the majority of the crop being dependent on seasonal precipitation. Afghanistan is producing 4.26 million tons of wheat from 2.55 million ha with an average productivity of 1765 kg ton ha. The average wheat production in Afghanistan is very low which can be due to poor plant protection measures, imbalance nutrition, lack of drought resistant and high yielding varieties and substandard method of cultivation (FAO, 2015). Nitrogen is one of the major essential elements which influence the growth, yield and quality of wheat more than any other single nutrient element. Indian and Afghanistan soils are deficient in nitrogen which this deficiency limits the crop production in both countries.

Many researchers found that the wheat yield and quality has been increased with increasing the level of nitrogen to a certain limit. Lower dose of nitrogen results reduced yield, while the excessive use of nitrogen fertilizer makes wheat plant susceptible to diseases. Intensive agriculture involving high yielding varieties of cereals, particularly wheat exploits large amount of nitrogen from agricultural soil every year. The recent scenario for application of nitrogen fertilizer in wheat is to increase environmental quality, minimize the cost of production, improve soil fertility and sustain productivity of wheat. Continuous and imbalance application of nitrogen fertilizers through inorganic sources causes health and environmental problems, which ultimately results more nitrogen losses (Fan *et al.*, 2005). Further high cost of inorganic fertilizer increases the cost of cultivation for small holding farmers.

The use of inorganic fertilizers for the past 50 years without any addition of organic manures resulted in large scale deficiency of micro nutrients which play an important role in enhancing the quality and quantity of the agriculture produce. Further, nutrient losses in inorganic fertilizer is very high and loss of nutrients like NO_3



some time leads to water pollution. Looking at all the above facts it is very much essential to find out the alternative to the chemical fertilizers which maintain the soil fertility and enhance the productivity of crops. Under such situation the use of organic manures in agriculture play an important role. Due to depletion of soil fertility the demand for organic manure is growing day by day. In India, sufficient amount of organic manures like crop residues (603.5 mt), animal dung manure (791.6 mt), rural compost (148.3 mt), green manure (4.50 m ha⁻¹), city compost (12.2 mt) and bio-fertilizer (0.41mt) are available (Bhattacharya and Chakraborty, 2005). Therefore for maintaining soil fertility, producing healthy food, keeping the environment clean and sustaining crop productivity these organic wastes can be a good substitute for chemical fertilizers.

Joshi and Prabhakarasetty (2006) reported that application of farm yard manure results in improved crop yields, microbial activity, soil physical properties, nutrient availability, and had direct residual effects to succeeding crops. Ranwa and Singh (1999) declared that application of FYM @ 10 t ha⁻¹ produced significantly higher yield over control, but remained at par with application of vermicompost 5 t ha⁻¹. Vermicompost contains the vital macro nutrients viz., N, P, K, Ca, Mg and micronutrients such as Fe, Mo, Zn, Cu etc. Apart from this, it also contains plant growth promoting substances like NAA, cytokinins, gibberellins etc. (Giraddi, 1993.) Vermicompost contains considerable amount of nutrients, a large beneficial microorganisms and biologically active metabolites, particularly gibberellins, cytokinins, auxins and group B vitamins which can be applied alone or in combination with organic or inorganic fertilizers Bhawalker, (1991). Among bulky organic manures poultry manure contains higher percentage of nitrogen and phosphorous (Malone *et al.*, 1992). Nahm, (2005) stated that the nitrogen content in poultry manure is produced through combination of recalcitrant organic nitrogen and uric acid, which is rapidly converted to NH₄⁺-N, given appropriate conditions for microbial activity and current uric acid hydrolysis. Therefore the amount of NH₄⁺-N in poultry manure would change rapidly after the manure is land-applied. Singh *et al.* (2001) observed that application of 75 per cent N through poultry manure + 25 per cent N through urea in wheat increased yield attributes and yield of wheat. Channabasavanagowda *et al.* (2008) found that integrated use of vermicompost 3.8 t ha⁻¹ + poultry manure 2.45 t ha⁻¹ in wheat significantly increased the growth, yield and quality of wheat as compared to other treatments.

