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

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Wheat is one of the major staple crops in the country in terms of both production and consumption. It is the nation's second-most significant food, after maize, in terms of calories consumed. Nutritious characteristics of wheat farming have been extensively researched and extensively recorded. Research being conducted in several parts of Ethiopia has shown that applying chemical fertilisers to achieve all the necessary nutrients has a detrimental effect on soil health, resulting in yields that are not sustainable. 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 impact of important nutrients on crop physiology and their function on growth, quality, yield, and yield components of cereal crops—particularly wheat—are hardly in this level. Above all, the administration of essential nutrients to plants in the right amount and light ratio for a particular soil crop condition plays a crucial role in balanced fertilizer's ability to improve wheat production's yield, quality, and other characteristics. In association with this, research on integrated nutrient management in wheat and its effect on growth, yield, yield components and quality parameters are significance.

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1. 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. Therefore, an ongoing supply of wheat is crucial for the nation's future food security. In 2050 there will be a requirement around more than 250 metric tonnes of food grains to meet the demand of rapidly growing population. Since there isn't any more land available to expand the wheat field, the increase in wheat production must come from the same area but use better technology to produce twice as much food grain. Increasing grain yield of wheat is an important national goal to ensure continuous increasing food demands of India [1]. Approximately 20% of the calories and 55% of the carbs consumed worldwide come from wheat. It is primarily eaten as chapati and bread. The cattle are fed with wheat straw. Compared to other cereals, wheat grains have a higher protein content (12%) and a reasonably high thiamine and niacin content. It primarily focuses on supplying the ingredient known as "gluten," which is crucial for bakers. In India, the usage of micronutrients has been acknowledged as crucial to boosting crop yields. It is also becoming clear that high yielding wheat cultivars and NPK fertiliser cannot be fully utilised without the administration of micronutrients. The availability of certain mineral nutrients that are vital to the completion of a plant's life cycle determines the plant's growth and production [2]. During the crop-growing season, integrated nutrient management strives to improve the physical, chemical, and biological health of the soil and increases the availability of both applied and native soil nutrients. By encouraging carbon sequestration and limiting the loss of nutrients to water bodies and the atmosphere, this serves to slow down the deterioration of soil and the quality of water and the environment. In nutritionally deficient soils, a scientifically regulated system of soil bacteria mycorrhiza and fungal plant association helps conserve energy by lowering crop fertiliser requirements and achieving production goals [3].

2. INTEGRATED NUTRIENT MANAGEMENT

The optimal use of synthetic fertilisers combined with organic nutrient sources is made possible by integrated nutrient management (INM) or integrated nutrient supply (INS). Understanding the relationships between crops, soils, and climate has helped develop integrated nutrient management (INM), which promotes the integration of both organic and inorganic fertiliser sources [4].

The opportunity presented by Integrated Nutrient Management is great for improving soil sustainability as well as overall productivity. Because of the global energy crisis and the ongoing increase in the cost of artificial fertilisers, using organic manure as a renewable source of plant nutrients is becoming more popular. The only method that can be used to increase soil productivity is integrated nutrient management, which combines organic matter and biological sources of plant nutrients with a balanced application of mineral fertilisers. 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 ultimately sustaining the physical and soil biospheres, include chemical and biological functioning of soil etc. Joy *et al*., [5].

Integrated nutrient management, which uses both natural and artificial plant nutrient sources, is a strategy for improving soil fertility and managing plant nutrients [6].In order to maximise productivity and preserve soil fertility, integrated nutrient management, or INM, refers to the prudent and effective use of mineral fertilisers, biofertilizers, and organic manures in an integrated way. In this endeavour, maintaining soil health as well as ensuring the right blend of inorganic and organic fertiliser is crucial. Increasing yield is crucial for maintaining soil health as well as for yield growth. The application of organic manures improved the efficacy of chemical fertilisers. Manure from the farm can be used as a beneficial amendment in place of chemical fertilisers. 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 [7]. 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 [8].

3. 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 and 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 environmentally unfriendly. 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 [9].

The management of soil organic carbon and the proper utilisation of organic inputs, such as crop residues, animal manure, green manure, sewage sludge, and wastes, along with integrated plant resource management, will be the main challenges for sustainable agricultural production [5]. The application of NPK through organics, such as crop residue, green manure, or farm yard manure (FYM), increased the concentration and rate of sequestration of microbial biomass carbon (MBC) and particulate organic carbon (POC) [10]. In order to boost crop productivity, farmyard manure (FYM), is regarded as a significant source of macro and micronutrients. The increased cost of inorganic fertilisers made it easier for Indian farmers to manufacture FYM on their farms and apply it to fields. All of the plant nutrients, including trace elements, required for crop growth are found in manure. A crop's ability to use manure effectively depends on the way it is applied, how long it takes to absorb, and how quickly microorganisms in the soil break down the manure (Hasim *et al*., 2015).

