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Biological and economical feasibility of intercropping vegetables with rainfed upland rice (*Oryza sativa*) in Eastern Ghats, Orissa

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ABSTRACT

Eight intercropping systems comprising 2 crop combinations, viz. rice (*Oryza sativa* L.) + okra (*Hibiscus esculentus*) and rice + radish (*Raphanus sativus* L.), 2 row ratios (2:1 and 4:2) and 2 land configurations (level bed and ridge-furrow) and 3 sole crops (rice, okra and radish) were grown during the rainy season of 1998, 1999 and 2000 at Phulbani, Orissa. Rice + okra and rice + radish intercropping systems gave mean rice-equivalent yield of 62.20 and 40.34 q/ha, net return of Rs 19, 657 and Rs 9,918/ha, and return/ rupee investment of Rs. 2.82 and Rs 2.00 respectively. Planting rice in furrows and vegetables in ridges recorded rice-equivalent yield of 54.85 q/ha, net return of Rs 16, 066/ha and return/rupee investment of Rs 2.45 compared with 47.67 q/ha, Rs 13,510 and Rs 2.37 /Re from planting both on level bed. The 2 row ratios exhibited marginal difference s in rice-equivalent yield, net return and return/rupee investment. Rice + okra (4:2) in ridge and furrow planting gave rice-equivalent yield of 67.01 q/ha, net return of Rs 21,466/ha and return/rupee investment of Rs 2.89 compared with 28.01 q/ha, Rs 5,132/ha and Rs 1.60/Re, respectively, from sole rice. Considering crop compatibility, intercultural advantages, yield and economics, this system may be advocated in place of sole rice in rainfed uplands.

Key words : Rainfed, Upland rice, Eastern Ghats, Land-equivalent ratio

The major production system in Orissa is rainfed rice-based cropping. Only 38% of the total rice area in the state is under irrigation. Rice is grown in various topo-sequences ranging from uplands in foot-hills to lowlands in lower elevation. Under upland condition farmers grow early or extra-early local rice varieties, which give very low economic returns. Rice crop is subjected to partial or complete failure in most of the years. Rice is the staple crop of the farmers. Several efforts have been made in the past to substitute this crop with other crops but farmers continue to grow this

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crop because of their affinity. There is a need to include other crops in rice-based system to stabilize yield and income across seasons under upland condition (Umapathy *et al.*, 1991). Light-textured well-drained soil conditions in uplands provides opportunity for cultivation of vegetables. Radish as an intercrop proved to be economically viable in maize (Prasad and Prasad, 1998). Okra was found compatible with field crops like sugarcane (Tiwari *et al.*, 1983) and ginger (Chowdhury, 1988). The present experiment was designed to find out a suitable rice + vegetable intercropping system which would give higher economic return besides providing insurance against failure of any crop.

MATERIALS AND METHODS

An experiment involving intercropping of vegetables with rainfed upland rice was conducted at the Dryland Agriculture Research Station, Phulbani, Orissa, during the rainy seasons of 1998, 1999 and 2000. Phulbani is located in North Eastern Ghat Zone of Orissa with 20^0 28' N, 84^0 14' E and altitude 736 m above mean sea-level. It has a tropical sub-humid climate with pre-monsoon, monsoon and post-monsoon rainfall of 137, 1,187 and 116 mm respectively. The soil was acidic (pH 5.5) sandy loam, with bulk density 1.6 g/cm^3, organic carbon 0.24%, electrical conductivity 0.018 dS/m, available P 7 kg/ha and available K 360 kg/ha.

Two vegetable crops, viz. okra and radish, were intercropped with rainfed upland rice in 2 row ratios and grown under 2 seed-bed configurations (Table 1) and the performance of the systems was compared with sole crop of rice, okra and radish. Eleven treatments were tried in randomized block design with 3 replications. Rice cv. 'Khandagiri' (1998) and 'ZHU 11-26' (1999 and 2000), okra cv. 'Parbhani Kranti' and radish cv. 'Pusa Chetki' were selected for the experimental purpose. Rice cv. 'ZHU 11-26' was a mutant of 'ZHU LIAN-AI' from Taiwan, China. The crops were sown during the second week of July in 1998 and the last week of June in 1999 and 2000. Rice was harvested during the last week of October in 1998 and the third week of September in 1999 and 2000. Radish was uprooted during 14 August–4 September, 5 August– 21 August and 7 August–20 September in the first, the second and the third year respectively. Okra was harvested between 30 August and 30 October, 20 August and 28 September and 20 August and 4 October during the respective years.

