Asian Journal of Plant Sciences

ISSN 1682-3974

science alert

ANSInet
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http://ansinet.com

Asian Journal of Plant Sciences 5 (6): 1022-1026, 2006
ISSN 1682-3974

Evaluation of Crop Establishments and Split Application of N and K on Growth, Yield Attributes, Yield and Economics of Hybrid Rice CoRH2

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Abstract: A field experiment was conducted to study the effect of crop density, establishment methods and split application of N and K on growth and yield of hybrid rice CoRH2 during late *Pishanam* season (November 2001-April 2002) at Agricultural College and Research Institute, Killikulam in Tambaraparani command area. The experiment was laid out in factorial randomized block design with seven treatments replicated thrice. The treatments consisted of two establishment methods, two plant densities and three methods of split application of N and K. The results revealed significant increase in growth attributes of hybrid rice CoRH2 in seedling broadcasting with 40 hills m^{-2} viz., taller plants, higher DMP, more number of tiller $hill^{-1}$ and higher LAI, CGR and yield parameters viz., productive tillers m^{-1}, panicle length, panicle weight, thousand grain weight, number of filled grains $panicle^{-1}$ and registered higher grain and straw yield of 7206 and 8870 kg ha^{-1}, respectively. With regard to split application of N and K, five splits of N and four splits of K exhibited significantly increased values of growth and yield components and recorded significantly superior grain yield of 6967 kg ha^{-1}.The treatment combination of seedling broadcasting of 40 hills m^{-2} with five splits of N and four splits of K application registered significantly higher growth and yield parameters, which in turn exhibited higher rice grain yield of 7316 kg ha^{-1} and maximum net return of Rs. 46,170 ha^{-1} and the highest B:C ratio of 4.08. Minimum number of man days was utilized with seedling broadcasting of 50 hills m^{-2} with three splits of N and two splits of K. Energy use was significantly higher under seedling broadcasting with 40 hills m^{-2} and three splits of N and two splits of K.

Key words: Hybrid rice, establishment methods, split application of N and K

INTRODUCTION

In India rice is cultivated in an area of 42.2 million ha with a production of 110 million tonnes, while China produces 187.45 million tonnes of rice in 33.1 million ha. The productivity of rice in India and China are 2.69 and 5.73 t ha^{-1}, respectively. The increase in rice productivity of China is mainly due to cultivation of hybrids (Ali, 2000). In India the increasing demand for rice grain production has to be met by using limited available resources in a sustainable manner. It is generally felt that a yield plateau has been reached in conventional rice varieties and any further increase in the productivity of rice warrants the breaking of this yield barrier. Hybrid rice offers an opportunity to raise rice yields to higher levels than the present. India is yet to fully exploit the technology which offers a 10-15% yield advantage over the best conventional inbred varieties (Li, 1981; Yang and Sun, 1992). The average yield of hybrid rice is 6 to 7 t ha^{-1} with a yield advantage of 30% over conventional varieties (Pandian *et al*., 2001). Invention of commercial hybrid rice and its popularization has prompted agronomic investigations on its establishment and management. Growing hybrid rice is a complex process since agronomic management of hybrid rice differs considerably from that of conventional inbred varieties in many respects. Establishment technique, plant density, nutrient requirement and management, water management etc. need to be standardized to achieve the reported yield potential of rice hybrids of different duration in various environments. Method of establishment is one of the cultural practices, which influence the hybrid rice through its effect on growth and development. Of the several agronomic practices, optimum plant density and fertilizer management are considered as challenges in hybrid rice cultivation. Grain yield of rice per unit area per unit time is dependent on the duration of the variety, its response to plant population and fertilization. Delayed application of N and K, coinciding with flowering could help to realize the potential yield of rice hybrids. However, all these

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practices have to be scientifically standardized as a location specific study. In this context, the present research was undertaken to evaluate the feasibility, economic advantage of different establishment methods and split application of N and K for *Pishanam* season in Tambaraparani command area of Tamil Nadu.

MATERIALS AND METHODS

A field experiment was conducted at Agricultural College and Research Institute, Killikulam, Tamil Nadu during late *Pishanam* season of 2001-2002 to investigate the effect of crop establishment methods and split application of N and K on the yield enhancement of hybrid rice CoRH2. The soil of the experimental field was sandy clay loam in texture, nearly neutral in pH 6.9. The fertility status of the soil was low in available N 173 kg ha^{-1}, high in available phosphorus 27.90 kg ha^{-1} and medium in available potassium 214.50 kg ha^{-1}.The trial was laid out in Factorial Randomized Block Design and each treatment was replicated thrice. The details of treatments are given below.

