



## A REVIEW

# Green manure intercropping in direct seeded rice

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Green manuring to rice crop improve the soil fertility and productivity. The green manure application to the soil promotes the activities of soil micro-organisms through which CO<sub>2</sub> is liberated, the chemical reactions in the soil are speeded up and more plant nutrient is made available to rice crop. Organic acids produced during the decomposition of green manure helps to release phosphates and made them available to the crop. The green manure crop withdraws plant nutrients from the lower layers of soil and concentrates them to the surface, when ploughed in and this assists the succeeding or associating crop. For sustainable crop production, Pathak and Ghose (1996) emphasized that application of greenmanure, complementary use of N through organic manures and improved composted manures and crop residue utilization are important. *In situ* incorporation of *Sesbania aculeata* @ 12 t ha<sup>-1</sup> recorded higher grain yield and higher cooking time of rice due to the increased hardness of grain (Hemalatha *et al.*, 2000).

Concomitant changes that favoured the switch to wet seeding included the release of modern rice varieties with high yielding vigour and tillering ability, increased

crops ability to compete with weeds and improved water control and increased availability of selective herbicides such as butachlor and thiobencarb for effectively controlling weeds (De Datta and Bernasar, 1971 and Moody and Cordova, 1985). Expansion of irrigated area, availability of selective herbicides, introduction of early maturing rice varieties and improved fertilizer management coupled with increased cost of transplanting and declining profitability of rice production encouraged many farmers to switch from transplanting to wet seeding (De Datta, 1986 and De Datta and Flinn, 1986). Generally, it was believed that transplanting would give more stable grain yield than the direct seeding. Stand establishment is often poor under wet seeding because of poor land preparation, high temperature, severe weed competition and poor weed control (De Datta, 1981). However, under ideal conditions similar higher grain yield is possible in wet seeded rice (Reddy *et al.*, 1987). Nayak and Lenka (1989) also reported that sowing rice by broadcasting sprouted seeds in puddled soil gave paddy yields similar to or higher than those obtained by transplanting.

Studies using semi dwarf IR cultivars indicated that

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direct seeded flooded rice culture resulted in crop growth dynamics profoundly different from those resulting from transplanted rice culture (Dingkuhn *et al.*, 1990 and Schnier *et al.*, 1990). Early production of large vegetative biomass, leaf area and tiller number can be considered as characteristic features of direct seeded flooded rice. As a result of difference in tillering behaviour, direct seeded rice in general had more panicle per unit area, but fewer spikelet per panicle and eventually fewer grains per panicle (Schnier *et al.*, 1990). When there is uncertainty in canal water supply, direct seeding of an early duration culture would be useful (Budhar *et al.*, 1990). In command areas, synchronization of planting is needed for effective pest management and efficient water management but non cooperation by labourers has been quoted as a constraint for getting optimum population in rice. So the alternatives for manual transplanting will be mechanization of transplanting and direct seeding in puddled soil as reported by Rangarajan and Veerabadran (1993). Wet seeding practices include broadcasting or drilling pre-germinated seeds on puddled soils. Research conducted by Khuntia *et al.* (1989) proved that direct seeding either by broadcasting or drilling of seeds gave similar yields to that of transplanted rice. About 63 to 73 per cent seed establishment was obtained, when seeds were sown by using a machine comprising of furrow openers and seed drills and this was 10 per cent higher than the values obtained for direct sowing by broadcasting in submerged field as reported by Okazaki *et al.* (1990).

Wang and Sun (1990) observed that the vegetative growth period of machine sown direct seeded rice was shortened by 7 to 15 days and had more productive tillers and highly developed root system than manually transplanted rice. According to Schnier *et al.* (1990) the higher plant density of wet seeded rice lead to decreased leaf nitrogen concentration during the reproductive stage. However, they noted that through the control of heavy tiller number per unit area and leaf area, wet seeded rice had the potential for higher yields. Kabaki and Kon (1991) opined that germinated rice seeds that were broadcasted at a rate of 70 to 100 kg ha<sup>-1</sup> on puddled clayey soil produced similar grain yields as that of conventionally transplanted rice. In Karnataka, Channabasavanna and Setty (1992) obtained increased grain yield with increase in seed rate. Panicles per m<sup>2</sup> increased upto a seed rate of 100 kg ha<sup>-1</sup>, but the increase was substantial upto 80 kg ha<sup>-1</sup>. The study conducted by

