Asian Journal of Plant Sciences

ISSN 1682-3974

science alert

ANSInet
an open access publisher
http://ansinet.com

Asian Journal of Plant Sciences 6 (2): 282-287, 2007
ISSN 1682-3974

Exploitation of Hybrid Vigour in Rice Hybrid (*Oryza sativa* L.) Through Green Manure and Leaf Colour Chart (LCC) Based N Application

S. Ravi, S. Ramesh and B. Chandrasekaran
Department of Agronomy, Tamil Nadu Agricultural University, Coimbatore-641 003, India

Abstract: Field experiments were conducted during Kharif 2000 and 2001 in the wetland research farm of Tamil Nadu Agricultural University, Coimbatore to study the effects of green manuring and fertilizer N application based on LCC grades on the yield enhancement, nutrient uptake and economics of hybrid rice. Treatments consisted of two hybrids in the main plot and seven levels of N management practices during Kharif 2000 and eight sub-plot treatments during Kharif 2001. Among the hybrids, PA6201 registered significantly higher grain yield of 7363 and 7555 kg ha^{-1} during Kharif 2000 and 2001 respectively with a yield advantage of 9.5% over CoRH2 in both the seasons. The N, P and K uptake at different growth stages revealed that rice hybrid PA 6201 was superior than CoRH2 in both the seasons. Application of green manure @ 6.25 t ha^{-1} in combination with N application based on LCC critical value 5 recorded significantly higher grain yield compared to other treatments in both the seasons. The N, P and K uptake in green manure @ 6.25 t ha^{-1} combined with LCC critical value 5 based N application (N_4) was significant at all the stages, however it was comparable with 200 kg N ha^{-1} alone (N_1) except at tillering stage. In both the years PA6201 hybrid recorded high net returns of 15.05 and 14.60% over CoRH2. Application of green manure @ 6.25 t ha^{-1} combined with LCC critical value 5 based N application (N_4) recorded higher net returns and B:C ratio during both the years and it was followed by application of 200 kg N ha^{-1} alone (N_1). Therefore, the rice hybrid PA6201 with application of green manure 6.25 t ha^{-1} combined with LCC critical value 5 based N applications significantly increased grain yield, nutrient uptake and in turn resulted in higher net return and B:C ratio.

Key words: Nitrogen management, hybrid rice, yield, nutrient uptake

INTRODUCTION

In view of plateauing trend in yield potential of high yielding varieties and decreasing natural resource base, hybrid rice technology with a yield superiority of 15-20% is a viable avocation (Hari *et al*., 2000). In hybrid rice cultivation, developing a package of optimum nitrogen management practices is vital to explore the full hybrid potential. Nitrogen requirement of hybrid seems to be on the higher magnitude than that of conventional inbred varieties. The normal practice of timing of N application on specified growth stages, at times, fails to result in a better match between N supply from applied fertilizer and crop demand mainly because of variation in crop N requirement and soil N supply. Therefore, a more reliable method is needed for better N management. One of the recently introduced N management approach was estimating the leaf N concentration by the measurement of leaf greenness. Among the different tools available to measure the leaf greenness, the non-destructive measurement of leaf green colour intensity using Leaf Green Colour Charts (LCC) are gaining importance. Nitrogen management based on LCC cv.4 helped to avoid excess application of N to rice and reduces N requirement from 12.5 to 25% without causing yield reduction (Bajpai *et al*., 2002). Saravanan (2003) registered highest grain and straw yield of ADT 43 with N applied at LCC cv.3 for inbred rice varieties. But standardization of leaf colour chart values for Nitrogen management especially for hybrids has so far not been accomplished. Green manuring is an inexpensive, eco-friendly alternative to mounting prices of fertilizer nitrogen and has become an effective technology in economizing the agricultural production system, ensuring productive capacity of soil without causing environmental problem (Bana and Pant, 2000). The insight knowledge about the Integrated Management Practices involving green manure and N application based on LCC are scanty and hence present study was made to evolve leaf colour chart values for optimum N application under green manure supply to exploit the dual advantage of higher grain yield of hybrids and soil fertility enhancement in India.

