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Review Paper

Effects of different fertilizers on growth and productivity of rice (*Oryza sativa* L.): a review

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Abstract: Rice (*Oryza sati*va L.) is one of the most important cereal crops in the world. Fertilizer is the major input in rice production. This article reviews on general overview of the effects of different fertilizers on the growth, development and production of rice. Growth and yield traits of rice are affected by nutrients deficiency. Soil testing and use of crop nutrient uptake and removal information are important in determining the actual rates of nutrients. Practice of adequate rate and timing of fertilizer application can increase rice yield. Nitrogen (N), phosphorus (P), and potassium (K) are applied as fertilizers in large quantities to rice fields, and a deficiency of either of the nutrient leads to yield losses. The use of micronutrients such as zinc and Sulphur is one of the important inputs that can increase productivity. Application of NPK fertilizer improves rice plant NPK uptake and also increases the grain yield. The integrating organic and inorganic fertilizers enhances the growth parameters and yields of rice. The balanced use of fertilizers improves crop productivity and soil fertility in a sustainable manner without any environmental damage. This study is a useful tool for scientists, farmers and academics who are interested in rice production, research and development.
Keywords: Fertilizers, Rice, Growth, Yield

INTRODUCTION

Rice is one of the staple food crops for about half of the world's population. Therefore, rice production should be significantly increased to meet the needs of a growing world population. The global demand for rice is expected to increase from 439 million tons in 2010 to 496 million tons by 2020 and 553 million tons by 2035 (FAO, 2013). The adoption of improved varieties, judicious use of fertilizers and irrigation with appropriate management practice helps to increase the productivity of rice at farmers' fields (Gairhe et al., 2018; Timsina et al., 2012). The nutritional imbalance causes a decrease in grain yield and marginal net returns (Zafar et al., 2018; Wattoo et al., 2018). The N, P and K are macro elements; Ca, Mg and S are secondary macronutrients; and Fe, Mn, Zn, Cu, B, Mo, and Cl are trace elements. Zinc is one of the most important micronutrient essential for plant growth especially for rice grown under submerged condition. Zn deficiency is the most widespread micronutrient disorder in lowland rice. Zinc deficient plant show signs of low levels of auxins such as indole acetic acid (IAA). Zinc plays a greater role during reproductive phase especially during fertilization. The Sulphur requirement of rice varies according to the nitrogen supply. When S becomes limiting, addition of N does not change the yield or protein level of plants. Sulphur is required early in the growth of rice plants. If it is limiting during early growth, then tiller number and therefore final yield will be reduced (Blair and Lefroy, 1987). Many studies have shown that the appropriate use of NPK fertilizers has enhanced the yield and substantially improved rice quality (Oikeh et al., 2008; Walker, 2008; Saidu et al., 2012). The use of organic manure, particularly poultry droppings and cow dung, helps to maintain the soil's physical state and is a major contributing factor to plant nutrients (Bagayoko, 2012). Recommendation of chemical fertilizers should be based upon soil analysis and crop response. A good fertilization strategy should be developed that combines the use of organic and chemical fertilizers, as well as improving crop productivity and environmental quality (Devkota et al., 2019). Nitrogen is most often required during early and mid-tillage, initiation of panicles, booting and grain development phases of ripening. Use of the nitrogen fertilizer can enhance the plant height, number of spikelets, number of panicles, and number of filled spikelets which ultimately determine rice yield potential (Dobermann and Fairhust, 2000). Application of half dose of N fertilizer during planting time and the rest was given at 42 days after planting) was the best treatment in terms of rice growth and production (Gribaldi et al., 2017). Phosphorus (P) plays a crucial role in fostering the early flowering and maturing phase, maintaining root growth system as well as disease resistance and drought resilience. Phosphorus deficient can prolong the rice plant's maturity (Fageria, 1980) and raising vulnerability to rice disease (Fageria et al., 2003). P uptake by the grain was significantly higher in split application than the treatment receiving basal P. With respect to time of P application, the split application produced the highest P uptake at 30, 60 90 DAT over basal application of P (Archana et al., 2017). Suitable usage of potassium is closely linked to sclerenchyma cell lignification, vascular bundles, and culm endurance that strengthens the resistance of the lodging (Kong et al., 2014). Potassium deficiencies of rice plants may typically be associated with high scales of infection with disease that can contribute to incidence lodging. Furthermore, there are substantial yield discrepancies between optimum NPK plots managed by researchers and fertilizer techniques used by farmers (Ladha et al., 2003), which shows a great chance to improve rice yield and productiveness through enhanced management of nutrients.