Judicious use of FYM with chemical fertilizers improves soil physical, chemical and biological properties and improves the crop productivity. Although integrated nutrient management (INM) makes use of both organic and inorganic nutrients, it is a viable choice for producing wheat in order to create farming systems that are both environmentally and financially sustainable. Fazily *et al*., [11]. Microorganisms, natural minerals, and vermicompost are combined to create enriched vermicompost. Adding organic matter—either in the form of farmyard manure, compost, vermicompost, or crop residues—is essential for maintaining soil fertility and providing additional plant nutrients since it is a key component of soil that affects the physical, chemical, and biological aspects of the soil. Because of the makeup of the additional materials or because they boost the soil's microbial activity, the incorporation of organic manures affects the enzymatic activity of the soil [12].

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 [13]. 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 [14].

The management of soil organic carbon and the sensible use of organic inputs including crop residues, green manure, animal manure, sewage sludge, and wastes—a process known as integrated plant resource management—will be crucial to the sustainability of agricultural output. Since organic manure alone cannot give all of the nutrients needed for contemporary agriculture, it is imperative to utilise fertilisers and organic sources in tandem to ensure that plants receive the nutrients they need and that the soil remains healthy [5]. To raise the pH of the soil to a point where available Fe, Al, or Mn (non-toxic) are present, lime and organic matter are required. Because well-decomposed organic matter improves soil buffering capacity, it can be applied on a regular basis to acidic soils to minimise abrupt pH fluctuations. Additionally, in acid soils, it decreases the toxicity of Fe and Al and raises the availability of P. It is possible to use lime, compost, cow dung (CD), poultry manure (PM), and compost to preserve soil fertility and reduce acidity. thought to be an effective strategy for producing crops sustainably in acidic soils. 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 [15].

4. 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 [16].

The growing trend towards the use of organic manures is a result of chemical fertilisers' limited ability to meet crop and cropping system requirements due to their high cost and minimal chemical residue [12]. Even when approved levels of N, P, and K fertilisers are applied, productivity is showing a downward tendency in long-term fertiliser trials using intensive cereal-based cropping systems. When chemical fertilisers and organic manures are applied together, crop yield rises. This mixture improved the soil's organic matter and nutrient quality as well as its physical, chemical, and biological characteristics [17].

Out of the 16 essential elements, nitrogen (N), phosphorus (P), and potassium (K) are required for crop growth. Plant nutrients are important factors in crop growth. Since N is essential to protein, chlorophyll, and other metabolic processes, it is the element that crops need most in significant quantities, followed by C. Consequently, high N fertiliser dosages are needed due to the growing population's demand for grain, which results in losses to the economy and environment. In particular, sandy soil has high N losses from leaching and low nitrogen usage efficiency [18].

5. BIO-STIMULANTS

Crops are treated with bio-stimulants, which are mixtures of various microorganisms and/or materials that are intended to promote growth, development, and resistance to abiotic stress. The process of nitrogen fixation, enhanced plant nutrition, and the synthesis of complex biologically active compounds like gibberellins, pyridoxine, biotin, nicotinic acid, and pantothenic acid—which promote seed germination and accelerate plant growth in favourable environmental conditions—are all linked to the beneficial effects of Azotobacter on plants [19]. *Trichoderma* based products have been particularly successful because of their capacity to control phyto-pathogenic fungi [20].

Since biostimulants are employed in the commercial sector to boost wheat yield, it was important to investigate how exogenous biostimulants affected the wheat growth process. The totality of a plant's metabolic processes adds up to its yield, which is influenced by several elements that impact the plant's metabolic activity during growth. The quantity of spikelets, number of viable florets, number of grains per spikelet, and grain size all affect the wheat's potential yield, which is reliant on early events. During the tillering period, a number of factors affect wheat production, including genotype, seeding rate, photoperiod, temperature, water content, and nutrient status. An essential adaptive trait of wheat is tillering, which allows plants to make full use of the resources and space that are available to them Majathoub, [21], Sustainable agriculture uses seaweed extracts to boost shelf life, growth, and quality. Numerous studies have shown that seaweed extracts are beneficial for a variety of crops, such as cereals, vegetables, field crops, decorative and flowering plants, and flowers (Leoni *et al*., 2019). Materials known as bio-stimulants have the ability to stimulate plant growth in modest doses. Both nanoparticles (NPs) and nanomaterials (NMs) are regarded as bio-stimulants because they promote plant growth within certain concentration ranges, usually at low levels [22].

6. VARIETIES FOR ORGANIC FARMING

Stability and dependability of quality and production for fifteen (ancient and modern) genotypes of durum wheat in organic farming. In order to assess the effects of "genotype × environment" (GE) interactions on genotype selection for protein and gluten content in N-limited environments, genotypes were grown at two different N levels (0 and 80 kg/ha). The results show that there is a high degree of environmental variability and that there are crossover "N × environment" interactions, which supports the need for specialised breeding programmes in N-deficient environments. A small number of genotypes produced good yield and quality at both fertilisation levels, and the average response was significantly influenced by N availability (on average, yield was 2.95 and 3.42 t/ha, protein content was 11.6% and 12.85%, and gluten content was 8.55% and 9.92%, respectively, at 0 and 80 kg N/ha) [23].

