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In situ green manuring with daincha (*Sesbania aculeata* Pers.): a cost effective management alternative for wet seeded rice (*Oryza sativa* L.)

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Abstract

Two field experiments were conducted on simultaneous growing and incorporation of daincha (*Sesbania aculeata* Pers.) in wet seeded rice in the humid tropics of Kerala, India. The objectives were to optimize the stage and method of incorporation of daincha, to evaluate N release pattern following green manure addition, and to assess its potential to supplement the nutrient requirement of rice crop, besides evaluating the cost effectiveness of *in situ* green manuring. Treatments consisted of two stages of incorporation of *in situ* grown daincha (20 and 30 days after sowing), three methods of incorporation (using cono weeder, spraying 2, 4-D at1.0 kg·ha^{-1}, and spraying met sulfuron methyl at 5.0 g·ha^{-1}), and two levels of N application (100 and 75% of the recommended N dose of 90 kg·ha^{-1}). Wet sown rice without daincha, receiving 5 Mg·ha^{-1} farm yard manure and 90, 45, 45 kg N, P, and K ha^{-1} respectively, served as control. The experiment was laid out in a completely randomized factorial design during 2004 and 2005 and was replicated thrice. Incorporation of daincha at 30 days added about 14 Mg·ha^{-1} of organic matter, reduced weed population by 70% and supplemented about 25% of the N requirement of rice. Peak release of NH_4^+ - N from daincha coincided with panicle initiation stage of rice, signifying N availability at the most critical physiological stage (synchrony in the release of green manure held nutrients and nutrient uptake by the rice crop). Green manuring with intercropped daincha also enhanced rice yield by 544 kg·ha^{-1} and returns by Rs.10220 ha^{-1}, implying the potential of integrated nutrient management systems to augment crop productivity and profitability.

Keywords: Integrated nutrient management. Nitrogen release pattern, Nutrient savings. Synchrony principle.

Introduction

Major constraints affecting rice production in Kerala are high production costs and low crop productivity. Although direct seeding of rice in the lowlands is a cost effective and labour saving method of crop establishment (Johnkutty et al., 2002), excessive weed growth is a major constraint, leading to high production costs and low nutrient use efficiency (Prasad, 2009). Scarcity and high costs of organic manures also constrain wetland rice productivity in this state. *In situ* green manuring offers not only an effective method of providing organic manures but also has considerable potential for weed suppression (Musthafa and Potty, 2001). Although many green manure crops are available (KAU, 2002), the N_2-fixing leguminous crop daincha (*Sesbania aculeata* Pers.) is particularly important. The system involves growing rice and daincha simultaneously in the puddled soils in alternate rows, using a rice-cum-green manure seeder, and its subsequent incorporation using a cono weeder. However, hassles in establishing the crop in lines pose problems in using cono weeder for incorporating daincha. Information is also lacking on the correct stage and method of incorporation of daincha as well as manurial requirement of this integrated system. Understanding the N release pattern after the incorporation of concurrently grown daincha is also important in formulating an efficient fertilizer management schedule. The present investigation was undertaken against this backdrop and with the specific objectives of finding out the optimum

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stage and method of incorporation of daincha in the rice field, studying the nitrogen release pattern following its incorporation, working out the nutrient supplementation potential of this integrated system, and evaluating its cost effectiveness.

