Indian Journal of Agronomy **55** (3): 165–170 (September 2010)

Dual cropping of rice (*Oryza sativa*) and green manure crops – A cost effective management alternative for direct seeded semi-dry system of rice cultivation

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Received: October, 2009

ABSTRACT

Field experiments were conducted at Agricultural Research Station, Mannuthy during 2004 and 2005 to fine tune the technology of dual culturing of rice (*Oryza sativa*) and green manure crops to ensure the supply of required quantity of organic manure to dry seeded rice in a cost effective manner. Two green manure crops viz., horse gram (*Macrotyloma uniflorum* (Lam) Verdc) and cowpea [*Vigna unguiculata* (L.) Walp.] sown along with rice were incorporated at 45 days after sowing by three methods viz., using cono weeder, spraying 2,4-D, and allowing self decomposition due to flooding at the onset of monsoon. Two levels of nitrogen (100 and 75% of recommended dose of N i.e. 90 kg) were super imposed over them. Dual cropping of cowpea with dry seeded rice could add about 12 t/ha of organic manure and resulted in a weed suppression of 69-75% and reduction in labour requirement for weeding (40 man-days/ha). This system guarantees 25% nitrogen saving (22.5 kg/ha) with 11% yield enhancement and increase in profitability (Rs 14,562/ha). The study revealed that, cowpea can be effectively incorporated by spraying 2, 4-D with effective weed control. The peak nitrogen release from concurrently grown cowpea coincides with the critical growth stages of rice, the panicle initiation stage, and thereby ensures availability of N at the critical stage.

Key words: Economics, Green manures, Intercropping, Nitrogen metabolism, Rice, Yield

Rice (*Oryza sativa* L.) production is fast shrinking in Kerala due to a sharp fall of its area from 0.8 m ha in 1980-81 to 0.28 m ha in 2003-04 (Balachandran, 2007) and due to increasing cost of production particularly for labour intensive operations like crop establishment and weeding. The dry sown (semi-dry) system of rice cultivation is a unique and extensively adopted rain fed rice ecosystem in Kerala, which constitute more than 60% of the area under rice during *kharif*. In this system, the early growth of 30-40 days (up to the onset of South-West monsoon) is in a dry soil environment thus cause serious problems with regard to application of organic manures and weed management affecting its productivity adversely. The new system of dry seeding rice with concurrent growing of green manure assumes significance in this context. In this system, concurrently grown green manure crops are allowed for self incorporation due to flooding at the onset of monsoon. But these systems require major refinement for large scale field adoption due to certain constraints. An undue delay in the onset of monsoon may cause problem in the incorporation of green manure crop in dry seeded system. Thus it is highly essential to identify alternate methods to incorporate the green manure crops particularly in situations of delayed monsoon without any adverse effect to the system. The extent of nutrient saving by concurrent growing of green manure crop has to be worked out. It will be an added advantage, if the leguminous crop grown for the green manuring purpose can yield some economic produce and no work has been done in this line. The present study was undertaken in this background to further refine the technology of concurrent growing of green manure crops in dry seeded rice so as to improve the adoptability of the technology and to make rice cultivation more profitable through reduced production cost and enhanced productivity.

MATERIALS AND METHODS

Field experiments were conducted at the Agricultural Research Station, Mannuthy, (geographically situated at 10^0 31' N latitude, 76^0 13' E longitude and at an altitude of 40.3 m above mean sea level) Thrissur, Kerala during the April-August of 2004 and 2005. The area of the experi-

