Review Article

Advances in Integrated Nutrient Management Practices for Cereal Crops: A Comprehensive Review

ABSTRACT

Integrated Fertilizer Management (INM) is an agricultural practice that maximizes the use of all available fertilizer sources to maintain and improve soil fertility and crop yield. The major goal of INM is to create sustainable agricultural output through a balance of organic, inorganic, and biological nutrition sources. INM promotes soil health by recycling nutrients, using less chemical fertilizer, and combining organic manures, crop waste, biofertilizers, and mineral fertilizers.INM entails meeting crop nutrient requirements with a variety of nutrient sources, including organic manures (e.g., farmyard manure, compost), crop residues, biofertilizers (e.g., Rhizobium, Azotobacter), and chemical fertilizers. INM requires soil fertility management, crop rotation, green manuring, and balanced fertilizer application. INM focuses on increasing nutrient efficiency, maintaining soil organic matter, stimulating biological activity, and limiting environmental effect.INM helps farmers by improving soil health, increasing nutrient efficiency and crop yields, lowering environmental pollution, and maintaining economic sustainability. INM has aided many crops, including wheat, maize, barley, and rice. For wheat, INM improves grain yield, quality, and protein content. It improves maize biomass yield, nitrogen uptake, and soil fertility. It allows barley to grow quicker, produce larger grains, and withstand abiotic stress better. In rice, INM enhances tillering, grain quality, and yield.Finally, INM is a holistic method that integrates a variety of fertilizer sources to promote long-term crop production and soil health management, and it offers a feasible solution to the difficulties produced by traditional agricultural practices.

Keywords: *INM; Nutrients; Crop waste; Biofertilizers; Mineral fertilizers; Farmyard manure*

1. INTRODUCTION

The growing global population has resulted in resource over exploitation, particularly on agricultural grounds where crops are intensively cultivated, resulting in land degradation. Food production is predicted to increase by 70% by 2050 to meet the needs of a growing population (Hunter *et al.,* 2009).To meet global demand, grain production will need to expand by 43 million metric tonnes per year on average. The employment of chemical and biological approaches is part of integrated nutrition management (Albahri et al., 2023). The amount of native soil nutrients and fertilizers that have previously been used by prior crops is impacted by increased fertilizers application, especially in regions where two or three crops are planted each year.It's not always the best option to use inorganic fertilizers because they can damage the land and increase expenses for small-scale farmers. Crops have been fertilized with organic fertilizers, such as farmyard manure, since the Middle Ages.Applying organic manure improves the crop's capacity to efficiently absorb nutrients while also restoring soil fertility (Iqbal et al., 2019).Modern concepts of integrated nutrient management have revolutionized agriculture by bringing a comprehensive perspective to the preservation and replenishment of soil fertility. It also reduces wasteful use of nutrients and cuts back on overuse of pesticides and fertilizers (Haddad *et al*.,2010).

While research supports and encourages farmers to apply integrated nutrient management (INM) practices, in order to effectively support farmers, support from a variety of sectors is required, including government agencies, NGOs, extension officers, and scientific researchers. In order to accomplish the goals of sustainable agriculture and improve soil productivity, farmers also contribute their efforts to boost the utilization of INM (Wuand Ma 2015).The present fall in food grain yield is worrying, and poses a severe threat to our country's food security. The deterioration of the soil, which is particularly apparent in places that are intensively farmed, is a major cause of this stalemate. India has an abundance of natural fertilizers, such as animal manure, compost from rural and urban regions, residual crops, green fertilizers, and bio fertilizers (manna et al., 2018).These resources are vital for conserving the physical, chemical, and biological aspects of soil and represent a prospective substitute for synthetic fertilizers. Vermicompost and farm yard manure are two examples of organic fertilizers that are essential for restoring soil health. Crop residues help to maximize the effectiveness of applied fertilizers, whereas vermicompost helps to lessen the detrimental impacts of chemical fertilizers on soil health (Kumar et al., 2018).