Ten winter wheat (*Triticum aestivum* L.) cultivars with very good, acceptable, and satisfactory baking quality were examined for grain yield and quality features in the context of organic agriculture. Grain output was lowest but grain quality was highest when growth conditions were warmer and drier than the long-term average. Grain from most winter wheat types also met the parameters needed to make bread. The cultivars "Lars" and "Zentos" yielded a high yield while maintaining stability; their respective sum integral assessments of grain yield were (11+) and (10+). Good baking utilisation possibilities may be provided by high-quality varieties from the very good / good baking quality groups grown ecologically, however this greatly depends on the surrounding conditions (Cesevičienė *et al*. 2009). In organic agriculture, choosing the right variety is one of the key elements affecting the output of cereal grains in terms of both quantity and quality. 13 spring wheat types were chosen for their appropriateness for organic farming based on their ability to compete with weeds, susceptibility to fungi, and grain production. In the organic system, KWS Torridon, Kandela, Arabella, Zadra, and Waluta were high-yielding types. While Brawura, Izera, Korynta, and Ostka Smolicka displayed the highest infection rate, the KWS Torridon and Kandela types shown resistance to fungal pathogen infestation. Because the ethos variety had a high percentage of weed infestation and a poor plant density, its yields were the lowest. 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 [24].

7. CHEMICAL FERTILIZERS AND ORGANIC MANURES

Wheat grain production and biomass increased when chemical and organic fertilisers were applied together. In order to improve sustainable crop production, farmers were also urged to compost the crop leftovers and apply them to their soils. A net increase in land production should be matched by an increase in soil fertility [25]. Verma et al. [12] investigated the long-term effects of applying both chemical and organic fertilisers in combination with NPK on the growth, development, and yield of the following wheat crop.

According to Ibrahim et al. [26], it was found that the 50% N through FYM+ 50% RDF to rice combined with 100% RDF to wheat performed better than N substitution through crop residue, green manuring, and artificial sources of nutrients. Using compost and organic manure improved wheat output and growth more than using artificial fertilisers. Using both organic and inorganic fertilisers in combination can definitely increase wheat output (Singh et al., 2017).

According to Yaduvanshi [27], fertilisers produced comparable nitrogen use efficiency (NUE) in rice when compared to organic manures plus inorganic fertilisers. However, the residual effects of organic manures plus inorganic fertilisers boosted NUE in wheat.

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 [28].

When organic manures and chemical fertilisers are treated together, the results are superior to those obtained by applying them separately in terms of yield, seed quality, and plant nutrient uptake. Therefore, it is concluded that for the development of environmentally friendly crops, greater yields, and sustained quality seed production, emphasis should be placed on the use of combination applications of organic manures and chemical fertilisers to soil [29].

The application of 5t of FYM ha^{-1} under INM resulted in the maximum nutrient recovery and economic return because FYM incorporation significantly increased yield and nutrient uptake in conjunction with inorganic fertilisers. When combined with organic nutrients, added fertiliser nutrients shown a beneficial impact on improving fertiliser recovery and economy [30].

Application of organic manures like press mud, vermin-compost 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 [31].

8. BIO-STIMULANTS AND CHEMICAL FERTILIZERS

The best results were obtained in terms of all yield parameters in wheat when FYM@ 5t/ha +NPK-G @ 200 kg/ha + NPK-bio-fertilizer + Urea@ 20 kg/ha at 40DAS and foliar spray NPK-P @ 1% along with Bio-stimulant-L 625 ml/ha at 55&70DAS were applied. According to Jat, L. et al. [7], the control group had the lowest yield. The use of bio-stimulants to wheat helps these plants become more resilient to environmental stressors. The type of biostimulant has an impact on wheat plant development and yield, according to data. Treatments with bio-stimulants are affordable, simple to use, and safe to handle. When compared to other bio-stimulants, Vigro's main benefit is its economic viability. Additional research in the fields of biochemistry and cytology is necessary to further our comprehension of how bio-stimulants impact wheat tillering [21].

For improved plant performance, bacterial fertilisers are added to chemical fertilisers and farmyard manure. It is crucial to simultaneously screen native rhizobacterial strains for growth and yield promotion in pot and field experiments in order to identify effective PGPR for the development of biofertilizers. This could help save the agro ecosystems from becoming contaminated while also lowering the expense of farming [32].

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 [33-36].

9. CONCLUSION

The application of vital plant nutrients in a light proportion and in the ideal quantity for a particular soil crop condition is known as balanced fertiliser, and it is crucial for improving the yield, quality, and other aspects of wheat production. The impact of integrated nutrition management on wheat development, yield, yield components, and quality indices is of great importance and warrants further investigation.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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