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mental site experiences a typical humid tropical climate. Soil of the experimental site is sandy loam (Oxisol with a pH of 5.6). During first and second year, the experiments were laid out in different plots. During 2004, initial available soil nutrient status showed low in nitrogen (235.5 kg/ha), high in available phosphorus (52.5 kg/ha) and low in available potassium (112 kg/ha). The initial available soil nutrient status during 2005 showed low in nitrogen (238.3 kg/ha), high in available phosphorus (44.6 kg/ha) and high in available potassium (896 kg /ha). The experiments were laid out in randomized blocks design (factorial) with one control replicated thrice. Treatments consisted of two green manure (GM) crops viz., horse gram (*Macrotyloma uniflorum* (Lam) Verdc.) and cowpea [*Vigna unguiculata* (L.) Walp.], three methods of incorporation of GM crops at 45 days after sowing (DAS) viz., using cono weeder, spraying 2, 4-D, and allowing self decomposition due to flooding at the onset of monsoon and two levels of nitrogen (100 and 75% of the recommended dose of N i.e. 90 kg/ha). Direct sown rice grown alone, with 5 t /ha of FYM (0.34% N, 0.27% and 0.21% K determined following standard procedures by Hesse, 1971) and recommended nutrient dose, 90 - 45 - 45 kg N-P-K/ha as per package of practices recommendations of KAU, was taken as control. A medium duration rice variety 'Aiswarya' was used for the study. Short duration synchronous flowering bush type vegetable cowpea 'Pusa Komal' and local variety of horse gram were used as GM crops. For concurrent growing of GM crops, one row of cowpea/horse gram was sown in between two rows of rice in finely prepared soil by dibbling. Paddy seeds @ 60 kg/ha and GM crops @ 20 kg/ha was used for sowing. FYM @ 5 t/ha was applied to control plot alone and incorporated well before sowing. Recommended dose nitrogen (90 kg/ha) was applied according to the treatment schedule as $^1/_3$ N Basal, $^1/_3$ N at 45 DAS, $^1/_3$ N at 60 DAS. GM crops of cowpea and horsegram on an average producing 12.35 (1.62) and 3.77 (0.83) tonnes of fresh (dry) mass added 27.92-4.08-40.21 and 11.40-1.64-9.02 kg/ha N-P-K. One hand weeding at 50 DAS was given to all the treatments. Observations on weed incidence and weed dry matter was collected by placing a quadrate of 50 cm x 50 cm randomly at four places. Growth and yield attributes were measured from 10 randomly selected hills. The grain yield was recorded at 13% moisture and straw yield on oven dry basis. Ammoniacal and nitrate nitrogen was extracted using 2 M KCl extract (Hesse, 1971) of wet soil samples collected from the experimental area at periodical intervals till the rice harvest. The cost of cultivation of rice was calculated on the basis of prevailing rates of inputs in the market during the experimentation period and averaged over 2 years.

RESULTS AND DISCUSSION

Green matter and nutrient contribution

Incorporation of cowpea resulted in a green (dry) matter addition of about 12 (1.62) t/ha and was almost three times to that of horse gram. That is more than sufficient to meet the requirement of 5 t /ha of organic manure (FYM) recommended for rice in Kerala (KAU, 2002). Biomass production of 12 t /ha utilizing the rainfall received only from the pre-monsoon rains (337 mm) also indicate that the system is viable and is capable of meeting the organic matter requirement of rice with minimum investment on water. Similar was the findings of Resmy (2003). GM crops incorporated using different methods behaved similarly in the biomass addition and thereby in the nutrient contribution. Application of nitrogen at 100% level with high biomass production of GM crops resulted in significantly higher contribution of N.

Weed count and dry weight

Major weed flora in the experimental field was *Echinochloa colona*, *Panicum repens* and *Ischaemum rugosum*, among grasses; *Ludwigia parviflora*, *Alternanthera sessilis, Cleome viscose* and *Oldenlandia aspera*, among broad leaved weeds; *Cyperus rotundus*, and *Fimbristylis miliacea,* among sedges.

