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Review Article

A Review on the Effect of Integrated Nutrient Management on Soil Properties and Yield of Wheat *(Triticum Aestivum* L.)

Hanuman Prasad Parewa*, Amitava Rakshit, Janardan Yadav*****

Author's Affiliation: *Assistant Professor, College of Agriculture, (Agriculture University, Jodhpur) Sumerpur, Pali, Rajasthan-306902. **Assistant Professor, ***Professor, Department of Soil Science and Agricultural Chemistry, Institute of Agricultural Sciences, BHU, Varanasi, Uttar Pradesh-221005.

Abstract

Wheat (*Triticum aestivum* L) ranks first among the world's cereals production with the productivity of 3039 kg ha^{-1} whereas India is the second largest producer of wheat (93.90 MT) next only to the China (120.60 MT). In India, wheat covers the largest area under its cultivation (29.80 m ha), which is about 13.53 % of the world wheat area (217 m ha) [1]. About 40% of the total food grain reserve of the country is contributed by this crop. Wheat is a good supplement for nutritional requirement of human body as it contains 8-15 % protein, 60-68% starch, 1.5-2.0% fat, 2-2.5% cellulose and 1.5-2% minerals [2]. "Green Revolution" in India, took place in 1960s, has increased dramatically wheat yield by introducing high yielding varieties and using huge amount of chemical fertilizers and pesticides. However, in recent years the grain production have stagnated or even declined for both rice and wheat crops [3]. One of the major constraints in boosting up the wheat production is the deleterious effect on soil health. Long time studies being carried out at several locations in India and abroad indicated that application of imbalance chemical fertilizers have deleterious effect on soil health leading to unsustainable yields. Therefore, there is an urgent need to improve nutrient supply system in an integrated manner. Integrated nutrient management could help in meeting the goals of balanced fertilization. The research findings on various aspects of the integrated nutrient management (INM) on wheat are reviewed.

Keywords

Green Revolution; INM; Soil Health; Wheat.

Introduction

Integrated nutrient management (INM) envisaging conjunctive use of chemical fertilizers, organic manures and bio-fertilizers enhances nutrient use efficiency, soil health, crop yields and profitability. It is a combination of economic and efficient traditional and improved technologies from the symbiosis and synergy of crop-soil environment bio-interactions. As early as 1974 the need for INM was elucidated. INM means the supply of nutrients to the plants from various sources of nutrients- (i) nutrient reserves in the soil, (ii) organic sources – FYM, vermicompost, compost, green manure, crop residues and other organic fertilizers and (iii) fertilizers. INM is a concept "which aims at the maintenance or adjustment of soil fertility and of 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 [4].

Soil health degradation as a result of continuously imbalance use of fertilizers and multi-nutritional deficiencies (P, K, S, Zn, Fe, Mn, Cu, and B) has emerged as a major factor responsible for stagnation in agricultural production. Arresting the decline of soil organic carbon by use of organic sources is the most potent weapon in fighting unabated soil degradation. Organic matter helps in improving soil quality to sustain biological productivity, maintain environmental quality and promote plant and animal health. But the organic sources alone are not sufficient to meet the nutritional needs for higher productivity.

Corresponding Author: Hanuman Prasad Parewa,
Assistant Professor, College of Agriculture, (Agriculture University, Jodhpur) Sumerpur, Pali, Rajasthan-306902.
E-mail: haniparewa@gmail.com

Use of adequate amount of fertilizers along with development of other production technologies has played a key role in augmenting food grain production by 2-3 times [5].

INM approach is flexible and minimizes use of chemicals but maximizes use efficiency. Therefore, INM is the most logical way for managing long term soil fertility and productivity. Integrated use of chemical fertilizers, organic manures and biofertilizers has been found promising in arresting the decline in productivity through increase fertilizer use efficiency and correcting marginal deficiencies of secondary and micronutrients and their beneficial influences on the physical and biological properties of the soil. It can bring about equilibrium between degenerative and restorative activities in the soil environment [6].

Therefore, integrated use of chemical fertilizers, organic manure and plant growth promoting rhizobacteria / biofertilizers regarded as the best solution to restore our natural resources and to safeguard our environment. It is a holistic production management system, which promotes and enhances agro eco-system health including bio-diversity, biological cycles and soil biological activities. Keeping these points in view, the available and relevant literature pertaining to the effect of Integrated Nutrient Management on wheat (*Triticum aestivum* L.)" has been reviewed.