Wahab (1994) at Killikulam, Tamil Nadu revealed that a seed rate of 100 kg ha<sup>-1</sup> could be adopted for getting an optimum yield in direct sown rice. Although transplanting is the most popular crop establishment method in the irrigated rice growing areas of Asia, this practice is being increasingly replaced by direct wet seeding which eliminates labour demand for seed bed preparation, pulling of seedlings and transportation and is more conducive for mechanization (Schnier *et al.*, 1990 and Annadurai and Palaniappan, 1999). The advantages of wet seeded rice culture include its drought tolerance, less labour requirement for establishment, better weed control and high returns (Bhuiyan *et al.*, 1995). Pandey and Velasco (1999) quoted some of the advantages of wet seeded rice as follows, i. It saves labour; it can reduce the labour requirement by as much as 50 per cent depending on the nature of production system. ii. When rainfall at planting is highly variable, direct seeding may help to reduce the population risk. iii. It can facilitate crop intensification. iv. Irrigation water can be reduced if dry seeded rice can be established earlier using pre-monsoon showers. The growth duration of direct seeded rice was shortened by 7 to 15 days as compared to transplanted rice (Wang and Sun, 1990). The rate of tillering, leaf area expansion, N uptake and dry matter accumulation during the vegetative stage were considerably more rapid in broadcast rice than in transplanted rice (Peng *et al.*, 1996). Rice dry weight was higher in wet seeded rice (WSR) than in transplanted rice (TPR). Wet seeded rice has higher root density at all soil depths than transplanted one (Nabheerong, 1995 and Pal *et al.*, 1999). Wet seeded rice is more drought tolerant than transplanted rice (Khan, 1990). The yields of WSR were high in both water sufficient and stress conditions (Sattar, 1992). Research studies conducted at IRRI, Philippines indicated that wet seeded rice culture is superior to the transplanted rice culture in terms of WUE (Bhuiyan *et al.*, 1995). The vigorous growth of seedling in wet seeded rice was due to rapid uptake of nitrogen which resulted in reduced volatilization and immobilization loss of nitrogen (Diekmann, 1990). The recovery of inorganic nitrogen was greater for wet seeded rice (47%) as compared to transplanted rice (37%) under similar nitrogen management practices. Hence, a net saving of nine to ten per cent of applied inorganic nitrogen was observed in wet seeded rice (Obcemea *et al.*, 1990). Direct seeding not only provides more turn-around period for double cropping due to reduction in crop duration but

also beneficial to maintain the granular crumb structure of the soil (Singh and Bhattacharya, 1988). Fertilizer use efficiency was generally higher in direct sown rice than transplanted rice which may be attributed to lower fertilizer N losses through volatilization and immobilization as indicated by  $^{15}\text{N}$  studies (De Datta *et al.*, 1989 and Schnier *et al.*, 1990). Under similar N management practices, with applied urea  $^{15}\text{N}$  recovery was greater in broadcast seeded rice than in transplanted one due to rapid vegetative growth and absence of transplantation shock (De Datta *et al.*, 1989 and Peng *et al.*, 1996).

Direct seeding on puddled land gave yield comparable to that of transplanting (Rajan and Mahapatra, 1980). Direct sown rice was advantageous in securing more values of yield attributes *viz.*, number of panicles  $\text{m}^{-2}$ , number of filled grains panicle $^{-1}$  and test weight (Budhar *et al.*, 1991 and Thakur, 1993). Results of most of the field experiments and on farm trials revealed that upon proper management, comparable yields from direct seeded rice could be secured as that of transplanted crop and this might be the reason as to why majority of the rice growing countries are striving hard to make a shift from transplanted to direct seeded rice (Ramasamy *et al.*, 1994; Peng *et al.*, 1996). The direct sown rice by virtue of slightly higher yield stability makes itself an attractive practice over transplanting (Lantican *et al.*, 1999). The economic returns for adoption of wet seeding are provided by its labour saving feature. Transplanting typically takes about 20 persons  $\text{day}^{-1} \text{ha}^{-1}$ . With the real price of rice falling over time, increasing adoption of wet seeding can be viewed as a response to the ensuring cost price squeeze (Panday, 1995). Input requirement is less for direct sown rice (DSR) than transplanted rice (TPR) which ultimately results in more gross margin (IRRI, 1995). Although gross margins for both transplanted rice and wet seeded rice crops are very similar sometimes, the paid out costs for transplanted rice is higher than that of wet seeded rice. The main difference was due to saving in the cost of hired labour in wet seeded rice. Although the cost of herbicide in wet seeded rice is higher, this increased cost was less than savings in labour cost. As the paid out cost associated with transplanting is higher, farmers who have limited access to credit are more likely to adopt wet seeded rice as an attempt to save the cost of production (Erguiza *et al.*, 1990). Leguminous green manure has the greater advantage of transferring N to