Corresponding Author: S. Ramesh, Department of Agronomy, Tamil Nadu Agricultural University, Coimbatore-641 003, India
Tel: 091 09360613120

MATERIALS AND METHODS

Field experiments were conducted during Kharif (June-September) 2000 and 2001 in wetland research farm of Tamil Nadu Agricultural University, Coimbatore to study the effect of green manuring and fertilizer N application and management through LCC grades on rice hybrids. The soil of the experimental field was moderately drained, deep clay loam, classified taxonomically as *Typic haplustalf* having organic carbon 0.64% with pH 7.3, low in available soil N 244 kg ha^{-1}, medium in available soil P 17.2 kg ha^{-1} and high in available soil K 505 kg ha^{-1}, respectively. The experiment was laid out in split plot design with three replications. The main plot treatments consisted of two hybrids PA6201, CoRH2 and the sub-plots were allotted with seven levels of N management practices during Kharif 2000.The rice hybrid PA6201 was released in 2000 by Central Variety Release Committee (CVRC). It is a medium duration (125-130 days) semi dwarf, erect type having long panicle with long slender grain. The rice hybrid CoRH2 released in 1998 by Paddy Breeding Station, Tamil Nadu Agricultural University, Coimbatore is also a medium duration (125 days) semi-dwarf type having compact panicle with medium grain type.

The details of the treatments and notations for Kharif 2000 used were:

- Main plot: Hybrid rice
  - H_1-PA 6201
  - H_2-CoRH2

- Sub-Plot: Nitrogen Management
  - N_1-Basal + 3 splits top dressing of recommended dose
  - N_2-Green manure 6.25 t ha^{-1} + N application as per LCC cv. 3
  - N_3- Green manure 6.25 t ha^{-1} + N application as per LCC cv. 4
  - N_4- Green manure 6.25 t ha^{-1} + N application as per LCC cv. 5
  - N_5-20 Kg N ha^{-1} as basal + N as per LCC cv .3
  - N_6-20 Kg N ha^{-1} as basal + N as per LCC cv. 4
  - N_7-20 Kg N ha^{-1} as basal + N as per LCC cv. 5

During Kharif 2001 one more sub-plot treatment was included with the treatments imposed during Kharif 2000 i.e., N_8 which consisted of Green manure 6.25 t ha^{-1} + 3 split top dressing of recommended dose and it is the existing recommended practice under integrated nitrogen management approach. An absolute control was maintained separately in the experimental field to find out the efficiency of applied nitrogen. *Sesbania aculeata* was raised in a separate field with a seed rate of 40 kg ha^{-1}. At the time of incorporation, the age of green manure was 40 days and 45 days during Kharif 2000 and 2001 respectively. Above ground biomass was harvested, weighed and applied to the respective plots as per treatment schedule. The green manure was spread uniformly and incorporated one week before transplanting. All the recommended agronomic practices and need based plant protection measures were carried out as per the crop production guide of Tamil Nadu Agricultural University (TNAU, 2000). The fertilizer nitrogen was applied to the rice crop as per the treatments. In LCC based N management treatments, the LCC values were recorded as per the standard procedure (IRRI, 1996) at weekly intervals starting from 14 DAT to flowering. Whenever the LCC values were found to be below the fixed critical level, recommended quantity of fertilizer N was applied (Table 1 and 2). The amount of N to be applied at different growth stages was as per the schedule given below (IRR1, 1996).

Crop growth stages	N to be applied
Early growth stage (14-21DAT)	20 kg N ha^{-1}
Rapid growth stage (28-42DAT)	30 kg N ha^{-1}
Late growth stage (45-Flowering)	20 kg N ha^{-1}

Table 1: Leaf colour chart based N application at weekly intervals-Kharif 2000

Time of fertilizer application (DAT)		H_1N_1	H_1N_2	H_1N_3	H_1N_4	H_1N_5	H_1N_6	H_1N_7	H_2N_1	H_2N_2	H_2N_3	H_2N_4	H_2N_5	H_2N_6	H_2N_7
Basal		50	-	-	-	20	20	20	50	-	-	-	20	20	20
Early growth stages	14	-	-	20	20	-	20	20	-	-	20	20	-	20	20
(EGS)	21	50	20	-	20	20	-	20	50	20	-	20	20	-	20
Rapid growth stages	28	-	-	30	-	-	30	-	-	-	30	-	-	30	-
(RGS)	35	-	30	-	30	30	-	30	-	30	-	30	30	-	30
	42	50	-	30	-	-	30	-	50	-	30	-	-	30	-
Late growth stages	49	-	20	-	20	20	-	20	-	20	-	20	20	-	20
(LGS)	56	-	-	20	20	-	20	20	-	-	20	20	-	20	20
	63	50	20	-	20	20	-	20	50	20	-	20	20	-	20
	70	-	-	20	20	-	20	20	-	-	20	20	-	20	20
Total (kg ha^{-1})		200	90	120	150	110	140	170	200	90	120	150	110	140	170

