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A review on integrated nutrient management (INM) on performance of summer rice

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Abstract
Rice (*Oryza sativa* L.) is a crucial commodity for Asia's food security and a major source of nutrients and energy in India. Exploiting the production potential of high yielding rice varieties through agronomic management is one of the alternatives to feed the ever growing population. Excessive application of chemical fertilizers to attain higher yield has not only reduced the nutrient use efficiency but has also adversely affected the soil productivity and environmental stability. The adoption of the idea of Integrated Nutrient Management (INM), which must be given high priority, will significantly enhance rice output in order to fulfil the demand for the grain from the world's expanding population. Integrated nutrient management (INM) refers to the application of both chemical and organic fertilisers, including organic and inorganic manures, green manures, bio-fertilizers, and other organic decomposable materials. The total responses on the grain crop have improved with the application of integrated nutrition management in rice, which results in maximum growth characteristics and yield attributes. The objective of this paper is to comprehensively review the literatures and recommend the best proportion different source of fertilizers for sustainable rice production and soil properties improvement. Different original research articles published elsewhere in the world were reviewed to compile the information.

Keywords: Rice, agronomic management, INM, organic, improved, sustainable

1. Introduction

Rice (*Oryza sativa* L.) is a significant source of nutrients and energy in India (Monika 2013) [15]. It belongs to family Poaceae (Gramineae). More over two billion people in Asia consume rice and rice-derived products to provide 60-70% of their energy needs (Tomar *et al*., 2018) [24]. In 2020, world production of paddy rice was 756.7 million metric tons, led by China and India with a combined 52% of this total (NFSM 2022). According to a report by the Press Information Bureau, total production of Rice during 2021-22 is estimated at record 127.93 million tonnes. It is higher by 11.49 million tonnes than the last five years' average production of 116.44 million tonnes. However, with severe deficiency of monsoon rainfall in the eastern regions hitting paddy sowing activities, the country's rice production for 2022-23 crop year (July-June) may turn out to be at least 10 million tonne (MT) less than last year's record level of 129 MT. In West Bengal, rice is cultivated in an area of 5.58 million hectare with an annual production of 16.65 million tonnes (Agricultural statistics at a glance 2021). The population of the world is growing every day. The world's population, which is currently 7.3 billion, is projected to increase to 8.5 billion by 2030, 9.7 billion in 2050, and 11.2 billion in 2100 (UNSD, 2015) [24]. Thus, it is anticipated that by 2050, the world's demand for grains would have doubled, making it difficult to increase rice output much further. Global food production must increase by at least 70% by 2050 in order to meet the demands of a growing population (Bruinsma, 2009) [5].

Due to the advent of high yielding and fertilizer-responsive varieties after the green revolution, rice farming has become more intensive, which has increased use of chemical fertilisers and pesticides. Due to the increased usage of chemicals, the environment, including the soil, water, and atmosphere, have been negatively impacted, resulting in pollution and decreased soil productivity (Surekha *et al*., 2008) [23]. Despite the size of the rice-growing region, productivity is low because of a number of interrelated problems. One of the main causes of the low productivity is the uneven fertiliser application, and the ongoing use of inorganic fertilisers has also caused the soil's fertility to decline. Integration of nutrients from organic and inorganic sources is required to address the issue and preserve soil fertility, which can help to increase crop yields and improve the sustainability of production.

The idea of Integrated Nutrient Management (INM) must be given high importance if rice production is to increase to satisfy the everyday needs of the expanding population. By maximising the benefits from all potential sources of plant nutrients in an integrated way, integrated nutrient management refers to the maintenance or adjustment of soil fertility, plant nutrient supply, and desired productivity (Roy, 1995) [20]. The application of organic manures, including vermicompost, farmyard manure, bio-fertilizers, and recycling of crop biomass, is important for nutrient cycling and for enhancing the physical, chemical, and biological qualities of the soil (Patel *et al*., 2015) [7].

Rice production decline has been linked to widespread zinc shortage in addition to deficiencies in nitrogen, phosphate, and potassium. In India, it is estimated that 67% of soils lack sufficient nitrogen, which has led to the rice crop becoming a major consumer of nitrogen fertiliser (Hooper, 1982) [8]. The application of high nitrogen without the proper balancing of phosphorus, potassium, and other nutrients had a deleterious impact on the soil (Kumar *et al*., 2011) [12]. Therefore, appropriate nutrient management practice is required for obtaining higher yield of summer rice.

