

## INTEGRATED NITROGEN NUTRITION IN RICE-BASED CROPPING SYSTEMS - A REVIEW

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### ABSTRACT

On the basis of the following reviews it may be inferred that combined use of organic and inorganic sources of N has resulted in better rice yield than inorganic source alone. So also their residual effect boosted the productivity of succeeding crop. Thus integrated use of organic and inorganic fertilizers are effective in enhancing the productivity of the cropping system. Besides, it has beneficial influence on physico-chemical properties of the soil in respect of lowering bulk density and pH and improving the organic carbon as well as available nutrient status of soil in general and N in particular apart from improving N use efficiency in rice-based cropping systems.

Integrated approach of plant nutrition has a major role to play in solving the problem of nutrient mining. In simple words, it involves the judicious use of organic, chemical and microbial sources so as to sustain optimum yields and to improve or sustain the soil health to provide crop nutrition packages which are technically sound, economically attractive, practically feasible and environmentally safe (Biswas *et al.*, 1997).

In practice, the nutrient management strategies adopted in one crop often influence the fertilizer needs of the succeeding crops due to carry over effect of nutrients and crop residues, which is more significant under integrated nutrient management systems. Crop response to organic and biological nutrient carriers are not as spectacular as to the fertilizers, but the supplementary and complementary use of these sources is known to enhance the use efficiency of applied fertilizers, improve crop yield and physical status of soil (Lal and Mathur, 1989 and Kumar and Tripathi, 1990).

Studies carried out with cropping systems under Cropping System Research Project have established that 25-50% fertilizer NPK dose of *kharif* crops can be curtailed with the use of FYM as well as total productivity was found to increase (7-45%) with the integrated use of chemical fertilizers and FYM

(Panda and Sahoo, 1989, Hegde, 1992 and Anonymous, 1994). Mathew *et al.* (1993) also reported a reduction in the mineral fertilizer requirement to the extent of one third dose of N and  $K_2O$  and two third dose of  $P_2O_5$  from a recommended fertilizer dose of 70:35:35 kg  $ha^{-1}$  when FYM was regularly applied in all seasons @ 5 t  $ha^{-1}$ . While studying rice-wheat cropping system it was observed that amount of N, P and K added through chemical fertilizer, organic manure and bio-fertilizer were found to be effective in building up N and P but not K as removal of K was more than that of applied through various treatments (Nambiar and Abrol, 1989 and Prasad, 1994).

Working on rice-blackgram-rice rotation, Gnanamani and Bai (1994) obtained the highest yields with the use of Recommended dose of fertilizer (RDF) + bio-digested slurry @ 40 t  $ha^{-1}$ . Whereas, at Bilaspur in Chhattisgarh, Singh *et al.* (1996) noted the highest yields from rice-wheat cropping system when it was nourished with poultry manure @ 10t  $ha^{-1}$  + RDF. In another study, rice yield was the highest with recommended NPK followed by application of 50% NPK + FYM @ 5t  $ha^{-1}$  but the residual effect of latter was significantly more in producing the highest linseed yield. Combination of organic + inorganic fertilizers increased the soil pH, organic carbon as well as total N, P and K contents of soil (Sarkar and

Singh, 1997). Similarly, Adiningsih *et al.* (1997) also noticed increased nutrient availability by the use of N-fixing and P solubilising microorganisms.

In rice-mustard cropping system, application of 100% RDF + FYM @ 5t ha<sup>-1</sup> and 150% RDF were found to be equally effective in terms of yield and nutrient uptake (Dhurandher *et al.*, 1999). Whereas, application of 75% RDF + FYM @ 10 t ha<sup>-1</sup> produced the highest yields under rice-linseed/safflower/niger cropping system (Puste *et al.*, 1999). The findings of Jeyabal *et al.* (1999) revealed that application of either FYM or enriched FYM along with *Azospirillum* + PSB + RDF to rice crop increased yield (17.2 to 23.4%) and resulted in higher nutrient uptake and benefit : cost ratio over application of RDF alone. Katyal and Gangwar (2000) also noted best yield stability of cropping systems with integration of 25-50% nutrients through organic manure.