Table 2: Leaf colour chart based N application at weekly intervals-Kharif 2001

Time of fertilizer application (DAT)		H_1N_1	H_1N_2	H_1N_3	H_1N_4	H_1N_5	H_1N_6	H_1N_7	H_1N_8	H_1N_1	H_1N_2	H_1N_3	H_1N_4	H_1N_5	H_1N_6	H_1N_7	H_1N_8
Basal		50	-	-	-	20	20	20	-	50	-	-	-	20	20	20	-
Early growth	14	-	-	20	20	-	20	20	-	-	-	20	20	-	20	20	-
stages (EGS)	21	50	20	-	20	20	-	20	50	50	20	-	20	20	-	20	50
Rapid growth	28	-	-	30	-	-	30	-	-	-	-	30	-	-	30	-	-
stages (RGS)	35	-	30	-	30	30	-	30	-	-	30	-	30	30	-	30	-
	42	50	-	30	-	-	30	-	50	50	-	30	-	-	30	-	50
Late growth	49	-	20	-	20	20	-	20	-	-	20	-	20	20	-	20	-
stages (LGS)	56	-	-	20	20	-	20	20	-	-	-	20	20	-	20	20	-
	63	50	20	-	20	20	-	20	50	50	20	-	20	-	-	20	50
	70	-	-	20	20	-	20	20	-	-	-	20	20	20	20	20	-
Total (kg ha^{-1})		200	90	120	150	110	140	170	150	200	90	120	150	110	140	170	150

All the treatments including control received a uniform dose of 50 kg P_2O_5 and 50 kg K_2O ha^{-1}. The entire dose of P was applied as basal before transplanting. Potassium was applied in three equal splits viz., 50% as basal and 25% each at active tillering and panicle initiation stages. Zinc sulphate @ 25 kg ha^{-1} was applied to the crop during both the seasons. The moisture content of the grain was recorded by using moisture meter and adjusted to 14% moisture. Plant samples were collected at active tillering, panicle initiation, flowering and harvest stages, finely ground in willey ground mill and uptake of nutrients at different stage of sampling was analysed. The nutrient contents of samples was multiplied with the respective dry matter to calculate the nutrient uptake and expressed as kg ha^{-1}. Gross and net returns were computed by considering the prevailed market price of inputs and produces.

RESULTS AND DISCUSSION

Grain yield: The experimental results revealed that rice hybrid PA6201 has recorded significantly higher grain yield of 7363 and 7555 kg ha^{-1} during Kharif 2000 and 2001, respectively. The other hybrid rice CoRH2 has produced considerably lower yield of 6665 and 6845 kg ha^{-1}. The yield advantage in PA6201 was accounted to around 9.5% over CoRH2 in both the years. Application of green manure @ 6.25 t ha^{-1} in combination with N application based on LCC critical value 5(N_4) recorded significantly higher grain yield of 8036 and 8239 kg ha^{-1} in 2000 and 2001, respectively. The straw yield exhibited the same trend with hybrids whereas N management practices, of 200 kg N ha^{-1} application alone produced significantly higher straw yield over green manure @ 6.25 t ha^{-1} combined with LCC critical value 5 based N application (N_4) in 2000 whereas it was comparable with application of green manure @ 6.25 t ha^{-1} with 150 kg Nha^{-1} in 2001, respectively (Table 3). The strategy of applying green manure @ 6.25 t ha^{-1} combined with LCC critical value 5 based N application (150 kg N ha^{-1}) in seven splits(N_4) matched the crop demand at different physiological stages and reduced the losses through de-nitrification, volatilization and resulted in the highest grain yield. The increased availability of nutrient at distinct physiological phases would have supported for better assimilation of photosynthates towards grain and also due to the favourable effect of accelerating the yield characters. Similar findings have been reported by many workers (Vaiyapuri *et al*., 1998; Stalin *et al*., 1999). The significant increase in grain yield due to green manure application over other sources could be attributed to the enrichment of soil fertility (Gopalsamy and Vidhyasekaran, 1987) and improved soil physical property as well as fertility through addition of organic matter. This in turn might have promoted the yield attributes contributing to the increased grain yield (Kalpana and Balasubramanian, 2000). The slower and steady rate of release of nutrients from green manures resulted in nutrient availability to rice at all the crop stages and thereby favourably influencing the various yield parameters resulting in higher yield (Budhar, 1994). Though rice responds to liberal supply of N, it cannot absorb excess quantity of ammonical N available in soil solution. Excess N application above the requirement is ultimately lost due to various loss mechanisms. Declining rate of response with higher level of N application at 200 kg N ha^{-1} (N_1) has been well documented by many workers (Siddeswaran, 1992; Pradeep *et al*., 1994; Budhar *et al*., 1994). Application of higher dose of 200 kg N ha^{-1} promoted more biomass resulting in significant increase in straw yield. It may be due to higher number of tillers and higher level of N uptake at active tillering stage. This trend of results was also confirmed by Rajarathinam and Balasubramanian (1999).