Sole rice was sown in 15 cm apart rows, while sole okra and sole radish were sown with spacing of 30 cm × 30 cm and 30 cm × 10 cm respectively. In rice + vegetable (2:1) system, both the crops were sown with uniform spacing of 15 cm from line to line. In rice + vegetable (4:2) system, 4 rows of rice with uniform 15 cm spacing were sown in the 75 cm inter-pair distance of okra or radish. Bed height of 15 cm was made for planting vegetables in ridges and rice in furrows at the time of final land preparation. Sole crop of rice, okra and radish were fertilized with 60, 30, 30; 75, 50, 50 and 50, 50 and 75 kg N, P_2O_5 and K_2O/ha respectively. In intercropping systems, fertilizer was applied based on the proportion of plants of component crops.

Nitrogen was applied in 3 splits in rice, i.e. 25% basal, 50% at first weeding (20 days after sowing) and 25% at panicle-initiation stage. In okra and radish, nitrogen was applied in 2 splits, i.e. 50% basal and 50% 20 days after sowing coinciding with the first weeding and hoeing.

Monsoon and total annual rainfall received were 775 and 1,175 mm, 975 and 1,291 mm and 821 and 942 mm during 1998, 1999 and 2000 respectively. Monsoon rain and distribution were more of less favourable for the experimental crops during all the 3 years.

RESULTS AND DISCUSSION

Yield of rice

Grain yield of rice was higher during 1999 and 2000 than that during 1998, mainly owing to growing of short-statured, high-yielding rice variety 'ZHU 11-26' in place of rice cv. 'Khandagiri' (Table 1). Mean rice yield was 17.13 and 18.94 q/ha when okra and radish were intercropped with rice respectively. The decrease in grain yield of rice in rice + okra system may be attributed to greater competition between the 2 crops. Radish was harvested early before the flowering stage in rice, while flowering and fruiting in okra continued even after the harvesting of rice. Rice + vegetable (2:1) system gave mean rice grain yield of 19.26 q/ha compared with 16.82 q in rice + vegetable (4:2). Rice yield was 17.23 q/ha in level bed condition compared with 18.84 q in ridge furrow system.

Yield of intercrops

Sole okra and radish gave mean fruit and swollen root + green leaf yield of 61.99 and 205.46 q/ha respectively. Okra intercrop gave higher fruit yield than its sole crop on proportionate area basis, while radish intercrop recorded lower yield compared to sole radish. Okra intercrop could manage with tilth and interculture given to rice, while radish did not perform well with such tilth and interculture. Vegetable intercrop, particularly radish performed better under ridge and furrow system. Rotting of swollen root of radish during prolonged wet spell was less under ridge-furrow system as compared to level bed.

Rice-equivalent yield

Intercropping system involving okra and radish gave mean rice-equivalent yield of 62.20 and 40.34 q/ha respectively. Behera *et al.* (1996) also found okra to be the most feasible intercrop with rainfed pigeonpea in Orissa. Level bed system recorded mean rice-equivalent yield of 47.67 q/ha compared with 54.85 q/ha in ridge-furrow system. Ridge-furrow system favoured both rice and vegetable, leading to higher rice-equivalent yield. Vegetable crops got well aerated soil conditions while rice, a water-loving crop, got a relatively more moist soil environment. The row ratios did not differ much in respect of rice-equivalent yield. All intercropping systems, sole okra and sole radish recorded higher rice-equivalent yield than sole rice.

Land-equivalent ratio

The values of land-equivalent ratio (LER) in rice + okra intercropping system were higher than rice + radish. Rice + okra (2:1) in ridge-furrow system registered the

Table 1. Yield performance of rice + vegetable intercropping system during 1998-2000

