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A REVIEW

Efficacy of integrated nutrient management on soil properties and wheat yield

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Abstract : One of the most important aspects of agricultural production is soil fertility and nutrient management which has a direct impact on crop output and quality. However in the long run intensive cropping and chemical fertilizers harmed soil fertility and crop productivity by causing soil erosion, loss of top fertile soil, nutrient leaching, and uneven fertilizer use or little organic manure addition have resulted which caused human and animal suffering. To avoid nutrient mining and fertilizer imbalance, integrated nutrient management (INM) is a strategy for increasing agricultural productivity while also protecting the environment for future generations. It's a method that uses both organic and inorganic plant nutrients to boost crop yield, reduce soil degradation, and satisfy future food supply demands. So INM is a vital aspect in achieving increased and long-term soil fertility and crop output. This study discusses the importance ofINM in wheat production in today's intensive farming.

Key Words : INM, Physico-chemical properties, Wheat yield

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INTRODUCTION

In most nations, cereals are the good source of protein and calories. Wheat (*Triticum aestivum* L.) is one of the most important *Rabi* cereal crops in India's northwestern region, because to its distinctive protein content. It is one of most significant cereal crops in the world, coming in second place after rice in terms of both acreage and output. India is the world's second largest wheat producer, spanning around 29.14 million hectares and producing 102.19 million tonnes (Mt) of wheat with a productivity of 3507 kg ha^{-1} in 2018-2019 (Anonymous, 2019). Implementation of intensive cropping systems will fulfill the food demands of a growing population, but it will necessitate a large amount of input energy, which will not only pollute the environment but also increase production costs. Synthetic fertilizer production is extremely cost-effective, but it is dependent on nonrenewable fossil fuels, which are in limited supply. Organic sources such as farm yard manure (FYM), vermicompost, compost, green manure, and residual should indeed be encouraged to compensate for inorganic fertilizer supply and price increases, since they provide plant nutrients, boost soil biodiversity, and hence raise soil fertility and productivity. Chemical fertilizers used indiscriminately have led in nutrient depletion, soil organic

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carbon loss, and worsening of soil physical conditions, resulting in low wheat yield. The diminishing reactivity to inputs has been identified as a key concern threatening the wheat-based farming system's long-term viability (Desai *et al*., 2015).

As a result, integrated nutrient management (INM) is a strategy for increasing agricultural productivity while also protecting the environment for future generations. It's a method that uses both organic and inorganic plant nutrients to boost crop yield, reduce soil degradation, and satisfy future food supply demands. Application of farm yard manure improves crop yields, biological growth, soil physical characteristics, nutrient availability, and has direct residual impacts on subsequent crops. Organic manures may enhance the soil's health, physico-chemical characteristics and biological conditions in addition to providing nutrients. Organic manure application may increase the availability of natural nutrients in the soil and even the efficacy of applied fertilizers. The use of organic sources in conjunction with chemical fertilizers increases the physical, chemical, and biological aspects of the soil, as well as crop yield. When compared to a system that exclusively used mineral fertilizers, the conjunction of mineral fertilizers and organic manures increased wheat productivity (Pandey *et al*., 2009). The integrated management of both organic and inorganic nutrient sources boosts field crop productivity and profitability while also assisting in soil fertility maintenance. The goal of this evaluation was to investigate the benefits of INM on physico-chemical properties of soil, nutrient transformation and wheat crop.

Efficacy of integrated nutrient management strategy on wheat crop :

It is commonly acknowledged that in current intensive farming, when nutrient renewal in the soil-plant system is rather rapid, neither organic amendments nor chemical fertilizers employed separately can provide yield resilience at a higher order. In wheat production, an integrated plant nutrient delivery system incorporating the simultaneous use of chemical fertilizers and organics is critical.