Table 3: Effect of hybrids and Nitrogen management strategies on the grain and straw yield (kg ha^{-1})

	Grain yield (kg ha^{-1})						Straw yield (kg ha^{-1})					
	Kharif 2000			Kharif 2001			Kharif 2000			Kharif 2001		
Treatments	H_1	H_2	Mean	H_1	H_2	Mean	H_1	H_2	Mean	H_1	H_2	Mean
N_1	7862	7193	7528	7922	7214	7568	9707	9054	9381	9573	8874	9224
N_2	6623	5925	6274	6719	6018	6368	7775	7097	7436	7692	7001	7346
N_3	7567	6838	7202	7648	6891	7269	8706	8060	8383	8664	7992	8328
N_4	8386	7685	8035	8595	7881	8238	9457	8666	9061	9311	8538	8924
N_5	6298	5606	5952	6353	5698	6025	7544	6852	7198	7418	6725	7071
N_6	7124	6412	6768	7192	6483	6837	8296	7527	7911	8208	7472	7840
N_7	7682	6997	7339	7760	7030	7395	8838	8214	8526	8928	8152	8540
N_8	-	-	-	8251	7539	7895	-	-	-	9685	8814	9249
Mean	7363	6665		7555	6844	-	8618	7924	-	8685	7964	
	SEd	CD(0.05)		SEd	CD(0.05)		SEd	CD(0.05)		SEd	CD(0.05)	
H	16.8	72.2		10.9	47.3		18.4	79.5		13.9	59.9	
N	140.6	290.3		146.0	299.1		166.4	343.5		169.0	346.3	
H at N	184.9	NS		193.4	NS		218.7	NS		224.0	NS	
N at H	198.9	NS		206.5	NS		235.3	NS		239.1	NS	

(ha^{-1} - per hectare)

Nutrient uptake: One way to achieve better use of the applied N is to apply the fertilizer in time to meet the demand of rice plant (De Datta, 1981). Studies on the nitrogen uptake at different growth stages revealed the rate of nutrient absorption in unit time for the transformation to different parts of the plant. It was evident from N uptake studies that the rice hybrid PA6201 was superior than CoRH2 in all the stages during both the years (Table 4). The N uptake pattern had showed an uniform trend in all the stages during the Kharif 2000.The N uptake with application of green manure @ 6.25 t ha^{-1} combined with LCC cv.5 based N application (N_4) treatment was significantly higher in all the stages, however it was comparable with 200 kg N ha^{-1} application alone (N_1) all through the growth stages except active tillering stage. During the crop season of 2001, N_4 treatment exhibited significantly higher N uptake and it was on par with application of green manure @ 6.25 t ha^{-1} along with 150 kg N ha^{-1} (N_8) and N_1 in all the stages except active tillering stage. The uptake of both P and K was significantly higher with PA 6201 than CoRH2 in both the years. With regard to the P and K uptake as influenced by different N management practices, green manure @ 6.25 t ha^{-1} combined with LCC critical value 5 based N application (N_4) produced considerably higher values than the rest of treatments and it was on par with 200 kg N ha^{-1} application alone (N_1) during Kharif 2000. During the Kharif 2001, though N_4 recorded significantly higher P and K uptake than other treatments it was comparable with (N8) green manure @ 6.25 t ha^{-1} with 150 kg N ha^{-1} and 200 kg N ha^{-1} (N1) alone. Uptake of N associated with the green manuring of *Sesbania aculeata* which contains an appreciable quantity of N (2.5-2.6%) favoured the release of N for growth and uptake of rice. This corroborates the findings of Somasundaram (1991) who reported that in lowland rice soils, green manure incorporation undergoes decomposition resulting in the release of ammonical N into the soil solution, which is readily available to rice plant. Higher uptake of nutrients by the crop due to organic manure addition was also reported by Padmavathy (1992).