Materials and Methods

The field experiment was conducted at Mannuthy, Thrissur, Kerala (10°31'N, 76°13' E; altitude 40.3 m) during the rainy season (June-September) of 2004-2005 and 2005-2006. The site experiences a typical humid tropical climate. The soils are classified as Ultisol and are acidic, deep, well drained kaolinitic and ustic sandy loam (NBSS & LUP, 1996). Pre-treatment soil nutrient status was determined following standard procedures (Hesse, 1971). It showed that the soil is low in available N (110 mg·kg^{-1}), and medium in available P_2O_5 (29.5 mg·kg^{-1}) and available K_2O (62.5 mg·kg^{-1}). The green manuring treatments included two stages of incorporation of daincha (20 and 30 days after sowing), three methods of incorporation (using the IRRI cono weeder, spraying 2, 4-D at1.0 kg·ha^{-1}, and spraying met sulfuron methyl at 5.0 g·ha^{-1}), and two levels of N (100 and 75% of the recommended dose of 90 kg N ha^{-1}; KAU, 2002). Wet sown rice without daincha but receiving farm yard manure (FYM; 0.34% N, 0.62% P_2O_5 and 0.25% K_2O) at the rate of 5 Mg·ha^{-1} incorporated by digging before sowing and recommended dose of nutrients (90, 45, 45 kg N, P, and K ha^{-1}) served as control. The experiment was laid out in a completely randomized factorial design, replicated thrice, with the rice cultivar 'Aiswarya' as the test variety. Paddy seeds (60 kg·ha^{-1}) with radicle just emerging and un-sprouted daincha seeds (20 kg·ha^{-1}) were sown simultaneously into the puddled soil using a rice-cum-green manure seeder (TNAU, Coimbatore, India). Seeds were placed at a row spacing of 25 cm and at a plant-to-plant spacing of 6 to 8 cm. There was one row of daincha plants between every two rows of rice. Sowing was done with no standing water and the field was lightly flooded after 24 h. Nitrogen fertilizer at the rate of 100% and 75% of the recommended dose (90 kg·ha^{-1}; KAU, 2002) were applied ($^1/_3$rd basal, $^1/_3$rd at 45 days, and $^1/_3$rd N at 60 days). Fertilizers containing P and K were applied uniformly. For incorporation of daincha, herbicides were applied as a blanket spray using a knapsack sprayer (500 L·ha^{-1} spray volume). One hand weeding was uniformly given at 45 days after sowing. Data on weed counts and weed dry matter were collected from 1 m^2 area by placing a 50 x 50 cm quadrat randomly at four places in a plot. Biomass production (fresh and oven dry weights of 10 plants), and nutrient content (Jackson, 1958) of daincha were estimated, prior to its incorporation. Growth and yield attributes of rice were observed on 10 randomly selected hills. Upon harvest, grain yields from the net plots (5 x 4.5 m) were recorded after sun drying (13% moisture), cleaning, and winnowing and the straw yield on oven-dry weight basis. Ammoniacal and nitrate nitrogen were extracted using 2 *M* KCl extract (Hesse, 1971) of wet soil samples collected from the experimental area at periodic intervals till harvest. Labour charges, cost of inputs, and the additional cost of incorporating the treatments were worked out to compute the gross expenditure and expressed in Rupees ha^{-1}. Gross returns were calculated based on the local market prices of paddy and straw and net returns by subtracting total cost of cultivation from gross returns, treatment-wise. Benefit: cost ratio was computed by dividing the gross returns with the gross expenditure. Data were analyzed using ANOVA and the significance tested by Fisher's least significant difference (p=0.05).

Results and Discussion

Stage of incorporation

In situ growing of daincha contributed substantial biomass and nutrients to the rice crop (Table 1). However, such effects were more pronounced (p<0.05) when the daincha crop was incorporated at 30 days—143% increase in fresh weight compared to that at 20 days after planting. Although comparisons involving rice+daincha and rice alone treatments showed that most of the growth and yield characters and nutrient uptake of rice were significantly higher in rice+daincha, regardless of the stage of incorporation (Table 2), plant height, tiller production, grain yield, and N uptake of rice were significantly higher when daincha was incorporated at 30 days compared with that at 20 days (Table 2). Incorporation of daincha at 30 days after

Table 1. Biomass production, dry matter addition, and nutrient contribution of daincha grown along with wet sown rice (pooled data) in Thirssur, Kerala, India.

Stages of incorporation (days after sowing)	Fresh biomass ($kg \cdot ha^{-1}$)	Dry matter ($kg \cdot ha^{-1}$)	N (%)	P (%)	K (%)
20	5644	2651	1.518	0.213	2.276
30	13698	6069	2.114	0.147	2.246
CD (p=0.05)	856	176	NS	0.015	NS

sowing gave an yield of 5184 $kg \cdot ha^{-1}$, implying its potential for improving crop performance.

