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Review article

INTEGRATED NUTRIENT MANAGEMENT IN RICE: A CRITICAL REVIEW

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Rice is an important food grain crop and is consumed by majority of the human population. Nutrient management is an important aspect in rice to be given pivotal importance so as to attain sustainability of grain yield production. In the present chapter, aspects' relating to integrated nutrient management in rice is critically reviewed. The effects of integrating chemical fertilizers with organic supplements on biometric characteristics and ultimately on grain and straw yields were discussed in detail.

Growth Characters

Plant Height (cm)

Deshumk et al (1988) conducted an experiment to find out the response of paddy to different fertility levels and observed that plant height increased progressively with increasing fertility levels of NPK.

The effect of duck weed application @ 2t ha^{-1} was found to be equivalent to 18 kg N ha^{-1} as urea in terms of plant height (Ahmad et al., 1990).

Budhar et al (1991) found that plant height significantly influenced due to incorporation of farm wastes viz., FYM, biogas slurry and poultry manure @ 5 t ha^{-1} and sunnhemp, neem leaf, calotropis and pongamia @ 12.5 t ha^{-1} as green manure.

Drymatter production

Drymatter yield of rice was higher with the application of FYM and urea together than in the treatment receiving urea alone (Khan et al., 1986).

Results of various experiments conducted on the pattern of dry matter accumulation in rice indicated increase in drymatter accumulation with increasing levels of nitrogen (Gurbachan Singh et al., 1990; Balasubramaniyan and Palaniappan, 1991 and Shashikumar et al., 1995).

Tripathi et al (1990) noted that each level of FYM (5 to 20 t ha^{-1}) increased the drymatter production of rice at various stages. However, maximum response was found at 15 t ha^{-1} .

Drymatter of rice increased with the supply of N either through inorganic form (50 kg N ha^{-1}) or through combination of organic (10 t FYM ha^{-1}) and inorganic sources (25 kg N ha^{-1}) as compared with organic source alone @ 20 t FYM ha^{-1} on sandy clay loam soil of Kharagpur (Ghosh et al., 1994).

Mandal et al (1994) observed that increasing the nitrogen dose even by 150% of the recommended level would increase the drymatter accumulation.

Tiller Number

Increase in number of tillers per hill was observed with increasing levels of nitrogen (Deshmuk et al., 1988; Hussain et al., 1989; Singh et al., 1991; Karunasagar and Ramsubba Reddy, 1992 and Shashikumar et al., 1995).

On sandy loam soils at Ludhiana, incorporation of wheat straw and FYM @ 67 and 12 t ha^{-1}, respectively had recorded higher tiller per unit area (Maskina et al., 1987).

Relatively more number of tillers per hill were observed with the application of poultry manure @ 15 t ha^{-1} compared to FYM application @ 5 t ha^{-1} (Budhar et al., 1991).

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Application of FYM or straw with and without inorganic N significantly increased tillers per hill on silty loam soil at Faizabad (Rajput and Warsi, 1991).

Yield Attributes

Number of panicles per square meter

Productive tillers recorded were more, when calotropis was incorporated @ 12.5t ha^{-1} and it was followed by poultry manure application @ 5 t ha^{-1} to rice on clay loam soils of Coimbatore (Budhar et al., 1991).
Maximum number of productive tillers was produced with 120 kg ha^{-1} of inorganic nitrogen which was compatible with substituting the same nutrients through glyricidia @ 30 kg N and 60 kg N ha^{-1} as urea (Hari Prasad, 1993).
Sharma and Sharma (1994) observed an increase in number of panicles per m^2 when FYM was applied along with urea.
Similar observations were also made on clay loam of Coimbatore by Thangamuthu and Balasubramaniyan (1987) when urea super granules were applied @ 58 kg ha^{-1} along with Azolla or paddy straw to supplement 29 kg N ha^{-1}.

