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Performance of intervarietal intercropping on rice (*Oryza sativa*) in summer

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ABSTRACT

An experiment was conducted during 1996 and 1997 at Kalyani to study on growth, production potential, competition functions and economics of intervartietal intercropping systems in transplanted summer rice (*Oryza sativa* L.). An intercropping of 'Jaya' + 'IR 36' rice at 4:2 planting ratio gave the maximum dry matter, highest number of tillers/m^2, matured panicles/m^2, filled grains/panicle and minium percentage of unfilled spikelets/panicle and resulted in the highest grain yield (6.24 tonnes/ha) per unit area and time which was 28.4 and 30.82% higher than sole 'Jaya' and 'IR 36' respectively. This system was also found to be advantageous compared with monocropping of respective component varieties, with the highest land-equivalent ratio (1.29), area-time equivalent ratio (1.23) and relative crowding coefficient (5.58) values. 'Jaya' + 'IR 36' at 4.2 row ratio proved to be the most remunerative system with maximum net return (Rs 24,211), net production value (1.48), relative value total (1.28), relative net return (1.27) and monetary advantage (7715.3) among the intercropping systems. Net returns accrued with sole 'Jaya', 'IR 36' and 'Pant 4' were increased significantly by Rs 8,687, 8,964 and 7,979/ha owing to intercropping of 'Jaya and 'IR 36' at 4:2 row ratio respectively.

Key words : Rice, Intervarietal intercropping, LER, RCC, ATER, Relative Net return, Monetary advantage, Net production value, Net return

Intervarietal intercropping is an advanced agro-technique practised to minimize the losses caused due to biotic and abiotic stresses. Proper adoption of this technique in rice boosts up the productivity per unit area and time (Mandal *et al.*, 1986). This technique provides scope for intercropping of early and late-maturing rice varieties (Chatterjee and Bhattacharya, 1982), tall and dwarf rice cultivars (Subrahmanyam, 1984) and resistant and succeptible rice strains consequently facilitates 2 crop harvests at different times (Saikia *et al.*, 1990) and harness growth resources efficiently and effectively (Sharma *et al.*, 1996) resulting in higher

total productivity. Before adopting this practice in rice, location-specific information on its advantages, production potential, economics, combination should be assessed. With this objective in view, the present study was undertaken.

MATERIALS AND METHODS

Three rice varieties were grown as sole and intercropped at 3 different row ratios during summer seasons of 1996 and 1997 at the University Farm, Kalyani (23 °N, 80 °E and 9.75 m above mean sea-leavel). The soil was sandy loam, having pH 7.1, total nitrogen (0.078%), available P (8.02 kg/ha) and available K (85.65 kg/ha). All the 12 treatments comprising rice varieties 'Jaya', 'IR 36' and 'Pant 4' grown as sole and intercropped at 1:1, 2:2 and 4:2 row ratios were tried in randomized block design replicated thrice. Thirtyfive-day old seedlings were planted as per the treatments in the first week of February during both the years at 20 cm × 10 cm spacing with 3 seedlings/hill. The crop received basal application of 20 kg N, 40 kg each of P_2O_5 and K_2O/ha and another 40 and 20 kg N/ha were top-dressed at active tillering and panicle-initiation stages respectively. Growth studies were made as per the standard procedures at 55, 70 and 85 days after transplanting (DAT). Competition functions were calculated basing upon the yield data of intercropping systems and economic analysis done taking prevailing market prices (Rs 5,500 and Rs 800/tonne of rice grain and straw respectively) into consideration.

Relative crowding coefficient (RCC), land-equivalent ratio (LER), area-time equivalent ratio (ATER), relative value total (RVT), relative net return (RNR) and monetary advantage (MA) were calculated. Cost of cultivation of various systems were calculated taking number of labourers engaged as one variable and keeping other inputs as constant.