Concurrent growing of GM crops significantly reduced the weed population and weed dry matter than sole cropping of rice (Table 1). Between the two GM crops, cowpea was the most effective in suppressing weeds and recorded the minimum weed population and weed dry matter. The reduction in weed growth evidently was due to the successful smothering effect of cowpea (Resmy, 2003). The system of concurrent growing of green manures resulted in the reduction of weed population and required only 20 man-days/ha for weeding. However, pure crop of rice required 60 man-days/ha for weeding and thereby a labour saving of 40 man-days/ha for weeding alone in green manure intercropped treatments was seen. The decrease in the population of weeds in GM intercropped system implied that GM crop had grown only at the expense of weeds by using the growth resources which weeds would have otherwise utilized and may not have competed with rice for growth resources.

Methods of incorporation of GM crops significantly influenced the weed count and weed dry matter production at 50 DAS. Compared to pure crop of rice, incorporation of concurrently grown GM crops by self decomposition, by application of 2, 4-D and by conoweeding caused 60, 75 and 69% reduction in weed count and 43, 57 and 52% reduction in weed dry matter, respectively. Weed count and weed dry matter of all the three types of weeds

(grasses, sedges, broad leaved weeds) were higher in treatments, wherein the GM crops were allowed to be incorporated due to flooding. Incorporation of GM crops using cono-weeder significantly reduced the count and dry matter production of grassy weeds. Cono weeder used for uprooting and burying the GM crops could also bury the weeds in between standing rows of rice. That may be the reason for reduced weeds due to cono-weeding. Conjoint cropping of rice + *dhaincha* and incorporation of *dhaincha* on 37 DAS using cono-weeder proved better in reducing total weed density over sole rice (Sankar *et al*., 2003). The highest reduction in population and dry weight of broad leaved weeds and sedges was noticed in 2, 4-D applied treatments. This has resulted in the lowest total weed count and dry matter production in 2, 4-D applied plots. Gupta *et al*. (2006) reported that co-culture of *Sesbania* in rice and its subsequent knock down by 2, 4-D ester reduced the weed population by nearly half without any adverse effect on rice yield. Therefore there was a substantial saving in labour requirement and weeding cost when the GM crops were incorporated using 2, 4-D.

Application of 100 and 75 % of the recommended dose of N (RDN) had no significant influence on the weed count and dry matter of weeds at 30 DAS and 50 DAS. Reduced weed population in green manure intercropped treatments appreciably reduced the competition for growth resources for rice and might have resulted in increased nutrient uptake and yield of rice compared with pure crop of rice.

Growth, yield and nutrient uptake

Two years pooled data revealed that the better growth and yield contributing characters were noticed when rice was grown along with GM crops than when grown alone (Table 1). Rice in rice + cowpea system recorded better growth and yield contributing characters than rice in rice+ horsegram system and pure crop of rice. Jayachandran and Veerabadran (1996) reported an increase in plant height, leaf area index and total tillers of semi-dry rice as a result of incorporation of intercrops. Concurrent growing of cowpea significantly increased the nutrient uptake of rice over pure crop of rice. The increased nutrient uptake of rice (Table 2) can be attributed to the better nutrient availability due to the incorporation of GM crops over control. Better performance in terms of these growth and yield characters and higher nutrient uptake have resulted in 11 % increase in yield of rice in rice + cowpea system compared with pure crop of rice. This implied that competition to rice due to concurrent growing of cowpea was almost absent.

All the three methods were found to be equally effective in incorporating the GM crops as these methods of incorporation did not significantly vary in their influence on the growth, nutrient uptake and yield of dry sown rice

Table 1. Effect of concurrently grown green manure crops, methods of incorporation and levels of nitrogen on weeds and on growth, yield attributes of dry sown rice crop (pooled data)