INM technology is sustainable as compared to modern chemical farming as it relies more on organic inputs (Singh *et al*., 2001) [16]. The effectiveness of integrated nutrient management practice can depend on season, soil type, climate, water management, variety and cropping pattern. In general, by using different INM approaches to boost rice production, it has a huge potential to greatly benefit rice production systems through increased yield and other qualities for fulfilling the world's food need.

2. Integrated Nutrient Management

For crop production, integrated nutrient management (INM) refers to the application of both chemical and organic fertilisers, including organic and inorganic manures, green manures, bi-fertilizers, and other organic decomposable materials. The fundamental principles of INM are the maximising of benefits from all potential sources of plant nutrients in an integrated way in order to maintain soil fertility and supply of plant nutrients to an optimal level for maintaining targeted crop productivity.

2.1 Components of INM

1. The application of organic manures such as FYM, compost, vermicompost, biogas, slurry, chicken manure, bio-compost, press mud cakes, and phosphor-compost.
2. using biological fertilisers.
3. using fertiliser nutrients in a balanced way, taking into account the crop's needs and desired output.
4. crop residue recycling.

2.2 Objective of INM

The primary goal of integrated nutrient management is to sustain economic production over an extended period with minimal impact on native soil fertility and environmental contamination, educating farmers about eco-friendly practises (such as organic farming systems) to produce healthy food free of toxins and ensure adequate financial returns (Selim and Imhoff, 2020) [21].

3. Integrated Plant Nutrient Management through Macro- and Micronutrients

The growth in plant height, leaf size, panicle quantity, and high yield per hectare all depend heavily on nitrogen. Nitrogen is required by rice for it to produce a sufficient number of panicles. Total number of tillers plant-1 decreased progressively with decreasing levels of nitrogen and became the least when no nitrogen was applied.

Phosphorus helps plants store energy and distribute it to various sections of the plant. Hence, the appropriate phosphorus dosage is required. In addition, phosphorus is necessary for rice's early maturity, strong straw, crop quality, and resistance to disease.

Disease resistance, root thickness and expansion, leaf tenacity, and panicle initiation and growth are all influenced by potassium (K).

Some micronutrients, such zinc, iron, and manganese, are crucial for paddy crops. Micronutrient deficits are becoming more prevalent in the rice production. Zn and Fe deficiencies are prevalent in high pH soils. In order to address the lack of micronutrients, green manuring is also beneficial (Fageria *et al*., 2008) [6]. 75% N + 25% N through vermicompost + ZnSO4 (25 Kg/ha) + 100% PK through inorganic fertilizer + microbial consortium was increased number of productive tiller/m2 (Vignesh *et al*., 2019) [26].

4. Effect of INM on Diseases in Paddy

By controlling the levels of nitrogen, phosphorus, potassium, and other vital components, INM helps to lessen the disease infestation. Nitrogen deficiency in paddy leads to chlorosis in older leaves, necrosis and retarded growth of plants. Excessive application of nitrogen increases the disease and insect susceptibility, weakens the stem and led to patchy appearance of the crop. Other ailments, such bacterial leaf blight (BLB), bacterial leaf streak, false smut, leaf blast, sheath blast, and sheath rot, etc., are brought on by excessive nitrogen fertiliser. An appropriate amount of N promotes higher growth, maintains plant health, and guards against damage. Phosphorus plays an important role to minimize the incidence of BLB, but on the other hand, it encourages other diseases in rice such as leaf blast and sheath blight (Nas *et al*., 2012) [27]. Insufficient potassium availability can cause diseases including stem and sheath rot, kernel smut, and sheath rot in rice plants.

5. Integrated plant Nutrient Management in Relation to Plant Growth

The application of the optimum amount of inorganic and organic fertilizers, which is a crucial choice and critical component for increasing crop development and nutrient uptake as well as an important element in sustaining the crop life cycle and yield potential, is one aspect that affects plant growth. Success of INM relies on a number of factors, including appropriate right combination, right dose, and right form at right time of plant need.

5.1 Growth Characters

5.1.1 Plant Height (cm) in Rice plant as affected by integrated nutrient management

Application of both chemical and organic fertilisers could not only support increased grain output but also increase plant height by reducing the biotic stressors in Rice cultivation. In addition, organic sources with slow releases and ongoing availability of nutrients enhanced cell division, elongation, as well as various metabolic processes, which ultimately resulted in an increase in plant height. Neti *et al*. (2022) [18] reported that the maximum height of the plants was recorded at 90 DAT in the treatment receiving 50% RDF + 50% N through green leaf manure and it was closely followed by100% RDF, 50% RDF + 50% N through FYM,75% RDF + 25% N through green leaf manure,75% RDF + 25% N through FYM. Elongations were slower, especially between 90 DAT and harvest, mostly due to a higher need for photosynthetic energy to support reproduction after the reduction division stage. Vermicompost and Zn applied in plant might help in enhancing photosynthesis rate by involving in chlorophyll formation, intercellular CO2 concentration which induces better plant height (Khan *et al*., 2009 and Ahmed *et al*., 2009) [10, 3]. The tallest plant (96.0 cm) was registered under75% RDF+ 2 t ha-1 Vermicompost + 25 kg ha-1 ZnSO4 (kwami *et al*., 2022) [13].

