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Effect of integrated nutrient management practices on growth and productivity of rice: A review

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Abstract
Rice (*Oryza sativa* L.) is one of the world's most essential and reliable food crops. The current global population is 7.3 billion people, with an estimated increase to 8.5 billion by 2030. As a result, it's expected that the world's need for grains would treble. It remains challenging to boost rice production levels, nevertheless. Integrated Nutrient Management (INM), a system of agronomy, uses both organic and inorganic fertilizer sources. INM's main objective is to use as little chemical fertilizer as possible. It also helps to boost revenue and reduce environmental risks. Nutrient conversion, microbial activity, and nutrient absorption are all regulated by plant roots. The root zone is hence prone to INM practice. Additionally, it increases the activity of bacteria. By employing INM technique, it is feasible to limit the disease infestation while regulating the amounts of potassium, nitrogen, and other essential elements. To increase soil organic carbon and production, apply organic manure along with the necessary amount of fertilizers. On the basis summarized results, it can be concluded that integrated use of nutrients *viz.*, 50% recommended dose of NPK and Zn through chemical fertilizers and 50% N equivalent farm yard manure provided higher yield of scented rice which was comparable to 100% recommended NPK and Zn through chemical fertilizers alone.

Keywords: NPK, farm yard manure, vermicompost, green manure, neem cakes

Introduction
Rice (*Oryza sativa* L.) is one of the most important stable food crops in the world. It belongs to genus *Oryza* and family Poaceae. It is the most important and extensively cultivated food crop grown extensively in tropical and subtropical regions, which provides half of the daily food for one of every three persons on the earth. About 70% of the world population takes rice as staple food while in Asia alone, more than two billion people obtain 60 to 70 per cent of their energy intake from rice and its products.

India's 2022/23 rice production is forecast at 125 MMT from 46 million hectares planted area, with yields of 4.08 MT/hectare (rough rice) respectively. (USDA 2022.) It is the major source of calories for 40 percent of the world population. There is no way to increase the net cultivable land for agricultural production as the world population is growing at an alarming rate right now. Using agronomic management to maximize the production potential of high yielding rice cultivars is one of the solutions for feeding the world's expanding population. Since rice yield has increased dramatically, fertilizers have played a significant role in this.

However, growing crop with indiscriminate use of fertilizers has resulted into degradation of lands owing to low yields with poor quality of produce. The use of inorganic fertilizer to sustain cropping was found to increase yield only for some few years but on long-term, it has not be effective and leads to soil degradation (Satyanarayana *et al.*, 2002) [29]. However, prolonged use of organic fertilizer alone on rice fields leads to low yields and low N and K contents during the mid-tillering stage of the rice plant. This suggests that coordinated nutrition management is required for the cultivation of rice. Therefore, by correcting minor deficiencies of secondary and micronutrients, increasing the effectiveness of the nutrients that are provided, and creating favourable soil physical conditions, the combined use of organic manures and inorganic fertilizers aids in maintaining yield stability. The major components of INM framework are fertilizers, farmyard manure/compost, green fertilizer, trim residues/recyclable squanders and bio fertilizers. Thus, the objective of this paper is to comprehensively audit the literary works and prescribe the finest extent of natural and inorganic source of fertilizers in coordinates supplement administration framework for feasible rice generation and soil enhancements.

Integrated Nutrient Management and its Concept

The optimization of the advantages from all potential sources of plant nutrients in an integrated way in order to maintain the soil fertility and plant nutrient supply at an optimal level for maintaining the target productivity. An efficient combination of soil, water, organic matter, etc. is used in integrated nutrient management, which was developed on the principles of environmentally friendly and effective balanced fertilization. It is based on optimizing nutrient supplies from all available sources, both inorganic and organic, for the crop's pre-determined yield targets. INM is a technology that assists in detecting emerging micronutrient shortages as well as restoring and maintaining crop output.

Objectives of INM

The objectives of integrated plant nutrient management are:

1. To balance the supply of nutrients from all sources with the crop's demand for nutrients.
2. To increase the availability of nutrients from all sources in the soil during the growing season.
3. To decrease the need for inorganic fertilizer
4. To reduce the amount of nutrients that are lost to the environment by leaching outside the rooting zone, surface runoff, Denitrification, and volatilization.