Treatment	Weed count (No/m^2)		Dry weight of weeds (g/m^2)		Plant height (cm)	Tillers/ m^2	Dry matter production (t /ha)	Panicles /hill	Test weight (g)	Panicle weight (g)	Filled grain (%)
	30 DAS	50 DAS	30 DAS	50 DAS							
Rice+ green manure											
Horsegram	179.8	134.0	16.08	20.19	105.7	486.5	9.9	10.25	29.45	24.88	81.15
Cowpea	113.6	86.5	12.63	15.56	106.2	566.6	10.2	11.81	29.62	27.30	82.30
SEm ±	6.3	2.1	0.26	0.85	1.1	18.2	0.2	0.30	0.22	0.78	0.60
CD (P=0.05)	17.9	6.1	0.67	2.20	NS	NS	NS	NS	NS	2.24	NS
Method of incorporation											
Cono-weeding	151.3	106.6	14.25	17.07	105.9	509.1	10.1	11.29	29.52	25.93	82.27
2,4-D spray	144.9	88.1	14.43	15.76	105.6	477.7	9.8	10.63	29.54	25.35	81.62
Self decomposition	143.8	136.1	14.38	20.80	106.2	518.3	10.3	11.17	29.56	26.99	81.29
SEm ±	7.6	2.6	0.31	1.16	1.4	22.3	0.3	0.37	0.27	0.95	0.73
CD (P=0.05)	NS	7.4	NS	2.56	NS	NS	NS	NS	NS	NS	NS
Level of nitrogen (% RDN)											
100%	146.9	108.7	14.34	17.70	106.8	507.0	10.0	11.42	29.62	26.24	81.82
75%	146.5	111.9	14.36	18.05	105.0	496.4	10.0	10.64	29.46	25.95	81.64
SEm ±	6.3	2.1	0.26	0.85	1.1	18.2	0.2	0.30	0.22	0.78	0.60
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Rice alone	285.7*	346.7*	19.88*	36.69*	102.3*	460.0*	9.4*	10.33*	28.40*	22.15*	71.24*

*Rice alone *vs.* treatments significant; DAS- Days after sowing; RDN : Recommended dose of nitrogen (90 kg/ha)
Interaction effect -non significant

during both the years. Concurrent growing of cowpea and its subsequent incorporation using cono weeder or by spraying 2, 4-D was found to be equally effective to that of self decomposition of cowpea due to flooding in increasing the yield of rice compared with dry sowing of rice alone. This shows that in places where there is an undue delay in the onset of monsoon, green manure crops can be effectively incorporated by employing cono weeding or by 2, 4-D spray without affecting the yield.

The yield of rice in concurrent growing of GM crops receiving both 100 and 75% RDN registered higher yield compared to pure crop of rice receiving 5 t/ha of FYM and 100% RDN (Table 3). The straw yield was higher with rice grown alone receiving 5 t/ha of FYM and 100% RDN. Nitrogen at 100% produced more yield than 75% RDN; however the treatment difference did not reach the level of significance. The absence of the yield difference between the application of 100 and 75% RDN to rice in the system of concurrent growing of GM crops indicated that 75% RDN is sufficient along with GM crops. There is a clear saving of 25% nitrogen to dry seeded rice by the concurrent growing of GM crops.

The cowpea variety used in this study was a short duration bush type with synchronous flowering facilitating additional pod yield from cowpea before it was incorporated with out affecting the yield of rice crop. There was an added advantage from the concurrent growing of cowpea as it gave additional returns from green pod yield (573 kg/ha).

Economics

Concurrent growing of cowpea was found more economically viable than concurrent growing of horsegram (Table 3). System of concurrent growing of GM crops in dry seeded rice is economically profitable with an increase in net return by four times when rice is grown along with cowpea (Rs 19,133/ha) and two times with horsegram (Rs 11,991/ha) compared with pure crop of rice (Rs 4,737/ha). The added advantage of the concurrent growing of cowpea was that it gave additional returns from green pod yield (573 kg/ha). The net return and B: C ratio was not significantly affected by the methods of incorporation. Concurrent growing of GM crops in dry seeded rice could save 25% N to the current season rice crop with positive effects on the productivity and profitability of the system.