Application of organic matter in soil not only increases soil fertility and sustain wheat productivity but also it is of the best economic ways to reduce the rate of chemical fertilizers (Reza *et al.*, 2015). Single application of organic manures cannot increase the wheat yield (Bair, 2000). Integrated use of mineral and organic fertilizer increases the nutrient efficiency, nutrient availability and

provides greater stability in wheat production in long term basis. To produce the economically profitable yield of wheat, avoid nutrient losses, improve the fertility status of soil and maintain soil and environment health. Integrated use of organic and inorganic fertilizer is the most important (Akhtar *et al.*, 2011).

Integrated application of organic manures not only increases the crop yield but also it has significant effect on soil physical, chemical and biological properties. The literature related impact of integrated nutrient management on wheat productivity and sustaining soil fertility to the crops has been reviewed as under.

EFFECT OF INTEGRATED NUTRIENT MANAGEMENT ON GROWTH AND YIELD OF WHEAT

Farm yard manure occupies an important position among bulky organic manures. The cattle excrete based FYM in India can potentially supply approximately 33 million tons of N, P and K per year (Gaur, 1984). Tulsa and Mir (2006) concluded that integrated application of 10 t ha⁻¹ of FYM + 120 kg N ha⁻¹ in wheat significantly produced taller plant height and effective tillers per meter row length over + 100 kg N through inorganic fertilizer + FYM 10 t/ha. Ali *et al.* (2007) concluded that integration of FYM with NPK and Zn significantly increased the grain yield of wheat over farmer's practice and recommended dose of Fertilizer.

Shah *et al.* (2010) recorded highest grain yield of wheat with treatments received 50% N through urea and 25% N through FYM+ 25% N either from city waste or poultry manure. Aslam *et al.* (2011) recorded highest plant height and number of effective tillers of wheat with plots treated with poultry litters 20 t ha⁻¹ over other organic manures application. Higher growth attribute with 20 t ha⁻¹ of poultry litter was due to higher nutrient composition of this manure. Hafiz *et al.* (2011) revealed that combined application of green manure+poultry litter+sewage and sludge equivalent to RDN produced higher grain yield as compared to RDF alone. The mean of two years pooled field experimental data showed that application of 60 kg nitrogen through vermicompost + rice residue 6 ton/ha+ biofertilizer was the most productive treatment, while plots received 60 kg N through FYM+ rice residue 6 t/ha +biofertilizer was the most economical treatment with respect to increasing net profit. This was because of the higher price of vermicompost compared with FYM. Both of these combinations resulted in improved grain quality and nutrient uptake by grain (Davari *et al.*, 2012).

The pooled mean data of five years field experiments (2003-08) in wheat indicated that, application of RDN through urea produced maximum wheat yield (4.63 t/ha), which was significantly higher than other treatments. Among the organic sources of nitrogen nutrition, FYM @ 125% of RDN gave maximum wheat



yield (3.65 t/ha), which was at par with vermicompost and neemmax at same rate but significantly higher than FYM @ 50% of RDN (Kumar *et al.*, 2013). Zhengchao *et al.* (2013) indicated all organic manure treated plots produced higher grain and biomass yield of wheat as compared to N and P fertilizer treatment plots. Sharma *et al.* (2013) in their both years of their experiment (2007-8) recorded significantly higher grain yield of wheat with treatments received 75% NPK+FYM 5 t/ha + *Azotobacter* + PSB+ ZN 5 kg/ha over 100% as compared to RDF and other treatments. They concluded that 25% NPK can be substituted through farmyard manure in recommended dose of NPK along with 5 kg Zn/ha and PSB + *Azotobacter*. Further higher yield of wheat in combined application of inorganic fertilizer and organic manure is attributed to controlled release of nutrients in soil through mineralization of organic manure which resulted to better crop growth. Shah *et al.* (2013) found that incorporation of FYM at 6 tons/ ha with mineral fertilizers enhanced the grain yield of wheat by 13% over sole inorganic fertilizer and 9% over combinations of sesbania and mineral fertilizers. They concluded that integrated use of inorganic fertilizers with FYM not only increased the grain yield of wheat but also enhanced N and P uptakes and their recoveries over mineral fertilizer alone. They also stated that the increase in yield of wheat was due to faster release of nutrient by inorganic sources of fertilizer and additional supply of NH₄-N, P and micronutrient by FYM. Zahoor (2013) revealed that, application of FYM 10 t/ha before sowing in wheat increased the grain yield over control but the maximum grain yield of wheat was achieved with integrated use of FYM 10 t/ha + 90 kg N through inorganic fertilizer.