Higher N uptake of rice in green manuring treatment might be due to better synchorinisation between green manure N availability and rice N uptake. This is in line with the results of Clement *et al.* (1998). Samantary *et al.* (1990) observed that N uptake was high between vegetative and reproductive stages. Studies on N management of hybrid rice at IRRI also showed a significantly higher response to late season N application (IRRI, 1993). In addition to the inorganic source of N, the constant supply of N from green manure mineralization accelerated the uptake of N. The present finding is supported by Buresh *et al.* (1993).The results revealed that economic yield could be better even if the crop was maintained with a low N status in the early stage of the growth provided a continued N supply is maintained up to flowering phase. The beneficial effect of more number of splits, the last one coinciding with flowering on nutrient uptake has also been suggested by Sanbagavalli *et al.* (1999). Surekha *et al.* (1999) also confirmed higher uptake of nutrient by hybrids with four splits compared to three splits of N. The increased P availability due to green manure application might be due to the organic acids produced during the decomposition of organic material in flooded soils and that resulted in mineralizing the insoluble iron phosphate into more soluble phosphorus, which inturn favoured better P uptake (Sreedevi and Thangamuthu, 1991). The increase in K availability and uptake could be also due to the priming effect of the K besides direct contribution of K by organic residues (Thomas, 1996).

Table 4: Nutrient uptake (kg ha^{-1}) as influenced by hybrids and nitrogen management strategies

	Nitrogen uptake								P uptake		K uptake	
	Kharif 2000				Kharif 2001				Kharif 2000	Kharif 2001	Kharif 2000	Kharif 2001
Treatments	T	P.I	F	H	T	P.I	F	H	H	H	H	H
H_1	44.95	83.93	135.6	129.8	46.91	86.63	138.4	132.5	31.61	31.97	113.02	115.29
H_2	39.40	78.25	126.5	123.1	41.10	81.40	129.6	126.0	29.16	29.68	108.89	111.96
SEd	0.10	0.18	0.31	0.30	0.07	0.13	0.26	0.24	0.07	0.05	0.27	0.18
CD	0.44	0.77	1.34	1.32	0.33	0.58	1.14	1.04	0.31	0.22	1.18	0.80
N_1	44.94	91.25	139.0	134.9	46.89	92.65	140.9	136.7	32.58	32.70	122.19	123.13
N_2	39.38	71.34	120.8	116.2	43.92	84.37	135.1	129.0	30.31	30.44	97.53	98.02
N_3	42.22	82.95	133.5	128.1	48.62	95.51	145.4	141.4	33.50	33.59	113.69	114.51
N_4	46.41	94.11	144.4	139.3	38.96	70.47	119.6	115.6	27.40	27.00	126.65	127.29
N_5	37.44	68.56	117.5	113.5	42.08	79.18	129.0	123.6	30.08	30.16	93.68	94.12
N_6	40.82	77.18	127.2	122.3	45.08	86.80	137.1	133.4	31.10	31.16	105.45	106.27
N_7	44.11	85.19	135.7	130.6	47.22	93.07	142.4	138.8	-	32.83	117.49	120.56
N_8	-	-	-	-	47.22	93.07	142.4	138.8	-	32.83	-	125.08
SEd	0.84	1.62	2.62	2.53	0.89	1.70	2.70	2.61	0.60	0.62	2.22	2.30
CD	1.74	3.35	5.41	5.22	1.82	3.48	5.54	5.35	1.25	1.27	4.58	4.71
H at N	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
N at H	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

T-Tillering, PI-Panicle Initiation, F-Flowering, H-Harvest, ha^{-1} - per hectare, NS: Not Significant