In conclusion, adding organic fertilizers improves the amounts of nutrients available to plants and their ability to absorb them.The primary goal of Integrated Nutrient Management (INM) is to maintain and maybe improve soil fertility in order to ensure long-term crop productivity. In reality, INM is a crop nutrition approach that covers plant nutrient requirements by a balanced application of mineral fertilizers, organic resources (such as green manure, vermicompost, crop residues, and Farm Yard Manure), and bio-fertilizers (Kumari et al., 2023). The strategic blending of these many nutrient sources is tuned to meet the system's specific requirements, land use patterns, and local ecological, social, and economic settings.According to studies conducted by Janssen (1993), Prasad *et al.* (2002) and Zhang *et al*. (2012), integrating nutrient management significantly improves rice production by reducing nutrient losses, optimizing nutrient supply, increasing resource efficiency, lowering costs, and increasing resilience to both biotic and abiotic stresses. Integrated nutrient management (INM) is a beneficial agricultural approach for maintaining food security and improving environmental conditions around the world, particularly in rapidly growing economies. This article discusses the concepts, objectives, principles, and INM methods in three cereal crops (wheat, rice, maize).The INM's opportunities for futuredevelopment are also discussed in this article.

2. OBJECTIVE OF INTEGRATED NUTRIENT MANAGEMENT

1. Reduce the use of synthetic fertilizers.
2. Maintain agricultural yield sustainably without endangering the health of the soil.
3. Conserve and make prudent use of local services.
4. Reduce the difference between the amount of nutrients given and the amount that crops absorb.
5. Enhance the physical, chemical, and biological qualities of soil.
6. Encourage the health of the soil by providing balanced nutrients from multiple sources.
7. Reduces or attenuate the adverse effects of a persistent dependence on artificial intelligence.
8. Improve farmers' financial situation.
9. Increase the efficiency of fertilizer (FUE).

3. CONCEPT OF INTEGRATED NUTRIENT MANAGEMENT

The phrase integrated nutrient management (INM) relates toa collection of cutting-edge and conventional techniques for efficiently controlling nutrients. This strategy integrates different resources and makes optimal use of both organic and inorganic sources, as described by Janssen in 1993. Its main objective is to meet crop nutrient demands while minimising environmental discharge and cycling nutrients like potassium, phosphorus, and nitrogen. Zhang *et al.* (2012) have underlined that INM techniques also address losses that occur between 1950 and 2010 and include leaching, runoff, immobilization, and volatilization. In addition,INM aims to enhance the chemical, biological, and physical properties of soil in order to boost production. As noted by Janssen in 1993, these actions also help to reduce soil degradation. The importance of using INM to protect soil resources as well as increase crop output is becoming increasingly apparent.According to Janssen (1993), applying techniques like intercropping, crop rotations, conservation tillage, and water conservation techniques like drainage, as well as using organic manures like farmyard manure and crop residues in addition to chemical fertilizers, green manures, and cover crops, all help to improve soil structure and increase plant nutrient availability. Furthermore, Zhang *et al.* (2012) highlighted the use of sophisticated methods such as the deep implantation of fertilizers and the administration of urea coated with neem, which acts as an inhibitor, to reduce nutrient losses and improve nutrient uptake by plants. Integrated Nutrient Management (INM) is a comprehensive method that blends conventional and current fertilizer technologies to maximize nutrient utilization (Chouhan et al., 2023).