Importance of INM

1. Enhance crop and soil productivity through a balanced use of mineral fertilizers combined with organic and biological sources of plant nutrients to ensure sustainability of the production systems.
2. It is more effective in maintaining higher productivity and stability through correction of deficiencies of secondary and micronutrients in the course of mineralization on one hand and favourable physical and soil ecological conditions on the other.
3. Improve the efficiency of plant nutrients use, limiting losses of N and P to the environment.
4. Improve the capital stock of plant nutrients in the soil.
5. It enhances the microbial population in the soil.
6. INM improve the physico- chemical properties of the soil.
7. It helps to restore natural resources and improve environmental quality.

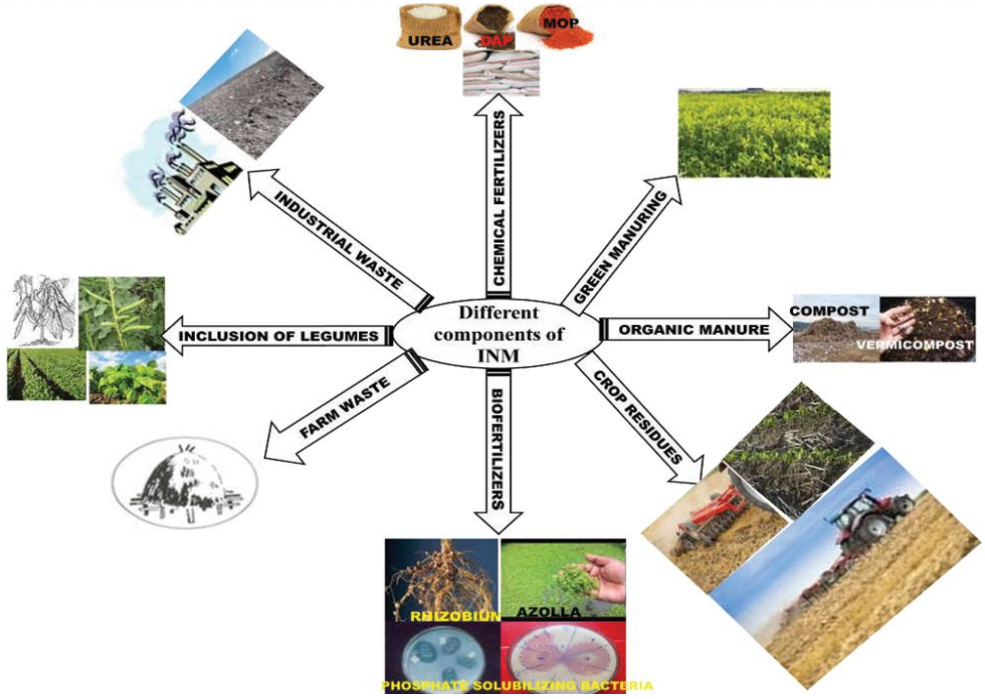

Fig. 1: Different Components of INM

Why is INM Needed?

Soils which receive plant nutrients only through chemical fertilizers are showing declining productivity despite being supplied with sufficient nutrients. The decline in productivity can be attributed to the appearance of deficiency in Secondary and

micronutrients. The physical condition of the soil is deteriorated as a result of long-term use of chemical fertilizers, especially the nitrogenous ones. It also aggravates the problem of poor fertilizer nitrogen use efficiency (NUE). The recent energy crisis, high fertilizer cost and low purchasing power of the farming community have made it necessary to rethink alternatives. Unlike chemical fertilizer, organic manure and biofertilizer available locally at cheaper rates. They enhance crop yield per unit of applied nutrients by providing a better physical, chemical and microbial environment. This ultimately improves crop yield. The available quantity of animal excreta and crop residues cannot meet the country's requirements for crop production. Therefore, maximizing the usage of organic waste and combining it with chemical fertilizers and biofertilizers in the form of integrated manure appears to be the best alternative.

