INTEGRATED USE OF VARIOUS ORGANIC AND INORGANIC NITROGEN SOURCES ON GROWTH, YIELD AND QUALITY OF RICE (ORYZA SATIVA L.) - A REVIEW

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ABSTRACT

Rice growing countries indicate that application of Nitrogen through organic sources or chemical fertilizers plays a dominant role in increasing the yield. To meet the current shortage of chemical fertilizers caused by energy crisis and socio economic constraints, it has become desirable to conserve crop residues and organic manure’s and recycle them into the soil to increase the efficiency of soil nutrients. In general, integrated use of organic and inorganic nitrogen is the best combination of available nitrogen management techniques, which would facilitate achieving the required productivity and sustainability by efficient use of soil and applied nitrogen.

Integrated use of N sources on growth and yield of rice

Increased fertilizers N cost and possible long term adverse effect due to the heavy use of chemical fertilizers lead to the combined use of organic like green manure with inorganic fertilizers for higher N use efficiency, more yield and sustained fertility (Nagarajah et al., 1989; Singh et al., 1991; Saravanan et al., 1988 and Khind et al., 1991). Integrated use of inorganic N fertilizer and crop residue management have received attention in recent years for efficient and economic management of N in rice-based cropping system (Meelu and Morris, 1987; De Datta, 1988 and Siddeswaran, 1992).

Combined application of organic plus inorganic fertilizer increased the grain yield of rice - wheat cropping system (Gupta and Gupta, 1997). Application of S. aculeata with prilled urea @ 40 kg N ha\(^{-1}\) increased the plant height, productive tillers and grain yield (Ramaswamy et al., 1988). Maximum dry matter production was recorded in S. aculeata green manuring (60 kg N ha\(^{-1}\)) plus Azolla inoculation (30 kg N ha\(^{-1}\)) (Mahapatra et al., 1994). The highest grain yield and biomass were recorded by the combined applications of green manure with urea (80 kg N ha\(^{-1}\)) (Azam, 1990; Singh et al., 1993 and Burench et al., 1993). Application of 6 - 8 week old S. aculeata with urea 60 kg N ha\(^{-1}\) recorded rice yield comparable to 120 kg N ha\(^{-1}\) urea alone, (Mahapatra and Khan, 1983; Incencia et al., 1989; Mishra et al., 1990; Saheb et al., 1990; Sahoo et al., 1990 and Nair and Gautam, 1992).

Substituting basal dose of 50 % N through green manure plus 50 % by prilled urea top dressed recorded the highest grain yield (Harron et al., 1992; Rao and Moorthy, 1994; Das et al., 1995 and Mahapatra et al., 1997). Application of 50% of N as inorganic fertilizer plus 25 % of N as S. aculeata plus Azolla recorded the highest grain yield of 5.9 t ha\(^{-1}\) and B:C ratio of 4.5:1 (Balasubramanian and Veerabadran 1997). Incorporation of 50 days old S. aculeata plus prilled urea (45 kg N ha\(^{-1}\)) at panicle initiation stage significantly increased panicle numbers, grain weight, grain yield and uptake (Mahapatra and Sharma, 1996).

Application of Sesbania aculeata with 30 kg N ha\(^{-1}\) significantly increased the grain yield, N use efficiency and apparent N recovery with Sesbania alone (Shukla et al., 1989). Shinde (1995) reported that application of 50 kg N ha\(^{-1}\) as prilled urea plus 8 t ha\(^{-1}\) Glyricidia
Incorporation of *Crotolaria juncea* plus 80 kg N ha\(^{-1}\) increased the grain yield (Mehta *et al*., 1996).

Incorporation of rice straw and wheat straw 5 t ha\(^{-1}\) with 20 kg N ha\(^{-1}\) as PU promoted straw decomposition and increased grain yield, besides reducing carbon content from 34.9 to 23.7 % by lowering the C:N ratio of rice straw with fertilizer N application (Mishra *et al*., 1996 and Singh *et al*., 1995).

Application of 87 kg N ha\(^{-1}\) of USG plus rice straw at the rate of 5 t ha\(^{-1}\) incorporation recorded the highest grain and straw yields (Kamalam *et al*., 1989). Incorporation of crop residue showed positive correlation with (lignin plus polyphenol)/N ratio, which is helpful for best prediction of grain yield (Clement *et al*., 1995). Incorporation of *S. rostrata* plus rice straw for two crops showed no response, possessed residual effect on third crop by increasing 10 % rice yield without fertilization (Becker *et al*., 1994).

