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Effect of intercropping rice (*Oryza sativa*) with groundnut (*Arachis hypogaea*) and pigeonpea (*Cajanus cajan*) under different row orientations on rainfed uplands

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ABSTRACT

A field experiment was conducted during the rainy (*kharif*) seasons of 2000 2001 at Baruipur, Kolkata, to evaluate the production potential and economic feasibility of intercropping in rainfed direct-seeded rice (*Oryza sativa* L.) with groundnut (*Arachis hypogaea* L.) and pigeonpea [*Cajanus cajan* (L.) Millsp.] under different spatial arrangements. The intercropping system of rice with either groundnut or pigeonpea was found beneficial over sole cropping of rice. Among the intercropping systems, rice with groundnut in 4:2 row proportion was most productive and remunerative, as it gave the maximum rice-equivalent yield (2,815 kg/ha), net returns (Rs 7,720/ha), income-equivalent ratio (1.61) and higher land-utilization efficiency (31%).

Key words : Direct-seeded rice, Groundnut, Pigeonpea, Intercropping, Productivity

Of the 43 million ha of area under rice, rainfed uplands mostly of which direct-seeded constitutes about 16%, where the productivity of rice is very low (0.5 to 0.6 tonne/ha). The major constraints of growing rice in such lands include severe weed competition, nutrient losses due to light-textured soils, poor growth due to input use, occasional drought and problem of pests and diseases. Inadequate and uncertain distribution of rainfall and low radiation due to cloudy weather in the rainy season limits the yield of rice. In such rainfed uplands, rice-based intercropping is useful in overcoming the risks of aberrant weather and also in increasing productivity (Angadi and Chittapur, 1990). Stability of crop yield can be achieved in upland with crop substitution and intercropping (Rao *et al.* 1982). Spatial arrangement and plant population in an intercropping have important effects on the balance of competition between component crops and their productivity. Hence present experiment was undertaken to evaluate the comparative performance of intercropping rice with groundnut and pigeonpea at different row proportions under rainfed Gangetic alluvial uplands.

MATERIALS AND METHODS

The field experiment was conducted during the rainy seasons of 2000 and 2001 at the experimental farm of Calcutta University, Baruipur (22°22 N, 88°26 E and 1.3 m above mean sea-level), on Gangetic alluvial upland soil (Entisol) having organic carbon 0.71%, available P 22 kg/ha, available K 248 kg/ha, with pH 6.2. The treatments consisted of sole crops of rice ('Rasi'), groundnut ('AK-12-24') and pigeonpea ('UPAS 120') and 12 additive cereal–legume intercropping systems of rice with each groundnut and pigeonpea in row ratios of 2:1, 4:1, 6:1, 2:2, 4:2 and 6:2 (Table 1).

Fifteen treatments were laid out in randomized block design with 3 replications. The additive rows of groundnut and pigeonpea were adjusted according to row ratio of treatments. The nutrients in sole stands of rice, groundnut and pigeonpea were applied as 60: 40:20; 20:60:40; 20:60:40 kg N, P_2O_5 and K_2O/ha, respectively, and in intercrops as per their row ratios. The row spacing for rice, groundnut and pigeonpea was 20 cm, 30 cm and 60 cm respectively. The total rainfall during the crop period of June–Novemebr in 2000 and 2001 was 1,286 and 1,215 mm respectively. The treatment effects during both the years were more or less similar and hence 2 years data were pooled and statistically analysed. Different competition indices were calculated (Wiley, 1979). Rice-equivalent yield was computed by converting the yields of intercrops in the yield of rice on the basis of prevailing market price of individual crops. The economics of different crops and crop combinations were computed on the basis of prevailing market rates of the different commodities.

RESULTS AND DISCUSSION

Productivity of main crop

Sole crop of rice showed higher number of effective tillers/m^3 over intercropped rice (Table 1). Number of ef-

fective tillers/m^2 of rice decreased considerably in intercropping system depending on nature of intercrops and their spatial arrangement. Number of filled grains/panicle and unfilled spikelets/panicle, test weight of rice showed greater variation due to intercropping system. Rice in association with each groundnut and pigeonpea in 6:1 row proportion recorded higher number of effective tillers/m^2, filled grains/panicle, test weight of grains, and lower number of unfilled spikelets/panicle owing to regular and timely availability of nitrogen fixed by associated legume plants and higher plant population of base crop.