Effect of FYM on Soil Properties and Yield of Wheat

Application of organic manures like FYM gradually supplied almost all nutrients to the plants and improved the physical, chemical and biological properties of soil for longer time and ultimately helps in crop production in many ways. *FYM played a significant role in the formation of soil aggregation over the unmanured plots and decreased the bulk density of the soil [7]. Similarly,* soil density undergoes greater reduction with the use of FYM than chemical fertilizers [8]. Incorporation of FYM resulted higher percentage of water stable aggregate, lower bulk density, higher porosity, higher available water holding capacity and higher hydraulic conductivity in compared to control [9]. The increase in infiltration rates, organic carbon content, available N, P and K in soil due to FYM application was reported by so many researchers [10-12]. Application of FYM @10 t ha^{-1} in rice-wheat cropping system significantly increased N, P and K uptake as compared with control [13]. FYM @ 10 t ha^{-1} increased the organic carbon (42.86 and 44.44%) microbial population, soil microbial biomass carbon (4.31 and 5.28%), water holding capacity (11.90 and 12.04%), cation exchange capacity (10.26 and 11.54%), available N, P and K and enzymatic activity significantly during 2009-10 and 2010-11 [8]. The increasing microbial population in rhizosphere soil could be attributed to more availability of organic matter due to higher amount of FYM derived carbon, in addition to rhizodeposition [14]. The Long- term experiments was carried out under AICRP on Farming system from 1993-2002 indicated that FYM can substitute a part fertilizer N needs of monsoon crop without any adverse effect on the total productivity of cereal based cropping system. It was further noticed that Fertilizer needs of the winter wheat could be reduced to the extent of 25 per cent by substituting 25 per cent needs of proceeding monsoon crop through FYM. [15] FYM application @10 t ha^{-1} significantly enhanced grain yield 36.60 and 38.14 q ha^{-1} and straw yield 52.65 and 54.69 q ha^{-1} during 2009-10 and 2010-11, respectively, over no FYM treatment. This increase in grain and yield was might be due to capacity of FYM to supply all the nutrients under favorable physicochemical and biological conditions of soil [16].

Effect of Fertilizers on Soil Properties and Yield of Wheat

Fertilizers are mined or manufactured commercial products which contain one or more essential plant nutrients. The adequate amount of fertilizer application is considered for the economic yield, minimum environmental pollution [17] and bumper crop production [18]. Fertilizer significantly enhanced organic carbon, cation exchange capacity, water holding capacity, chemical and biological properties of the soil as compared to the control [8]. The increased water holding capacity with increasing levels of fertilizer application in soil was might be due to enhanced root growth leading to accumulation of more root residues in the soil which ultimately enhanced water holding capacity in soil. Increase in doses of inorganic fertilizers increased the activity of enzyme activity [19-22]. Grain and straw yield of wheat increased 49.29 q ha^{-1} and 69.23 q ha^{-1} and 51.16 q ha^{-1} and 72.13 q ha^{-1}, respectively during 2009-10 and 2010-11 with the full doses of NPK fertilizers [16]. The growth and yield attributing characters and Grain and straw yield of wheat increased with increasing levels of fertilizer [23]. Similarly, recommended dose of fertilizers enhanced quality parameters of wheat [24-26]. Application of 100 % NPK significantly improved the grain yield of wheat by 21.5% over application of 75% NPK [27].

Conjunctive Effect of Fertilizer and FYM on Soil Properties and Yield of Wheat

Integrated nutrient supply which involves the conjunctive use of fertilizers and organic sources assumes great importance in recent years due to consistently increasing trend in the cost of fertilizers. Integrated treatment of 100% NPK fertilizer levels and FYM gave numerically more water holding values as compared to control and 100% NPK fertilizers applied treatments. The available P content of soil recorded with combined use of 10 t FYM ha-1 + 75% NPK application (18.27 and 18.32 kg P_2O_5 ha^{-1}) was significantly higher than application of 100% NPK without FYM (17.26 and 17.36 kg P_2O_5 ha^{-1}) [8]. Incorporation of FYM along with inorganic fertilizer

increased the availability of P to crop and mineralization of organic P due to microbial action and enhanced mobility of P [28]. Application of 50% or 75% NPK + FYM (10 t ha-1) recorded significant increase in biological parameters viz. bacterial and fungal population compared to 100% NPK through chemical fertilizers without FYM [8]. Hence the result indicated that higher dose of the fertilizer adversely affect the microbial activity in the soil and it indicates that native soil has sub-optimum population of these bacteria and responds to single as well as combined application with positive interaction [29]. Application of FYM @ 12 t ha^{-1} with 75% NPK improves the fertility status and also recorded higher grain and straw yield of wheat than 100% NPK [30]. A field experiment was conducted by at Hissar to study the long-term effect of inorganic fertilizers in combination of organic amendments such as wheat straw, farmyard manure (FYM) and green manure (*Sesbania bispinosa*) on crop yield and soil properties in pearl millet (*Pennisetum glaucum*)–wheat (*Triticum aestivum*) cropping system and they investigated that soil organic matter level, mineralizable C and N, microbial biomass carbon, dehydrogenase, urease and alkaline phosphatase activities were significantly increased with a combination of inorganic fertilizers and organic amendments as compared to unfertilized soil or application of inorganic fertilizers alone [31]. Application of FYM and poultry manure along with full recommended dose of NPK fertilizers to wheat improved productivity, grain quality, profitability, soil health and sustainability of wheat-soybean system [32]. Application of 100 % NPK + 50% N through FYM showed beneficial effect on plant height and dry matter accumulation at harvest in wheat [33]. NPK and FYM amended soil have higher microbial biomass in wheat [34]. Application of 100% NPK + FYM @10 t ha^{-1} recorded significant increase in biological parameters viz. soil microbial biomass carbon (SMBC),soil microbial biomass nitrogen (SMBN) and dehydrogenase activities (DHA) to the extent of 8.8, 9.8 and 9.0% compared to 150% NPK through chemical fertilizers without FYM [35].