Treatment	Yield (q/ha)							
	Main crop				Intercrop			
	1998	1999	2000	Mean	1998	1999	2000	Mean
T_1, Rice + okra (2:1), level bed	9.77	21.91	20.27	17.32	35.43	28.95	47.50	37.29
T_2, Rice + okra (2:1), ridge and furrow	9.73	25.92	22.57	19.41	34.99	39.41	49.10	41.17
T_3, Rice + okra (4:2), level bed	9.05	21.02	15.97	15.35	32.61	28.63	42.90	34.71
T_4, Rice + okra (4:2), ridge and furrow	9.86	23.27	16.23	16.45	38.09	42.20	44.00	41.43
T_5, Rice + radish (2:1), level bed	10.61	22.95	24.13	19.23	70.99	67.78	67.70	68.82
T_6, Rice + radish (2:1), ridge and furrow	13.24	24.83	25.10	21.06	100.50	68.30	77.70	82.17
T_7, Rice + radish (4:2), level bed	9.05	22.74	19.30	17.03	101.22	62.86	68.80	77.63
T_8, Rice + radish (4:2), ridge and furrow	11.39	23.68	20.23	18.43	95.09	104.60	72.90	90.86
T_9, sole rice	18.03	34.90	31.20	28.04				
T_{10}, sole okra					61.97	61.60	62.40	61.99
T_{11}, sole radish					243.80	175.59	197.00	205.46

Table 2. Rice-equivalent yield, land-equivalent ratio and comparative economics (mean data of 3 years) of various rice-based intercropping systems

Treatment	Rice-equivalent yield (q/ha)				Land-equivalent ratio (LER)				Net return (Rs/ha)	Return/ rupee invest-ment (Rs/Re)
	1998	1999	2000	Mean	1998	1999	2000	Mean		
T_1, Rice + okra (2:1), level bed	57.00	56.56	66.77	60.11	1.11	1.10	1.41	1.21	19,052	2.87
T_2, Rice + okra (2:1), ridge and furrow	55.43	73.09	70.68	66.40	1.10	1.38	1.51	1.33	21,364	2.88
T_3, Rice + okra (4:2), level bed	52.68	55.19	58.00	55.29	1.03	1.07	1.20	1.10	16,745	2.65
T_4, Rice + okra (4:2), ridge and furrow	60.66	80.97	59.39	67.01	1.16	1.36	1.23	1.25	21,466	2.89
T_5, Rice + radish (2:1), level bed	26.39	43.12	44.01	37.84	0.88	1.05	1.11	1.01	9,216	1.99
T_6, Rice + radish (2:1), ridge and furrow	35.66	45.25	47.95	42.95	1.14	1.10	1.19	1.14	10,637	2.02
T_7, Rice + radish (4:2), level bed	31.52	41.53	39.51	37.52	0.92	1.01	0.97	0.97	9,025	1.98
T_8, Rice + radish (4:2), ridge and furrow	32.52	54.97	41.67	43.05	1.02	1.28	1.02	1.11	10,795	2.02
T_9, sole rice	18.03	34.90	31.21	28.05	1.00	1.00	1.00	1.00	5,132	1.60
T_{10}, sole okra	82.83	73.78	61.18	72.60	1.00	1.00	1.00	1.00	22,115	2.71
T_{11}, sole radish	54.18	52.56	57.99	54.91	1.00	1.00	1.00	1.00	15,477	238
SEm ±	3.72	0.91	6.52							
CD (P = 0.05)	10.99	2.68	19.24							

Sale price (Rs/q) : rice 450, 490 and 510; okra 600, 600 and 500; radish 100, 100 and 150 during 1998, 1999 and 2000 respectively

maximum LER of 1.33. The LER values less than 1 in rice + radish (4:2) in level bed indicated crop incompatibility.

Economics

Sole okra, sole radish and all rice + vegetable intercropping systems recorded higher net returns and return/rupee investment than sole rice (Table 2). Rice + okra and rice + radish intercropping systems gave average net return of Rs 19,657 and Rs 9,918/ha and return/rupee investment of Rs 2.82 and Rs 2.00/Re, respectively. The 2 row ratios exhibited marginal differences in these 2 economic indicators. Ridge-furrow and level bed gave average net return of Rs 16,066/ha and Rs 13,510/ha and return/rupee investment of Rs 2.45 and Rs 2.37 /Re respectively. Rice + okra (4:2) and rice + okra (2:1) in ridge and furrow system gave the maximum net returns of Rs 24,466 and Rs 21,364/ha and return/rupee investment of Rs 2.89 and Rs 2.88 respectively. Considering crop compatibility, yield and economics, rice + okra (4:2) in ridge and furrow system may be adopted in place of sole rice. Economic viability of okra intercrop in rainfed pigeonpea was earlier reported by Behera *et al.* (1999).

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