This involves considering various factors such as nutritional characteristics, crop requirements, soil and farm resources and skillfully applying suitable nutrients to improve efficiency. INM also includes the safe processing and processing of organic waste into high-quality compost. Key aspects of INM include raising awareness among farmers, reducing dependence on chemical fertilizers, and promoting sustainable agricultural practices. It is important to focus on environmental impact and safe food production rather than simple profits, as consumer preferences for food safety can ultimately increase farmers' incomes.There is growing recognition that integrated nutrient management (INM) not only improves crop yields but also conserves soil resources. INM integrates production goals with environmental and environmental concerns, striving for optimal crop nutrition, soil health and minimal nutrient loss or environmental damage. Essentially, it is an essential component of sustainable agriculture, helping to safely process organic waste and convert it into high-quality compost. To boost crop yields and sustain soil fertility, it is vital to implement holistic nutrient management strategies adapted to the growing system rather than the single crop (Mahajan*et al.,* 2008).The integrated nutrient management (INM) approach described by Mahajan *et al.* (2008) prioritizes the whole system over individual crops. Core principles include raising farmers' awareness of the benefits of INM practices, preventing over-reliance on chemical fertilizers, and promoting sustainable, long-term approaches to agriculture. INM is trying to enhance soil nutrient management by increasing crop productivity and resource use efficiency using renewable nutrient sources, while considering environmental concerns, rising chemical fertilizer costs, soil degradation, and yield volatility. By minimizing the demand for inorganic fertilizers, INM helps small farmers in underdeveloped nations save money (Meena & Vishnuvardhan, 2021).

The basic principles of integrated nutrient management (INM) are:

1. Optimize plant nutrition supply to attain the target yield.
2. Manage the application of chemical fertilizers, organic fertilizers, agricultural residues, and nitrogen-fixing crops in accordance with the land's individual needs, while accounting for environmental, social, and economic issues.
3. Integrated nutrient management techniques enhance soil physical properties such as soil structure, aggregate stability, moisture retention, and hydraulic conductivity. This change in soil physical qualities helps to promote soil fertility and productivity.

INM has traditionally been used to maintain soil fertility for the reasons listed below:

1. This improves the availability of soil amendments and local nutrients throughout the growing season.
2. Match nutritional requirements to plant needs in both temporal and spatial distribution using nutrients from soil and applied sources.
3. Promotes overall soil health, including physical, chemical and biological aspects.
4. Minimizes unnecessary leaching of fertilizer nutrients into waterways and the atmosphere, mitigating losses to soil, water and environmental quality.

4. COMPONENTS OF INM

The main components of integrated nutrient management (INM) can be divided into three main groups (Fig. 1):

1.Compost
2.Green Manure
3. Crop Residue
4. Fertilizer
5. Manure
6. Bio fertilizer

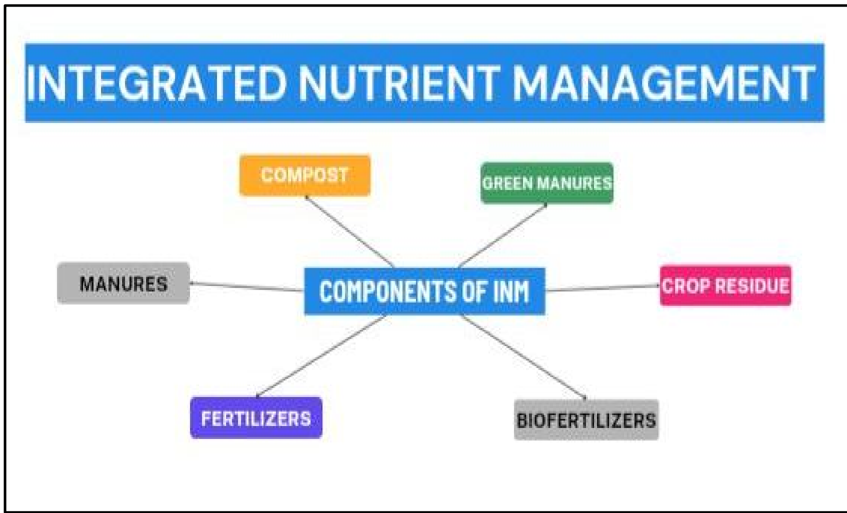

Fig. 1:components of INM

5. PRINCIPLE OF INTEGRATED NUTRIENT MANAGEMENT

The fundamental concepts of integrated nutrition management (INM) are:

a)The primary purpose of INM is to increase crop output and resource efficiency through optimal soil nutrient usage.

b) It is important to supply nutrients to the soil according to the needs of the crops in terms of space and time. Tailoring fertilizer application rates and timing to match crop nutritional requirements is essential to maximize yields and improve nutrient utilization.

c) Another key principle is to minimize nitrogen (N) losses while increasing crop yields. Excessive use of nitrogen fertilizers can increase nitrate leaching into groundwater and air emissions.