Proper use of chemical fertilizers and organic manures supports increased agricultural productivity and at the same time, helps maintain soil fertility (Gami and Sah, 1988). For sustainable, efficient and environment-friendly rice production fertilizer application should be based on

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plant and soil tests, either it derived from different model or crop nutrient response study. Soil analyzes give an idea of the state of nutrients as well as fertilizer recommendations for crops. Soil tests also provide information on the reaction of the soil. The choice of fertilizer should be based on the reaction of the soil. In acid soils, only fertilizers with an alkaline residual effect should be used. In alkaline soils, acidic fertilizers should be preferred. Imbalanced use of synthetic fertilizers contribute to deterioration of soil quality as well as environment. Unbalanced fertilization leads to nutrient deficiency. The balanced fertilizations help the soil to build bacterial diversity and enzyme activities (Ling et al., 2014). A balanced fertilization strategy is better economically and is a more sustainable agricultural practice (Mader et al., 2002). A balanced nutrient application using NPK fertilization is a key management strategy for enhancing rice productivity and environmental safety. Nutrient uptake is influenced by graded levels and time of nutrient applications. Improvement in N, P and K uptake by crop was reported with increased N levels (Sandhu and Mahal, 2014), P levels (Sanusan et al., 2009), K levels (Arif et al., 2010) and NPK levels (Sandhyakanthi et al., 2014).This review study was carried out with the objective to identify the effects of different fertilizer management practices on rice growth, productivity and nutrient uptake of rice.

Effect of fertilizers on growth of rice

Plant height

The plant height is not a yield component in grain crops but it indicates the influence of various nutrients on plant metabolism. Miah (1974) has reported that application of NPK significantly affected plant height. The shortest plant height can be caused by a lack of fertilizer, which significantly reduces plant growth and development due to the nutrient deficiency that causes the lowest plant height. Budhar et al. (1991) noticed that the use of farm waste, including biogas slurry, poultry manure, and FYM @ 5 t/ha and calotropis, neem leaf, sun hemp, and pongamia @ 12.5 t/ha as green manure, rendered plant height substantially. Applying neem cake mixed field boosted plant height and tiller number per square meter (Bains et al., 1971).

Dry matter production

In general, dry matter accumulation increased at slow rate up to 30 days after transplanting and thereafter increased at faster rate up to harvest. The higher dry mass of nitrogen treated plants could be connected with the positive effect of nitrogen in some important physiological processes. Reports of different experiments on the occurrence of dry matter accumulation in rice revealed improved accumulation of dry matter with improved nitrogen concentrations (Balasubramaniyan and Palaniappan, 1991 and Shashikumar et al., 1995). Tripathi et al. (1990) observed that each concentration of FYM (5 to 20 t/ha) risen rice production in the dry matter at different phases. Rice dry matter improved either by the inorganic process (50 kg N/ha) with the availability of N or by incorporating organic (10 t FYM/ha) and inorganic (25 kg N/ha) sources as contrasted to organic sources itself @ 20 t FYM /ha in sandy clay loam soil of Kharagpur (Ghosh et al., 1994). The dry matter yield of rice was higher when FYM and urea were added together than when urea was supplied alone (Khan et al., 1986). Mandal et al. (1994) recorded that increasing the concentration of nitrogen would increase the accumulation of dry matter even by 150% of the recommended level. Semoka and Shenkalwa (1985) reported a significance increase in dry matter yields from the application of 60 kg P/ha in rice.

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Tiller number

Tillering in rice is an important agronomic trait for number of panicles per unit land area as well as grain production (Moldenhauer and Gibbons, 2003).The application of NPK enhances the number of tillers in rice. The application of N fertilizer may increase the number of productive tillers (Budhar and Palaniappan, 1996). Usage of FYM or straw on silty loam soil at Faizabad with and without inorganic N substantially increased tiller per hill (Rajput and Warsi, 1991). Higher tiller per unit area had been recorded on sandy loam soils at Ludhiana, integrating wheat straw and FYM @ 67 and 12 t/ha respectively (Maskina et al., 1987). Application of poultry manure @ 15 t/ha have been observed comparatively more tillers per hill than FYM @ 5 t/ha (Budhar et al., 1991). An increase in the tillers per hill was observed as the nitrogen level increases (Hussain et al., 1989; Singh et al., 1991; Karunasagar and Ramasubba Reddy, 1992 and Shashikumar et al., 1995).

