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Impact of inorganic organic and biological sources of nutrients for evaluating soil fertility in rice production: A review

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Abstract
Excessive application of the chemical fertilizers is to attain higher yield that has not only reduced the nutrient use efficiency but it also adversely affect the soil productivity, soil micro-organisms and environmental stability. Because of this reason, immediate conversion to organic farming would drastically reduce production at initial phases which is of major concern to feed the growing population. This review article has written with the prime focus to notify on the impact of inorganic, organic and biological sources of nutrients in rice. Organic manures like farm yard manure, poultry manure, vermicompost, press mud and coir pith compost and biological sources of nutrients like biofertilizers, zinc solubilizing bacteria, seaweed extract are given prioritized due to local availability with integration with inorganic fertilizers to give nutrients like nitrogen, phosphorus, potassium and zinc on growth and yield of rice. From the study, integrated nutrient management is best practice than chemical fertilizers and also to over complete shift of organic cultivation in terms to improve productivity and also to maintain soil health in a long run. Application of organic sources of nutrients can be made from local availability to decrease the cost of cultivation over inorganic fertilizers.

Keywords: Inorganic, organic, biological, nutrients, nitrogen, phosphorus, potassium, zinc, rice

Introduction
Rice (*Oryza sativa* L.) is one of the main principal food crop in India and it is grown in over diverse agro-ecosystems. After green revolution, due to introduction of high yielding varieties and fertilizer-responsive varieties, rice cultivation has been shift to intensify and it has led to increased use of chemical fertilizers and pesticides. The increased use of chemicals led to many harmful effects on soil, water and atmosphere causing pollution and reduce the productivity of soil (Surekha *et al.*, 2008) [45].
To sustain soil health and to provide adequate plant nutrients, an alternative to chemical fertilizers has to be supplied in integration instead of sudden stoppage of chemical and total conversion to organic would lead to drastic yield gaps during the early stages of the crop (Singh *et al.*, 2009) [42]. The demand in rice is expected to rise @ 1.6 per cent per year due to increasing population, while area of rice cultivation is expect to reduce to 40 million ha in the next 15 to 20 years (Shobarani *et al.*, 2010) [40]. Hence it is a need to increase the yield and productivity of rice cultivation using reduced inputs and resources to feed the growing population. Moreover, increasing cost of chemical fertilizers is reduced the profitability of cultivation. Therefore, alternative use of organic manures like green manuring and crop residues along with inorganic fertilizers it not only reduce the demand of inorganic fertilizers, but it also increases the efficiency of applied nutrients due to favorable effect on physical, chemical and biological properties of soil (Prasad *et al.*, 1992) [29].
The effectiveness of integrated nutrient management practice which depend on season, soil type, climate, water management, variety and cropping pattern. Thus, this article is written to discuss on the impact of inorganic, organic and biological sources of nutrients in various aspects of rice.

Impact of inorganic organic and biological sources of nutrients in growth attributes of rice
Plant height
The plant height is not a yield component in grain crops that indicates the influence of various nutrients on plant metabolism. Miah (1974) [25] has reported that application of NPK significantly affected plant height.

The shortest height of the plant can be caused by a lack of fertilizer, which significantly reduces the plant growth and development due to the nutrient deficiency that causes the lowest plant height. Budhar *et al.,* (1991) [7] 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, improved plant height substantially. Applying neem cake mixed field boosted plant height and tiller number per square meter (Bains *et al.,* 1971) [3].

Dry matter production

In general, dry matter production is 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 connect with the positive effect of nitrogen in some important physiological processes of the crop. Reports of different experiment on the accumulation of dry matter in rice revealed increased accumulation of dry matter with increased nitrogen applications (Balasubramaniyan and Palaniappan, 1991 and Shashikumar *et al.,* 1995) [4, 39]. Tripathi *et al.,* (1990) [48] observed that each concentration of FYM (5 to 20 t/ha) risen in rice production in dry matter at different phases. Rice dry matter has 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) [10]. The dry matter yield of rice was higher when FYM and urea were applied together than when urea was supplied alone (Khan *et al.,* 1986) [17]. Mandal *et al.,* (1994) [22] 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) [36] reported a significant increase in dry matter yields from the application of 60 kg P/ha in rice.