5.1.2 Tiller Number in rice plant as affected by integrated nutrient management: Integrated nutrient management help plant nourishment by making the nutrients available which ultimately increased the tillers and source capacity of the plant. Ashem *et al*. (2022) [4] observed that application of 75% RDN through fertilizer + 25% RDN through vermicompost + 25 kg ZnSO4 ha-1 resulted in significantly higher number of effective tillers m-2(377.83) over RDF. Vermicompost and inorganic fertilizer enabled rice plant to assimilate sufficient photosynthates resulting in production of more productive tillers. The treatment with 75% RDN+25% N through vermicompost recorded the maximum number of tillers m-2(273.3) (Ram *et al*., 2020) [19]. Neti *et al*. (2022) [18] reported the maximum values of number of tillers hill-1 were found at 90 DAT. The treatment with 50% RDF + 50% N through green manure recorded the maximum number of tiller hill-1(16.16) and it remained statistically at par with other treatment except control (10.06). Maximum tillers m-2 was recorded under integrated nutrient management 50% RDF+50% N as FYM which was at par with either 25 or 50% N substituted by organic source at all the growth stages and at harvest stage (Singh *et al*., 2018) [22]. Application of higher level of N (180 kg ha-1) produced more number of tillers as compared to application of 150 kg of N ha^{-1} (Adhikari *et al*., 2018) [1].

6. Integrated plant nutrient management in relation to crop yield: In addition to improving soil characteristics, integrated use of organic, chemical, and biofertilizers also effectively reduces crop nutrient requirements, reduces nutrient loss, and increases cation exchange, water storage capacity, and service to sustain better yield (Khoshgoftarmanesh *et al*., 2010) [11].

6.1 Yield Attributes

6.1.1 Number of panicles per square meter as affected by Integrated nutrient Management: The number of panicles per square meter can be affected by various factors such as nitrogen fertilizer, plant height, effective tiller per square meter, and more. The pooled data reported that highest number of panicles m-2 were recorded in 75% RDF+ 2 t ha-1 Vermicompost+ 25 kg ha-1 ZnSO4 (274.9) which was at par with 75% RDF+ 2 t ha-1 Vermicompost (264.7) and 75% RDF+ 5 t ha-1Farm Yard Manure + 25 kg ha-1 ZnSO4 (255.3) while control treatment 100% RDF- 100: 50: 50 kg ha-1 showed the lowest number (181.43) (kwami *et al*., 2022). Ashem *et al*. (2022) [4] reported that maximum panicle m-2 (348.72) was obtained when 75% RDN through fertilizer applied along with 25% RDN through vermicompost and 25 kg ZnSO4 ha-1.Among the various nutrient management practices 75% RDN + 25% N through vermicompost recorded better yield attributes number of panicle/m2 (213.3) (Ram *et al*., 2020) [19]. Maximum number of panicles per square meter area (323.85) was noted in plants treated with 50% RDF and 50% FYM (Singh *et al*., 2018) [22].

6.1.2 Number of grains per panicle under integrated nutrient management: kwami *et al*. (2022) [13] reported that yield attributes (grains panicle-1) significantly higher with 50% RDF + 50% N as green leaf manure which remained at par to all the yield attributes were higher with the substitution of green manure/FYM in combination with 50% and 75% RDF. Singh *et al*. (2018) [22] observed that Combination of 50%RDF +50% wheat straw increases grains per panicle (127.23).