Need of INM

1. The crop's inefficient use of the nutrients.
2. N application alone decreases on soils with severe P deficiencies.
3. Soil organic matter decline brought on by ongoing nitrogen fertilizer use.
4. A decline in the crop's productivity as a result of a drop in the availability of nutrients.
5. The constant application of fertilizers that cause acidification of the soil.
6. Depletion in Soil organic matter and poverty of soil fertility are caused by a shift in land use from the forest ecosystem to the agro ecosystem.
7. Rapid emergence of P, S, and Zn deficiency linked to increased N fertilizer use.

Components of INM

The major components of integrated nutrient management are:

1. The application of organic manures such as FYM, compost, vermicompost, biogas, slurry, chicken manure, bio-compost, press mud cakes, and phosphor-compost.
2. Crops that improve soil fertility, such as green manures and legumes.
3. Using biological fertilizers.
4. Finally, efficient genotypes.
5. Agricultural waste is recycled.
6. Balanced application of fertilizer nutrients in accordance with crop needs and desired yields.

Resources Used

Different original research articles from throughout the world were reviewed to create the information on integrated nutrition management.

Results and Discussion

Rice Growth Parameters affected by Integrated Nutrient Management

Khan *et al.* (2007) [18] observed the combined fertilizer application of NPK: GM: Zn (soil application) at a rate of 120-90-60 kg ha-^{1}: 10 t ha-^{1}: 10kg ha-^{1} gave significantly maximum plant height.

Singh *et al.* (2012) [35] reported that plant height of rice was significantly higher due to the integrated application of biofertilizers and organic manure in combination with chemical fertilizer. The results revealed that, the application of 100% RDF + 5 t ha^{-1} FYM enhanced the growth and yield of rice. The height of the rice plants is significantly influenced with increase in N level.

Tomar *et al.* (2018) [41]. Observed that the dry matter accumulation (g) of rice were maximum with the application of F_2 (75% NPK+25% FYM) which was at par with F_1 100% NPK during course of investigation.

The maximum height of the plants was recorded in crop receiving 100% recommended dose of N (Shankar *et al.*, 2020) [30]. Several researches (Kumar *et al.*, 2010; Babar and Dongale, 2011; Singh *et al.*, 2018) [22, 4, 37] made comparable observations on the influence of varying proportions of organic manures and chemical fertilizer mixture on changing the height of the rice plants.

The maximum height of the plants was recorded at 90 DAT in the treatment receiving 75% RDN+25% N through vermicompost Ram *et al.* (2020) [24].

Biswas *et al.*, (2020) [7] reported that the application of 100% RDF + S_{40} Zn_5 $B_{1.5}$ ha^{-1} was found significantly superior to 100% RDF, 75% RDF + 25% N through Sludge, 75% RDF + 25% N through Vermicompost and 75% RDF + 25% N through Sesbania and control almost all the stages in respect of plant height and dry matter accumulation hill^{-1}. The increase in plant height may be due to the adequate supply of major as well as secondary micronutrient (S, Zn, and B) through chemical fertilizers.

Rao *et al.* (2020) [25]. Showed that the dry matter accumulation (gm-^{2}) of rice was significantly recorded the maximum values with T_{10} (125% RDF+ 25% V.C.) during both the cropping seasons.

Shankar *et al.* (2020) [30]. reported that the application of 75% RDN with chemical fertilizers + 25% RDN through poultry manure (T_4) recorded the highest Dry Matter Accumulation, which was closely followed by treatments using 100% RDN (T_5) and 75% RDN+25% RDN through FYM (T_8). The treatment where no fertilizer was applied (the control) had the lowest DMA measured. The outcomes made it abundantly evident that both organic and inorganic fertilizers needed to be combined for improved crop growth in terms of dry matter accumulation, which eventually assisted in raising the productivity of summer rice. The results are in conformity with the findings of Yadav *et al.* (2007) [43].

Rice Yield and Yield Attributes affected by Integrated Nutrient Management

The grain yield (3140.28 kg ha-1) and straw yield (8888.89 kg ha-^{1}) was found highest in F_2 (100% RDF + 5 t ha-1 FYM). The increasing fertilization might have increased the biological yield in terms of more biomass production thus resulting in reduction in harvest index of rice.