Establishment methods:

P_1- Line planting at 25×10 cm (40 hill m^{-2})
P_2- Line planting at 20×10 cm (50 hill m^{-2})
P_3- Seedling broadcasting with 40 hills m^{-2}
P_4- Seedling broadcasting with 50 hills m^{-2}

Split application of N and K:

S_1- Three splits of N at 50% B, 25% AT, 25% PI and two splits of K at 50% B, 50% PI
S_2-Four splits of N at 50% B, 16.5% AT, 16.5% PI, 16.5% H and three splits of K at 50% B, 25% PI, 25% F
S_3- Five splits of N at 50% B, 12.5% AT, 12.5% PI, 12.5% H, 12.5% F and four splits of K at 50% B, 25% PI, 12.5% H, 12.5% F
(B-basal, AT-active tillering, PI- panicle initiation, H- heading and F-flowering)

The hybrid CoRH2 is a medium duration (125 days) developed by three line breeding system using cytoplasmic male sterile line, maintainer line and restorer line. The grain is medium slender and white. A seed rate of 20 kg ha^{-1} was adopted and under line planting seedlings of 25 days old were planted at the rate of single seedling $hill^{-1}$ by adopting spacing as per the treatments. Seedlings were broadcasted as per the treatments over the field by maintaining thin film of water. The recommended dose of 200:50:50 kg of NPK ha^{-1} was applied to CoRH2 rice hybrid in the form of urea, superphosphate and potash, respectively. Entire P fertilizer was applied basally and potash and nitrogenous fertilizers were applied in different splits as per the treatments.

RESULTS AND DISCUSSION

Growth components: Among the establishment methods of planting, seedling broadcasting with 40 hills m^{-2} registered significantly taller plants. The increased height in seedling broadcasting might be due to zero depth of planting resulting in better inducement of root growth for anchorage. This result corroborates with the findings of Matsushima (1979) and Sanbagavalli *et al.* (1999). Seedling broadcasting method ensures shallow depth of planting of seedlings as compared to line planting. This might be a possible reason to produce more tillers per hill under seedling broadcasting, as deeper planting caused reduction in tillering. Increased plant height and more number of tillers $hill^{-1}$ resulted in higher DMP. Application of five splits of N and four splits of K was proved as better agronomic method and thus increased the plant height, more tiller number $hill^{-1}$ and LAI at later stages. The same methods of application of nutrients increased DMP due to higher number of tillers $hill^{-1}$ and LAI (Table 1). Split application of N and K extended after panicle initiation stage to meet the plant requirement led to the higher values of growth characters. Similar findings were observed by Biswas (1976) and Senthivel and Palaniappan (1985).

Yield components and grain yield: The better yield attributes viz., productive tillers m^{-2}, panicle length, panicle weight, thousand grain weight and filled grains $panicle^{-1}$ were significantly higher with seedling broadcasting method of planting compared to line planting (Table 2). It confirms the earlier findings of Esther Shekinah and Kandasamy (1998). Stand establishment methods and plant density caused significant variation in hybrid rice grain yield. Among the methods of establishment, seedling broadcasting produced higher grain yield than rest of the treatments. Adoption of 40 hills m^{-2} with seedling broadcasting method of planting produced significantly higher rice grain yield of 7206 kg ha^{-1} as compared to other methods and population. A reduction of 240 kg ha^{-1} grain yield was noticed in transplanting in the similar plant density. Hybrid rice grain yield was significantly lowered with increasing plant density to 50 hills m^{-2} in both planting methods of broadcasting and line planting. Adoption of line planting with 50 hills m^{-2} (P_2) produced significantly lower grain yield of 6631 kg ha^{-1}. Increased nutrient

Table 1: Effect of establishment methods and split application of N and K on growth attributes of CoRH2 rice hybrid