6.1.3 Grain yield in rice plant as affected by integrated nutrient management: N through different organics would have facilitated better photosynthesis activity and promoted the dry matter production as well as grain yield. The yield attributes increased significantly by the combined use of fertilizer nitrogen and FYM. Singh *et al*., (2018) [22] found that the maximum rice grain yield of (55.10 q ha-1) was obtained with 50% RDF+50% N as FYM. Higher yield in the NPK+FYM treatment was due to the prolonged availability of plant nutrients. Ram *et al*. (2020) [19] showed that the treatment with 75% RDN+25% N through vermicompost resulted in more grain yield (5.18 t/ha) and it was closely followed by the treatments having 75% RDN+25% N through FYM (5.13t/ha) and 100% RDN (2.68t/ha). Among the nutrient management treatments, it showed positive and significantly higher grain yield under 75% RDN through fertilizer + 25% RDN through vermicompost + 25 kg ZnSO4 ha-1 (5.10t/ha) than the rest of the treatments (Ashem *et al*., 2022) [4]. Application of 50% RDF + 50% N through green leaf manure to rice produced maximum grain yield (44.90 q ha-1), closely followed by 100% RDF (43.66 ha-1) (Neti *et al*., 2022) [18].Vignesh *et al*. (2019) [26]. Observed that 75% N + 25% N through vermicompost + ZnSO4 (25Kg/ha) + 100% PK through inorganic fertilizer + microbial consortium recorded significantly higher yield (6180 kg/ha) in comparison to other treatments and this was followed by 75% N + 25% N through poultry manure + ZnSO4 (25Kg/ha) + 100% PK through inorganic fertilizer + microbial consortium (5930kg/ha).

6.1.4 Straw Yield as affected by Integrated nutrient management: Integrated nutrient management involve in improving physical, chemical, and biological characteristics of the soil that increased its capacity to use both applied and natural nutrients quickly, favouring better plant development and enhancing rice yield components. Mehdi *et al*. (2011) [14] found that various mixtures of chemical fertilisers and organic manures boosted straw yield relative to applying only organic manures. Among different combinations, Sesbania at 20 ton ha-1 + 75% recommended dose proved to be the best combination followed by Sesbania 20 t ha-1 + 50% recommended dose. Singh *et al*. (2018) [22] revealed that 50%RDF integrated with 50% farm yard manure resulted in the highest straw yield (66.94q/ha) of rice, closely followed by 50% RDF+50% green manure (66.29q/ha).

The maximum straw yield was found under 75% RDF+ 2 t ha^{-1} Vermicompost + 25 kg ha^{-1} ZnSO4 (7.23 t ha^{-1}), followed by 75% RDF + 2 t ha^{-1} Yeast Vinasse + 25 kg ha^{-1} ZnSO4 (6.83 t ha^{-1}) and 75% RDF+ 5 t ha^{-1} Farm Yard Manure + 25 kg ha^{-1} ZnSO4 (6.95 t ha^{-1}). However, 100% RDF (control) showed the minimum straw yield 6.05 t ha-1 (kwami *et al*., 2022) [13].

The straw yield were found maximum in treatments receiving 75% RDN + 25% N through vermicompost (7.29t/ha) and it was closely followed by the treatment with 75% RDN + 25% RDN through FYM (7.18t/ha) (Ram *et al*., 2020) [19].

7. Conclusion

If farmers utilise integrated nutrient management properly, it has amazing advantages. Because of the increasing use of chemical fertilisers nowadays, which causes environmental degradation, soil fertility is declining day by day. Due to the soil's inability to supply the growing demand for food, food security will overtake other concerns in the future years. INM is therefore the greatest alternative to safeguard soil in order to maintain soil fertility. INM has attracted the attention of many farmers and researchers because of its many benefits, and in addition, the government has launched numerous programmes including soil health cards that allow farmers to assess the fertility of their soil.