INM strives to achieve high crop yields while mitigating N loss and its negative environmental impacts. The destiny of nitrogen in the field is regulated by factors such as N intake by crops, immobilization, soil residues, and losses to the environment. INM also promotes organic fertilizer systems, which have the potential to increase long-term agricultural sustainability and lessen environmental consequences.Organic fertilizers, along with crop residue integration and conservation tillage (e.g., no-till or reduced-till methods), can not only reduce greenhouse gas emissions, but also enhance soil quality and encourage carbon storage, resulting in higher yields.

6. ADVANTAGES OF INTEGRATED NUTRIENT MANAGEMENT

Advantages of integrated nutrient management (INM) illustrated in Fig. 2.

1.Increases the availability of soil nutrients, both naturally existing and supplemented.

2.Aligns the crop's nutrient supply from applied and native sources to its nutritional needs.

3.Minimizes the negative impacts caused by nutrient imbalance and hidden inadequacies while providing crops with adequate nutrition. enhances and maintains the soil's capacity for chemical, biological, and physical processes.

4. Reduces nutrient losses to ground and surface water bodies, the atmosphere, and carbon sequestration, which lessens the degradation of soil, water, and ecosystems.

5. Sustainability of food production.

6. Reduction in cost of cultivation.

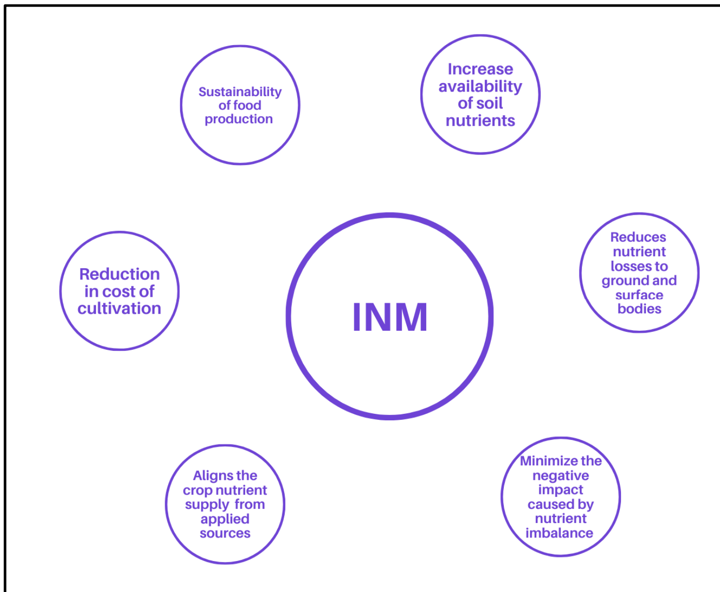

Fig.2:Advantages of INM

7. EFFECT OF INTEGRATED NUTRIENT MANAGEMENT ON DIFFERENT CROPS

1. WHEAT

Several studies have demonstrated the benefits of integrated nutrient management in enhancing the crop yield, yield component and quality indices of wheat crop.(Chauhan *et al.*,2024) performed an experiment on the effect of INM on growth indices, yield attributes, yield and economics of wheat and concluded that the combined application of 75 % RDF + vermicompost @ 5 t/ha+ Azospirillum + PSB or 75 % RDF + FYM @ 10 t/ha+ Azotobacter + PSB gives the higher yield and net return of wheat crop. (Kaur *et al.,*2024) stated that bymaximizing the use of organic (vermicompost, FYM, biostimulants, compost) and inorganic (macro- and micronutrients containing synthetic chemical fertilizers) inputs can improve soil fertility,crop yield and reduce environmental consequences to ensure the long-term viability of agricultural systems. (Prasad *et al.*,2024) found that nnutrient treatment with 85% RDF and 15% VC (N3) greatly improves growth, yield, and economic performance andrreturns on Wheat.(Mohan *et al.*, 2018) found that the INM with 100% RDF + 25% N through vermicompost is an appropriate mix of fertilizers and organic manures for sustainable wheat production and increased nutrient availability. Devi *et al.* (2011) discovered that combining 75% RDF (120:26:4:50 N:P:K kg ha-1) with vermicompost (1t ha-1) and PSB resulted in greater wheat growth and yield, enhanced NPK uptake, improved residual fertility, and higher payment when compared to utilizing prescribed or organic fertilizer alone. (Patyal*et al.,*2022) discovered that using 100% RDF +25% N via vermicompost + ZnSO4 at 25 kg ha-1 resulted in the maximum wheat crop output.