Combined Effect of FYM Biofertilizer and Chemical Fertilizers on Physico-Chemical Properties of Soil and Wheat

Integrated use of chemical fertilizers, organic manure and plant growth promoting rhizobacteria / biofertilizers in sustainable manner and proper proportion may counter balance the shortage of costly fertilizers and provide sustainable fertile soils and also help in boosting up soil health and production through increased microbial population in soil. A field experiment was conducted at Jabalpur (M.P.) to study the effect of integrated nutrient management on soil fertility as well as yield and mineral nutrition of wheat in a Vertisols and revealed that recommended dose of NPK + FYM + 5 kg Zn ha^{-1} along with PSB + *Azotobactor* significantly increased grain yield, protein content, nutrient uptake and physico-chemical properties of soil over the 100% NPK treatment [26]. Integrated use of 75% NPK and FYM @ 5 t ha^{-1} or poultry manure @ 1.5 t ha^{-1} or phosphocompost @ 5 t ha^{-1} to rainy season crops and 75% NPK to wheat significantly improved the yield of wheat over application of 100% NPK in both the season [27]. The combined application of biofertilizer + FMY + 50% NPK as compared to control or 100% NPK alone gave the significant result in all growth and yield attributes, Leaf pigments, total carbohydrates and crude protein in leaves, total carbohydrates and crude protein in wheat grains [25]. Integration of FYM @ 10 t ha^{-1} in combination with half of the recommended NPK + biofertilizer gave the significant higher yield attributes, grain and straw yields and grain protein content of wheat as compared to the other treatments and recommended dose of fertilizer. Thus, can saving half the rate of chemical NPK, with high productivity of wheat crop [36]. Combined application of 75% RDF (120:26:4:50 N:P:K kg ha^{-1}) along with vermicompost @ 1 t ha^{-1} + PSB produced growth and yield attributes, grain and straw yield of wheat, higher NPK uptake, better residual fertility and more remuneration than recommended fertilizer or organic fertilizer alone[37]. A field experiment was carried out at Gujarat to study the effect of bio-inoculant on wheat under dryland condition and revealed that seed bacterization with *Azotobacter*- 8 along with 60 kg N / ha (Urea) and 40 kg N / ha (FYM) was most responsive treatment in respect of 23 and 36% increase in shoot fresh and dry weight, 26 and 38% increase in root fresh and dry weight, 39% increase in test weight of seed and 27% increase in yield as compared to control. The result clearly indicated that there was a saving of 20 kg N / ha, when *Azotobacter*-8 culture was used along with 60 kg N / ha (Urea) and 40 kg N / ha (FYM) [38]. The grain yield of wheat at 75% recommended dose of NP along with the application of FYM @ 10 t ha^{-1} and inoculation of PSB resulted in significantly higher yield even over the 100% recommended dose of NP [39]. The integrated use of inorganic fertilizer, biofertilizers and FYM enhanced the growth and yield of wheat. Higher plant height and yield attributes were recorded in 50 kg N ha^{-1} + *Azospirillum* + FYM @ 5 t ha^{-1}, followed by 150 kg N ha^{-1}. Further, seed and stover yields of wheat enhanced significantly at higher levels of N and integrated use of organic and bio-fertilizers. Interaction between 50 kg N ha^{-1}, *Azotobacter/Azospirillum* and FYM @ 5t ha^{-1} revealed

that the application of 150 kg N ha^{-1} may be replaced by the various combinations of biofertilizers, FYM and chemical fertilizers which will be more remunerative in terms of low input cost and sustainable productivity and soil health for longer period [40].

Conclusion

Integrated use of chemical fertilizers, organic manures including FYM, vermicompost, green manure and recycling of crop residues and biofertilizers not only improve the soil health but also enhanced crop productivity of wheat. The system becomes long term productive by protecting soils and enhancing their fertility ensuring productive capacity for future generation.

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