Yadav *et al.* (2014) found that, integrated application of 100% RDF (120:60:40 kg NPK ha⁻¹) + 10 t FYM ha⁻¹, significantly produced higher grain and straw yield of wheat. Further, it was followed by of 50% RDN through vermicompost + 50% RDN through poultry manure. Essam (2014) found that application of half of the recommended NPK + 10 tons FYM + biofertilizer produced higher grain and straw yield of wheat over full dose of recommended dose of NPK (190:70:120 kg NPK/ha). Essam and Lattief (2014) revealed that integrated application of 50% NPK through chemical fertilizer+6 ton FYM per ha in wheat, significantly produced higher grain yield (4.75 t/ha) and straw yield (7.51 t/ha). They concluded that application of 6 ton FYM with 50 NPK in addition increased the grain and straw yield, also replaced 50% NPK through inorganic sources of fertilizers. Yousefi and Mehdi (2014) found that the combined application of 100 % recommended urea fertilizer along with vermicompost 10 and 15 t/ha in wheat produced at par grain yield with 75% urea plus 15 t ha⁻¹ vermicompost, they concluded that application of vermicompost 15 t/ha can replace chemical fertilizer urea up to 25 percent.. Reza *et al.* (2015) indicated that integrated use of 1800 kg vermicompost + 80 kg NPK through inorganic fertilizers

significantly improved the grain yield of wheat. Similarly all yield attributing character such as test weight, number of spikes per hectare, number of grains per spike and harvest index were higher with this treatment.

Application of 75% N through vermicompost+10 ton FYM in wheat significantly produced taller plant and more number of effective tillers, which these characters contributed towards production of higher grain and straw yield. Further, this integration decreased 25% rate of inorganic fertilizer (Patel *et al.*, 2017). Gora *et al.* (2017) indicated that integrated use of 50% RDF + 50% RDN + FYM 5 t/ha in wheat, produced highest grain yield (5.2 t/ha.) and straw yield (7.4 t/ha) as well as highest net return (Rs.72,666) with high B:C ratio (1:3) over all other combinations. They concluded the higher grain and straw yield wheat was due balanced nutrient supply to crop, which increased the soil fertility level and produced higher number of tillers, higher dry matter accumulation and finally improved the grain and straw yields of wheat. The higher B:C was due to higher production of grain and straw yield of wheat. Chala and Gurmu (2017) in two years of their experiment found that, integrated application of 50% RDF through vermicompost+ 50 % recommended dose of N and P through inorganic fertilizer in wheat produced highest grain yield which was followed by 100% recommend dose of N and P. They stated that it is possible to fairly produce higher yield of wheat through integrated nutrient application approach, rather than applying nutrient from one source. Choudhary *et al.* (2017) revealed that application 100 % RDF + *Azotobacter* + PSB in wheat, significantly increased the plant height, dry matter accumulation and translocation, dry matter translocation efficiency, LAI, LAD, CGR, RGR and NAR over the farmer's practice but remained at par with 100 % RDF. They concluded that optimum nutrition involving combination of all nutrients improved the growth parameters and led to higher interception and absorption of radiant energy, resulting into greater photosynthesis and finally dry matter accumulation.

Yadav *et al.* (2018) in both years of their experiment (2013-15) found that application of 125% recommended dose of NPK increased the growth characters and yield attributes of wheat which contributed to higher grain and straw yield. However it was statistically at par with 100 % NPK through chemical fertilizer and integrated use of 75 % NPK + vermicompost @ 2.5 t ha⁻¹ + phosphorus solubilizing bacteria +*Azotobacter*. The integrated use of organic with inorganic fertilizer could maintain the soil fertility and had residual soil fertility status after harvest of wheat crop. They concluded that higher growth and yield of wheat with combined use of organic and inorganic fertilizer is due to improvement of soil physiochemical and biological properties which maintained a continuous supply to crop. Whereas the inorganic fertilizer directly and quickly supplied the nutrient for crop growth and the organic manure supplied



the essential nutrient in a steady manner throughout crop growth. Admasu and Tadesse (2018) reported that, integrated use of organic fertilizers (vermicompost and compost) with chemical fertilizers produced at par yield components and yield of wheat to NP fertilizer alone in both years of the experiment (204-15). Lower yield and yield component was produced by treatments received organic fertilizer alone. They concluded that organic fertilizer alone cannot be a viable substitute for inorganic fertilizer without causing a significant yield. Therefore, integrated use of organic and inorganic fertilizers is essential for achieving higher yield and sustaining wheat productivity.