2. MAIZE

Baradhan and Kumar, (2018) studied the effect of Integrated Nutrient Management in yield of Maize amd found that using 100% RDF, vermicompost at 5 t ha-1, and azospirillum at 2 kg ha-1 can improve hybrid maize productivity through eco-friendly and cost-effective nutrient management.Nanjappa *et al.*(2001) found that by combining 50-75% recommended fertilizer with 12 tonnes/ha FYM or 2.7 tonnes/ha vermicompost increases maize productivity and reduces nitrogen loss in the soil. (Singh *et al.,* 2024) found that the Using 50% RDF together with 5 t/ha poultry manure, farm yard manure, or both increased maize productivity and significantly improved soil physicochemical qualities, comparable to using 100% RDF. Additionally, Jamwal, (2006) found that applying 10 tons FYM/ha and the recommended amount of NPK to maize during kharif had a considerable impact on following crops, including chickpea and gobhi sarson. Ponmozhi *et al.,* 2019 found that the combination of 100% RDF, 25% vermicompost, 25% FYM, and 25 kg ZnSo4 generated the best results, and they conclude that organic fertilizer can boost maize growth and productivity when compared to inorganic fertilizers.Sunda *et al.,* 2023 concluded that the application of Vermicompost at 5 t ha-1 (VC2), 75% RDF (F2), and Azotobacter + PSB (B1) significantly increased the nutritive and protein content of maize seeds in typic haplustepts.

3. RICE

Dhruve*et al.*(2023) studied the effect of integrated nutrient management on yield and yield attributed of scented rice and found that by using 75% RDF and 5 tonnes of vermicompost per ha, enhanced with consortia, is a promising approach for increasing productivity through integrated nutrient management.(Bashiya *et al.,* 2015) found that aapplying 75 kg N, 16.5 kg P, 31.3 kg K, and 2.5 t poultry manure per hectare was determined to be the most beneficial for sustainable rice production, profitability, and soil fertility. Adding 5 tonnes of Sesbenia green manure per hectare, along with 75 kg of nitrogen, 16.5 kg of phosphorus, and 31.3 kg of potassium, may result in a greater benefit-to-cost ratio. (Sahu *et al.,* 2015) found that the STCR dose with 5 t FYM for a yield target of 50 q ha-1 and 100% GRD + 5 t FYM ha-1 resulted in increased plant height, total and effective tillers, panicle length, total filled grains, test weight, dry matter production, and rice yield.Accordingly, (Yadav *et al.,* 2021) found that to ensure good agriculture, farmers in eastern Uttar Pradesh should use Chemical fertilizers provide 75% RDF, whereas hybrid rice bio-compost provides 25% nitrogen.(Kumar *et al.,* 2012) found that Combining organics (FYM, SPM, GM, and WR) with fertilizers can promote sustainable rice yields and soil fertility in recycled sodic soils. Green manure, SPM, and FYM increased soil Fe and Mn content compared to chemical fertilizers alone.