Choudhary *et al.* (2007) [9]. The maximum grain yield, straw yield and higher harvest index were recorded in treatment T_1 received 50% recommended NPK through fertilizers and 50% recommended N through FYM and 5 kg zinc which was statistically at par to the treatments T_7 received 100% recommended dose of NPK and zinc through chemical

fertilizers and T_3 received 100% nutrients through FYM + 5 kg Zn was significantly superior over rest of the treatments. This might be due to adequate nutrient availability, which contributed to better growth parameters and yield attributes. Similar results have also been reported by Dongarwar *et al.* (2007) [13] and Shukla *et al.* (2002) [32]. Application of RDF with FYM, improved straw yields which might be due to favorable soil condition. Alim (2012) [2] and Urkurkar *et al.*, (2010) [42] reported similar findings. Straw yield increased with the increase of N levels. Similar results were found by Ali (2006) and Islam *et al.* (2007) [17].

Baishya *et al.* (2015) [5] reported that among the organic sources, addition of vermicompost (1t ha^{-1}) produced higher crop growth and grain yield closely followed by 2.5 t poultry manures ha^{-1} and 5t FYM ha^{-1}. This might be due to better and timely nutrient availability to the crop from the vermicompost as compared to other sources of organic manure. This is in conformity with the findings of Singh and Kumar (2014) [36].

Another finding by Sharma *et al.* (2018) [31] reported that the all yield attributes, including number of effective tillers m^{-2}, length of panicle, filled and unfilled grain $panicle^{-1}$, number of grain $panicle^{-1}$, and test weight. These factors were influenced by various organic manures, fertilizers, and inoculants. In comparison to 100% fertilizers of NPK + Zinc (T_7) and 100% N as FYM + Zinc (T_3) treatments, which were both noticeably better than other treatments, the most effective tillers m^{-2} were recorded with the 50% recommended NPK+ 50% N as FYM + 5 kg Zinc ha^{-1} (T_1).

Apon *et al.* 2018 [3] observed that the application of 100% RDF + 5 t ha^{-1} FYM recorded highest number of panicles m^{-2} (120), length of panicle (28.93 cm), test weight (30.55 g), grain yield (3140.28 kg ha^{-1}) and straw yield (8888.89 kg ha^{-1}). This is in close conformity with the findings of Hossian *et al.* (2010) [16].

Aasif *et al.* (2018) [1] found that the yield attributes, ultimately increased the grain yield in the application of 100% RDF with Poultry manure as soil and foliar application of Panchakavya. Similar results have been reported by Dhaka *et al.* (2012) [11].

Behera *et al.* (2021) [6] reported that the integrated effects of fertilizer and farm yard manure were noted to be more beneficial than the use of chemical fertilizer alone. Additional increase in grain yield was registered due to the integrated effect of FYM with inorganic fertilizer. The 50% doses of RDF combined with FYM alone resulted in significant increase in grain yield as compare to control and remained at par with 75% doses of RDF. Similar findings were reported by Ghosh and Singh (2003) [15], Chaudhary and Thakur (2007) [8] and Urkurkar *et al.*, (2010) [42]. Higher harvest index of 50% of RDF indicates better partitioning of photosynthetic substance to economic yield. Appreciably high harvest index shows the efficiency of converting biological yield into economic yield. The effect of integration of inorganics and organics on harvest index was non-significant indicating proportionate partitioning with increasing and decreasing supply of nitrogen (Singh, 2001 and Singh *et al.*, 2002) [33, 34].

Nutrient content and Nutrient Uptake affected by Integrated Nutrient Management

Satyanarayana *et al.* (2002) [29] reported that application of farmyard manure increased the uptake of N, P, and K by 20, 12, and 9%, respectively .There were significant interactions between organic manure and fertilizer treatment. Maximum uptake of N, P, and K was observed at a fertilizer level of 120: 60: 45 kg N: P_2O_5: K_2O ha^{-1} in combination with application of farmyard manure. The increase in P and K in farmyard manure application treatment could be attributed to enhanced availability of these nutrients due to improved soil structure and increased microbial activity.