Tiller number

Tillering in rice is the most important agronomic trait for the number of panicles per unit land area as well as grain production of the crop (Moldenhauer and Gibbons, 2003) [26]. The application of NPK increases the number of tillers in rice. The application of N fertilizer may increase the number of productive tillers (Budhar and Palaniappan, 1996) [6]. 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) [32]. Higher tiller numbers 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) [24]. Application of poultry manure @ 15 t/ha has been observed comparatively more number of tillers per hill than FYM @ 5 t/ha (Budhar *et al.,* 1991) [7]. An increase in 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) [14, 41, 16, 39].

Impact of inorganic organic and biological sources of nutrients in yield attributes of rice

Number of panicles per square meter

N, P, and K fertilizers have affected the number of panicle per square meter. Panicle per m^2 differing about nutrient management practices. When FYM applied along with the urea, the number of panicles increases per m^2 (Sharma and Sharma, 1994) [38]. Analogous findings were also made by Thangamuthu and Balasubramaniyan (1987) [47] on the clay loam of Coimbatore when the 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 the application of poultry manure @ 5 t/ha (Budhar *et al.*, 1991) [7].

Panicle Length

Hasanuzzaman *et al.,* (2010) [12] reported that the increase in panicle length with the application of NPKS fertilizer. Heluf and Mulugeta (2006) [13] were noted that increase in rice panicle length with increasing N supply up to 90 kg N/ha. Jayaraman and Purushothaman (1988) [15] report say that in combination with 75 kg/ha of inorganic N with the integration of organic manures such as Leucaena tender lopping record an increased length of the panicle in rice. In comparison with organic alone or combined 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) [16]. Panicles which is having a low sterile flower rate require higher nitrogen doses application which provides higher yields (Yoshida, 1981) [55].

Number of grains per panicle

N, P, and K fertilizers also affect the number of grains per panicle. The grain numbers per panicle increased by 31.4%, 23.9%, and 48.2%, and panicle numbers increased by 55.1%, 29.2%, and 6.7% after application of N, P, K fertilizers, respectively (Ye *et al.,* 2019) [54]. Nutrient management practices affect the number of fertile grains per panicle. The 30 kg of N/ha in FYM, integrated with 90 kg of N/ha in urea contribute in more spikes per panicle (Sharma and Sharma, 1994) [38]. Basmati rice has significantly increased grains per panicle with an increase in nitrogen levels of up to 90 kg/ha were recorded (Tripathi *et al.,* 1998) [49]. In addition to inorganic fertilizer, nitrogen was given by 75% and glyricidia and rice straw by 25%. Setty and Channabasavanna (1990) [37] report say that a more filled grain in a panicle. Many researchers reported that nitrogen has a beneficial effect on rice panicle numbers per grain (Narsa Reddy *et al.*, 1987; Rai *et al.,* 1991) [27, 31]. Basal use of agricultural waste such as green manures such as *Calotropis* and *sesbania* @ 12.5 t/ha and FYM @ 5 t/ha in rice was not changed in production of panicle filled grains (Budhar *et al.,* 1991) [7].

Test weight

Thousand grain weight is a genetic character and it is affected by fertilizer applications. Yang *et al.,* (2004) [53] observed that 1000-grain weight was increased with application of chemical fertilizer along with organic manure. The increase in grain yield attributes can be due to fact that available water enhanced nutrient availability which has improved nitrogen and other macro and micronutrients absorption as well as enhance the production and translocation of the dry matter content from source to sink (Ebaid and El-Refaee, 2007) [9].

The test weight cannot be affected significantly 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) [7]. Jeyaraman and Purushothaman (1988) [15], Thangamuthu and Balasubramaniyan (1987) [47], Setty and Channabasavanna (1990) [37] have observed that an increase in test weight was obtained with combined use of organic and inorganic forms of nitrogen.