Intercropping daincha in wet seeded rice also significantly reduced the weed count and weed dry matter production. The intercropped plots had 72 and 57% less weed count and weed dry matter production compared to sole rice (Table 2). Stage of incorporation of daincha (20 and 30 days), however, did not show any particular influence on these parameters. The beneficial effects of concurrent growing of green manure in reducing the weed population and weed biomass in dry sown rice have been previously demonstrated too (e.g., Musthafa and Potty, 2001). The reduction in weed population and weed dry matter in the system of concurrent growing of daincha may be attributed to its shading effects.

Methods of incorporation

Incorporation of daincha using 2,4-D significantly (p<0.05) reduced weed population (Table 2). 2,4-D, being a selective herbicide and recommended for broadleaved weeds and sedges in rice, such a response is plausible. Moreover, Gupta et al. (2006) reported that

Table 2. Effect of stages and methods of incorporation of concurrently grown daincha and nitrogen levels on weeds at 50 days after sowing, growth and yield parameters, nutrient uptake of wet sown rice (pooled data) in Thirssur, Kerala, India.

Treatments	Weed count m^{-2}	Dry weight of weeds[1] ($g \cdot m^{-2}$)	Plant height (cm)	Tillers m^{-2}	N uptake ($kg \cdot ha^{-1}$)	P uptake ($kg \cdot ha^{-1}$)	K uptake ($kg \cdot ha^{-1}$)	Grain yield ($kg \cdot ha^{-1}$)	Straw yield ($kg \cdot ha^{-1}$)
Stage of incorporation (days after sowing)									
20	35.69	24.82	102.6	607.5	57.90	9.83	130.33	4907	3672
30	34.19	25.28	106.9	642.5	68.56	11.01	123.80	5184	3725
CD (p=0.05)	NS	NS	4.1	22.9	7.75	NS	NS	202.3	NS
Methods of incorporation									
Conoweeding	43.13	25.91	104.7	622.5	63.88	10.75	126.99	5115	3663
2,4-D spray	27.54	23.82	104.3	635.6	65.24	10.46	127.25	5033	3735
Met sulfuron methyl spray	34.17	25.43	105.4	616.9	60.56	10.05	126.96	4988	3697
CD (p =0.05)	2.56	NS	NS	NS	NS	NS	NS	NS	NS
Levels of nitrogen (% of the recommended N dose of 90 $kg \cdot ha^{-1}$)									
100	34.25	24.10	106.6	630.0	66.06	10.77	126.18	5165	3697
75	35.64	26.00	102.9	620.0	60.39	10.07	127.95	4925	3700
CD (p =0.05)	NS	NS	NS	NS	NS	NS	NS	202.3	NS
Rice alone	125.67*	57.80*	96.1*	657.0	35.95*	5.08*	89.89*	4501*	3650

* Rice alone *vs.* other treatment effects significant.

[1]Weed flora in the experimental field was mainly constituted of grasses such as *Echinochloa* colona, *Isachne miliacea, Panicum repens*, *Ischaemum rugosum*, broadleaved weeds such as *Monochoria vaginalis*, *Ludwigia parviflora*, *Marsilea quadrifoliata, Nymphaea nouchali, Spenoclea zeylanica* and sedges such as *Cyperus rotundus*, *Schoenoplectus sp*. and *Fimbristylis miliacea.*

co-culture of *Sesbania* in rice and its subsequent knock down by 2,4-D ester reduced weed population by nearly half without any adverse effect on yield. Metsulfuron methyl, a selective herbicide recommended for broadleaved weeds and sedges in rice, also showed significantly (p<0.05) lower weed count than cono weeded plots. However, the methods of incorporating green manure did not alter the weed dry matter production. Likewise, the N, P, and K uptake and grain and straw yields of rice were also similar under different methods of incorporation, implying that all the three methods of incorporation of daincha were equally effective. Therefore, in situations where it is difficult to use cono weeder, daincha can be effectively incorporated by spraying 2,4-D or metsulfuron methyl without any reduction in yield. Similarly, in situations where it is not feasible to use rice seeder, due to unfavourable soil physical conditions, daincha can be broadcast sown with rice seeds instead of drum sowing and the herbicides mentioned above could be effectively used for incorporating the green manure crop.