#### INTEGRATED NITROGEN NUTRITION

**Effect on crop productivity:** In evaluating the productivity of rice-wheat cropping system, Singh *et al.* (1995) observed no positive interaction effect due to combined use of cattle manure and urea. Similarly, Deor *et al.* (1997) found no significant difference with the use of 25, 50 or 100% N + FYM @ 10t ha<sup>-1</sup> and 100% N alone. Whereas, use of poultry manure and urea in 1:1 ratio on equivalent N basis produced yields in between the yields from the two sources applied alone (Singh *et al.*, 1996). However, application of 45:45:45 kg NPK ha<sup>-1</sup> as mineral fertilizers and 45 kg N ha<sup>-1</sup> as FYM in rice followed by 90:45:45 kg NPK ha<sup>-1</sup> to wheat in *rabi* gave the highest yields (Devi *et al.*, 1997). While, at Ludhiana, Dhillon *et al.* (1998) obtained the highest production under 100 kg N ha<sup>-1</sup> as urea + 5 t FYM.

Working at Raipur on rice-linseed cropping system, Singh (1997) reported that

combined application of FYM + urea (1:1) to meet 80 kg N ha<sup>-1</sup> was equally efficient to sole urea in terms of plant height, LAI, productive tillers, grains panicle<sup>-1</sup>, test weight, grain and straw yields of rice but in linseed, the residual effect of urea + FYM excelled in terms of plant height, branches plant<sup>-1</sup>, capsules plant<sup>-1</sup>, test weight, grain and straw yields than urea alone. The results obtained by Sarwar *et al.* (1998) showed that *Azospirillum* inoculation + 45 kg N ha<sup>-1</sup> produced significantly higher growth and yield of rice in comparison to control and 90 kg N ha<sup>-1</sup> with or without *Azospirillum*. Kaloianova (1999) and Ganguly and Manna (1999) also noticed increased plant height, panicle length and root biomass of rice with 60 kg N ha<sup>-1</sup> along with inoculation of *Azospirillum*.

In acidic soils of Andaman Island, the grain and straw yields of first season rice under 50% NPK + 50% N as poultry manure or FYM and NPK alone were statistically comparable. Whereas, in second season rice, use of 50% NPK + 50% N as poultry manure registered the highest increase in yield (79.8%) but remained at par to 50% NPK + 50% N as FYM (Dubey and Verma, 1999). On the contrary, at Rajendranagar, Katyal and Gangwar (2000) recommended no variation in *kharif* rice yield due to 50% NPK + 50% N from compost/FYM/*gobar gas* slurry as compared to 100% inorganic N. Further, no significant difference in *rabi* rice yield was observed when these two *kharif* treatments were followed by addition of 100% NPK in *rabi*. However, they recorded significantly higher *kharif* and *rabi* rice yields at Chiplima under integration of organic and inorganic N in comparison to inorganic source alone.

Similarly, Raju and Reddy (2000) found that application of 50:50 and 75:25 (compost N : inorganic N) produced 8.5% and 5.7% more rice grain yield than 100% inorganic N in rainy season. Use of 50%

inorganic N + 50% N as compost in rainy season followed by 100% inorganic N in winter had 11.0% more system productivity compared to 100% inorganic N applied in both rainy and winter seasons separately. The agronomic efficiency of these two treatments was 14.7 and 11.1, respectively. Field experiment at Hebbal (Karnataka) on direct sown rice resulted in higher grain yield with 50kg N + FYM @ 5 t ha<sup>-1</sup> than 50 kg N + FYM @ 10t ha<sup>-1</sup> or poultry manure @ 3t ha<sup>-1</sup> (Babu and Reddy, 2000). The findings in rice-mustard cropping system showed that combined application of FYM with urea at an equivalent N basis proved to be significantly effective in increasing growth and grain yield of rice as compared to control. Seed and stover yields of mustard increased significantly under residual effect of FYM+urea (3:1) over control (Singh *et al.*, 2001).

