Review Article

Integrated Nutrient Management in Wheat (*Triticum aestivum L.*): An overview

Abstract

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. Research on nutritional aspects relating to wheat cultivation is abundant and is documented comprehensively. Studies being carried out at different locations in Ethiopia indicated that application of all the needy nutrients through chemical fertilizers have deterious effect on soil health leading to unsustainable yields. Therefore; there is a need to improve nutrient supply system in terms of integrated nutrient management involving the use of chemical fertilizers in conjunction with organic manures coupled with input through biological processes. However, the role of major nutrients on crop physiology and the effect of these nutrients on growth, quality, yield and yield components of cereal crops in general and wheat in particular are unsatisfactory. Above all, the role of balanced fertilizer is the application of essential plant nutrients in light proportion and in optimum quantity for a specific soil crop condition in alleviating the yield, quality and its attributes of wheat production is important. In association with this, research on integrated nutrient management in wheat and its effect on growth, yield, yield components and quality parameters are significance.

Key words: *Triticum aestivum*, integrated nutrient management, farm yard manure, organic manures, bio-stimulants.

Introduction

Wheat (*Triticum aestivum L.*) is a major cereal crop, which plays an important role in food and nutritional security. In India, total area under wheat is 31.0 million hectares use 2020-2021 data with production of 86.53 metric tonnes and the productivity of 2.8 tonnes hectare. It is the staple food and meets about 35 percent caloric need of country. Thus assured supply of wheat is very important for future food security of the country. In 2050 there will be a requirement around more than 250 metric tonnes of food grains to meet the demand of rapidly growing population. As no additional land is vacant for wheat area expansion, this increase in wheat production has to come from the same land but through improved technology to double the food grain production. Increasing grain yield of wheat is an important national goal to ensure continuous increasing food demands of India (Kakraliya *et al*., 2017). World-wide, wheat provides nearly 20% of the food calories and 55% of the carbohydrates consumed globally. It is consumed mostly in the form of bread and chapati. Wheat straw is used for feeding the cattle. Wheat grains contain more protein (12%) than other cereals and has a relatively high content of thiamine and niacin. It is a basically concerned in providing the characteristics substance "gluten" which is very essential for bakers. The importance of micronutrients applications in increasing crop production has been recognized in India and it is becoming evident that without the use of the micronutrient it is not possible to get the maximum benefits of NPK fertilizer and high yielding varieties of wheat. The growth and yield of a plant is determined by the availability of some specific mineral nutrient that are absolutely essential for completion of their life cycle (Singh *et al*., 2019). Integrated nutrient management aims and improves the physical, chemical and biological health of soil and enhances the availability of both applied and native soil nutrients during growing season of the crops. This helps in retarding soil degradation and deterioration of water and environmental quality by promoting carbon sequestration and checking the losses of nutrients to water bodies and atmosphere. A scientifically managed system of soil bacteria mycorrhiza and fungi plant association is useful in conserving energy by reducing fertilizer requirement of crops and meeting production targets in nutritionally deficient soils (Meena *et al*., 2013).

Integrated Nutrient Management

Integrated nutrient management (INM) or integrated nutrient supply (INS) help to achieve efficient use of synthetic fertilizers integrated with organic sources of nutrients. Integrated nutrient management (INM) is developed with an understanding of the interactions among climate, soils and crops which advocates the integration of organic sources and inorganic of nutrients (Sharma *et al*., 2019).

The Integrated Nutrient Management provides an excellent opportunity not only for enhances the overall productivity but also sustainability of the soil. On account of continuing spiralling price of chemical fertilizers and world energy crisis, the use of organic manure as a renewable source of plant nutrients is assuming. Integrated nutrient management is the only possible approach in enhancing the soil productivity through a balanced use of mineral fertilizers combined with biological sources of plant nutrients and organic. It plays a vital role in improving the stock of plant nutrients in soil by increasing the efficiency of plant nutrients thus limiting losses to the environment. It optimizes the function of the ultimately sustaining the physical and soil biosphere, chemical and biological functioning of soil etc. (Joy *et al*., 2018).

Integrated nutrient management approach for the enhancing soil fertility and management of plant nutrient for maintaining, where both manmade and natural sources of plant nutrients are used (Singh *et al*. 2020). Integrated nutrient management (INM) means judicious and efficient use of mineral fertilizer, bio-fertilizers and organic manures in an integrated manner to get the maximum productivity and maintain soil fertility. In this endeavor proper blend of inorganic fertilizer and organic is important not only for but also for sustaining soil health increasing yield. The efficiency of chemical fertilizers increased with the use of organic manures. Farmyard manure is a valuable amendment and may replace the chemical fertilizers. It stimulates plant growth and may help to prevent plant disease, besides increasing the quality of the produce. Integration of FYM with inorganic N sources increases productivity and monetary returns of wheat and improves soil fertility (Jat *et al*., 2020). Integrated nutrient managements involving residue mixed farmyard manure, fertilizer levels in conjunction with biofertilizers to improve profitability, productivity, production and efficient utilization of nutrient are the need of the hour (Hasim *et al*., 2015)