Wheat yield and yield attributes :

In comparison to treatments where only inorganic fertilizer was administered, combined application of both organic and inorganic source boosted wheat dry matter accumulation, number of tillers, leaf area index and yield (Kakraliya *et al*., 2017). Fazily *et al*. (2021) found that during both consecutive years, the highest yield attributes and yield of wheat were produced with the application of 100 per cent recommended dose of nitrogen (RDN) + 25 per cent N through vermicompost, but there was no significant difference between the application of 100 per cent RDN + 25 per cent N through FYM. They generated more effective tillers, test weight, spike length, straw yield and grain yield of wheat than control. Integrated nutrient management (100 % NPK + FYM 10 t ha^{-1}) maximized wheat crop yields and improved fertility of the soil (Mauriya *et al*., 2013). According to Patel *et al*., (2014) using organic manures such as FYM (10 t ha^{-1}) and vermicompost (5 t ha^{-1}) with P_2O_5 (60 kg ha^{-1}) or P_2O_5 (40 kg ha^{-1}) + Phosphate solubilizing bacteria (PSB) and S (40 kg ha^{-1}) resulted in the highest wheat grain and straw yields. Argal *et al*. (2017) observed that by application of 75 per cent RDF + FYM (2.5 t ha^{-1}) + PSB+ $ZnSO_4$ (25 kg ha^{-1}) approach enhanced soil health and wheat crop performance. Jan *et al*. (2018) recorded that by using PM(2 t ha^{-1}) in conjunction with P (100 kg ha^{-1}) led in better wheat productivity. Singh *et al*. (2018) found that application of 100 per cent RDF + Vermicompost (2 t ha^{-1}) + PSB resulted in an increase in crop yield and yield attributes that was comparable to the application of 75 per cent RDF + Vermicompost (2 t ha^{-1}) + PSB and 100 per cent RDF + Vermicompost (2 t ha^{-1}) + PSB (2 t ha^{-1}). Singh *et al*. (2014) discovered that combining *Sesbania* as green manure (GM) with FYM in a long-term rice-wheat cropping system considerably boosted rice and wheat grain yields. In addition, the soil nutrient status was dramatically improved when compared to the control and prescribed fertilizer doses. Combined application of NPK (150: 60: 50 kg) + FYM (5 t ha^{-1}), Bhaduri (2012) found that wheat grain and straw yields were significantly boosted. The use of FYM in combination with inorganic fertilizers significantly boosted yield and nutrient absorption, resulting in the maximum nutrient uptake and economic return.

Nutrient transformation :

Nitrogen fractions :

In general, there are two types of nitrogen in soil they are inorganic and organic. The majority (95–99 %) is found in organic forms as component of the soil organic matter complex, which is not readily accessible to agricultural plants. Plants only take up the inorganic forms of nitrogen, such as NH_4-N and NO_3-N. Organic

nitrogen is found in soil as integrated amino acids or proteins, amino sugars, free amino acids and various complexes, most of which are unidentified. Basumatary and Talukdar (1998) found that combined application of chemical fertilizers with organic manures or biofertilizers enhanced the NH_4-N, NO_3-N, total N, and organic N percentages when compared to plots that only used chemical fertilizers. Guldekar and Ingle (2009) found that using N in conjunction with FYM, Zn, and S enhanced the condition of N fractions. Insoluble humin-N > hydrolysable NH_4-N + amino sugar-N > amino acid-N > acid soluble humin-N > fixed NH_4-N >NO_3-N > exchangeable NH_4-N were the most abundant N components in soil. In an acid Alfisol, Babita (2010) discovered that continual application of chemical fertilizers and organic amendments for 36 years resulted in significant increases in the organic and inorganic fractions of N, total N, and accessible N when compared to untreated plots. She also discovered that the hydrolysable NH_4-N had the most critical role in the supply of nitrogen, with NH_4-N having the strongest association with crop yields and total nitrogen absorption.

Phosphorus fractions :

Depending on soil and crop conditions the distribution of distinct inorganic P fractions and associated changes occur under continuous fertilization varies. The rebuilding of the labile pool when it is exhausted by P removal by the plant is governed by the comparative solubility of inorganic P fractions. The addition of organic manures has a significant effect on the availability and kinds of P in the soil. Sihag *et al*. (2005) found that when chemical fertilizers and organics were used together the amount of P retrieved as saloid-P, Al-P, and Ca-P increased significantly and the magnitude of the increase with inorganic fertilizer treatments were greater in the presence of organic material than in the absence. Farm yard manure had the largest quantity of all kinds of P among organic amendments followed by press mud and green manuring treatments. Organic amendments and higher NPK fertilizerthe status of $NaHCO_3$-Pi, NaOH-Po, HCl-P and residual-P improved. The ratio of the P fraction which comprises more labile P forms, to integrated inorganic P fractions, was shown to be negatively connected with soil pH and strongly correlated with the part of integrated Fe fractions related to weakly crystalline oxides (Saavedra and Delgado, 2005). Long-term manure application increases microbial activity and the capacity for decomposition of soil organic matter which may result in the transition of soil P organic fractions into P inorganic fractions (N'dayegamiye and Angers, 1990).