Nitrogen release pattern and soil N status after rice

Data on soil NH_4^+-N and NO_3^--N suggested that decomposition of both the green manure crops was fast and they have rapidly released nitrogen (Fig 1). An increase in soil NH_4^+-N was noticed up to 30 days after incorporation (DAI) of both GM crops followed by a slight decline up to harvest. The gradual increase in soil NH_4^+-N in the initial stages may be probably due to the gradual decline in C: N ratio due to the release of CO_2 and the later decline may be due to the crop uptake (Johnkutty, 1996). The decline after 30 DAI may be due to the vigorous uptake of N by rice. From 10 DAI onwards, the release of NH_4^+-N was significantly higher under cowpea incorporated treatments com-

Table 2. Effect of concurrently grown green manure crops, methods of incorporation and levels of nitrogen on nutrient uptake (kg/ha) of dry sown rice at different growth stages (pooled data) and soil N balance (kg /ha)

Treatment	N uptake			P uptake			K uptake			N balance	
	AT	PI	H	AT	PI	H	AT	PI	H	Ist year	2nd year
Rice+ green manure											
Horsegram	49.6	59.1	84.8	6.07	10.24	9.84	66.5	131.5	127.9	265.4	262.0
Cowpea	51.4	67.7	88.4	6.99	9.33	10.21	68.2	142.1	130.3	294.7	281.5
SEm ±	1.6	1.7	2.7	0.17	0.52	0.81	1.7	2.2		5.4	7.6
CD (P=0.05)	NS	4.9	NS	0.46	NS	NS	NS	6.3	**	15.5	NS
Method of incorporation											
Conoweeding	53.1	59.2	91.0	6.66	9.04	10.09	72.6	139.9	127.4	279.2	269.8
2,4-D spray	47.9	65.6	82.9	6.39	10.66	9.28	63.4	138.3	125.2	273.1	269.7
Self decomposition	50.4	65.5	85.9	6.54	9.65	10.72	66.3	132.2	134.7	287.7	275.7
SEm ±	1.9	2.0	3.3	0.21	0.63	1.00	2.1	2.7		6.7	9.3
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	7.7	**	NS	NS
Level of nitrogen (% RDN)											
100%	52.8	63.9	89.0	6.28	10.10	10.20	67.1	139.2	126.5	299.3	280.2
75%	48.2	62.9	84.2	6.78	9.47	9.86	67.6	134.4	131.8	260.8	263.4
SEm ±	1.6	1.7	2.7	0.17	0.52	0.81	1.7	2.2		5.4	7.6
CD (P=0.05)	4.5	NS	NS	NS	NS	NS	NS	NS	**	15.5	NS
Rice alone	27.4*	48.8*	63.4*	4.96*	8.10*	7.99*	57.9*	104.1*	107.2*	233.7	221.6

* Rice alone *vs.* treatments significant; AT- Active Tillering; PI- Panicle Initiation; H- Harvest

** Pooling not possible as the errors heterogenous and interaction absent

Table 3. Effect of concurrently grown green manure crops, methods of incorporation and levels of nitrogen on yield and economics of dry sown rice (pooled data)

Treatment	Grain yield(t/ha)		Straw yield (t/ha)		Pod yield (kg/ha)	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	Net B : C ratio
	2004	2005	2004	2005				
Rice+ green manure								
Horsegram	3.42	3.43	2.23	3.10		16,725	11,991	0.72
Cowpea	3.61	3.66	2.29	3.15	573	18,175	19,132	1.05
SEm ±	0.06	0.07	0.06	0.05			695	0.03
CD (P=0.05)	0.18	0.21	NS	NS			1,980	0.11
Method of incorporation								
Conoweeding	3.62	3.55	2.29	3.17	596	17,596	16,048	0.91
2, 4-D spray	3.46	3.57	2.23	3.14	548	16,957	15,773	0.93
Self decomposition	3.47	3.51	2.26	3.08	573	17,796	14,865	0.84
SEm ±	0.07	0.09	0.07	0.06			848	0.04
CD (P=0.05)	NS	NS	NS	NS			NS	NS
Level of nitrogen (%RDN)								
100	3.53	3.61	2.26	3.16	586	17,573	15,851	0.90
75	3.50	3.47	2.63	3.12	560	17,326	15,273	0.88
SEm ±	0.06	0.07	0.06	0.05			695	0.03
CD (P=0.05)	NS	NS	NS	NS			NS	NS
Rice alone	3.32*	3.22*	2.36	3.21		22,796*	4,737*	0.21*