RESULTS AND DISCUSSION

Growth parameters

In general, intercropping at 4:2 row ratio produced more dry matter (DM) than that with 1:1 and 2:2 row ratios throughout the period of crop growth (Table 1). But for leaf-area indices (LAI) and root dry weight (RDW), 2:2 planting ratio was found superior to 1:1 and 4:2 planting ratios at 55, 70 and 85 days after transplanting (DAT). Average performance of 'Jaya' + 'IR 36' was better than 'Jaya' + 'Pant 4' and 'IR 36' + 'Pant 4' with regard to dry matter, while 'Jaya' + 'Pant 4' topped other 2 combinations for LAI and RDW almost at all the stages of growth. However, 'Jaya' + 'IR 36' at 4:2 row ratio produced the highest dry matter which was significantly higher than sole 'Jaya' and 'IR 36 at all the stages of growth. But the highest LAI and RDW were recorded with 'Jaya' and 'Pant 4' at 4:2 ratio which were significantly higher than respective monocultures at 55, 70 and 85 DAT. Mandal *et al.* (1996) also reported increase in LAI, DM and RDW with intercropping systems compared with the monocultures of rice. With a higher rate of increase during 55–70 DAT than during 71–85 DAT, production of DM and RDW reached peak values at 85 DAT. However, peak values of LAI were attained at 55 DAT with sole 'IR 36' and 'Jaya' + 'IR'

Table 1. Effect of intervarietal intercropping on growth of rice (pooled data of 2 years)

Treatment	Dry matter (g/m^2)			Leaf-area indices			Root dry weight (g/m^2)		
	55 DAT	70 DAT	85 DAT	55 DAT	70 DAT	85 DAT	55 DAT	70 DAT	85 DAT
'Jaya' sole	330.7	625.5	710.4	6.56	7.34	5.97	128.7	169.38	177.83
'IR 36' sole	360.4	604.7	628.3	6.85	4.94	3.30	117.51	160.25	167.80
'Pant 4' sole	354.3	667.1	775.3	6.27	6.65	5.79	130.21	168.35	171.85
'Jaya' + 'IR 36' (1:1)	461.7	646.8	735.7	6.41	6.23	4.66	110.3	156.82	168.4
'Jaya' + 'IR 36' (2:2)	463.8	620.1	740.9	6.60	6.29	4.93	159.7	206.70	224.06
'Jaya' + 'IR 36' (4:2)	478.8	676.9	754.6	6.62	6.34	4.88	165.04	224.80	243.53
'Jaya' + 'Pant 4' (1:1)	353.5	560.2	651.8	6.91	7.10	5.88	122.74	159.31	175.86
'Jaya' + 'Pant 4' (2:2)	362.5	580.8	668.2	6.90	7.19	5.98	166.95	207.00	228.07
'Jaya' + 'Pant 4' (4:2)	450.7	660.3	735.8	6.91	7.15	6.20	174.45	226.49	246.61
'IR 36' + 'Pant 4' (1:1)	392.7	635.4	649.5	5.86	5.64	4.04	168.83	224.17	244.13
'IR 36' + 'Pant 4' (2:2)	367.6	559.6	640.0	6.08	5.71	4.00	159.60	204.70	223.76
'IR 36' + 'Pant 4 (4:2)	376.6	530.6	633.2	6.07	5.58	3.80	113.54	154.03	165.15
CD (P = 0.05)	30.2	28.3	22.8	0.3	0.1	0.15	12.20	15.4	18.7

DAT, Days after transplanting

36, 'IR 36' + 'Pant 4' at all the row ratios and thereafter declined. But LAI, in case of 'Jaya' + Pant 4, increased during 55-70 DAT with a peak value at 70 DAT and declined during 71-85 DAT due to longer duration of 'Jaya' and 'Pant 4' compared with 'IR 36'.

Yield components

Intercropping enhanced the number of tillers and number of matured panicles/m^2 significantly with 'Jaya' + 'Pant 4' (4:2), followed by 'Jaya' + 'IR 36' (4:2) compared with the respective monocultures (Table 2). The enhancement was due to spatial and temporal complementarities. Mandal *et al.* (1996) and Subrahmanyam (1987) opined alike. However, the degree of complementarity, in general, was more pronounced with 'Jaya' + 'IR 36' and 'Jaya' + 'Pant 4' than 'IR 36'+ 'Pant 4' in all combinations. Improvement in yield attributes remained more or less uniform at different row ratios. Intercropping had no effect on 1,000-grain weight which happened to be a genetic character of the individual rice varieties. Among the intercropping systems, 'Jaya' + 'Pant 4' and 'Jaya' + 'IR 36' both at 4:2 row ratio significantly produced higher number of tillers/m^2 than the respective sole cultivars. But for matured panicles/m^2, 'Jaya' + 'IR 36' at 4:2 row ratio significantly surpassed sole 'Jaya' and 'IR 36' respectively. This system also produced the maximum filled grains/panicle and the lowest percentage of unfilled spikelets/panicle compared with respective component varieties as well as other intercropping systems. 'IR 36' + 'Pant 4' appeared to be inferior on the above aspects among the systems of intercropping.