Singh *et al.* (2018) indicated that maximum yield of wheat was recorded with integrated use of 100% RDF + vermicompost (2 t ha⁻¹) + PSB which was at par with the application of 75% RDF + Vermicompost (2 t ha⁻¹) + PSB and 100% RDF + Vermicompost (2 t ha⁻¹). They concluded that higher yield of wheat was due to better availability of nutrients with integrated nutrient management and additional supply of nutrients through azotobacter which might have increased nutrient uptake and better translocation of nutrients. Fazily and Hunshal (2019) found that integrated use RDF (100:75:50 kg NPK) + FYM 7.5 t ha⁻¹ produced higher grain and straw yield of wheat over all other organic manure combinations. Among organic manures treatment received sheep manure (50%) basal +poultry manure (50%) top dressing at 30 DAS produced higher growth and yield attributes which further contributed to increased final yield of wheat. However it was at par with all treatments received 50% poultry manure as top dressing at 30 DAS. They concluded that the higher growth and yield character is associated with faster decomposition and release of poultry manure, which resulted to higher yield of wheat.

EFFECT OF INTEGRATED NUTRIENT MANAGEMENT ON SOIL FERTILITY

Nambiar *et al.* (1989) found that growing rice and wheat sequentially for 16 years with recommended dose of NPK fertilizers decreased the organic carbon content of soil d by 30 and 38 percent than the value at the start of experimentation at Barrackpore and Pantnagar, respectively. Swarup (2002) revealed that long term application of chemical fertilizer caused deleterious effect on soil health leading to unsustainable yields. Selvi *et al.* (2005) noticed that integrated use of FYM and NPK significantly increased hydraulic conductivity than NPK fertilizer application alone. Bajpai *et al.* (2006) reported that organic manure incorporation remarkably reduced the soil bulk density. Control plot had the highest bulk density (1.56 Mg m⁻³). Whereas the lowest bulk density (1.43 Mg m⁻³) was noted with application of 50% NPK through fertilizer + 50% N through green manure treatments. Chaudhary and Thakur (2007) found a positive effect on

penetration resistance and bulk density of soil with integrated use of FYM along with inorganic fertilizers. Hati *et al.* (2007) indicated that, integrated use of 100% NPK + FYM significantly reduced bulk density of soil as compared to all other treatments. Dahiya *et al.* (2008) observed that combined application of vermicompost or farm yard manure with chemical fertilizers increased the nutrient availability and water holding capacity of soil which caused better plant growth with higher yield. Pothare *et al.* (2007) assessed that conjunctive use of 100% NPK + 10 t FYM ha⁻¹. Increased the available NPK in soil as compared to other treatments.

Kumar *et al.* (2008) found that addition of crop residues along with 50% NPK and FYM or GM could replace 50% NPK requirement of crop. Long-term application of crop residues and organic manures enhanced the soil organic carbon content of soil. Integrated use of crop residues, organic amendments and chemical fertilizers significantly increased the availability of N, P, K, S and micronutrients in soil over chemical fertilizers alone. Singh *et al.* (2008) found that, incorporation of rice residues in soil before sowing of wheat reduced the recommended dose of N fertilizers by 30 kg ha⁻¹ for both rice and wheat. Application of only recommend dose of NPK fertilizers decreased the OC, available P and K content of the soil in rice wheat cropping system. Kumar *et al.* (2008) after 8 years of rice-wheat cropping cycle on loamy sand soil in Ludhiana, Punjab found that integration of FYM, GM and crop residues with inorganic fertilizers significantly increased the availability of S and micronutrients Fe, Mn, Zn and Cu in soil over chemical fertilizers alone.

