Fitting Green Manures in Rice Based Cropping Systems - A Review
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ABSTRACT

In lowland rice ecosystems, green manure is considered to be the appropriate organic source. But this necessitates farmers to set apart 6 to 8 weeks exclusively for growing green manure crops. Due to its unattractive economics, crop intensification, ease in application and ready availability of inorganic N fertilizer, the use of green manures has declined. So if green manure is to be popularized, the capital, time and labour involved in raising a green manure crop and the economical competition with other high value cash crops should be minimized which can render it as a potential component of Low Input Sustainable Agriculture. A method of introducing the green manures in the rice based cropping system without unduly affecting the net returns to the farmers is imperative. Intercropping of Sesbania with cowpea in post-rice season recorded a net return of US $ 593 ha⁻¹ from a combination of cowpea and sesbania rows in the ratio of 3:1. Sesbania rostrata is proved to be a more efficient green manure crop for intercropping in the semi-dry rice which produced 9078 kg ha⁻¹ biomass and 1389 kg ha⁻¹ of dry matter. The research findings on the opportunities for fitting green manures in the rice based cropping systems and alternate uses of green manures are reviewed.

Intercropping of Green Manures and Grain Legumes

Rice-based cropping systems often include a 60 to 90 day period in summer during which a grain legume is normally grown. Integration of a green manure with grain legume during this period could help in producing grain besides biomass for green manure. Buresh and De Datta (1991) suggested a cropping system for rice farmers who are reluctant to devote land and resources to grow legumes exclusively for green manure. Buresh and De Datta (1991) suggested a cropping system for rice farmers who are reluctant to devote land and resources to grow legumes exclusively for green manures. They reported that Indigofera as green manure could be intercropped with upland food legumes after the harvest of which indigo could be incorporated during land preparation of wet season rice. Garrity et al. (1990) studied an intercrop system in which Indigofera tinctoria was intercropped with greengram. In this system, a yield reduction of 0.2 t ha⁻¹ was observed as compared to sole greengram and they concluded that if indigo planting was delayed until the hilling-up operation of greengram was performed, greengram yields remained unchanged.

Varughese and Kumari (1993) reported that maximum yield of dry sown rice could be obtained where cowpea and sunnhemp were raised as intercrops with rice and incorporated on 30 DAS by light hoeing. Kalpana and Balasubramanian (2000) studied a rice based cropping system in which two green manures Sesbania aculeata and Sesbania rostrata were intercropped with greengram and redgram and ratooned twice for fodder purpose. The ratooned regrowth was incorporated to the follow up rice crop treated with three levels of N at 0, 50, and 100 kg N ha⁻¹. Grain legumes yielded 364 – 401 kg ha⁻¹ of grain yield when intercropped with green manure crops. The green manure crops gave 14-17 t ha⁻¹ as fodder and ratooned regrowth contributed 5.2 – 8.6 t ha⁻¹ biomass as green manure with a N contribution of 20-65 kg ha⁻¹ and increased rice grain yield by 20-30% over no green manure. The loss in yield of grain legumes due to intercropping was well compensated by the green manure contribution to the succeeding rice. Rice yield obtained with incorporation of S. rostrata/S. aculeata in greengram plots or redgram with S. rostrata/S. aculeata along with application of 50 kg N
Intercropping of green manures with rice

*S. rostrata* alley cropped with rice improved rice growth, yield and N uptake (Mulongoy, 1986). He found that *S. rostrata* interplanted at 10 x 200 cm and 10 x 150 cm produced 3 and 4 t ha⁻¹ of dry matter respectively and their decomposition released an average of 70 kg N ha⁻¹. Liu Chung Chu (1988) found that broadcasting of sesbania seeds in the wide intervals of double wide narrow spaced rice in the early season did not affect the yield of early rice.