The highest grain yield and N uptake was recorded with the application of 5 ton rice straw along with 100 kg N ha\(^{-1}\) as PU (Singh 1991). Green manuring has been successfully adopted to improve the soil productivity, especially the available soil N, and can partially substitutes the N fertilizer requirement of the subsequent crop (Meelu and Singh 1991). Substitution of urea with Sesbania reduced pH over prilled urea, but also lowered the flood water NH\(_4^+\) N content (Biswa and Goswami, 1996).

**Effect of green manuring on growth and yield of rice**

The use of green manure in agriculture was recognised as early as 500 B.C in India (Kadke, 1965). Vachhani and Murthy (1964) extensively surveyed about 100 leguminous green manure in India and recommended several suitable ones for rice ecosystem. 

*Sunnhemp* (*Crotolaria juncea*) and dhaincha (*Sesbania aculeata*) were more acceptable to farmers in India and widely grown in other countries of tropics (Pandey and Morris, 1983; Meelu and Morris 1986 and Palaniappan *et al*., 1991). Lauren *et al*. (1996), while consolidating the research work carried out on biomass production and N accumulation of green manure and grain legumes, indicated the biomass production of leguminous green manure ranges from 0.6 t to 37 t ha\(^{-1}\) fresh weight while N accumulation vary from 9 kg to 302 kg N ha\(^{-1}\).

The green manure legumes produce significant yield increases in a succeeding rice crop. The direct effects of green manure on the yield of succeeding rice were summarised in review articles by (Singh *et al*., 1991 and Becker *et al*., 1995). Yield responses from soil ammended with green manure range from 0.4 t ha\(^{-1}\) to 4.1 t ha\(^{-1}\) relative to control without green manure. As expected higher grain yields are often accompanied by increases in plant height, tiller number, productive tillers and straw yield (Sreenivasulu Reddy, 1988; Siddeswaran, 1992 and Mridha, 1987). In low fertility soils, rice yield increased by 78 % while on high fertility soils yield increase was only 22 % (Gu and Wen 1981 and Siddeswaran and Palaniappan 1995). The increase in rice grain yield due to incorporation of 35-60 days old *Sesbania aculeata* ranges from 38 - 115 % over control (Tiwari *et al*., 1980; Ghai *et al*., 1988, Ramaswamy *et al*., 1988 and Beri *et al*., 1989).

The most common method for expressing N benefit from green manure is the N fertilizer equivalence (NFE) or quantity of fertilizer N that must be applied to obtain the grain yield equal to that obtained from green manure alone. Generally, the NFE values obtained with green manure rice ranged from 34 kg to 220 kg N ha\(^{-1}\), but averaged at 50 to 100 kg N ha\(^{-1}\) (Meelu and Morris 1988; Buresh
Effect of rice straw on rice

Crop residues are one of the important renewable organic resources which can be efficiently utilized for soil fertility replenishment. Large amount of residues of rice are incorporated into the soils in regions where rice straw is not used as fodder for cattle. The rice straw incorporation provides enough substrate for increasing soil microbial population, in early stage of crop growth and in conserving N for later use by the plant, as the death of these increased microbial population would slowly release N, which was locked in it earlier, and increase fertilizer N use efficiency (Oh, 1984). But straw incorporation tends to depress the early growth of rice. To provide adequate N to rice more fertilizer N should be added to the crop (Pathak and Sarkar, 1997).

Carbon-N and lignin-fibre ratios have all been associated with the decomposition-N mineralisation rates of green manure and residue (Shi et al., 1981; Palm et al., 1988 and Nagarajah et al., 1989). A favourable effect of combining rice straw with N on grain yield, physical properties of soil were noticed by Lanjewar et al. (1992) and Singh (1991). Successive incorporation of rice straw to three crops proved to be better than to one crop that increase soil total N content and organic matter accumulation in 10 - 20 cm layer (Lee Kyeongbo et al., 1995).

Studies conducted by Khind and Bajwa (1993) revealed that adding rice straw to flooded soil and allowing it to decompose for longer period followed by application of urea causes rapid urea hydrolysis through NH$_3$ volatilization.

Residual effects of organic manures

The various studies conducted to identify the residual effect of organic sources provided a mixed response. In rice-rice rotation, more than half of the surveyed studies recorded no residual effect (Morris et al., 1986; Furroc and Morris 1989; Watanabe et al., 1989 and Meelu et al., 1992); while other studies reported small but significant yield increases (13-43% over controls) in the second crop of rice (Jha et al., 1980; Morris et al., 1989; Ventura and Watanabe 1993 and Becker et al., 1994). Reasons for lack of a trend are not clear, but Morris et al. (1989) attributed the results to varied N loss mechanisms.