the main crop (Arunin *et al.*, 1988). When legumes and non legumes are intercropped, the non legume species sometimes perform better than it would in monoculture, possibly because of the additional N supplied by the legume. N transfer by excretion from the nodules occurred in a cereal - legume intercropping (Agarwal *et al.*, 1992).

#### **Intercropping green manure in direct rice :**

Combined use of green manure and fertilizer N increased the total number of tillers per hill. Incorporation of green manure 30 days after sowing and split application of N maximum tiller production. This is in accordance with the findings of Budhar (1994). Though intercropping is done from time immemorial, green manure intercropping in rice ecosystem is of recent origin, the main objective of which is to achieve a substantial increase in rice yield with additional biomass yield of green manure for building up the soil fertility (Somasundaram, 1991). In addition to increasing trends of cropping intensity and burgeoning demands formed the basis for switching over to green manure intercropping. Under the conditions of intensive agriculture, in which land and time are the major constraints, green manure crops can be accommodated in the cropping calendar when the growth interval is short or can be grown as intercrops (Watanabe and Liu, 1992). The farmers are reluctant to use their land, water and other inputs for raising a crop exclusively for green manuring prior to rice (Ali and Narsico, 1993). Intercropping one row of *Sesbania aculeata* seedlings at a spacing of every 3 m between rice with 20 x 15 cm spacing gave more profitable yield than sole crop of rice (Jha *et al.*, 1989). The highest rice yield was obtained when rice and *Sesbania aculeata* were grown at 2:1 ratio in 20 cm wide rows and dhaincha were grown in alternate rows at 15 cm spacing (Sharma and Das, 1994). Jayapaul *et al.* (1995) reported that wet seeded rice benefit from intercropping 20 days old seedling of *Sesbania rostrata*. They also reported that incorporating green biomass in the standing rice field positively increased the yield parameter *i.e.* panicle number, panicle length and filled grains per panicle resulting in higher grain yield at 45 Days after sowing with an intra row spacing of 15 cm. The effectiveness of *Sesbania aculeata* in smothering weeds was reported when grown as intercrop in rice (Angadi, 1997). Intercropping *Sesbania aculeata* in between the rows of rice in additive

series and incorporating 35 DAS proved superior to sole rice (Joseph, 1998). Wet seeding of rice lends more scope for intercropping green manure without sacrificing any of the economic crops in the cropping system, which was emphasized by Palaniappan and Siddeswaran (1999). Rajendran *et al.* (1999) emphasized the intercropping of *Sesbania aculeata* with wet seeded rice using rice cum green manure seeder of TNAU. However, *insitu* incorporation of *Sesbania aculeata* @ 12 t ha<sup>-1</sup> recorded higher grain yield and higher cooking time of rice due to the increased hardness of grain (Hemalatha *et al.*, 2000).