4. BARLEY

(Meena *et al.,*2017) found that using a combination of 75% NPK inorganic fertilizer and 5 t of well-decomposed FYM with 20 kg zinc sulfate per acre increased crop output and improved soil fertility compared to using chemical fertilizers alone.(Karol *et al.,*2023) studied the effect of integrated nutrient management on growth and yield of Barley and concluded that by using 100% RDF + vermicompost 2.5 t ha-1 + Azotobacter resulted in increased plant height, tillers, ear length, and nitrogen content in grain and straw of barley and with the use of 100% RDF resulted in the highest net returns and B:C ratio for barley. (Jat *et al.,*2010) found that for increased productivity and profitability, barley crops should be treated with 100% RDF + 5 t FYM/ha and seed inoculated with liquid biofertilizer Azotobactor + Azospirillum + Phosphates solubilizer + PGPR. (Jat *et al.,* 2018) found that by using FYM, 100% NPK based on STR, and the addition of Azotobacter + PSB enhanced yield and nutrient uptake in sorghum-barley cropping sequences under present agro-climatic conditions.Dinka *et al.* (2018) concluded that integrated nutrient management boosted food barley output in Dada Gelan kebele, TokeKutaye District, and that using NPS: FYM ha-1 is suggested for barley farming in Toke Kutaye district and related agro-ecologies (66.6:33.4%).

8. CONCLUSION

Integrated Nutrient Management (INM) in cereal crops is a sustainable way to improve crop yields and maintain soil health.INM combines organic and inorganic nutrient sources to provide a balanced and timely shipment, resulting in increased crop development and yields. INM methods contribute to the long-term maintenance or improvement of soil fertility. Adding organic improvements like compost and green manure improves soil structure, microbial activity, and nutrient-holding capacity. INM reduces dependency on chemical fertilizers, minimizing the risk of environmental pollution, such as water contamination from nutrient runoff. It reduces the carbon footprint associated with synthetic fertilizer manufacture. INM can lower production costs by reducing dependency on chemical fertilizers and improving nutrient efficiency, making it more cost-effective for farmers. INM promotes soil health and sustainable farming methods to enhance resilience against climate change's harmful effects, including drought and soil degradation.ThereforeIntegrated Nutrient Management in cereal crops is a comprehensive technique that not only increases productivity but also protects soil fertility, the environment, and economic sustainability.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

REFERENCES

Hunter, M. C., Smith, R. G., Schipanski, M. E., Atwood, L. W., & Mortensen, D. A. (2017). Agriculture in 2050: recalibrating targets for sustainable intensification. *Bioscience*, *67*(4), 386-391.

Albahri, G., Alyamani, A. A., Badran, A., Hijazi, A., Nasser, M., Maresca, M., & Baydoun, E. (2023). Enhancing essential grains yield for sustainable food security and bio-safe agriculture through latest innovative approaches. *Agronomy*, *13*(7), 1709.

Iqbal, A., He, L., Khan, A., Wei, S., Akhtar, K., Ali, I., ... & Jiang, L. (2019). Organic manure coupled with inorganic fertilizer: An approach for the sustainable production of rice by improving soil properties and nitrogen use efficiency. *Agronomy*, *9*(10), 651.

Haddad, N., Duwayri, M., Oweis, T., Bishaw, Z., Rischkowsky, B., Hassan, A.A. and Grando, S. (2011). The potential of small-scale rainfed agriculture to strengthen food security in Arab countries. *Food Security*, *3*, 163-173.

Wu, W. and Ma, B. (2015). Integrated nutrient management (INM) for sustaining crop productivity and reducing environmental impact: A review. *Science of the Total Environment*, *512*, 415-427.

Manna, M. C., Rahman, M. M., Naidu, R., Sahu, A., Bhattacharjya, S., Wanjari, R. H., ... & Khanna, S. S. (2018). Bio-waste management in subtropical soils of India: future challenges and opportunities in agriculture. *Advances in agronomy*, *152*, 87-148.