Intercropping one row of *S. aculeata* seedlings at a spacing of every 3m between rice rows with 20 x 15 cm spacing gave more profitable yield than a sole crop of rice (Jha et al., 1989). Transplanting of *S. rostrata* seedlings 30 DAS as intercrop in rice with different levels of N resulted in considerable amount of N accumulation and recorded the highest rice yield (Alagappan, 1990).

Intercropping of *S. rostrata* raised at 1.5 m interval and ratooned along with application of 50 and 100 kg N ha⁻¹ in rice gave 7 and 13 % more grain yield respectively than that of pure stand of rice (Balasubramanian, 1989).

The growth of rice was affected initially when *S. aculeata* was raised simultaneously as an intercrop. Later on, tillering of rice increased after the incorporation of green manure. The highest rice yield (3.48 t ha⁻¹) was obtained when rice and *S. aculeata* were grown at 2:1 ratio in 20 cm wide rows and the clonal tillers uprooted from the adjoining rice rows were planted in lines vacated by *S. aculeata* (Sharma and Das, 1994). This was followed by intercropping of rice and dhaincha in 15 cm wide alternate rows (3.43 t ha⁻¹) and rice and dhaincha raised by direct planting method (3.18 t ha⁻¹) as compared to yield obtained from transplanting after incorporation of pure dhaincha (3.06 t ha⁻¹).

Intercropping green manure and subsequent incorporation increased the values of yield attributes and enhanced semi dry rice yield (Jayachandran and Veerabadran, 1996). Among the different green manure tested as intercrop in semidry rice at 1.4 m interval, *S. rostrata* performed better than other green manure followed by *S. aculeata*. *S. rostrata* produced 9078 kg ha⁻¹ biomass and 1389 kg ha⁻¹ of dry matter compared to biomass yield of 8975 and 8923 kg ha⁻¹ by *Crotalaria juncea* and *S. aculeata* respectively. *S. rostrata* recorded high N content than other green manures. The addition of increased quantity of N (45.01 kg ha⁻¹) through *S. rostrata* resulted in increased growth and yield of rice. Incorporation of *S. rostrata* recorded 3180 kg ha⁻¹ while 100 kg N ha⁻¹ recorded 3490 kg ha⁻¹. *S. rostrata* with 100 and 75 kg N ha⁻¹ recorded 4112 and 3992 kg ha⁻¹ respectively. Thus it can be concluded that intercropping *S. rostrata* with semi dry rice and application of 75 kg N ha⁻¹ to rice crop is ideal in increasing yield.

Intercropping *S. rostrata* in transplanted rice at every 10 rice rows and later incorporating even at 30 DAS reduced rice yield as compared to sole rice. Allowing green manure growth upto 45 DAT suppressed and reduced the associated rice yield further indicating that in transplanted rice, green manure intercropping even at further interval of raising (1 row after every 10 rows of rice) had detrimental effect (Somasundaram et al., 1996). Relaying green manure at the ripening stage of rice-rice sequence would be a potential feasible approach (Torres et al., 1995).

Ratooning of green manures

Ratooning was found to have two advantages, one is that there is no additional cost for the growth of *S. rostrata* in paddy field and secondly a continuous supply of high amount of biofertiliser is ensured. More over
ratooning the green manure in the intercropped stand also helps to reduce the intercrop competition. Mulongoy (1986) showed that *S. rostrata* was highly responsive to ratooning and produced 3 and 4 t ha$^{-1}$ of dry matter as regrowth after two priming in an alley cropping system with rice. Carangal *et al.* (1988) found that *S. rostrata* and sunnhemp were amenable to clipping management, which increased the biomass production. He reported that these legumes could be pruned two to five times during the growing period.

Becker *et al.* (1988) reported that ratooned sesbania showed faster growth rate than seeded plants. They found that compared with seeded plants ratooned and those planted through stem cuttings produced a higher biomass and N accumulation after 6 weeks of growth. They showed that ratooned plants started growing 2-3 days after cutting and put forth faster growth rate than seeded plants. Furc and Manguiat (1989) reported that ratooned sesbania produced 0.66 t ha$^{-1}$ of fodder for ruminants and subsequent cuttings could be taken at 30 to 60 days interval depending on the regrowth of the species.