*Rice alone *vs.* treatments significant; Interaction effect -non significant

Price of produce, Paddy, Rs 8/kg; Paddy straw, Rs 0.5/kg; Cowpea pods, Rs 12/kg

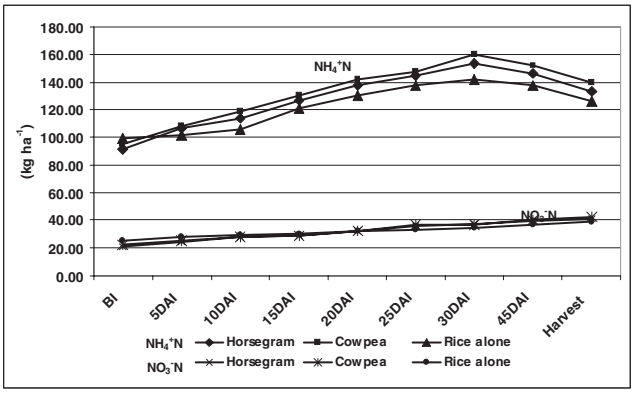

Fig. 1. Effect of green manure crops on the ammonical and nitrate nitrogen release pattern in dry sown rice

pared to horse gram incorporated treatments. This may be due to the higher biomass of cowpea (12 t/ha) compared to horsegram (3.7 t/ha). Soil NH_4^+-N increased from 94.75 kg/ha to 159.53 kg/ha up to 30 DAI, there after decreasing to 139.66 kg/ha up to harvest in cowpea incorporated plots. In horsegram incorporated plots, soil NH_4^+-N increased from 91.47 kg/ha to 153.25 kg/ha up to 30 DAI, there after decreased to 132.84 kg/ha at harvest. Increased NH_4^+–N release ensured adequate availability of N at the critical stage (panicle initiation) enabling better nutrient uptake and higher yield by rice. This most likely is to contribute to synchrony between nutrient release and uptake.

The release of NO_3^--N was less compared to NH_4^+-N. But an increasing trend was noticed in the release of NO_3^--N up to harvest. Method of incorporation of green manure crops did not show any difference in the release of NH_4^+-N and NO_3-N (Fig 2). Treatments receiving 100% RDN showed significantly higher release of NH_4^+-N and NO_3^--N compared to 75% RDN (Fig 3).

A substantial build up of soil fertility with respect to N status was noticed after the incorporation of intercropped cowpea and horsegram (Table 2). Concurrent growing of cowpea registered the highest N status of soil. Increase in availability of N in soil by cowpea is 1.6 times more than

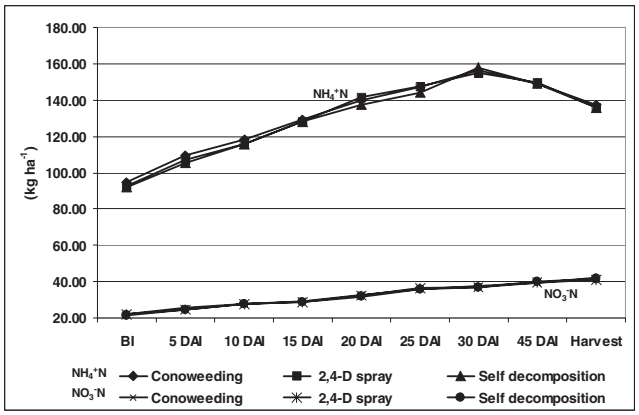

Fig. 2. Effect of methods of incorporation of green manure crops on the ammonical and nitrate nitrogen release pattern in dry sown rice