Grain yield

An intercropping significantly reduced the grain yield of 'Pant 4' (38–58.6%), followed by 'IR 36' (29.98–6.0.59%) and 'Jaya' (10.29–41.36%) compared to their respective monocultures (Table 2). However, 'Jaya' with 67% of its sole crop population recorded 89.71% of its sole crop yields with 'IR 36' at 4:2 row ratio, while 'IR 36' at the same population obtained 70% of its sole crop yields with 'Pant 4'. Consequently both of them resulted significantly in highest grain yields compared with other combination with 'IR 36' and 'Pant 4'. But intercrop 'IR 36' suffered a significant reduction towards yield of grain (60.59%), followed by 'Pant 4' (58.6%) with 'Jaya' and so also 'Pant 4' (57.8%) with 'IR 36' due to 67% reduction in plant population of both the intercrops as compared to their respective sole plantings. As a result, they gave significantly the lowest grain yields. Nevertheless, combined grain yield of all the intercropping systems was higher than their respective monocultures. Chatterjee and Bhattacharya (1982) and Mandal *et al.* (1996) also made similar observations. The highest combined grain yield was obtained, among the intercropping systems with 'Jaya' + 'IR 36' at 4:2 row ratio due to significant improvement towards yield attributes and production of dry matter. The combined grain yield was 28.4 and 30.82% higher than sole 'Jaya' and 'IR 36' respectively. The lowest grain yield was recorded with 'IR 36' + 'Pant 4' at 4:2 row ratio due to poor development of yield components.

Table 2. Effect of intervarietal intercropping on tiller number, yields attributes, grain and straw yields of rice (pooled data of 2 years)

Treatment	Tillers/ m^2	Matured panicles/ m^2	Filled grains/ panicle	Unfilled spikelets/ panicle	1,000-grain weight (g)			Grain yield (tonnes/ha)				Comb-bined straw yield (tonnes/ha)	Harvest index
					'Jaya'	'IR 36'	'Pant 4'	'Jaya'	'IR 36'	'Pant 4'	Combi-ned		
'Jaya' sole	441	424.4	65.60	18.2	23.44	21.88		4.86			4.86	6.32	43.47
'IR 36' sole	414	396.8	57.80	20.3	23.47	21.95			4.77		4.77	5.59	46.04
'Pant 4' sole	434	418.7	65.10	22.4	23.54	21.86				5.00	5.00	6.24	44.48
'Jaya' + 'IR 36' (1:1)	466	441.5	59.93	20.2	23.38		22.68	3.16	2.96		6.12	7.57	44.70
'Jaya' + 'IR 36' (2:2)	455	435.4	57.54	20.1	23.31		22.72	3.32	2.85		6.17	7.65	44.65
'Jaya' + 'IR 36' (4:2)	466	443.8	61.96	19.5	23.41		22.69	4.36	1.88		6.24	7.87	44.22
'Jaya' + 'Pant 4' (1:1)	460	427.0	59.88	22.5		21.16	22.79	2.85		2.89	5.74	7.31	43.98
'Jaya' + 'Pant 4' (2:2)	446	440.9	61.35	22.2		22.19	22.83	3.14		2.63	5.77	7.37	43.91
'Jaya' + 'Pant 4' (4:2)	472	442.9	60.94	21.9		22.24	22.74	3.78		2.07	5.85	7.50	43.82
'IR 36' + 'Pant 4' (1:1)	435	410.7	59.81	23.3					2.56	3.04	5.60	6.80	45.16
'IR 36' + 'Pant 4' (2:2)	450	417.1	55.19	23.7					2.41	3.10	5.51	6.70	45.13
'IR 36' + 'Pant 4'(4:2)	423	398.5	54.34	24.1					3.34	2.11	5.45	6.54	45.45
CD (P=0.05)	17	12.3	4.1		NS	NS	NS	0.40	0.35	0.30	0.38	0.42	

Straw yield and harvest index

Among the intercropping systems, 'Jaya' + 'IR 36' at 4:2 row ratio gave signifi- cantly the highest straw yield, while 'IR 36' + 'Pant 4' at 4:2 row ratio recorded significantly the lowest (Table 2). But 'IR 36' + 'Pant 4' at 4:2 row ratio recorded the highest harvest index owing to the lowest yield of straw.