Though the nitrogen content decreased due to higher biomass production than sown crop, the N accumulated by ratooned plants was more (Balasubramanian, 1989; Alagappan, 1990). In rice + *S. rostrata* intercropping system, when *S. rostrata* was ratooned at 30 DAT it not only helped to minimize the intercrop competition with rice, but the ratooned biomass when incorporated, increased the yield of succeeding rice (Balasubramanian, 1989).

Alternate uses of green manure crops

*Sesbania* is a promising legume for fodder and green manure purposes in Asian countries. Because of its high protein content, sesbania has strong potential for animal feeding in integrated crop-livestock farming systems (Carangal and Calub, 1986). *Sesbania sesban* and *Sesbania formosa* appear promising with high yields, reasonable leaf retention over the dry season and high nutritive value (Topark-Ngram and Gutteridge, 1985). Being a fast growing annual legume crop, *S. rostrata* could produce enough biomass to supply a part of the protein needs of animals. Arunin *et al.* (1988) reported that sesbania had potential as forage crop, besides being useful as green manure.

Alternate crops as green manures

Several indigenous plants have been identified to have good potentials as green manure in rice based cropping system. Adhatoda *vasta*, a gregarious thickly branched, evergreen woody shrub with medicinal, pesticidal, fungicidal and manurial properties was studied as green manure for rice by Subedi (1993) in the warmer regions of Nepal. This non-leguminous species was applied at 15 t ha$^{-1}$ and compared with compost applied at 10 t ha$^{-1}$ and chemical fertilizer (60:30:30 NPK kg ha$^{-1}$). Mean rice yield was highest with Adhatoda (4.8 t ha$^{-1}$) as compared to the other sources, which could be due to high nutrient content in its foliage.

Perennial leguminous trees grown extensively in roadsides, hedges and field boundaries can also be exploited for their green manurial value. Kundu *et al.* (1993) suggested *Glycrridia sepium* for its high foliage yields, vigorous cropping ability and tolerance for regular lopping as a good green manure. The efficiency of 8 week old sesbania and 1 m long tender loppings of glycrridia were compared with chemical fertilizer. Sesbania and glycrridia recorded 0.5 % and 0.64 % total N on fresh weight basis. Efficiency of glycrridia N and sesbania N was about 67 % and 45 % to that of urea N respectively.

Economics of intercropping systems with green manures

The adoption of green manures in rice
based cropping system is economically questionable due to high labour costs and high opportunity cost of land use (Rosegrant and Roumasset, 1988). In India, the estimated ratio of costs-benefits is less than 1.0 implying that green manure technology practised by farmers is not profitable. Over all added cost to produce a green manure crop varied from as low as US $11 ha\(^{-1}\) in E. India to more than US $25 ha\(^{-1}\) in the Philippines (Garrity and Flinn, 1988).

Growing green manure crops neither has cash or food value but yet requires human labour and hence not attractive as N source alone (John et al., 1989).

Accordingly Carangal et al. (1988) suggested that intercropping of green manures with grain legumes could be an acceptable technology. Intercropping sesbania with cowpea in post-rice season was studied by Furoc and Manguiat (1989). They reported a net return of US $593 ha\(^{-1}\) from a combination of cowpea and sesbania rows in the ratio of 3:1. This is nearly twice the income gained by using inorganic N fertilizer at 120 kg ha\(^{-1}\), which gave a net profit of US $330 ha\(^{-1}\). Nur-Elahi et al. (1991) indicated that intercropping greengram and sesbania could be profitable and reported a net return of US $1233 ha\(^{-1}\) from greengram + sesbania intercrop system as against US $1005 ha\(^{-1}\) in sole greengram-rice –rice system.

REFERENCES