Effect of fertilizers on yield attributes of rice

Number of panicles per square meter

N, P, and K fertilizers affect the number of panicle per square meter. Panicle per m^2 differs with regard to nutrient management practices. When FYM was applied along with urea, the number of panicles increases per m^2 (Sharma and Sharma, 1994). Analogous findings were also made by Thangamuthu and Balasubramaniyan (1987) on the clay loam of Coimbatore when urea super granules were added @ 58 kg/ha together with Azolla or paddy straw to contribute 29 kg N/ha to it. More efficient tillers were registered when calotropis was introduced @12.5 t/ha and rice on Coimbatore clay loam soils was accompanied by application of poultry manure @ 5 t/ha (Budhar et al., 1991).

Panicle Length

Hasanuzzaman et al. (2010) reported the increased panicle length with the application of NPKS fertilizer. Heluf and Mulugeta (2006) noted an increase in rice panicle length with increasing N supply up to 90 kg N/ha. Jayaraman and Purushothaman (1988) reported that in combination with 75 kg/ha of inorganic N the integration of organic manures such as Leucaena tender lopping recorded an increased length of the panicle. In comparison with organic alone or comparative use of organic and inorganic manures on an equal nutrient base, the increased levels of N significantly increased the length of the panicle (Karunasagar and Ramasubba Reddy, 1992). Panicles with a low sterile flower rate allow higher nitrogen doses application which provides higher yields (Yoshida, 1981).

Number of grains per panicle

N, P, and K fertilizers affect the number of grains per panicle. The grain numbers per panicle increased by 31.4%, 23.9%, and 48.2%, and the panicle numbers increased by 55.1%, 29.2%, and 6.7% after application of N, P, K fertilizers, respectively (Ye et al., 2019). Nutrient management practices affect the number of fertile grains per panicle. The 30 kg of N/ha in FYM, together with 90 kg of N/ha in urea contributed in more spikes per panicle (Sharma and Sharma, 1994). In Basmati rice significantly increased grains per panicle with an increase of nitrogen levels of up to 90 kg/ha were recorded (Tripathi et al., 1998). In addition to inorganic fertilizer, nitrogen was supplemented by 75% and glyricidia and rice straw by 25%. Setty and Channabasavanna (1990) reported a more filled grain in a panicle. Several researchers reported that nitrogen has a beneficial effect on rice panicle numbers per grain (NarsaReddy et al., 1987; Rai et al., 1991). Basal use of agricultural waste such as green manures such as calotropis andsesbania @ 12.5 t/ha and FYM @ 5 t/ha in rice did not change in the production of panicle filled grains (Budhar et al., 1991).

Test weight Thousand grain weight is a genetic trait and is affected by fertilizer applications. Yang et al. (2004) recorded that 1000-grain weight was increased by the application of chemical fertilizer along with organic manure. The increase in grain yield components can be due to the fact that available water enhanced nutrient availability which improved nitrogen and other macro- and microelements absorption as well as enhancing the production and translocation of the dry matter content from source to sink (Ebaid and El-Refaee, 2007).

The test weight could not be affected by basal incorporation of poultry manure, FYM, @ 5 t/ha or sesbania, sun hemp, pongamia, calotropis, neem leaf and soobabul @ 12.5 t/ha (Budhar et al., 1991). Jeyaraman and Purushothaman (1988), Thangamuthu and Balasubramaniyan (1987), Setty and Channabasavanna (1990) have noticed that an increase in test weight was obtained with combined use of organic and inorganic forms of nitrogen.

Effect of fertilizers on yield of rice

Grain yield

Yang et al. (2004) reported that application of chemical fertilizers with farmyard manure or wheat straw in alternate wetting and drying condition increased N, P, and K uptake by rice plants, increased 1000 grain weight and grain yield of rice. Increase in grain yield due to application of organic matter was observed by Ram et al. (2000). The application of rice straw and chaff together with 60-90 kg N/ha of inorganic nitrogen (Subbaiah et al., 1983), mixed with FYM + urea (Khan et al., 1986) and use of FYM @ 30 kg /ha + 90 kg N/ha as urea (Sharma and Sharma, 1994), produced the maximum rice grain production as compared to their individual applications. Several researchers have found that rice grain yield and yield attributes were increased with the application of organic manures such as wheat straw/FYM (Maskina et al., 1987), Prosopis/Withania/Abutilon/neem leaf @ 6 t/ha (Alam and Azmi, 1990), wheat straw/FYM/water hyacinth @ 5 t/ha (Sharma and Mitra, 1990), FYM / biogas slurry/poultry manure @ 5 t/ha or green leaf manure @ 12.5 t/ha (Budhar et al., 1991), and FYM @ 20 t/ha (Tandon, 1991). The usage of N @50 kg N/ha combined with two organic sources i.e., wheat straw and FYM demonstrated better than their independent usage (Rajput and Warsi, 1991). It has been found that the combined use of 12 t FYM/ha plus 60 kg N/ha (Kulkarni et al., 1978) and use of 12 t FYM/ha in combination with 80 kg N/ ha (Maskina et al., 1988) produced rice yields whaich was equivalent to that produced with application of 120 kg N/ha. In accordance with 30 kg of P_2O_5 /ha, Prasad and Prasad (1994) observed that usage of FYM, composts or biogas slurry produced rice higher than with 60 kg P_2O_5/ha, as superphosphate in Bihar's calcareous soil. Kumar and Yadav (1995) observed that 100% NPK fertilization in the initial years produced a greater yield of rice compared with their organic manures and 25-50% of the fertilizer recommended can be replaced with organic manures in the subsequent years to improve the soil and fertility. In accordance with the recommended dose of fertilizer, the use of organic manure (FYM @ 5 t/ha) has resulted in enhanced grain yields in rice considerably (Khanam et al., 1997). Xu (2010) and Kumar et al. (2014) observed significant improvement in yield characters of rice under integration of organic amendments with chemical fertilizers in comparison to sole fertilizer application.