Kumar, A., Prakash, C. B., Brar, N. S., & Kumar, B. (2018). Potential of vermicompost for sustainable crop production and soil health improvement in different cropping systems. *International Journal of Current Microbiology and Applied Sciences*, *7*(10), 1042-1055.

Kumari, S., Kumar, R., Chouhan, S., & Chaudhary, P. L. (2023). Influence of various organic amendments on growth and yield attributes of mung bean (*Vigna radiata* L.). *International Journal of Plant & Soil Science*, *35*(12), 124-130.

Janssen, B.H. (1993). Integrated nutrient management: the use of organic and mineral fertilizers. In *The role of plant nutrients for sustainable food crop production in sub-Saharan Africa* (pp. 89-105). Ver. KunstmestProducenten.

Prasad, P.V.V., Satyanarayana, V., Murthy, V.R.K. and Boote, K.J. (2002). Maximizing yields in rice–groundnut cropping sequence through integrated nutrient management. *Field Crops Research*, *75*(1), 9-21.

Zhang, F., Cui, Z., Chen, X., Ju, X., Shen, J., Chen, Q., Liu, X., Zhang, W., Mi, G., Fan, M. and Jiang, R. (2012). Integrated nutrient management for food security and environmental quality in China. *Advances in agronomy*, *116*, 1-40.

Chouhan, S., Kumari, S., Kumar, R., & Chaudhary, P. L. (2023). Climate resilient water management for sustainable agriculture. *Int. J. Environ. Clim. Change*, *13*(7), 411-26.

Mahajan, A. N. I. L., Bhagat, R. M., & Gupta, R. D. (2008). Integrated nutrient management in sustainable rice-wheat cropping system for food security in India. *SAARC Journal of Agriculture*, *6*(2), 29-32.

Meena, M., & Vishnuvardhan, R. K. (2021). A review on Integrated nutrient management for sustainable agriculture. *The International Journal of Analytical and Experimental Modal Analysis*, *8*, 541-51.

Chauhan, J., Pandey, S., Rawat, A., Chauhan, A., & Bhatt, P. (2024). Effect of INM on Growth Indices, Yield Attributes, Yield and Economics of Wheat (Triticum aestivum L. emend. Fiori & Paol.). *Journal of Experimental Agriculture International*, *46*(6), 733-739.

Kaur, G., Singh, I., Behl, R.K. and Dhankar, A. (2024). Effect of Different Integrated Nutrient Management Approaches on Growth, Yield Attributes and Yield of Wheat

(*Triticum aestivum* L.) Crop: A Review. *Asian Journal of Soil Science and Plant Nutrition*, *10*(1), 457-468.

Prasad, K.L., Wadatkar, H., Jadhav, D. and Reddy, H. (2024). Effect of Varieties and Nutrient Management on Growth and Yield of Wheat Crop under Irrigated Condition (*Triticum aestivum* L.). *Asian Journal of Soil Science and Plant Nutrition*, *10*(3), 191-207.

Mohan, B., Kumar, P. and Yadav, R.A. (2018). Effect of integrated nutrient management on yield attributes and yield of wheat (*Triticum aestivum* L.). *Journal of Pharmacognosy and Phytochemistry*, *7*(1), 1545-1547.

Devi, K.N., Singh, M.S., Singh, N.G. and Athokpam, H.S. (2011). Effect of integrated nutrient management on growth and yield of wheat (*Triticum aestivum* L.). *Journal of Crop and Weed*, *7*(2), 23-27.

Patyal, A., Shekhar, C., Sachan, R., Kumar, D., Yadav, A. and Kumar, G. (2022). Effect of integrated nutrient management (INM) on growth parameters and yield of wheat (*Triticum aestivum* L.). *International Journal of Plant & Soil Science*, *34*(22), 962-967.

Baradhan, G. and Kumar, S.S. (2018). Studies on the effect of integrated nutrient management in yield of maize (*Zea mays* L.).*Plant Archives,18(2),* 1795-1800.