Organic Manure

Present day agriculture practices are including pragmatic shifts from resource degrading to resource conserving technologies besides practices which embark on increase in production and productivity as well as maintain soil health sustainability. Use of organic manures is being emphasized to maintain for increase organic carbon as well as nutrient profiles of the soils for macro and micro nutrients as the fossil fuel based chemical fertilizers are energy intensive an environment non friendly. Organic manures contribute to good soil health and in turn yield sustainability. Improvement in soil structure, water retention characteristics, saturated hydraulic conductivity and lowering of bulk density for sandy clay loam soil were observed under permanent manurial trial (Nandapure *et al*., 2011).

The major issue for the sustainable agricultural production will be management of soil organic carbon and rational use of organic inputs such as animal manure, crop residues, green manure, sewage sludge and wastes known as integrated plant resource management (Joy *et al*., 2018). Application of NPK either through organics such as farm yard manure (FYM) or crop residue or green manure improved the SOC, particulate organic carbon (POC), microbial biomass carbon (MBC) concentration and their sequestration rate (Nayak *et al*., 2012). Farmyard manure (FYM) is also considered as an important source of macro and micronutrients to increase crop yield. Due to higher prices of inorganic fertilizers, farmers in India could easily manage to prepare FYM in their farms and to apply them in fields. 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 its application, time to incorporate and the rate of manure decomposition by microorganisms in soil (Hasim *et al*., 2015).

Judicious use of FYM with chemical fertilizers improves soil physical, chemical and biological properties and improves the crop productivity. To build ecologically sound and economically viable farming systems integrated nutrient management (INM) is a viable option for wheat production as it utilizes available organic and inorganic nutrients (Fazily *et al*., 2021). The enriched vermicompost is a mixture of vermicompost, natural minerals and microorganisms. Incorporation of organic matter either in the form of crop residues or farmyard manure/ vermicompost/compost are vital for supplementing plant nutrients and maintenance of soil fertility, as it is an important soil component which influences the physical, chemical and biological properties of soil. Incorporation of organic manures influence soil enzymatic activity either because of the composition of the added materials or they increase microbial activity of the soil (Verma *et al*. 2018).

Organic matter redistribution the forms of applied Zn into the exchangeable and organic matter fractions. Micronutrients are important for maintaining soil health and also increasing productivity (Priyanka *et al*., 2017). Poultry manure through drilling significantly increased the effective tillers, ear length, grains/ear and test weight. The beneficial effect of poultry manure on yield attributes was probably due to enhanced nutrient supplied during the entire growing season. These inputs maintained higher values for crop productivity in terms of grains, straw and biological yields (Dhaka *et al*., 2012).

The major issue for the sustainable agricultural production will be management of soil organic carbon and rational use of organic inputs such as animal manure, crop residues, green manure, sewage sludge and wastes known as integrated plant resource management. Organic manure cannot meet the total nutrient needs of modern agriculture, hence integrated use of nutrients from fertilizers and organic sources is highly essential in supplying the plant requirements and maintaining the soil health (Joy *et al*., 2018). Lime and organic matter in soil is needed to attain a soil pH level at which available Fe, Al, or Mn (non-toxic) are present. Regular application of well-decomposed organic matter in acid soils is effective to prevent sudden fluctuation of soil pH as it ameliorates the buffering capacity of soils. Moreover, it increases the availability of P and reduces the toxicity of Fe and Al in acid soils. Poultry manure (PM), cow dung (CD), compost, and lime may be applied to increase crop yield, maintain soil fertility, and ameliorate soil acidity. It is essential to identify the exact amount of manure to increase the soil pH, fertility, and productivity of acidic soils. Integrated use of lime with organic and chemical fertilizers is considered a good approach for sustainable crop production in acidic soils (Islam *et al*. 2021).

Chemical fertilizers

Fertilization is essential for replenishment of mined nutrients due to crop production for optimizing crop productivity on sustainable bases. Mineral fertilizers, particularly nitrogen (N), phosphorus (P) and (K) potassium are important for plant nutrition. However, excessive use of these chemical fertilizers is potential source of environment pollution. Nutrient over application has introduced major challenges in terms of soil infertility, N and P run off, environmental degradation, and climate change (Leoni *et al*., 2019)

The chemical fertilizers alone cannot meet the requirement of crops and cropping systems, because of their high cost and less residual effects of chemicals, hence there is increasing trend towards use of organic manures (Verma *et al*., 2018). Long term fertilizer experiments involving intensive cereal based cropping systems reveal a declining trend in productivity even with the application of recommended levels of N, P and K fertilizers. The crop productivity increases from the combined application of chemical fertilizers and organic manures. Such combination contributed to the improvement of physical, chemical and biological properties and soil organic matter and nutrient status (Dr. Mahajan *et al*., 2008).