#### Contribution of nitrogen by *Sesbania aculeata* :

*Sesbania aculeata* gave a dry biomass of 3.15 t ha<sup>-1</sup> with 1.45 per cent N concentration and accumulates about 42.5 kg N ha<sup>-1</sup> (Medhi, 1996) and is capable of contributing 224 kg ha<sup>-1</sup> of biomass at 45<sup>th</sup> day (Tamizhvendan and Rajeshwari, 1999). *Sesbania aculeata* recorded higher fresh biomass of 51.4 and 73.4 g plant<sup>-1</sup> within 40 and 50 DAS, respectively (Kalidurai, 1998). About eight weeks old *Sesbania aculeata* plants have been found to contain 3 per cent N in addition to K, Ca, Mg, P, S and micro nutrients and about 33 kg N, 1 Kg P, 14 kg K and 2 kg S are added to the soil, if a tonne of dhaincha dry matter is applied (Bhuiyan *et al.*, 1988). Besides being a deep rooted crop, *Sesbania aculeata* absorbs nutrients from the subsoil enriching the rice plough layer upon incorporation. The leaflets of *Sesbania aculeata* degrade rapidly in moist soil and release 50 per cent of their N within four weeks of incorporation (IRRI, 1985). Among the conventional intercrops, *Sesbania aculeata* has wide adaptability to even problem soils and 211 has the ability to produce dry matter ranging from 2.8 to 9.9 t ha<sup>-1</sup> accumulating 80 to 225 kg N ha<sup>-1</sup> on 60 DAS (Lauren *et al.*, 1996). The beneficial effect of N and the combined effect of green leaf manure and fertilizer N on plant height was reported by Siddeswaran (1992), Prem Sekhar (1993) and Budhar (1994). *Sesbania aculeata* could produce 21.1 t ha<sup>-1</sup> of green biomass and accumulate about 133 kg N ha<sup>-1</sup> (Sanyasiraju, 1952). Thirty days old *S. aculeata* released an equivalent of 38 kg N ha<sup>-1</sup>, while 45 and 60 days old plants released N equivalent of 60 to 120 Kg N ha<sup>-1</sup>, respectively (Khind *et al.*, 1987). It produce about 24 t ha<sup>-1</sup> of biomass with 106 kg N ha<sup>-1</sup> (Singh *et al.*, 1987) and can produce in general 20 t ha<sup>-1</sup> of green matter yield in tropical conditions of southern India (Abrol and Palaniappan, 1988).

*Sesbania aculeata* was considered to be the premier green manure crop because it fulfills the traits of the ideal green manure for low land rice such as early establishment and high seedling vigour, tolerance to flooding and dry, early onset of N fixation and efficient over varied climate and edaphic conditions, fast growth with an ability to accumulate large biomass and N within four to six weeks of growth and quick decomposability (FAO, 1977; IRRI, 1988; Ladha *et al.*, 1988 and Casico, 1990). Green manuring is a feasible alternative to the use of N fertilizer. The importance of green manuring in agriculture has been recognized as early as 500 BC in India (Kakde, 1965).

Green manuring is an inexpensive ecofriendly alternative to mounting prices of fertilizer nitrogen and has become an effective technology in economizing the agricultural production system ensuring production capacity of soil without causing environmental problem (Bana and Pant, 2000). Green manuring refers to addition of green plant tissue to soil. Objectives of green manuring are to increase organic matter content of soil, maintain and improve soil structure, reduce the loss of nutrients particularly N, provide a source of N for the succeeding crop and reduce soil erosion and there by increase the production of crops (Greenland *et al.*, 1979). Green manuring improves the yield and partially substitutes the N requirements of the crop (Singh, 1984) increases the soil N, P concentrate, helps in maintenance and renewal of organic matter and improves the soil physical and chemical condition (Jiao, 1983). Regular practice of green manuring over a long period not only improves the soil fertility but also resulted in noticeable residual effect in intensive cropping system (Palaniappan *et al.*, 1990).

Gosh and Sharma (1996) reported that the green manure on long term effect results in a very high residual effect than other organic sources. The literatures revealed that wet seeded rice resulted in saving of labour, increased net income, conserved water, minimized risk and increased yield. Further it paved way for intercropping of green manures. *Sesbania aculeata* green manure dual cropping in wet seeded rice resulted in higher growth and yield of wet seeded rice, and increased the soil N, P concentrate, helps in maintenance and renewal of organic matter and improves the soil physical and chemical condition thereby improved soil fertility status. Higher tiller production stage due to steady supply of N green manuring which favours more production of panicles and enhances rice yield.

Increased N both by applied fertilizer and greenmanure resulted with larger LAI and height with vertical manner resulted in increased productivity.

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