Table 5: Influence of hybrids and nitrogen management strategies on economics

	Cost of production (Rs. ha^{-1})		Gross income (Rs. ha^{-1})		Net income (Rs. ha^{-1})		B:C ratio	
Treatments	Kharif 2000	Kharif 2001	Kharif 2000	Kharif 2001	Kharif 2000	Kharif 2001	Kharif 2000	Kharif 2001
H_1N_1	17762	17260	51216	51479	53440	34219	2.88	2.98
H_1N_2	17125	16609	42747	43249	25622	26640	2.49	2.60
H_1N_3	17425	16909	48733	49174	31308	32265	2.79	2.90
H_1N_4	17702	17207	53893	55007	36171	37800	3.04	3.19
H_1N_5	16873	16357	40739	40979	23866	24622	2.41	2.50
H_1N_6	17173	16657	45940	46278	28767	29621	2.67	2.78
H_1N_7	17472	16956	49473	49976	32001	33020	2.83	2.94
H_1N_8	-	17207	-	53254	-	36047	-	3.09
H_1N_1	17276	16760	46851	46835	29575	30075	2.71	2.79
H_1N_2	16625	16109	38326	38803	21701	22694	2.30	2.40
H_1N_3	16925	16409	44154	44418	27229	28009	2.60	2.70
H_1N_4	17223	16707	49387	50437	32664	33730	2.86	3.01
H_1N_5	16373	15857	36345	36798	19972	20941	2.21	2.32
H_1N_6	16673	16157	41385	41760	24712	25603	2.48	2.58
H_1N_7	16972	16456	45160	45313	28188	28857	2.66	2.75
H_1N_8	-	16707	-	48637	-	31930	-	2.91

Data not statistically analyzed (Rs. ha^{-1} - Rupees per hectare)

Economics: The economics was worked out taking into consideration, the cost of production for each treatment, the corresponding marketable yield with prevalent prices per unit output. The mean data of the first season during 2000 revealed that the treatment H_1N_4(PA6201 hybrid with application of green manure 6.25 t ha^{-1} + N as per LCC cv.5) produced the gross income of Rs. 53,893 ha^{-1} for a total cost of production of Rs. 17,702 ha^{-1}. This has resulted in a net income of Rs. 36,171 ha^{-1} producing a higher B:C ratio of 3.04 during the Kharif 2000. The treatment H_1N_4 in both Kharif 2000 and 2001 produced highest benefit per rupee investment (Table 5). The higher net returns was due to steady supply of N, which synchronized with the peak period of N requirement that had produced higher yield. Similar results were obtained by Hiremath and Patel (1998).

CONCLUSIONS

It may be concluded from this experiment that the hybrid PA6201 with application of green manure @ 6.25 t ha^{-1} combined with N application at LCC critical value 5 registered significantly higher grain yield which resulted in the highest gross return, net income and B:C ratio during both years of experimentation. Organic manuring coupled with seven split doses of inorganic N maintaining a LCC value of 5 was highly beneficial for hybrid rice. Application of N based on LCC value found to be efficient in economizing N requirement with

increased nitrogen use efficiency as compared to conventional practices under Tamil Nadu condition.

REFERENCES

Bajpai, R.K., S.K. Upadhyay, B.S. Joshi and R.S. Tripathi, 2002. Productivity and economics of rice (*Oryza sativa* L.)-Wheat (*Triticum aestivum*) cropping system under integrated nutrient supply systems. Indian J. Agron., 47: 20-25.

Bana, O.P.S. and A.K. Pant, 2000. Green manuring for ecologically sound crop production. Indian Farmer's Digest, pp: 19-20.

Budhar, M.N., 1994. Effect of conjunctive and individual application of fertilizer and green manure on lowland rice (*Oryza sativa* L.), Ph.D Thesis, submitted to Tamil Nadu Agricultural University, Coimbatore.

Budhar, M.N., S.P. Palaniappan and T.M. Thiyagarajan, 1994. Influence of Substitution of Fertilizer Nitrogen by Green Manure on Growth and Yield of Lowland Rice. In: Ten, H.F.M. and M.C.S. Berge, Wopereis-Nitrogen Economy of Irrigated Rice: AB-AND TPE-Wageningen and IRRI, Los Banos, Phillipines.