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Straw yield

Satyanarayana et al. (2002) observed a significant increase in straw yield of rice due to application of NPK fertilizer. Rahman et al. (2009) reported that the application of organic manure and chemical fertilizers increased the straw yields of rice.

In conjunction with FYM or straw to rice, usage of inorganic N has also been noted to increase the production of straw (Rajput and Warsi, 1991). Usage of duckweed to rice @ 2 t/ha generated straw yield equal with those of 18 kg inorganic N/ha (Ahmad et al., 1990). Budhar et al. (1991) reported optimum straw yield by incorporating 5 t/ha poultry manure and considered superior to FYM @ 5 t/ha. Blaise and Prasad (1996) noted a marked increase only of up to 60 kg of N/ha, in rice straw production. With the application of poultry manure @ 5 t/ha, Datta and Banik (1994) reported that it was extremely effective at increasing rice straw yield. In combination with chemical fertilizer applications of different organic sources showed significant reinforcing effects on straw production (Tripathi et al., 1990).

Effect of fertilizers on nutrient uptake

Application of organic manure with chemical fertilizer accelerates the microbial activity, increases nutrient use efficiency (Narwal and Chaudhary, 2006) and enhances the availability of the native nutrients to the plants resulting higher nutrient uptake. Sharma and Mitra (1990) reported that organic materials like straw/water/hyacinth/FYM/wheat/compost @ 5 t/ha and the double cultivation of Azolla increased nitrogen absorption of Kharif rice on laterite soils. Khan et al. (1986) stated that N absorption was significantly greater during tilling, which incorporates the use of FYM and urea together than when urea was obtained alone. The application of poultry manure @ 5 t/ha increases phosphorus absorption that decreases with application of single super phosphates @ 21.8 kg P/ha (Datta and Banik, 1994). Despite the maximum P absorption of rice was observed when the inorganic P and poultry manure were integrated (Gupta et al., 1995). In addition to the recommended dose of fertilizers, FYM @ 5 t/ha generated considerably greater uptake of N, P and K by rice (Khanam et al., 1997). Khan et al. (1986) noted that during the initial growth process and the entire growth period the combination of 30 kg N/ha in the form of FYM at puddling and 30 kg N /ha as urea at planting produced appropriate usable N in the soil. The substitution of Urea by the constant application of FYM together with NPK fertilizer has contributed to a larger amount of N and P available, whereas incorporating compost together with K fertilizer has reported a higher K content available in soil (Udayasoorian and Paramasivam, 1991). Selvi and Ramaswami (1995) demonstrate that the available N, P, and K soil contents increased substantially in a rice-rice-pulse sequence effect of NPK plus organics, especially FYM. Singh et al. (1995) noticed that in rice N equivalents of fertilizer vary from 42% to 52% of the overall N supplied to FYM in which the apparent N regeneration rate was 20% as compared to 35% to 46% in urea. The FYM and compost application @ 25 t/ha increased usable K soil content (Udayasoorian et al., 1989).

CONCLUSION

The use of fertilizers containing nitrogen, phosphorus and potassium, as well as micronutrients like Zn and S is directly related to the growth, development and production of rice. Rice growth and yield traits are affected by the integrated use of manure and inorganic fertilizers. Farmers should use a combination of organic fertilizers and reduced inorganic fertilizers to increase rice yield and protect and

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improve soil health. It is undesirable to use too much or too little fertilizer in a production system. Balanced and proper amount application of fertilizers is an effective approach to increase the growth and productivity of rice and ensure environmental sustainability.

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