**Effect on nutrient content and uptake:** Prasad *et al.* (1990) reported that integrated N management is desirable for achieving higher N use efficiency. Singh *et al.* (1995) observed significantly higher total N uptake by rice under urea application rather than through application of manure. Apparent N recovery was 48 and 20% with urea and cattle manure, respectively. P and K uptake by rice increased in response to N application from urea and cattle manure, but the differences were small. In another study, Singh *et al.* (1996) found that over a period of 3 years apparent N recovery decreased from 45 to 28% in case of urea but it remained almost the same (33 to 37%) from poultry manure in rice-wheat cropping system. From a pot culture study it was noticed that N uptake by rice was in the order of FYM > poultry manure > bio-gas slurry (Rao and Sitaramayya, 1997). Dhillon *et al.* (1998) while working on rice-wheat cropping system also observed higher NPK uptake in FYM than control and improved with graded levels of N application.

Bandopadhyay and Sarkar (1999)

experimented on N nourishment in rice-wheat cropping system by taking urea, urea + FYM each at 60, 120 and 180 kg N ha<sup>-1</sup> and revealed that urea + FYM resulted in the highest fertilizer N recovery. Nutrients uptake decreased with the reduction in levels of inorganic fertilizers either alone or in combination with FYM and BGA. FYM proved superior to bio-fertilizer with respect to nutrient uptake (Kumar *et al.*, 2001). The N uptake by rice in FYM + urea (1:1) was less than recommended N through urea alone. But the residual effect of FYM + urea (1:1) in N uptake by mustard was significantly more than 100% N as urea alone and integration of FYM with urea in *khariif* resulted in increased N use efficiency for directly applied N in *rabi* (Singh *et al.*, 2001).

**Effect on soil physico-chemical properties:** Several researchers have established that integrated N use involving organic manure application in rice have significant residual effect on succeeding crop (Gill and Meelu, 1982, Dhillon *et al.*, 1998 and Dubey and Verma, 1999). Continuous application of FYM for 5 years helped in maintaining and improving physical properties of eroded alluvial soil compared to application of chemical fertilizer alone (Bhatia and Shukla, 1982). Organic manures can counteract the deleterious effect on bulk density that may be caused by the continuous use of mineral fertilizers and can increase the proportion of water stable aggregates and water holding capacity (Venkateswarlu, 1984). About 25 to 30% of the N contained in compost and FYM can be absorbed by rice plants during one crop season and the accumulated nutrients from the continuous application of organic matter are gradually mineralized and utilized by successive crops which sustain the productivity (Inoko, 1984 and Mathew *et al.*, 1993). Addition of manure and N-enriched manure delayed the hydrolysis of urea, reduced the loss of N and

also reduced the pH of soil. The organic carbon and available N status of the soil also increased by manure addition, but the simultaneous addition of fertilizers also increased the loss of carbon. Nitrogen enriched manures maintained a higher level of available N and P in soil for a long period than the fertilizer alone (Prasad and Singhania, 1989). On the contrary, no positive impact on total or available N contents of soil in rice was obtained by the use of urea + FYM or poultry manure (Rao and Sitaramayya, 1997).

Application of FYM reduced the loss of N but application of BGA increased volatilization (Singh and Prasad, 1991). Singh *et al.* (1995) found that cattle manure improved organic carbon, P and K contents of soil. Cattle manure at 120 and 180 kg N ha<sup>-1</sup> showed significant residual effects on the succeeding wheat crop, while urea had no residual effects. Poultry manure @ 120 kg N ha<sup>-1</sup> applied to rice also increased available P and was equivalent to 40 kg N ha<sup>-1</sup> in wheat (Singh *et al.*, 1996).

Multi-location trials in rice-rice cropping system on integrated N management revealed that about 50% of the N needs of the monsoon crop can be substituted through FYM. Integrated use of inorganic and organic sources of N in 1:1 combination increased soil organic carbon status but had no marked effect on available P and K contents of soil. Integrated use of FYM with chemical fertilizer had a more favourable effect on nutrient balance than use of green manure with chemical fertilizer (Hegde, 1997). Similarly, Basumatary and Talukdar, (1997) also noticed significantly higher inorganic, organic and total P contents of soil by substituting 50% N through FYM.