Maximum reduction in effective tillers/m^2, filled grains/panicle and test weight of grains were recorded in rice intercropped with either groundnut or pigeonpea in 2:1 row proportion. Intercropping system of rice with either groundnut or pigeonpea in 6:1 row proportion recorded higher grain yield of rice on account of improvement in yield attributes due to lesser competition effect offered by legume intercrops and also depressing effect of intercrops on rice under 6:1 row ratio was minimized due to more number of rows of rice.

Productivity of intercrops

Sole crops of groundnut and pigeonpea recorded higher yield attributes and grain yield over their respective intercropped stands. Yield attributes and yield of groundnut and pigeonpea decreased due to intercropping with rice irrespective of row arrangement. Magnitude of reduction in yield attributes of groundnut and pigeonpea varied with plant population and spatial arrangement of component species. Such reduction in yield attributes of groundnut and pigeonpea might be due to shading and competition effect by rice plants on associated legume components. Lesser reduction in yield attributes of groundnut and pigeonpea were recorded in intercropping with rice in 2:2 row proportion owing to balanced competition between component species having equal plant density. More reduction in yield attributes of groundnut and pigeonpea were recorded in intercropping system of rice with groundnut and pigeonpea in 6:1 row proportion due to intense competition effect owing to greater population pressure of rice.

Total Productivity

All the intercropping systems showed superiority to sole cropping of rice, as evident by rice-equivalent yield (Table 1). The maximum rice-equivalent yield (2,815 kg/ha) was recorded with rice+groundnut, followed by rice+pigeonpea, in 2:2 row ratio. Higher rice-equivalent yield under intercropping pattern of rice with groudnut or pigeonpea in 2:2 row ratio may be owing to better utilization of resources and balanced competition between component crop species. An increase in row proportion of rice to 6 over 2 and 4 in the intercropping system of rice with

Table 1. Yield components and yield of sole and intercrops as affected by intercropping system (mean of 2 years)

Treatment	Rice					Intercrop				
	Effective tillers/m^2	Filled grains/ panicle	Unfilled spikelets/ panicle	1,000-grain weight (g)	Grain yield of rice (kg/ha)	Pods/ plant	Kernels or Seeds/pod	100-kernels or 1,000-seed weight (g)	Seed yield (kg/ha)	Rice equivalent yield (kg/ha)
Sole cropping										
Rice	344.4	74.4	11.4	21.9	1,780					1,780
Groundnut						22.0	1.90	38.0	1,125	2,659
Pigeonpea						250.6	5.40	86.4	1,050	2,482
Intercropping										
Rice : groundnut										
2 : 1	192.6	69.6	16.2	22.2	1,390	17.2	1.78	34.2	515	2,607
4 : 1	230.4	74.9	14.1	22.4	1,630	14.4	1.56	32.3	445	2,682
6 : 1	245.0	76.2	13.6	23.3	1,660	12.8	1.52	31.9	305	2,381
2 : 2	206.8	72.0	14.6	22.5	1,420	19.0	1.82	36.2	590	2,815
4 : 2	225.5	76.4	13.2	22.9	1,460	16.2	1.71	34.8	470	2,571
6 : 2	221.9	69.9	15.3	22.1	1,535	13.8	1.58	30.8	438	2,570
Rice : pigeonpea										
2 : 1	174.6	71.2	14.0	22.0	1,350	215.0	4.6	81.3	492	2,513
4 : 1	224.8	75.1	15.1	22.6	1,570	208.6	4.4	79.6	325	2,338
6 : 1	236.4	77.2	16.7	23.1	1,655	203.0	4.2	76.4	275	2,305
2 : 2	201.0	71.9	14.1	21.9	1,350	235.0	4.9	81.6	578	2,716
4 : 2	222.6	75.4	13.0	23.1	1,450	212.8	4.5	79.8	525	2,691
6 : 2	215.0	70.1	15.0	22.0	1,500	204.0	4.3	74.4	380	2,398
CD (P=0.05)	3.7	3.7	1.5	NS	24	–	–	–	–	25

Table 2. Biological and economic parameters of rice, groundnut and pigeonpea intercropping system (mean of 2 years)