Baishya *et al.* (2015) [5] reported that the effect of organic manures and chemical fertilizers was significant on the uptake of N, P and K by the crop .The highest uptake of these nutrients was recorded in the treatment combination 125% CDF and 2.5t poultry manure ha^{-1} closely followed by 125% CDF + 1t vermicompost ha^{-1} and 125% CDF + 5t FYM ha^{-1}. This might be ascribed to greater dry matter production as well as nutrient concentration with combined use of organic and inorganic fertilizers. Better performance under these treatments might also be due to favorable soil environment, which encouraged better root proliferation and ensured higher nutrient uptake. These results corroborate with the findings of Sabina Ahmed *et al.* (2014) [26].

Tiwari *et al.* (2020) [40]. Observed that the Nutrient content (%) of grain and straw and its uptake as affected by various INM practices. The higher N, P and K content in grains and straw was found higher under treatment T_{10} (100% RDF through (IF) + 25% RDN through Neem Cakes) followed by T_9 (100% RDF through (IF) + 25% RDN through Poultry Manure) and are not affected by different INM practices. Similar responses were observed by Kumar *et al.* (2007) [20], Kumar *et al.* (2008) [19, 21] and Sultana *et al.* (2015) [39].

Another finding reported by Ram *et al.* (2020) [24] the content of nitrogen (N) of grain and straw of summer rice was maximum in the treatments with 75% RDN+25% N through Vermicompost (T_2) and it was closely followed by the treatment 75% RDN+25% RDN through FYM (T_3) and 100% RDN (T_1). The N content in straw of the treatment T_3 (75% RDN+25% RDN through FYM) was further significantly superior to 50% RDN+50% N through Vermicompost (T_4).The content of phosphorus (P) in grain and straw of rice was at par with all nutrient management treatments except control (T_8) was significantly inferior to others. The potassium (K) content of grain and straw was also shown the similar trend as noted in case of P content and as expected the control treatment (T_8) showed the least value in terms of K content which was further significantly inferior to other nutrient management treatments. The results are in conformity with the works of Garai *et al.* (2014) [14], Mondal *et al.* (2015) [23] and (Samaint, 2015) [27].

Physico-chemical properties of soil affected by Integrated Nutrient Management

Sarwar *et al.* (2008) [28] noticed that application of higher level of compost alone and in combination with chemical fertilizer in the same level reduced the soil pH and sodium absorption ratio; increasing electrical conductivity, available phosphorus, water soluble K and organic matter status of soil significantly, as compared to control as well as chemical fertilizer alone after harvesting of rice and in rice-wheat cropping system.

Another finding was noticed by Baishya *et al.* (2015) [5] reported that the addition of inorganic fertilizers along with organic manures helps in mineralization which resulted in rapid conversion of organically bound forms of nutrients to organic forms, however, it was observed that crop receiving same source of organic manures along with different levels of inorganic fertilizers did not vary significantly in respect of organic carbon content of soil. Such favorable effect of

integrated nutrient management on increasing the available N, P and K content in soil. Similar finding was noticed by Kumar *et al.* (2008) [19, 21].

Tiwari *et al.* (2020) [40] reported that the application of fertilizer in combination with organic manure is known to improve various physico-chemical properties resulting in enhanced nutrient absorption and uptake. These findings are in conformity with the findings of Kumar *et al.*, (2008) [19, 21], Shrivastava and Singh (2017) [38].

Conclusion

The results of the study show that applying organic manures (FYM) and inorganic fertilizers simultaneously increases rice yield and growth. Utilizing 100% RDF along with FYM @ 5 t ha-1 increased rice grain production. More fertile tillers, grains per panicle, panicles per hill, filled grains per panicle, 1000 grain weight, biological yield, grain yield, and harvest index all contributed to the higher yield attained with integrated use of FYM and inorganic fertilizers.

The results of the soil tests conducted after the rice harvest revealed a considerably greater soil BD, porosity, OC, available N, available P, and available K, as well as grain and straw yield of rice when FYM 5 t ha-1 was treated in combination with inorganic 100% RDF as opposed to using 100% RDF alone. The combined application of 5 t ha-1 FYM and 75% RDF inorganic fertilizer outperformed 5 t ha-1 FYM + 50% RDF but dramatically underperformed 5 t ha-1 FYM + 100% RDF when compared to the other treatments. For sustainable agriculture, integrated crop management should therefore include the use of FYM and inorganic fertilizers.

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