Bodruzzaman *et al.* (2010) indicated that application of organic manures had direct and residual effects on rice and wheat yields, however the effect of poultry manure was dominant compared to other organic sources. Application of poultry manure increased the soil pH and available P. Application of inorganic fertilizer reduced the exchangeable K in soil but it was sustained with organic manure treatments. After 9 years, the total N, organic manure and exchangeable K were increased with organic manure treatments and reduced inorganic fertilizer plots. Bandyopadhyay *et al.* (2010) investigated that combined use recommended dose of results indicated that conjunctive use of recommended dose of NPK through inorganic fertilizer+ FYM significantly decreased bulk density of soil. Senapati *et al.* (2010) indicated that continuous application of FYM, after 7 years of rice-wheat cropping cycles, increased total soil organic carbon and slow pool C at 0-0.15 m soil depth with the highest effect when FYM, rice straw and fertilizer N were applied together. Mohammadi (2011) reported that application of FYM or compost significantly increased the soil microbial biomass carbon as compared to inorganic fertilizer. Pathak *et al.* (2011) indicated that soil organic carbon was increased with application in both NPK and NPK+FYM treatments than the control treatment. NPK+FYM treatment



had higher soil organic carbon as compared to NPK treatments alone. This might be due to slow decomposition and release of nutrient from FYM resulting in more SOC accumulation in soil (Mandal *et al.*, 2007).

Sekhon *et al.* (2011) found that continuous rice-wheat cropping system without any fertilization resulted depletion of total N over their initial status in surface soil. However, application of chemical fertilizers alone or its integration with organic manures for 7 years, considerably increased the total N, compared with their initial status in soil. Incorporation of press mud, FYM and green manure along with mineral fertilizers increased N fractions over mineral fertilizer treatments. Bhaduri (2012) revealed that the grain and straw yields of wheat were considerably increased with application of 150: 60: 50 kg NPK+ 5 t of FYM ha⁻¹. FYM incorporation along with inorganic nutrients considerably increased the yield and nutrient uptake and hence highest nutrient recovery and economic return obtained by application of 5 t of FYM ha⁻¹ under INM. Katkar *et al.* (2012) observed that addition of FYM 10 t/ha in soil significantly decreased soil bulk density as compared to 100% NPK and 150% NPK through mineral fertilizer alone. Kumare *et al.* (2012) indicated that the long-term integrated nutrient management through FYM in 50% RDF + 50% FYM treatment increased the available N, P and K status in soil. Verma *et al.* (2012) summarized that the integrated use of organic and inorganic fertilizer significantly contributed in build-up of available N, P and K content in soil over three decades of period and meanwhile resulted to sustained soil fertility and productivity. Tadesse *et al.* (2013) indicated that combined use of FYM and chemical fertilizer enhanced the soil total N and available P. Moreover, FYM enhanced the soil organic matter, water holding capacity reduced soil bulk density and created a favorable environment for crop growth and development.

Mohana *et al.* (2013) found that continuous use of manures and fertilizer slightly lowered the soil pH. Kapoor (2006) observed that combined use of organic manure and inorganic fertilizer significantly increased nitrogen, soil microbial biomass and organic carbon in soil. Sharma (2013) observed an increased in nitrogen uptake by wheat with integrated use of chemical fertilizer+ organic+biofertilizer and concluded higher nutrient uptake is due solubilization of native nutrient, chelating of intermediate organic manure with their mobilization and accumulation in different plant parts. Yuan *et al.* (2013) concluded that continuous addition of organic manure along with inorganic fertilizers for 19 years enhanced SOC accumulation, whereas the control plots and treatments received inorganic fertilizer showed no significant increase in soil organic carbon level. Moreover the combined application of organic manure and mineral fertilizer improved macro-aggregation and macro-aggregates protected carbon over the control. Das *et al.* (2014) found that incorporation of organic material in soil improved the

soil aggregation and structural stability and increased the carbon content in macro-aggregates in 18 years of rice wheat rotations. Singh *et al.* (2014) found that combined application of Sesbania green manure along with FYM in long term rice-wheat cropping system, significantly increased the average grain yield of rice and wheat. The soil fertility status was also significantly enhanced over control and recommended dose of fertilizers.

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