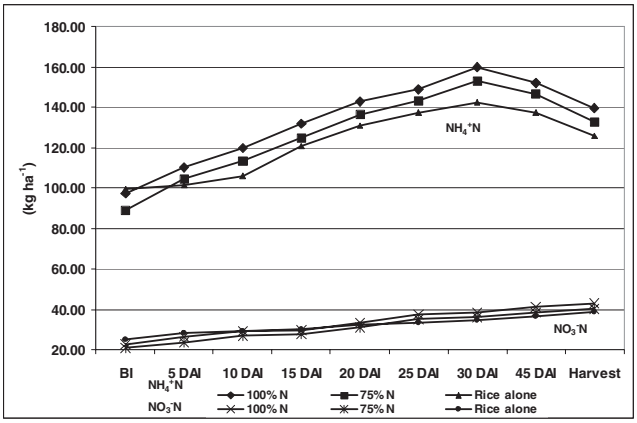

Fig. 3. Effect of levels of N on the ammonical and nitrate nitrogen release pattern in dry sown rice

that of horsegram. This showed the sustainable nature of this system. A decrease was noticed in the post-harvest soil nutrient status of rice grown alone compared with the initial status of soil nutrients. Methods of incorporation showed no significant effect on the available N status of the soil. The build up of soil fertility with respect to N status was higher in the system of concurrent growing of green manure crops receiving both 100 and 75% RDN compared to pure crop of rice receiving 5 t/ha of FYM and RDN.

Result of the study indicated that concurrent growing of cowpea met 25% N fertilizer need of rice besides reducing weed incidence by 75% ultimately enhancing rice yield by 365 kg/ha. Results indicated that peak nitrogen release from concurrently grown cowpea coincides with the critical growth stages of rice i.e. the panicle initiation stage, and thereby ensure availability of N at the critical stage.

REFERENCES

Balachandran, P.V. 2007. Rice scenario of Kerala and the future strategies. In: *Paddy cultivation in Kerala, Compilation of papers on the special session, 19th Kerala Science Congress* 29-31 January 2007, Kannur. (Muthunayagam, A. E. Ed.) KSCSTE, Thiruvananthapuram. pp. 22–32.

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

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

Jayachandran, M. and Veerabadran, V. 1996. Nitrogen economy through intercropping green manures in semi-dry rice. *Madras Agricultural Journal* **83**: 466–468.

Johnkutty, I. 1996. Nitrogen utilization, growth and yield of rice as affected by green manuring and timing of isotope and non-isotope N. Ph. D. Thesis, Division of Agronomy, Tamil Nadu Agricultural University, Coimbatore, India. 254 p.

KAU, 2002. *Package of Practices Recommendation – Crops.* 12th edn. 278 p. Kerala Agricultural University, Thrissur.

Resmy, O.N. 2003. Weed management in semi-dry rice intercropped with green manure crops. M.Sc. (Ag.) Thesis, Division of Agronomy, Kerala Agricultural University, Thrissur, India. 83 p.

Sankar, R.N., Chandrasekharan, B. and Nair, A.K. 2003. Evaluation of seeding methods and *in situ* incorporation of *dhaincha* (*Sesbania aculeata* Poir.) on productivity of wet seeded rice. In: *Proceedings of the National Symposium on "Resource Management for Ecofriendly Crop Production"* (Tiwari, A. N., Mohan, M. and Pathak, R.K. Eds.), 26-28 February, 2003, Indian Society of Agronomy, New Delhi pp.10.