Nanjappa, H.V., Ramachandrappa, B.K. and Mallikarjuna, B.O. (2001). Effect of integrated nutrient management on yield and nutrient balance in maize (*Zea mays*). *Indian Journal of Agronomy*, *46*(4), 698-701.

Singh, M., Jaswal, A., Sarkar, S., & Singh, A. (2024). Influence of integrated use of organic manures and inorganic fertilizers on physio-chemical properties of soil and yield of Kharif maize in coarse loamy typic haplustept soil. *Indian Journal of Agricultural Research*, *58*(4), 616-621.

Jamwal, J.S. (2006). Effect of integrated nutrient management in maize (*Zea mays*) on succeeding winter crops under rainfed conditions. *Indian journal of Agronomy*, *51*(1), 14-16.

Ponmozhi, C.I., Kumar, R., Baba, Y.A. and Rao, G.M. (2019). Effect of integrated nutrient management on growth and yield of maize (*Zea mays* L.). *International Journal of Current Microbiology and Applied Sciences*, *8*(11), 2675-2681.

Sunda, S.L., Singh, D.P., Jain, H.K., Bamboriya, J.S., Bhawariya, A., Meena, A.K. and Dhayal, S. (2023). Effect of INM on nutrient content and quality parameters of maize in typic haplustepts. *The Pharma Innovation Journal*, *12*(3), 1787-1790.

Karol, A., Sharma, P.K., Raj, A., Rawat, A. and Shaji, A. (2023). Effect of Integrated Nutrient Management on Growth and Yield of Barley (*Hordeum vulgare* L.). *International Journal of Environment and Climate Change*, *13*(10), 2968-2976.

Meena, R., Meena, R.N., Singh, R.K., Singh, Y.V. and Meena, R.K. (2017). Effect of Integrated Nutrient Management on Growth, Yield, Soil Fertility and Economics of Barley (*Hordeum vulgare* L.). *Environment & Ecology*, *35*(3C), 2361-2366.

Dinka, T.B., Goshu, T.A. and Haile, E.H. (2018). Effect of integrated nutrient management on growth and yield of food barley (*Hordeum vulgare*) variety in toke kutaye district, west showa zone, Ethiopia. *Advances in Crop Science and Technology*, *6*(3), 1-8.

Jat, M.K., Purohit, H.S., Choudhary, S.K., Singh, B. and Dadarwa, R.S. (2018). Influence of INM on yield and nutrient uptake in sorghum-barley cropping sequence. *International Journal of Chemical Studies*, *6*(3), 634-638.

Kumar, M., Yaduvanshi, N.P.S. and Singh, Y.V. (2012). Effects of integrated nutrient management on rice yield, nutrient uptake and soil fertility status in reclaimed sodic soils. *Journal of the Indian Society of Soil Science*, *60*(2), 132-137.

Yadav, D.K., Yadav, S., Anshuman, K., Rao, A., Srivastava, A., Dev, A. and Prakash, V. (2021). Studies on the effect of integrated nutrient management practices (INM) on yield and economics of aromatic rice (*Oryza sativa* L.). *Intl. J. Agric. Sci*, *12*(1), 101-105.

Sahu, Y. K., Chaubey, A. K., Mishra, V. N., Rajput, A. S., & Bajpai, R. K. (2015). Effect of integrated nutrient management on growth and yield of rice (*Oryza sativa* L.) in Inceptisol.*Plant Archives ,15(2),* 983-986.

Baishya, L.K., Rathore, S.S., Singh, D., Sarkar, D. and Deka, B.C. (2015). Effect of integrated nutrient management on rice productivity, profitability and soil fertility. *Annals of plant and soil research*, *17*(1), 86-90.

Dhurve, R., Pandey, T.D., Verma, N.K. and Bhagat, R.K. (2023). Effect of integrated nutrient management on yield and yield attributes in scented rice (*Oryza sativa* L.). *International Journal of Plant & Soil Science*, *35*(23), 244-249.