Panicle Length

Increasing the levels of N was found to increase the length of panicle significantly in several studies (Karunasagar and Ramasubba Reddy, 1992).
Jayaraman and Purushothaman (1988) stated that incorporation of organic manures like leucaena tender loppings in combination with 75 kg ha^{-1} inorganic N recorded more panicle length.
Hari Prasad (1993) reported increased panicle length with 120 kg N ha^{-1} through urea alone when compared with either organics alone or complementary use of organic and inorganic manures on equivalent nutrient basis.

Number of grains per panicle

Several research workers reported a positive effect of nitrogen on number of grains per panicles in rice (Narsa Reddy et al., 1987 and Rai et al., 1991).
Basal application of farm waste like FYM @ 5 t ha^{-1} and green manures like sesbania, calotropis etc. @ 12.5 t ha^{-1} in rice did not differ in producing filled grains per panicle (Budhar et al., 1991).
Setty and Channabasavanna (1990) observed more number of filled grains per panicle when nitrogen was supplemented through inorganic fertilizer by 75% and glyricidia or rice straw by 25%.
Hari Prasad (1993) reported significantly more number of grains per panicle with the application of 120 kg N ha^{-1} through urea on sandy clay soil of Bapatla when compared with other organic and inorganic nutrient combinations.
Application of 30 kg N ha^{-1} through FYM along with 90 kg N ha^{-1} as urea resulted in more number of spikelets per panicle than other treatmental combinations (Sharma and Sharma, 1994).
Significant increase in grains per panicle in Basmati rice was observed with increase in the level of nitrogen up to 90 kg ha^{-1} (Tripathi et al., 1998).

Test Weight

Most of the researchers (Jeyaraman and Purushothaman, 1988; Thangamuthu and Balasubramaniyan, 1987; Setty and Channabasavanna, 1990 and Tamil Selvan and Kannan, 1990) reported an increase in the test weight with the combined use of organic and inorganic sources of nitrogen. Conversely, basal incorporation of FYM, poultry manure @ 5 t ha^{-1} or sunnhemp, calotropis, pongamia, soobabul, sesbania and neem leaf @1 12.5 t ha^{-1} to rice could not influence test weight (Budhar *et al*., 1991).

Yield

Grain Yield

In general, many researchers have reported increase in grain yield of rice due to incorporation of organic manures like wheat straw/FYM (Maskina et al., 1987), FYM @ 12 t ha^{-1} (Purushotham et al.,1988), Prosopis/Withania/Abutilon/neem leaf @ 6 t ha^{-1} (Alam and Azmi, 1990), wheat straw/FYM/water hyacinth @ 5 t ha^{-1} (Sharma and Mitra, 1990), FYM/biogas slurry/poultry manure @ 5 t ha^{-1} or green leaf manure @ 12.5 t ha^{-1} (Budhar et al., 1991) and FYM @ 20 t ha^{-1} (Tandon, 1991).

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Incorporation of rice straw and chaff in conjunction with 60 to 90 kg N ha^{-1} of inorganic nitrogen (Subbaiah et al., 1983), combined application of FYM + urea (Khan et al., 1986) and application of FYM @ 30 kg N ha^{-1} along with 90 kg N ha^{-1} as urea (Sharma and Sharma, 1994) gave highest rice grain yields when compared with their individual applications.

Various studies conducted have shown that combined use of 12 t FYM ha^{-1} and 60 kg N ha^{-1} (Kulkarni et al., 1978) and application of 12 t FYM ha^{-1} in combination with 80 kg N ha^{-1} (Maskina et al., 1988) produced rice yields equivalent to that obtained with 120 kg N ha^{-1}. Also, application of 75% NPK through fertilizers + 25% through Glyricidia or rice straw (Setty and Channabasavanna, 1990), 25 % recommended N through FYM (Raju et al., 1993) and 50% recommended NPK through fertilizer plus 50% NPK through compost and FYM (Jayakrishna Kumar et al., 1994) recorded similar rice grain yields as that of 100% NPK applied through fertilizers.