Nitrogen levels

Rice+daincha receiving 100% of the recommended N, recorded significantly (p<0.05) higher grain yield (5165 $kg{\cdot}ha^{-1}$) compared to the lower dose of N (75%). Rice yield in daincha intercropped plots that received either 100 or 75% of recommended nitrogen fertilizer also was significantly higher than the control plots, which received 5 $Mg{\cdot}ha^{-1}$ of FYM and full dose of N. Growing daincha along with rice and its subsequent incorporation thus can reduce the use of nitrogenous fertilizers approximately by 25%, without affecting grain yield. This is consistent with the observations from a large number of agronomic investigations (see review by Prasad, 2009). Nitrogen application at 100 and 75% of the recommended dose (90 $kg{\cdot}ha^{-1}$) also had no significant impact on weed count and dry matter.

Nitrogen mineralisation pattern and synchrony

Soil NH_4^+- N content was consistently higher in daincha intercropped plots than sole crop of rice (Fig. 1). Release of NH_4^+-N from daincha was profoundly (p<.0.05) influenced by the stage of incorporation of daincha (Fig. 1). Thirty days old daincha upon incorporation released 78.80 ppm NH_4^+- N at 60 days after sowing as against 70.09 ppm NH_4^+- N from 20 days old daincha at 50 days. In general, release of NH_4^+- N peaked at about 30 days after incorporation for both 20 and 30 days old daincha, implying that the decay process may take some time before the organic matter bound nutrients are released. Incorporation of 30 days old daincha along with 100% N was ideal as it favoured the highest release of NH_4^+- N at 60 days. Increased NH_4^+- N release ensured adequate availability of N at the critical stage of 60 to 80 days (panicle initiation) enabling better nutrient uptake and higher yield by rice. This most likely underlies the synchrony between nutrient release and uptake, which refers to the matching through time, of nutrient availability and crop demand (Myers et al., 1997). The key to sustainable management of nitrogen is to synchronize N supply with N use by the crop (Campbell et al., 1995). Incorporation of 30days old daincha is pertinent in this regard.

The release of NO_3^-- N was less compared to NH_4^+- N (Fig. 1). However, an increasing trend was noticed in the release of NO_3^--N up to harvest. Although the methods of incorporation had no significant influence

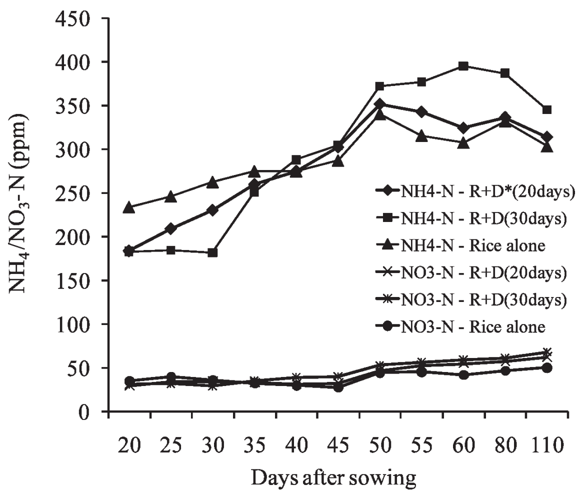

Figure 1. Effect of stages of incorporation of concurrently grown daincha on the ammoniacal and nitrate nitrogen release pattern in wet sown rice in Thirssur, Kerala, India (R= rice, D= daincha).

on N mineralization pattern of daincha, it was profoundly affected by the N levels. Release of NH_4^+- N and NO_3^--N was significantly (p<0.05) greater in treatments receiving 100% N.