Buresh, R.J., D.P. Garrity, E.G. Castillo and T.T. Chua, 1993. Fallow and sesbania effect on response of transplanted lowland rice to urea. Agron. J., 84: 801-808.

Clement, A., J.K. Ladha and F.P. Chalifour, 1998. Nitrogen dynamics of various green manure species and the relationship to lowland rice production. Agron. J., 90: 149-154.

De Datta, S.K., 1981. Principles and Practices of Rice Production. Wiley Inter. Science, New York.

Gopalsamy, G. and P. Vidyasekaran, 1987. Effect of green manure on soil fertility and rice yield. IRRN, 12: 41.

Hari, O., S.K. Katyal and S.D. Dhiman, 1997. Effect of nitrogen and seed rate on growth and yield of rice hybrid (*Oryza sativa* L.) Indian J. Agron., 42: 275-282.

Hiremath, S.M. and Z.G. Patel, 1998. Effect of winter green manuring and nitrogen application on summer rice. Indian J. Agron., 43: 71-76.

IRRI, 1993. Irristat. Biometric Unit. Rice Res. Inst., Los Banos, Philippines.

IRRI, 1996. Use of Leaf Colour Chart (LCC) for N Management in Rice. Intl. Rice. Res. Inst., P.O. Box. 933, Manila 1099, Philippines.

Kalpana, R. and A. Balasubramanian, 2000. Studies on intercropping green manuring with grain legumes in the pre-rice season and its effect on rice. Madras Agric. J., 87: 93-95.

Padmavathy, V.K., 1992. Effect of green manures and green gram on the economy of nitrogen management in rice based cropping system. M.Sc. (Ag.) Thesis. Tamil Nadu Agric. Univ., Coimbatore.

Pradeep, P., K. Ashoka and U.K. Prasas, 1994. Effect of irrigation and nitrogen on yield of medium duration direct seeded rice. Indian J. Agron., 39: 294-296.

Rajarathinam, P. and P. Balasubramanian, 1999. Effect of plant population and nitrogen on yield attributes and yield of hybrid rice. Indian. J. Agron., 44: 717-721.

Samantary, R.N., D. Panda and S. Patrick, 1990. Contribution of soil N towards the growth and yield of rice varieties of different duration. J. Indian Soc. Soil Sci., 38: 674-679.

Sanbagavalli, S., O.S. Kandasamy and A. Christopher Lourduraj, 1999. Nitrogen management and economic returns of seedlings throwing method of rice planting in wet season. Agric. Sci. Digest., 19: 27-30.

Saravanan, P., 2003. Prediction of post harvest nitrogen status and fertilizer nitrogen recommendation for rice-rice cropping sequence under integrated nitrogen nutrition system. Madras Agric. J., 89: 338-340.

Siddeswaran, K., 1992. Integrated nitrogen management with green manure and grain legumes in rice-based cropping system. Ph.D. Thesis, Tamil Nadu Agric. Univ. Coimbatore.

Somasundaram, E., 1991. Studies on the direct and residual effect of applied and intercropped *Sesbania rostrata* on rice. M.Sc. (Ag.) Thesis, Tamil Nadu Agric. Univ., Coimbatore.

Sreedevi, B. and G.S. Thangamuthu, 1991. Studies on NPK uptake by rice under integrated N management. Oryza, 28: 255-256.

Stalin, P., T.M. Thiyagarajan and R. Rangarajan, 1999. Nitrogen application strategy and use efficiency in rice. Oryza, 36: 322-326.

Surekha, K., M.N. Reddy, R.M. Kumar and C.H.M.V. Kumar, 1999. Effect of N sources and timing on yield and nutrient uptake of hybrid rice. Indian J. Agric. Sci., 69: 477-481.

Thomas, D., 1996. Integrated nitrogen management for wet seeded rice. M.Sc. (Ag.) Thesis, Tamil Nadu Agric. Univ. Coimbatore.

TNAU, 2000. Crop Production Guide. Tamil Nadu Agric. Univ., Coimbatore, pp: 1-26.

Vaiyapuri, V., M. Ravichandran and M.V. Sriramachandrasekaran, 1998. Effect of graded levels of *Sesbania speciosa* with time of N application on growth and yield in rice-rice sequence. Ann. Agric. Res., 19: 1-3.