Nitrogen mineralization pattern of crop residue ranged from rapid to immobilization at the beginning of the season (Cassia velosa L.). Immediately after incorporation, N mineralization was positively correlated to crop residue N concentration ($r^2 = 0.64$) and negatively correlated to tannin concentration. However, at tillering, the tannin-N ratio was best or related to the rate of N release ($r^2 = 0.86$) (Clement et al., 1995).

More distinct residual effects were evident from rice-wheat experiments where significant yield benefits were noted in 15 out of 22 studies. Boparai et al. (1992), Kolar et al. (1993), Rekhi and Bajwal (1993) and Gill et al. (1994) found quite low residual responses of 4-11% over controls, while Bhardwaj et al., (1981); Sharma and Mittra (1988); Chaudhary (1990); Rathore et al., (1995) and Sharma et al., (1995) reported intermediate yield increases (15-38%).

Variability in responses to organic manure additions were most likely due to the quantities of applied N, the quality of the GM, or methodological differences (Lauren et al., 1996). The residual responses are largely dependent on the green manure N remaining after the first rice crop (Lauren et al., 1996). The chemical composition or quality of GM is also an important factor for evaluating residual effects. Bouldin (1988) developed a hypothesis relating the direct benefit of a legume based green manure with a rapidly decomposing pool.
and the residual effect with the much slower decomposing pool. Becker et al. (1994) suggested that the magnitude of residual response may relate to N persistent as determined by the lignin to N ratio of the green manure. Residual effect can be increased with continued use of GM and organic source through cumulative addition to slow mineralisable N pool.

**Effect of organic and inorganic sources of Nitrogen on grain quality**

Quality refers to degree of excellence and suitability for specific utility of the plant product. The main aspects of rice quality indices are the size, shape and appearance of the grains; hulling, milling, cooking and nutritional quality and some other special qualities, which includes scent and linear expansion of kernel on cooking. The quality parameters have been reviewed by a number of research workers (Chatterjee and Maiti, 1985; Singh, 1993 and Mahendrapal et al., 1996).

Under organic farming Verma and Srivastava (1993) obtained a grain length of 6.8 mm, grain breadth of 2.0 mm and L/B ratio of 3.4 mm for scented rice variety Basmati 370. Tamaki et al. (1995), studied the relationship between the duration of organic farming and amylographic characteristics and mineral contents of rice. They concluded that higher viscosity and breakdown value of rice increased with duration of organic farming practices. Hsieh (1995) noted that eating quality of organic rice was better than conventionally produced rice. Organically grown rice had higher Mg, Zn content and embryo activity during storage and lower imperfect rice kernel ratios, N, K and Ca content than conventionally grown rice. (Nakagawa et al., 2000). Application of FYM 10t ha\(^{-1}\) combined with BGA inoculation increase the hulling and milling percentage, protein and amylose content (Dixit and Gupta; 2000). An incorporation of daincha at 12 t ha\(^{-1}\) remarkably increased the optimum cooking time, total amylose content, crude protein content and reduced the gruel loss (%) of grain reported by Hemalatha et al. (2000).

Nitrogen fertilization resulted in significant increase in rice recovery, protein content in grain, length and breath ratio of kernel and sensory aroma in cooked rice upto a dose of 100kg N ha\(^{-1}\) (Singh et al., 1997). Highest average protein content was reported @ 90kg N ha\(^{-1}\) along with 45 kg N ha\(^{-1}\) (Akaram et al., 1985). Seyoum (2001) reported that combined application of 150 kg N ha\(^{-1}\) and 26.4 kg P ha\(^{-1}\) significantly increased the protein content of rice grain by 21.7% over the untreated plots.

The head rice recovery and alkali value were higher with the application of 10t FYM and 80 or 120 kg N ha\(^{-1}\) than other treatments. Application of N fertilizer increased the kernel length, length: breath ratio, kernel length after cooking and elongation ratio (Pandey et al., 1999; Dahiphale et al., 2000). Subbiah and Kumaraswamy (2000) reported that recommended levels of N, P and K with green manure plus gypsum 500 kg ha\(^{-1}\) increased the protein content, bran oil content, total amylose content, percentage of milling recovery and hardness in the rice grain.

**REFERENCES**