Economics

Economic analysis showed that the system of concurrent growing of daincha in wet seeded rice and its subsequent incorporation is an economically viable option (Table 3). *In situ* daincha growing reduced the crop establishment and weeding costs to 59%, mostly by reducing the labour requirement (38 man-days·ha^{-1}), and increased rice yields by about 544 kg·ha^{-1}, resulting in an additional net return of Rs. 10220 ha^{-1}, compared to wet sowing + hand weeding. Johnkutty and Prasanna (2002) also reported that drum seeding of rice and green manure seeds and incorporation of weeds and green manures by cono weeder resulted in a saving of Rs. 2490 ha^{-1} over broadcast sowing and hand weeding.

Table 3. Comparison of rice + daincha system with rice alone in Thirssur, Kerala, India.

	Grain yield (kg·ha^{-1})	Labour requirement for treatments (man-days·ha^{-1})	Cost of treatments (Rs·ha^{-1})	Total cost of cultivation (Rs·ha^{-1})	Gross return (Rs·ha^{-1})	Net return (Rs·ha^{-1})	B:C ratio	Additional return due to treatment (Rs·ha^{-1})
Rice +daincha (30 DAS)*	5045	28	4407	15858	42213	26355	2.66	10220
Rice alone	4501	66	9600	21695	37830	16135	1.74	-

*Incorporation of daincha at 30 days after sowing
Price of produce- paddy - Rs. 8 kg^{-1}, straw -Rs. 0.5 kg^{-1}

Overall, the results indicate the superiority of *in situ* growing and incorporation of daincha at 30 days after sowing. It not only satisfies the organic manure requirement of rice but also reduces weed infestation, which is a major problem in direct seeded rice culture. Since herbicides are effective in incorporating daincha, in situations where rice seeder and cono weeder cannot be used due to unfavourable soil physical conditions, daincha can be directly broadcast with rice instead of drum sowing. Peak nitrogen release from concurrently grown daincha coincided with the critical growth stages of rice, the panicle initiation stage, implying synchrony between nutrient release and uptake. Green manuring of wet seeded rice with intercropped daincha also can reduce the chemical N requirement up to 25% and augment crop productivity and profitability.

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References

Campbell, C. A., Myers, R. J. K. and Curtin, D. 1995. Managing nitrogen for sustainable crop production. Nutr. Cycl. Agroecosyst., 42(1-3): 277–296.

Gupta, R., Jat, M.L., Singh, S., Singh, V.P., and Sharma, R.K. 2006. Resource conservation technologies for rice production. Indian Fmg., 56 (7): 42–45.

Hesse, P.R. 1971. *A Text book of Soil Chemical Analysis.* John Murray Ltd, London, 520p.

Jackson, M.L. 1958. *Soil Chemical Analysis.* Prentice Hall of India (pvt) Ltd. New Delhi. 498p.

Johnkutty, I. and Prasanna, K. P. 2002. Substitution of transplanting and hand weeding in lowland rice (*Oryza sativa*) by drum seeding and cono weeding. In: *Extended Summaries Vol.2. 2nd Int. Agronomy Congress,* November 26-30, 2002, Indian Council of Agricultural Research, New Delhi, pp 1086–1088.

Johnkutty, I., Mathew, G. and Mathew, J. 2002. Comparison between transplanting and direct-seeding methods for crop establishment in rice. J. Trop. Agric., 40; 65-66

KAU. 2002. *Package of Practices Recommendations: Crops*, 12th ed. Directorate of Extension, Kerala Agricultural University, Thrissur, 278p.

Musthafa, K. and Potty, N.N. 2001. Effect of *in situ* green manuring on weeds in rice. J. Trop. Agric., 39: 172–174.

Myers, R. J. K., Noordwijk, M. van, and Vityakon, P. 1997. Synchrony of nutrient release and plant demand: Plant litter quality, soil environment and farmer management options. In: *Driven by Nature: Plant litter quality and decomposition.* Cadisch, G. and Giller, K.E. (eds), CAB International, UK pp. 215–219.

NBSS & LUP. 1996. *Soils of Kerala: Soil Map.* National Bureau of Soil Survey and Land Use Planning, Regional Centre, Bangalore.

Prasad, R. 2009. Efficient fertilizer use: The key to food security and better environment. J. Trop. Agric., 47 (1-2): 1–17.