Plant nutrients are major components of crop growth and, out of 16 essential elements, nitrogen (N), phosphorus (P), and potassium (K) are essential elements for crop growth. After C, N is the element most required in large quantities by crops, because it is an integral constituent of protein, chlorophyll and other metabolic reactions. Therefore, high doses of N fertilizers are required, because of the increasing grain demand of the increasing trend in population, causing economic and environmental losses; specifically, in sandy soil, there are high N losses due to leaching and low nitrogen use efficiency (Sial *et al*. 2019).

Bio-stimulants

Bio-stimulants are formulated with diverse microorganisms and/or substances that are applied to crops with the aim of enhancing growth, development and adaptation to abiotic stress. The beneficial effect of Azotobacter on plant is associated not only with the process of nitrogen fixation and improved nutrition of plants but also with synthesis of complex biologically active compounds such as nicotinic acid, pantothenic acid, pyridoxine, biotin, gibberellins and other compounds which stimulate the germination of seeds and accelerate the plant growth under favourable environmental conditions (Desai *et al*., 2015). *Trichoderma* based products have been particularly successful because of their capacity to control phyto-pathogenic fungi (Bucio *et al*., 2015).

Bio-stimulants are used commercially to increase wheat yield, it was necessary to study the influence of exogenous bio-stimulants on the growth process in wheat. Yield is the integration of metabolic reactions in plants and all factors that influence this metabolic activity during plant growth can affect the yield. The yield potential of wheat is dependent on early events and determined by number of spikelets, number of fertile florets, grains per spikelet and grain size. Production of wheat is largely dependent on genotype, seeding rate, photoperiod, temperature, water and nutrient status during the tillering period. Tillering is an important adaptive characteristic of wheat that enables plants to utilise fully available space and resources (Majathoub, 2004). Seaweed extracts are used in sustainable agriculture in order to increase growth, quality, and shelf life. Many studies have demonstrated the positive effects of seaweed extracts on a wide range of crops, including cereals, ornamental and flowering plants, vegetables, and field crops (Leoni *et al*., 2019). Bio-stimulants are materials that when applied in small amounts are capable of promoting plant growth. Nanoparticles (NPs) and nanomaterials (NMs) can be considered as bio-stimulants since, in specific ranges of concentration, generally in small levels, they increase plant growth (Maldonado *et al*., 2019).

Varieties for organic farming

Stability and reliability of yield and quality for 15 durum wheat genotypes (old and modern) in organic farming. Genotypes were grown at two N levels (0 and 80 kg/ha), with the aim of evaluating ‘genotype × environment’ (GE) interactions and their role on genotype selection in N-limited environments. for protein and gluten content, results indicate high environmental variability and the presence of crossover ‘N × environment’ interactions, which supports the need for specific breeding programmes in N-deficient environments. The average response was strongly affected by N availability (on average, yield was 2.95 and 3.42 t/ha, protein content was 11.6% and 12.85%, gluten content was 8.55% and 9.92%, respectively, at 0 and 80 kg N/ha), and few genotypes gave high yield and quality at both fertilization levels (Stagnari *et al*. 2013).

Grain yield and quality characteristics of ten winter wheat (*Triticum aestivum L.*) varieties from the very good, good and satisfactory baking quality under the conditions of organic agriculture. When the growing conditions were rather dry and warmer compared with the long-term mean, grain yield was the poorest but grain quality was the best and grain of most of the winter wheat varieties met the requirements set for bread-making. The varieties 'Lars' and 'Zentos' combined high yield with stability, their sum of integral assessment of grain yield was respectively (11+) and (10+). High-quality varieties from the very good / good baking quality groups, an ecological way of growing may give good baking utilization possibilities but this strongly depends on environmental conditions (Cesevičienė *et al*. 2009). The selection of a proper variety is one of the main factors influencing the quantity and quality of cereal grain yield in organic agriculture. The suitability of 13 varieties of spring wheat for cultivation in organic farming according to their competitive potential against weeds, susceptibility to fungal diseases and grain yield. High-yielding varieties in the organic system were: KWS Torridon, Kandela, Arabella, Zadra and Waluta. The KWS Torridon and Kandela varieties were resistant to fungal pathogens infestation, while Brawura, Izera, Korynta and Ostka Smolicka showed the highest infestation rate. Ethos variety yields were the lowest due to its low plant density, with a high weed infestation rate. The wheat yields proved to be significantly correlated with plant density and the thousand grain weight, but no significant negative effects of weed infestation and pathogen infestation were found. A synthesis of the three-year results showed that the varieties most useful for organic farming were: Arabella, KWS Torridon, Kandela, Katoda, Waluta and Zadra (Szewczyk *et al*. 2020).