From a long term integrated N management trial, Bellakki *et al.* (1998) concluded that 75% RDF + 25% N through organic sources had better influence on humus, water stable aggregates, porosity, P and K

status and also decreased the bulk density of soil. Dhurandher *et al.* (1999) noticed significant increase of N and no difference in P and K status of soil in 100% RDF + 5t FYM ha<sup>-1</sup> as compared to 100% RDF alone in rice-mustard cropping system. In rice-rice-cowpea cropping system, 100% NPK and 50% NPK + 50% N as poultry manure or FYM could not influence soil pH and EC but significantly higher OC was noted in 50% RDF + 50% N as FYM than others. However, significantly highest available N, P and K were noted in treatment having poultry manure (Dubey and Verma, 1999).

On the basis of six years experimentation on rice-rice cropping system involving treatments 100% inorganic N, 50% and 25% N substitution from compost, Raju and Reddy (2000) noticed decline in pH in all the treatments and lower EC values as well as increased available P and K in treatments involving compost. Higher organic carbon was observed where material involving wider C: N ratio was applied. Supply of NPK through chemical fertilizer caused heavy depletion of K in the long run. They also found negative N balance in almost all treatments but the magnitude was very low when half of N was supplied with compost (Kumar *et al.*, 2001). However, in another trial, the available soil N in case of 100% N (urea) treated plots was higher than urea + FYM plots after rice harvest but the organic carbon trend was reverse (Singh *et al.*, 2001).

#### **INTEGRATED N NUTRITION THROUGH NUTRIENT BLENDING**

The need for adding inorganic nutrients to improve the nutritional value of organic manures was realized quite early (Hutchinson and Richards, 1921). The necessity to add mineral N for composting organic materials with wide C:N ratio has been proved in number of experiments (Asija, 1984 and Bhargavanshi, 1988). Considering the fact that

N content of compost can not be increased beyond 2.0-2.5% with the addition of mineral N during composting and there is significant loss of N during decomposition, incorporation of mineral N in the decomposed manures was suggested by Gupta and Indrani (1970) and Garg (1971). In multi-locational field experiments on rice, urea enriched FYM was found equivalent to prilled urea on equal N basis (Mishra, 1992).

**Effect on crop productivity:** Patel *et al.* (1982) at Raipur, observed that application of N as granulated compost gave the highest grain yield of rice and produced maximum number of panicles  $m^{-2}$ , filled spikelets  $panicle^{-1}$  and test weight. Working in sandy loam soil in rice-wheat cropping system, Singh *et al.* (1986) revealed that urea enriched compost (5% N) was similar to urea applied in four splits and recorded comparable plant height, panicles  $m^{-2}$ , 1000-grain weight and grain yield of rice. Further, enriched compost left sufficient residual effect, which increased the yield of succeeding wheat by 83.5% as compared to 55.8% by four-split urea over no nitrogen. Chandra *et al.* (1991) inferred that basal application of 40kg N as FYM conditioned urea in upland rice produced 62.2% higher yield compared to basal application of 40kg N  $ha^{-1}$  as urea. Singh and Sangliene (1991) reported that granulated compost @ 60kg N  $ha^{-1}$  gave good rice yield in calcareous silty loam soil. Similarly, Mishra (1994) found that urea conditioned with cattle dung compost as single dose top dressing at seedling stage was comparable with dibbling of USG in producing rice grain yield.

In *inceptisols*, the yield attributes *i.e.*, effective tillers  $hill^{-1}$ , panicle weight, test weight and harvest index of wet season rice were significantly higher with the application of urea in conjunction with FYM and soil (1:3:1), but the panicle length and filled grains  $panicle^{-1}$  were found similar, compared to prilled urea.

The highest HI and lowest N-requirement was observed with the application of urea + FYM + soil (1:3:1) and prilled urea, respectively (Patel *et al.*, 1997). Lakpale *et al.* (1999) noticed that preconditioning of urea with FYM and soil (1:3:1) gave significantly higher effective tillers, spikelets  $panicle^{-1}$ , panicle weight, 1000-grain weight and grain yield than prilled urea. Jeyabal *et al.* (1999) reported that application of P enriched FYM or FYM + *Azospirillum* + PSB + RDF to rice gave 17.2 to 23.4% higher grain yield over inorganic fertilizer alone.

Upadhyaya *et al.* (2000) from Raipur (C.G.) stated that N @ 60kg  $ha^{-1}$  applied through urea : FYM : soil (1:3:1) as basal or two splits or three splits was as good as prilled urea applied in three splits for number of grains  $panicle^{-1}$ , productive tillers  $m^{-2}$ , 1000-grain weight, grain and straw yields.