8. References

1. Adhikari J, Sarkar AR, Uddin MR, Sarker UK, Hossen K, Rosemila U. Effect of nitrogen fertilizer and weed management on the yield of transplant aman rice. Journal of the Bangladesh Agricultural University. 2018;16(1):12-16.
2. Agricultural Statistics at a Glance. Directorate of Economics and Statistics, Ministry of Agriculture and Farmers Welfare, Government of India; c2021.
3. Ahmed Niaz, Ahmad Fiaz, Abid Muhammad, Ullah MA. Impact of zinc fertilization on gas exchange characteristics and water use efficiency of cotton crop under arid environment. Pakistan Journal of Botany. 2009;41(5):2189-2197.
4. Ashem SS, Roy AKS. Influence of integrated Nutrient Management in Summer Rice (*Oryza sativa* L.) under Terai Zone of West Bengal. Biological Forum – An International Journal. 2022;14(4):357-362.
5. Bruinsma J. The resource outlook to 2050: by how much do land, water and crop yields need to increase by 2050 Expert meeting on how to feed the world in 2050; c2009. Accessed on 4th April, 2023. http://www.fao.org/wsfs/forum2050/wsfs-background-documents/wsfs-expert-papers/en
6. Fageria NK, Stone LF. Micronutrient deficiency problems in South America. Micronutrient deficiencies in global crop production; c2008. p. 245-266.
7. Googoi AK, Chakrabarty S, Patel LC. Organic cultivation of chilli-an assessment in West Tripura district of Tripura. Journal of Eco-friendly Agriculture. 2015;10(1):15-19.
8. Hooper SR. Cropping System Research in Asia. In report on workshop IRRI, Los Bamos, Philippines; c1982. p. 123-148.
9. Indian States by Rice production. | Rice Cultivation in India (findeasy.in); c2022. https://www.nfsm.gov.in/
10. Khan R, Gurmani AR, Khan MS, Gurmani AH. Residual, direct and cumulative effect of zinc application on wheat and rice yield under rice-wheat system. Soil Environ. 2009;28(1):24-28.
11. Khoshgoftarmanesh AH, Schulin R, Chaney RL, Daneshbakhsh B, Afyuni M. Micronutrient-efficient genotypes for crop yield and nutritional quality in sustainable agriculture. A review. Agronomy for Sustainable Development. 2010;30(1):83-107.
12. Kumar V, Prasad RK, Suman SN, Tiwari S. Integrated nutrient management for better soil fertility and rice productivity. ORYZA-An International Journal on Rice. 2011;48(4):335-338.
13. Kwami E, Jaya Krishna VVS, Mahato M, Dey M, Dutta D. Influence of integrated nutrient management (INM) practices on performance of boro rice (*Oryza sativa* L.) in new alluvial zone of West Bengal. Journal of Crop and Weed. 2022;18(2):43-50.
14. Mehdi SM, Sarfraz M, Abbas ST, Shabbir G, Akhtar J. Integrated nutrient management for rice-wheat cropping system in a recently reclaimed soil. Soil & Environment. 2011;30:1.
15. Monika BD. Food security in Asia: challenges, policies and implications. International Institute for Strategic Studies (IISS), London; c2013.
16. Muneshwar Singh, Singh VP, Sammi Reddy K. Effect of integrated use of fertilizer nitrogen and FYM or GM on transformation of NKS and productivity of rice-wheat system on a Vertisol. Journal of the Indian Society of Soil Science. 2001;49(3):30-35.
17. Chandravanshi MD, Patel JR, Kasyap S. Effect of integrated nutrient management on growth and yield of Urdbean (*Vigna mungo* L.) in Chhattisgarh plain. Int. J Adv. Chem. Res. 2022;4(2):260-265. DOI: 10.33545/26646781.2022.v4.i2d.109
18. Neti S, Sidar RS, Singh VK, Yadav D. Effect of integrated nutrient management on rice (*Oryza sativa* L.) yield under Surguja district. Press Information Bureau (pib.gov.in); c2022.
19. Ram MS, Shankar T, Maitra S, Duvvada SK. Effect of integrated nutrient management on growth, yield, nutrient content and economics of summer rice (*Oryza sativa* L.). Indian journal of pure and applied Biosciences. 2020;8:421-427.
20. Teshome Y, Loyew A. Agronomic management status in cauliflower cultural practices in Ethiopia for vegetable crop production technology. Int. J Agric. Food Sci. 2021;3(1):10-13. DOI: 10.33545/2664844X.2021.v3.i1a.44
21. Selim MM. Introduction to the integrated nutrient management strategies and their contribution to yield and soil properties. International Journal of Agronomy; c2020.
22. Singh NP, Singh MK, Tyagi S, Singh SS. Effect of integrated nutrient management on growth and yield of rice (*Oryza sativa* L.). International Journal of Current Microbiology and Applied Sciences. 2018;7:3671-3681.
23. Surekha K, Rao KV, Viraktamath BC. Organic farming in rice. Kisan World Magazine. 2008;13(2):13-16.
24. Tomar R, Singh NB, Singh V, Kumar D. Effect of planting methods and integrated nutrient management on growth parameters, yield and economics of rice. Journal of Pharmacognosy and Phytochemistry. 2018;7(2):520-527.
25. UNSD. UN projects world population to reach 8.5 billion by 2030, driven by growth in developing countries; c2015. Accessed on 4th April, 2023 https://www.un.org/sustainabledevelopment/blog/2015/07/un-projects-world-population-to-reach-8-5-billion-by 2030-driven-by-growth-in-developing-countries.
26. Vignesh ET, Rao GS. Effect of organic and inorganic ammendments on yield and economics of rice. Plant Archives. 2019;19(1):1791-1796.
27. Nas M, Fin L. Integrating nutrient management with disease management. Agriculture (Philippines); c2012.
28. Roy RN. FAO, Rome; c1995.