Application of N in conjunction with two organic sources i.e., FYM and wheat straw proved better than their individual application and affected economy of 50 kg N ha^{-1} for rice grain production (Rajput and Warsi, 1991).

Arumugam et al (1992) reported that rice yield obtained by 100% N (soil test lab recommendation) application were on par with 75% N combined with FYM @ 5 t ha^{-1} and Azospirillum @ 5 kg ha^{-1} and concluded that there is possible saving of 25% of fertilizer N by adopting integrated nutrient management.

Datta and Banik (1994) noticed the higher grain yields (4.28 t ha^{-1}) of rice were obtained with the application of poultry manure @ 5 t ha^{-1} compared to other treatments involving organics.

Prasad (1994) found that application of FYM, compost or biogas slurry in combination with 30 kg P_2O_5 ha^{-1} gave higher rice yields than with 60 kg P_2O_5 ha^{-1} as super phosphate on a calcareous soil in Bihar.

Higher yields of rice have been realized without over depleting the soil fertility when fertilizers were applied based on soil test values (Prasad and Prasad, 1994).

At Kaul, rice responded significantly up to 120 kg N ha^{-1} on FYM amended plots as compared to 180 kg N ha^{-1} on unamended plots (Agrawal et al., 1995).

Results of Alok Kumar and Yadav (1995) revealed that during initial years, 100% NPK fertilization along gave higher rice yield than their combination with organic manures and 25-50% of recommended fertilizers can be substituted by organic manures in subsequent years for improving soil condition and its fertility.

The highest yield of rice was obtained with combined application of inorganic P and poultry manure (Gupta et al., 1995).

Yadvinder Singh and Meelu (1995) from Ludhiana reported that application of 4 t poultry manure per hectare along with 60 kg N ha^{-1} produced rice yield similar to that obtained with 120 kg N ha^{-1} as urea.

Application of organic manure (FYM @ 5 t ha^{-1}) in addition to the recommended dose of fertilizers produced significantly higher grain yields in rice (Rabeya Khanam et al., 1997).

Straw Yield

Application of duck weed to rice @ 2 t ha^{-1} produced straw yield equivalent to that of 18 kg inorganic N ha^{-1} (Ahmad et al., 1990).

Subramanian and Rangarajan (1990) reported that of the different inorganic and organic treatment combinations, combined application of organics (FYM @ 12.5 t ha^{-1}, Azadiracta leaves @ 6.25 t ha^{-1}, cowdung slurry @ 5 t ha^{-1}) and Azolla recorded highest rice straw yield on farmers fields in Coimbatore.

Maximum straw yield was obtained by Budhar et al (1991) with the application of poultry manure @ 5 t ha^{-1} and it was found superior to FYM @ 5 t ha^{-1}.

Rajkumar et al (1991) found that with increase in FYM level from 10 to 30 t ha^{-1} straw yield increased from 5.08 to5.39t ha^{-1} respectively. Also, application of inorganic N in combination with FYM or straw to rice has been reported to increase the straw yield (Rajput and Warsi, 1991).

Datta and Banik (1994) observed that with the application of poultry manure @ 5 t ha^{-1} was highly effective in increasing straw yield of rice. However, a relatively lower straw yield was obtained, by Radha Madhav (1995) from his experiment, with the application of FYM @ 120 kg N ha^{-1}.

Blaise and Rajendra Prasad (1996) observed a significant increase in straw yield of rice only up to 60 kg N ha^{-1}.

Applications of various organic sources in conjunction with chemical fertilizer had significant stimulatory effect on straw yield, with the trend being: paddy straw > FYM > Ipomoea> Control (Tripathi and Chaubey, 1996).

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Incorporation of organic manure (FYM @ 5 t ha^{-1}) in addition to the recommended dose of fertilizers produced significantly higher straw yield in rice crop (Rabeya Khanam et al., 1997).