Impact of inorganic organic and biological sources of nutrients in yield of rice

Grain yield

Yang *et al.*, (2004) [53] noticed that the application of chemical fertilizers with farmyard manure or wheat straw in an alternate wetting and drying condition increased N, P, and K uptake by rice plants, increased 1000 grain weight and grain yield of rice plants. An increase in the grain yield due to the application of organic matter was observed by Ram *et al.*, (2000) [33]. The application of rice straw and chaff together with 60-90 kg N/ha of inorganic nitrogen (Subbaiah *et al.*, 1983) [44], combined with FYM + urea (Khan *et al.*, 1986) [17], and use of FYM @ 30 kg /ha + 90 kg N/ha as urea (Sharma and Sharma, 1994) [38], produced maximum rice grain production as compared to its applications. Many 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) [24], Prosopis / Withania / Abutilon/neem leaf @ 6 t/ha (Alam and Azmi, 1990) [2], 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) [7], and FYM @ 20 t/ha (Tandon, 1991) [46]. The usage of N @50 kg N/ha combined with the two organic sources i.e., wheat straw and FYM demonstrated better than their independent usage (Rajput and Warsi, 1991) [32]. It has been found that combined use of 12 t FYM/ha plus 60 kg N/ha (Kulkarni *et al.*, 1978) [19] and use of 12 t FYM/ha in combination with 80 kg N/ ha (Maskina *et al.*, 1988) [23] produced rice yields which were equivalent to that produced with application of 120 kg N/ha. By 30 kg of P2O5 /ha, Prasad and Prasad (1994) [28] 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) [21] reported that 100% NPK fertilization in the initial years produced a greater yield of rice compared with their organic manures and 25-50% of fertilizer recommended can be replaced with organic manures in the subsequent years to improve the soil fertility. In accordance with the recommended dose of fertilizer, the use of organic manure (FYM @ 5 t/ha) has resulted in enhanced grain yields of rice (Khanam *et al.*, 1997) [18]. Xu (2010) [52] and Kumar *et al.*, (2014) [20] observed significant improvement in yield characters of rice under the integration of organic source of nutrients with chemical fertilizers in comparison to sole fertilizer application.

Straw yield

Satyanarayana *et al.*, (2002) [34] observed a significant increase in the straw yield of rice due to the application of NPK fertilizer. Rahman *et al.*, (2009) [30] reported the application of organic manure and chemical fertilizers increased the straw yield of rice.

In combination with FYM or straw to rice, usage of inorganic N has also been noticed to increase in the production of straw (Rajput and Warsi, 1991) [32]. Usage of duckweed to rice @ 2 t/ha generated straw yield equal to those of 18 kg inorganic N/ha (Ahmad *et al.*, 1990) [1]. Budhar *et al.*, (1991) [7] reported optimum straw yield by incorporating 5 t/ha poultry manure and considered superior to FYM @ 5 t/ha. Blaise and Prasad (1996) [5] noted a significant 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) [8] report that it was extremely effective at increasing rice straw yield. In combination with chemical fertilizer applications of different organic sources showed significant effects on straw production (Tripathi *et al.*, 1990) [48].

Impact of inorganic organic and biological sources of nutrients in nutrient uptake of rice

Application of organic manure with the chemical fertilizer accelerated the microbial activity in the soil, increases nutrient use efficiency (Narwal and Chaudhary, 2006) and it also enhances the availability of the native nutrients to the plants resulting in higher nutrient uptake. Khan *et al.*, (1986) [17] stated that N absorption was significantly higher during a tillering stage, which incorporates the use of FYM and urea together than when urea was obtained alone. Application of poultry manure @ 5 t/ha increases phosphorus uptake that decreases with an application of single super phosphate @ 21.8 kg P/ha (Datta and Banik, 1994) [8]. Despite maximum P uptake 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 significantly greater uptake of N, P, and K by rice (Khanam *et al.*, 1997) [18]. Khan *et al.*, (1986) [17] noted that during the initial growth process and the entire growth period the integration 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 constant application of FYM together with the NPK fertilizer was contributed to a larger amount of N and P availability, whereas incorporating compost together with K fertilizer has reported a higher K content available in the soil (Udayasoorian and Paramasivam, 1991) [50]. Selvi and Ramaswami (1995) [35] demonstrated the available N, P, and K soil contents increased substantially in a rice-rice-pulse sequence effect of NPK with organics, especially FYM. Singh *et al.*, (1995) [43] 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 available K soil content (Udayasoorian *et al.*, 1989) [51].

Conclusion

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