**Effect on nutrient content and uptake in plant:** Application of urea conditioned with FYM and soil (1:3:1) resulted in higher N uptake in rice grain, straw and their total (Patel *et al.*, 1997). The N concentration in rice plant at 30 and 90 DAT and at harvest was significantly higher in case of pre-conditioned urea than that of prilled urea. The pre-conditioned urea with FYM + soil (1:3:1) built up higher N status in soil than prilled urea (Lakpale *et al.*, 1999). The N uptake by rice nourished with 60kg N  $ha^{-1}$  as urea blended with FYM and soil (1:3:1) was noted to be similar to prilled urea application in three splits (Upadhyaya *et al.*, 2000).

**Effect on soil physico-chemical properties:** Reddy *et al.* (1980) showed that animal manure increased soluble P content. In a silty loam soil, an incubation experiment conducted by Prasad and Singhania (1989) revealed that addition of enriched manure reduced the pH of soil but with increase in time, the pH increased slightly. The organic carbon of soil increased with addition of enriched

manure. Urea hydrolysis was slowed down by addition of N-enriched manure. N enriched manures maintained a higher level of available N and P in soil for a longer period than the fertilizer alone.

Yadav and Srivastava (1985) observed that higher amount of  $\text{NH}_4\text{-N}$  was released from  $60\text{kg N ha}^{-1}$  as urea and soil pre-treated urea in the 1<sup>st</sup> and 2<sup>nd</sup> week of transplanting and there was gradual reduction in subsequent weeks. Similarly, under split and soil pre-treated urea, there was no more release of  $\text{NH}_4\text{-N}$  up to 6 weeks. In case of mud ball urea, the production of  $\text{NH}_4\text{-N}$  was quite slow upto 2<sup>nd</sup> week, thereafter it maintained more or less the same level till 8<sup>th</sup> week and then slowed down.

Lakpale *et al.* (1999) reported that application of urea preconditioned with FYM and soil (1:3:1) built up higher N status of soil. Urea blended with FYM and soil (1:3:1) on application to rice released N for longer period and also enhanced N uptake by grain and straw (Upadhyaya *et al.*, 2000).

#### INTEGRATED N NUTRITION AND ECONOMICS OF PRODUCTION

Mathew *et al.* (1993) noted the highest gross and net income and benefit: cost ratio with the use of 66% of recommended N,  $\text{K}_2\text{O}$  and 33%  $\text{P}_2\text{O}_5$  + 5t FYM  $\text{ha}^{-1}$  as compared to

100% recommended N,  $\text{P}_2\text{O}_5$ ,  $\text{K}_2\text{O}$  and all other inorganic and organic combinations. Singh *et al.* (1996) obtained the highest net return in rice-wheat cropping system by using poultry manure @  $10\text{t ha}^{-1}$  with or without recommended NPK as compared to FYM @  $10\text{t ha}^{-1}$  with or without NPK. In rice-mustard cropping system on an average, 22.2% more net profit was obtained when FYM was applied along with P (Sharma and Tripathi, 1999). Maximum grain monetary equivalence (GME) as well as highest monetary advantage was obtained from 75% NPK +  $10\text{t FYM ha}^{-1}$  as compared to 75% NPK +  $10\text{t cow dung ha}^{-1}$  or 100% recommended dose of NPK (Puste *et al.*, 1999). In a three year study in rice-rice-cowpea cropping system at Andaman Islands, the highest net return and benefit : cost ratio were obtained under 50% NPK + 50% N (poultry manure) followed by 50% NPK + 50% N through FYM and 100% NPK (Dubey and Verma, 1999). Ram and Saha (1999) observed higher gross and net return and net return per rupee investment under 50:50 ratio of poultry manure or FYM combined with chemical N in comparison to N applied as urea alone. Bhari *et al.* (2000) noted maximum net return and benefit : cost ratio from mustard with  $120\text{ kg N ha}^{-1}$  and  $45\text{kg P}_2\text{O}_5\text{ ha}^{-1}$  in comparison to their respective lower doses.

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