Competition functions

Land-equivalent ratio (LER), area-time equivalent ratio (ATER), relative crowding coefficient (RCC), relative value total (RVT) and relative net return (RNR) values in different intercropping systems were greater than unity, indicating both yield advantage and economic viability of the systems over their respective monocultures (Table 3). Mandal *et al.* (1996) reported similar observations. Among the intercropping systems, 'Jaya' + 'IR 36' recorded the highest value of LER and RCC at 4:2 row ratio. These results indicated that with 29% higher land-use efficiency, 23% more yield on per day basis, 'Jaya' + 'IR 36' found to be the most advantageous system perhaps due to greater spatial and temporal complimentrities between the component varieties. The results related to economic analyses also proved that this system was remunerative with the highest RNR, RVT and monetary advantage (MA) values owing to production of the highest combined grain yield, whereas 'IR 36' + 'Pant 4' at 4:2 row ratio secured the lowest values of LER, ATER, RVT, RNR and MA.

Economic profitability

Interspecies intercropping of rice led to higher net return and net production values

Table 3. Effect of intervarietal intercropping on competition functions and economics of rice (pooled data of 2 years)

Treatment	Relative crowding coefficient	Land equivalent ratio	Area time equivalent ratio	Relative value total	Relative net return	Monetary advantage (Rs/ha)	Net return (Rs/ha)	Net production value
'Jaya' sole	1.00	1.00	1.00	1.00	1.00		15,526	0.95
'IR 36' sole	1.00	1.00	1.00	1.00	1.00		15,247	0.94
'Pant 4' sole	1.00	1.00	1.00	1.00	1.00		16,232	0.19
'Jaya' + 'IR 36' (1:1)	3.01	1.27	1.18	1.26	1.24	7,156	22,871	1.36
'Jaya' + 'IR 36' (2:2)	3.16	1.28	1.19	1.27	1.26	7,423	23,480	1.42
'Jaya' + 'IR 36' (4:2)	5.58	1.29	1.23	1.28	1.27	7,715	24,211	1.48
'Jaya' + 'Pant 4' (1:1)	1.91	1.17	1.13	1.18	1.16	4,847	20,573	1.22
'Jaya' + 'Pant 4' (2:2)	2.00	1.18	1.14	1.19	1.18	4,841	21,056	1.27
'Jaya' + 'Pant 4' (4:2)	2.45	1.19	1.16	1.20	1.19	5,137	21,770	1.33
'IR 36' + 'Pant 4' (1:1)	1.79	1.15	1.11	1.17	1.15	4017	19,395	1.15
'IR 36' + 'Pant 4' (2:2)	1.13	1.13	1.09	1.16	1.14	3486	19,090	1.15
'IR 36' + 'Pant 4 (4:2)	1.67	1.12	1.06	1.14	1.14	3212	18,802	1.15
CD (P = 0.05)							2,460	1.16

than their respective monocultures (Table 3). In general, 4:2 planting ratio gave higher net return and net production value than 1:1 planting ratio, whereas 'Jaya' + 'IR 36' out yielded 'Jaya' + 'Pant 4' and 'IR 36' + 'Pant 4' . However, 2:2 and 4:2 planting ratios gave more or less same net return and net production values. Again 'Jaya' + 'IR 36' at 4:2 row ratio accrued the highest net return and net production value, followed by 'Jaya' + 'IR 36' at 2:2 and 1:1 row ration and 'Jaya' + 'Pant 4' at 4:2 row ratio. The lowest net return obtained from sole 'Jaya' + 'Pant 4' at 4:2 row ratio. The lowest net return obtained from sole 'Jaya' and 'IR 36' which was increased to the tune of Rs 8,685 and Rs 8,964, respectively, when both were intercropped at 4:2 row ratio. 'IR 36' + 'Pant 4' at 4:2 ratio secured the lowest net return among the intercropping systems.

Thus during summer season, interspecies intercropping of 'Jaya' + 'IR 36' could be practised at 4:2 row ratio for maximum grain yield, net return and net production value per unit area and time with less competition.

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