	Plant height (cm)			No. of tillers hill^{-1}		Dry matter production (kg ha^{-1})			LAI
Treatments	Tillering	Flowering	Harvest	Tillering	Flowering	Tillering	Flowering	Harvest	Flowering
Establishment methods									
P_1	48.00	95.95	105.49	12.59	14.56	2597	12748	14607	6.93
P_2	48.19	93.40	101.36	10.76	12.51	2699	12280	14272	5.61
P_3	48.68	97.25	106.98	13.96	15.60	2663	12945	14801	7.29
P_4	48.76	94.71	103.50	11.49	13.57	2744	12594	14452	6.57
CD (0.05)	0.1393	0.1274	0.1646	0.1581	0.2057	44.84	68.03	41.43	0.1334
Split application									
S_1	48.78	94.76	103.56	11.85	13.61	2821	12553	14466	6.51
S_2	48.97	95.25	104.43	12.07	14.05	2634	12679	14516	6.46
S_3	47.47	96.00	104.99	12.68	14.52	2572	12693	14616	6.83
CD (0.05)	0.1207	0.1104	0.1426	0.1369	0.1781	38.83	58.92	35.88	0.1159
PS									
CD (0.05)	0.2413	0.2207	0.2851	0.2739	0.3563	77.66	117.83	71.76	0.2317

Table 2: Influence of crop establishment methods and split application of N and K on yield components of CoRH2 rice hybrid

Treatments	Productive tillers m^{-1}	1000 grain weight (g)	Panicle weight (g)	Panicle length (cm)	Filled grains (panicle^{-1})	Chaffy grains (panicle^{-1})
Establishment methods						
P_1	512.00	22.50	3.16	24.56	138.46	19.94
P_2	416.00	21.48	2.43	23.28	124.16	25.60
P_3	565.00	23.50	3.58	25.70	140.27	16.96
P_4	483.00	22.14	2.90	23.76	126.97	22.96
CD (0.05)	13.41	0.0858	0.1301	0.2205	0.4261	0.1483
Split application						
S_1	473.80	22.08	2.82	24.08	131.52	22.12
S_2	495.70	22.41	2.96	24.25	132.63	21.43
S_3	512.50	22.72	3.26	24.64	133.25	20.55
CD (0.05)	11.61	0.0743	0.1126	0.1910	0.3691	0.1284
PS						
CD (0.05)	23.23	0.1486	0.2253	0.3820	0.7381	0.2568

Table 3: Grain yield (kg ha^{-1}) and Straw yield (kg ha^{-1}) of CoRH2 rice hybrid as influenced by establishment methods and split application of N and K

	Grain yield				Straw yield			
Treatments	S1	S2	S3	Mean	S1	S2	S3	Mean
P1	6921	6987	6992	6966	8593	8705	8820	8706
P2	6582	6640	6671	6631	8243	8493	8370	8368
P3	7066	7237	7316	7206	8870	8922	8820	8870
P4	6692	6783	6890	6788	8387	8430	8493	8436
Mean	6815	6911	6967		8523	8637	8625	
	SEd		CD (0.05)		SEd		CD (0.05)	
P	20.39		42.29		36.33		75.34	
S	17.66		36.62		31.46		65.24	
PS	35.32		73.25		62.92		130.49	

availability, better solar radiation distribution and less competition for growth were the possible reasons for getting superior yield under seedling broadcasting in late *Pishanam* season. Split application of N and K had significant positive influence on grain yield. With regard to split application of N and K, five splits of N and four splits of K recorded higher yield attributes and rice grain yield. Four splits of N and three splits of K registered higher straw yield, which was on par with five splits of N and four splits of K (Table 3). Fractional application of N and K after panicle initiation and flowering stages synchronizing with the crop demand may lead to conducive translocation of more amount of carbohydrates to sink, which produced superior yield attributes under five splits and four splits, respectively. Combined application of N and K was found to be the better method of fertilizer application and reflected by more number of productive tillers, filled grains panicle^{-1}, higher thousand grain weight, panicle weight, panicle length and lesser chaffy grains. These results are in accordance with Mondal *et al.* (1989). The interaction effect between stand establishment methods and split application of N and K was found significant. The higher grain yield of 7316 kg ha^{-1} was registered in the treatment with line planting at 20×10 cm (50 hill m^{-2}) and five splits of N and four splits of K. The lower grain yield of 6582 kg ha^{-1} was associated with P_2S_1 which was on par with P_2S_2 (6640 kg ha^{-1}).