Treatment	LER	CR_r	CR_i	A_r	K_r	Ki	K	Net	Increase in returns (Rs/ha)	Monetary net returns over rice (%)	LER advantage (Rs/ha)
Sole cropping											
Rice							4,790	100			
Groundnut							6,050	126			
Pigeonpea							6,325	133			
Intercropping											
Rice : groundnut											
2 : 1	1.23	1.29	1.15	–0.20	1.78	1.68	2.99	7,260	152	2,607	1.51
4 : 1	1.30	0.58	1.71	–0.52	2.71	2.61	7.07	7,315	154	3,403	1.52
6 : 1	1.20	0.67	1.44	–0.81	2.30	2.23	5.29	6,530	137	2,182	1.36
2 : 2	1.31	1.51	0.65	0.55	3.94	1.10	4.33	7,720	162	3,715	1.61
4 : 2	1.23	1.00	1.00	–0.02	2.28	1.43	3.26	6,915	145	2,643	1.44
6 : 2	1.24	1.19	1.32	–0.41	2.08	1.91	3.97	7,000	147	2,736	1.46
Rice : pigeonpea											
2 : 1	1.21	0.81	1.22	–0.27	1.56	1.76	2.74	6,675	140	2,399	1.39
4 : 1	1.18	0.66	1.36	–0.44	1.86	1.79	3.32	6,450	136	1,962	1.34
6 : 1	1.18	0.58	1.69	–0.75	2.20	2.12	4.66	6,385	134	1,934	1.33
2 : 2	1.30	1.36	0.73	0.41	3.13	1.22	3.81	7,525	158	3,477	1.57
4 : 2	1.31	0.81	1.22	–0.28	2.19	2.00	4.38	7,410	156	3,529	1.54
6 : 2	1.20	0.77	1.28	–0.32	1.78	1.70	3.02	6,870	144	2,198	1.43

LER, Land-equivalent ratio; CRr and CRi, competitive ratio of rice on intercrops and of intercrops on rice; aggressivity of rice; Kr and Ki, crowding coefficient of rice on intercrops and of intercrops on rice; K, product of crowding coefficient, Prevailing market prices of rice, groundnut and pigeonpea @ Rs 5.5, Rs 14.0 and Rs 13.0 respectively

either groundnut or pigeonpea in 6:1 row ratio gave the maximum rice-equivalent yield. Increased proportion of cereal component resulted in higher rice yield, resulting in increased rice-equivalent yield. Sole groundnut had more rice-equivalent yield compared with sole crop of rice and pigeonpea as well as intercropping system of rice with either groundnut or pigeonpea in almost all the row ratios except rice + groundnut in 4:1, 2:2 row ratio and rice+pigeonpea in 2:2 and 4:2 row ratio.

Biological feasibility

Intercropping system of rice with groundnut and pigeonpea resulted in land-equivalent ratio (LER) greater than 1, indicating intercropping advantages. The mean LER in 2 years ranged from 1.18 to 1.31, indicating that intercropping system had a greater impact on the productivity of the system. Intercropping system of the rice with groundnut in 2:2 row proportion and with pigeonpea in 4:2 row ratio showed the maximum biological efficiency (1.31) of the system. This yield advantage due to intercropping may possibly be attributed to the combined effect of better utilization of natural resources than sole cropping of companion crops, resulting in higher productivity per unit area. The association of rice with pigeonpea in 4.1 and 6.1 row ratios gave lower LER (1.18), indicating inefficient systems. The companion crop of groundnut or pigeonpea appeared more competitive than rice giving higher values for competitive ratio (Table 2), except under 2:1 and 2:2 row proportion of rice + groundnut and rice + pigeonpea, respectively, which is further evident from aggresivity factor where rice was only aggressive under 2:2 row ratio with both groundnut and pigeonpea. The relative crowding coefficient values of rice were always greater than 1, indicating that rice gave more yield than expected. The crowding coefficient indicated that it was advantageous to grow rice with groundnut and pigeonpea which gave higher values than unity, which was further established from the product of crowding coefficient. It indicated that intercropping of rice with groundnut or pigeonpea can be biologically sustainable.

Economic productivity

Intercropping of rice with groundnut and pigeonpea at different row ratios gave higher net returns than sole crops of rice, groundnut and pigeonpea (Table 2). There was 126 to 162% increae in net returns over sole rice under all intercropping situations. The intercropping of rice with groundnut in 2:2 ratio gave the maximum net return (Rs 7,720/ha) followed by rice + pigeonpea in 2: 2 ratio (Rs 7,525/ha). Intercropping of rice with groundnut in 2:2 ratio accounted for maximum monetary advantages (Rs 3,715/ha) and income-equivalent ratio (1.61) and also in-

creased net return by 162% over pure crop of rice. Intercropping of rice with pigeonpea in 2:2 row ratio also proved to be remunerative with higher net return, income-equivalent ratio (1.57) over other treatments.

Intercropping of rice with groundnut and pigeonpea under 2:2 ratio is more sustainable, as these associations are accounted for better values in respect of biological parameters and are economically more productive.

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