Potassium fractions :

Distinct forms of K such as water soluble, exchangeable and non-exchangeable K they are increased with increasing levels of organic and inorganic fertilizers when researching the transformation of K into distinct chemical pools. After 7 crop cycles with increasing levels of FYM, Singh *et al*. (2000) found a significant increase in NH_4OAc extractable and 0.01 M $CaCl_2$ extractable K. They also found that when FYM and fertilizer N were applied decrease in non-exchangeable K was observed. Pannu *et al*. (2001) suggested that wheat straw with GM and also rice straw treatments had the highest amount of non-exchangeable K, followed by FYM with GM and rice straw. They also found that non-exchangeable K rose with soil depth and that consistently incorporating rice straw for five years improved all K fractions as compared to removing it. Sood *et al*. (2008) discovered that continuous fertilizer and organic amendment treatment enhanced all K fractions in soil compared to control, and that K absorption was greater when lime or FYM was treated with 100 per cent NPK.

Physico-chemical properties of soil :

Chemical fertilization either alone or in conjunction with organic manures they are generally used to address the nutritional needs of crops and these substances are known to have an impact on the soil's physico-chemical characteristics. While in long-term usage of chemical fertilizers alone has a negative impact on soil health, resulting in unsustainable yields. Selvi *et al*. (2005) discovered that using FYM and NPK together boosted hydraulic conductivity substantially more than using NPK fertilizer alone. Dahiya *et al*. (2008) revealed that combined application of vermicompost or FYM with synthetic fertilizers boosted soil nutrient supply and water holding capacity which ultimately resulting in improve plant growth and output. Kumar *et al*. (2008) discovered that crop residues combined with 50 per cent NPK and FYM or GM may replace the crop's 50 per cent NPK need. Crop wastes and organic manures applied over time increased the soil's organic carbon content. When crop wastes, organic amendments and chemical

fertilizers were used together, the accessibility of N, P, K, S, and micronutrients in soil was much higher than when chemical fertilizers were used alone. Kumar *et al*. (2012) found that in long-term INM using FYM in a 50 per cent RDF + 50 per cent FYM treatment enhanced available N, P and K in soil. Tadesse *et al*. (2013) suggested that combining FYM and chemical fertilizer increased soil total N and accessible P. Additionally, FYM increased soil organic matter, lowered soil bulk density, and provided a favourable condition for growth and development of plants. Yuan *et al*. (2013) observed that continual addition of organic manure with inorganic fertilizers for 19 years increased soil organic carbon (SOC) accumulation, but treatments with inorganic fertilizer indicated no significant change in SOC content. Furthermore, when organic manure and inorganic fertilizer were applied together, macro-aggregation was enhanced, and macro-aggregates preserved carbon better than the control. Urkurkar *et al*. (2010) showed that in-situ implementation of GM combined with 50 percent of the prescribed fertilizer dosage resulted in the maximum accessible N in surface soil. The findings also demonstrated that FYM enhanced the accessible P and K status in soil, but pH and EC remained unchanged across all treatments. Argal *et al*. (2017) observed that soil pH, EC and bulk density were found to be significantly higher in the 150 per cent RDF, while mean weight diameter and moisture content were found to be significantly higher in the 75 per cent RDF + FYM (2.5 t ha^{-1}) + PSB + $ZnSO_4$ (25 kg ha^{-1}) than control.

Conclusion:

Chemical fertilizers generate the highest wheat yields but they also degrade soil health whereas organic manure helps to improve soil health over time. Given their beneficial effects on soil and role in reducing reliance on chemical fertilizers, INM is a tool that can provide good options and a cost-effective way to supply plants with adequate amounts of most macro- and micronutrients, as well as reduce the use of chemical fertilizers, improve soil physico-chemical properties, ensure long-term soil nutrient balance and generate an optimum level for sustaining desired crop productivity.

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There are no competing interests involved with this review.

Author's contributions:

Sunil Kumar designed the study and wrote the first draft of this review paper. Dharam Pal managed the draft and aided in information collection process. All the authors played their part in reading, drafting and have approved it for final submission process.

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