Labour requirement: The quantity of labour requirement was worked out for the treatmental operations along with the weeding to assess the total man days/woman days

Table 4: Effect of stand establishment methods and split application of N and K on labour requirement (man days ha^{-1}) and energy budget of rice (MJ ha^{-1})

	Labour requirement (man days ha^{-1})				Energy budget of rice (MJ ha^{-1})		
Treatments	Planting	Fertilizer application	Weeding	Total	Total energy Input	Total energy output	Energy use efficiency (output:Input)
P_1S_1	52	6	27	85	34120	164250	4.81
P_1S_2	52	8	27	87	34550	166110	4.80
P_1S_3	52	10	27	89	35220	167110	4.74
P_2S_1	52	6	22	80	34910	164920	4.72
P_2S_2	52	8	22	82	35020	166950	4.76
P_2S_3	52	10	22	84	35740	168590	4.71
P_3S_1	36	6	23	65	31115	174768	5.61
P_3S_2	36	8	23	67	32130	174530	5.43
P_3S_3	36	10	23	69	33110	177950	5.37
P_4S_1	36	6	21	63	31625	175768	5.55
P_4S_2	36	8	21	65	32950	177440	5.38
P_4S_3	36	10	21	67	33890	177620	5.24

*Data not statistically analyzed

Table 5: Economics (Rs.ha^{-1}) of rice hybrid CoRH2 as influenced by establishment methods and split application of N and K

Treatments	Gross income (Rs.ha^{-1})	Cost of Cultivation (Rs.ha^{-1})	Net Income (Rs.ha^{-1})	B:C ratio
P_1S_1	58294	14871	43423	3.92
P_1S_2	58903	14950	43953	3.94
P_1S_3	59135	14933	44202	3.96
P_2S_1	55563	14856	40706	3.76
P_2S_2	56363	15030	41333	3.75
P_2S_3	56341	14945	41397	3.77
P_3S_1	59685	14884	44809	4.01
P_3S_2	60845	15061	45784	4.04
P_3S_3	61160	14990	46170	4.08
P_4S_1	56502	14908	41594	3.79
P_4S_2	57147	14882	42265	3.84
P_4S_3	57925	14891	43034	3.89

*Data not statistically analysed

required for each treatment. In general, seedling broadcasting employed less number of labourers of 36 man days ha^{-1} for planting than line planting (52 man days ha^{-1}). Adoption of seedling broadcasting economized the labour requirement in transplanting to the tune of 30.76% over line transplanting. Among the split application of N and K, three splits of N and two splits of K (S_1) required 6 man days ha^{-1}, four splits of N and three splits of K(S_2) required 8 man days ha^{-1} and five splits of N and four splits of K (S_3) required 10 man days ha^{-1} in both establishments. The data on total labour requirement revealed that adoption of seedling broadcasting of 50 hills m^{-2} with three splits of N and two splits of K (P_4S_1) resulted in less labour requirement of 63 man days ha^{-1}, followed by P_3S_1, P_4S_2 (65 man days ha^{-1}) P_3S_2, P_4S_3 (67 man days ha^{-1}) and P_3S_3 (69 man days ha^{-1}). Line planting of 40 hills m^{-2} with five splits of N and four splits of K (P_1S_3) required more labourers of 89 man days ha^{-1}(Table 4).

Energy use: Adoption of seedling broadcasting with 40 hills m^{-2} and three splits of N and two splits of K (P_3S_1) recorded higher energy use efficiency (5.61). Though the energy input requirement was lower under this treatment, increased total dry matter positively influenced the energy use efficiency. On the other hand, line planting of 40 hills m^{-2} with five splits of N and four splits of K registered lower energy use efficiency, which was mainly due to higher energy input requirement coupled with lower output. Similarly, the energy use efficiency in various lowland rice systems was also reported by Patel *et al.* (1994) and Bhuvaneswari (1998) (Table 4).

Economics: The net return showed considerable difference in various treatments. Higher net income was realized with seedling broadcasting. Seedling broadcasting of 40 hills m^{-1} with five splits of N and four splits of K (P_3S_3) recorded higher net return and B:C ratio (4.08) due to increased gross return. Reduction in cost of cultivation with seedling broadcasting method resulted more benefit than line planting (Table 5). The results are in accordance with Ponnuswamy *et al.* (2000) and Kathiresan and Narayanasamy (2000).

The present study concludes that seedling broadcasting of 40 hills m^{-2} with five splits of N and four splits of K to late *Pishanam* season rice, is a viable crop establishment method and nutrient management package for getting higher income, B:C ratio through higher yield with higher Nitrogen use efficiency under Tambaraparani command area of Tamil Nadu.

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