Chemical fertilizers and organic manures

The joint application of organic manure and chemical fertilizers resulted in increase in biomass and grain yield in wheat. Also the farmers were advised to compost the crop residues to apply in their soils for the increased sustainable crop production. The soil fertility should commensurate net improvement in land productivity (Sarwar *et al*. 2007). The residual effect of combined application of organic and chemical fertilizers for NPK in respect of growth, development and yield of succeeding wheat crop was studied by Verma *et al*., (2018).

It observed that the 50 % N through FYM+ 50% RDF to rice accompanied with 100% RDF to wheat was better than N substitution through crop residue and green manuring as well as chemical sources of nutrients (Ibrahim *et al*., 2008). Improvement of wheat growth and yield with the use of organic manure and compost was better as compared to chemical fertilizer. It is quite possible to get higher wheat yield by the integrated use of organic and inorganic fertilizers (Singh *et al*., 2017). It was recorded that fertilizers resulted in similar nitrogen use efficiency (NUE) in rice as compared with organic manures along with inorganic fertilizers, Whereas NUE was increased in wheat by the residual effect of organic manures along with inorganic fertilizers (Yaduvanshi 2003).

It was observed that longterm application of balanced and integrated use of fertilisers and organic manures (e.g., NPK, NPK + FYM, NPK + S) is most desirable in order to improve nutrient availability in soil, their concentration in crops and crop yields. The benefits of balanced fertilization were accrued by favourable interactive effects contributing to better crop growth. Available N (mineralizable N and nitrate N) in soil up to flowering, and thereafter P were most significantly associated with grain yields, therefore, their timely supply and proper management are important (Mandal *et al*., 2009).

Combined application of organic manures and chemical fertilisers not only give better yield and seed quality but also improve the nutrient uptake by the plants as compared to organic manures and fertilisers applied alone. Therefore it is concluded that emphasis should be given to the use of combined application of organic manures and chemical fertilisers to soil for eco-friendly crop cultivation and higher yield as well as sustainable quality seed production (Mor *et al*., 2019).

FYM incorporation along with inorganic nutrients considerably enhanced the yield and nutrient uptake and hence highest nutrient recovery and economic return obtained by application of 5t of FYM ha^{-1} under INM. Added fertilizer nutrients in combination with organic nutrients showed its positive effect in enhancing the fertilizer use efficiency /recovery and economy (Bhaduri et al., 2012).

Application of organic manures like press mud, vermicompost and FYM alone and in combinations, was VC > VC + FYM > FYM > PM + VC > PM > PM + VC + FYM > PM + FYM with 68, 66, 55, 53, 38, 36, and 30% increase as compared to control during both years. The highest improvement (14.1%) in grain protein contents was recorded from vermicompost as compared to control the productivity and quality of bread wheat (Ali et al. 2020).

Bio-stimulants and chemical fertilizers

In wheat application of FYM@ 5t/ha +NPK-G @200 kg/ha + NPK-bio-fertilizer +Urea@ 20kg/ha at 40DAS and foliar spray NPK-P @1% along with Bio-stimulant-L 625ml/ha at 55&70DAS gave best results in respect to all yield attributes. The lowest yield was recorded in control (Jat, L. *et al.*, 2020). The treatments of wheat with bio-stimulants contribute to an increase in the tolerance of these plants to environmental stress conditions. Data showed that the biostimulant type affects plant growth and yield of wheat. Biostimulant treatments are safe to handle, easy to apply, and inexpensive. The most important advantage of Vigro versus other bio-stimulants is economically viable. Further biochemical and cytological studies are required to improve our understanding of the effects of bio-stimulants on wheat tillering (Majathoub *et al*. 2004).

Bacterial fertilizers act as a supplement to the chemical fertilizers and farmyard manure for better plant performance. Simultaneous screening of indigenous rhizobacterial strains for growth and yield promotion under pot and field experiment as a tool to select efficient PGPR for bio-fertilizer development is an important strategy. This may be helpful in reducing the cost of cultivation and simultaneously contribute to save the agro ecosystems from getting polluted (Singh *et al*. 2013).

Plant bio-stimulants such as arbuscular mycorrhizal (AM) fungi and humic substances (HS) can be used as an appropriate alternative to chemical fertilizers, as regards to environmental problems of chemicals. The interaction between mycorrhizal inoculation, HS application (especially foliar spray), and NK fertilizer treatment induced the maximum accumulation of photosynthetic pigments, starch, soluble sugars, total proteins, proline, total phenolics, and the antioxidants in leaves (Shahabivand *et al*. 2018)

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