Harvest Index

Hari Prasad (1993) from his experiment, observed higher harvest index with application of FYM @ 30 kg N ha^{-1} along with 60 kg N ha^{-1} as urea. And, Radha Madhav (1995) concluded from his findings that relatively higher harvest index was obtained with application of FYM @ 120 kg N ha^{-1}.

Nutrient uptake

Khan et al (1986) reported that N uptake at tillering stage was higher in the treatment which combines the application of FYM and urea together than in the treatment receiving urea alone.

Sharma and Mitra (1990) observed that on lateritic soils at Kharagpur, organic materials like FYM/wheat straw/water hyacinth/compost @ 5 t ha^{-1} and dual cropping of azolla increased the N uptake in Kharif rice.

Nitrogen uptake was higher with 120 kg N ha^{-1} applied through inorganic N as urea alone compared with organics alone or combined use of organic and inorganic sources of N on sandy clay loam soils of Bapatla (Hari Prasad, 1993).

Uptake of phosphorus by rice was maximum due to application of poultry manure @ 5 t ha^{-1} and minimum with application of single super phosphate @ 21.8 kg P ha^{-1} (Datta and Banik, 1994). However, highest P uptake by rice was recorded with combined application of inorganic P and poultry manure by Gupta et al (1995).

Application of urea was found to have positive effect on NPK uptake during early stages of crop growth whereas organic sources (FYM, gliricidia, ipomoea, eichornea) were found to be effective during later stages (Radha Madhav et al., 1996).

The replacement of urea-N to the extent of 25 and 50 % through FYM and vermicompost, respectively did not result in significant reduction in nitrogen uptake. Maximum P uptake was observed with the application of 25:75 proportion of FYM straight fertilizer while significant increase in K uptake was observed in the treatment of 25:75 proportions of vermicompost and straight fertilizer (Jadhav et al., 1997).

Application of FYM @ 5 t ha^{-1} in addition to recommended dose of fertilizers produced significantly higher uptake of N, P and K by rice (Rabeya Khanam et al., 1997).

Nutrient status

Khan et al (1986) observed that a combination of 30 kg N ha^{-1} in the form of FYM at puddling and 30 kg N ha^{-1} as urea at planting provided adequate available N in the soil during initial growth stages and met N requirements of the rice crop during entire growth period.

Budhar et al (1991) reported that there was higher amount of residual N in plots treated with poultry manure, FYM, biogas slurry @ 5 t ha^{-1} and sesbania @ 12.5 t ha^{-1}. Similarly, they also observed that P and K status of soil was higher in poultry manure @ 5 t ha^{-1}, pongamia and sesbania plots.

Continuous addition of FYM along with NPK fertilizers resulted in higher available N and P, while addition of compost along with K fertilizer recorded higher available K content in soil (Udayasoorian and Paramasivam, 1991). Similarly, application of FYM and compost @ 25 t ha^{-1} increased available K content of soil (Udayasoorian et al., 1989).

Udayasoorian and Sreeramulu (1991) reported that continuous manuring and fertilization resulted in less depletion of inorganic P fractions.

Bhandari et al (1992) observed that the NPK fertilizers at 100% recommended levels or more and their combined use with organic N sources also increased the available N and P by 5 – 22 kg and 0.8-3.8 kg ha^{-1} respectively from their initial values in a rice wheat sequence.

Selvi and Ramaswami (1995) revealed in a rice-rice-pulse sequence effect of NPK plus organics particularly FYM significantly increased the available N, P and K contents of soil.

Yadvinder Singh et al (1995) noticed that fertilizer N equivalents in rice ranged from 42 to 52% of the total N applied and the apparent N recovery was 20% from FYM as compared with 35 to 46% in urea. Moreover, the N mineralization in soil from poultry manure containing narrower C:N ratio is substantially faster than from FYM (Yadvinder Singh et al., 1988).

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