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Diversification of rice (*Oryza sativa*)–based cropping system in new alluvial zone of West Bengal

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ABSTRACT

In a field experiment with rice (*Oryza sativa* L.)-based crop sequences, viz. rice–rice–*dhaincha* [*Sesbania cannabina* (Retz.) Pers.], rice–rice, rice–mustard [*Brassica juncea* (L.) Czernj. & Cosson]–okra (*Hisbiscus esculentus*), rice–potato (*Solanum tuberosum* L.)–sesame (*Sesamum indicum* L.), rice–potato–groundnut (*Arachis hypogaea* L.), rice–potato–rice, rice–wheat (*Triticum aestivum* L. emend. Fiori & Paol.)–jute (*Corchorus olitorius* L.), rice–cabbage [*Brassica oleracea* L. convar. *capitata* (L.) Alef. var *capitata*]–rice and rice–mustard, were tested for their performances over 4 years during 1997–2000 at Kalyani, West Bengal. Rice–potato–groundnut gave the highest gross return, net return and benefit : cost ratio (Rs 105,117, Rs 68,019/ha/year and 1.833 respectively), followed by rice–cabbage–rice, rice–potato–rice and rice–potato–sesame. Maximum amount of energy was harvested (196,980 MJ/ha/year) from rice–potato–groundnut, followed by rice–potato–rice and rice–cabbage–rice. Rice–equivalent yield, production efficiency, land-use efficiency and energy-use efficiency were highest in rice–potato–groundnut sequence. The yield of subsequent rainy-season rice in pooled analysis was also higher in rice–potato–groundnut sequence indicating that this sequence has good effect on subsequent rice crop.

Key words : Cropping system, Net return, Benefit : cost ratio, Energy, Conservation

Diversification of cropping systems is necessary to get higher yield and return, to maintain soil health, preserve environment and meet daily requirement of human and animals. Thus, not only the number of crops but the type of crops included in the cropping sequence are also important. For this, heavy reliance on cereal crops need to be shifted to other food crops like potato, vegetables, pulses and oilseeds. Inclusion of potato in rice-based crop sequence in West Bengal has become attractive because of high yield and remunerative price of potato (IPCP, 1999), Samui *et al.* (1995), Roy Bardhan *et al.* (1999) and Raju and Reddy *et al.* (2000) reported that inclusion of legume increases soil fertility status. Baishya and Sharma (1990) and Parihar *et al.* (1999) reported that energy output of major products was highest in the rice–groundnut system. Hence it was felt necessary to work out location-specific cropping system for New Alluvial Zone in West Bengal, which can utilize resources judiciously to maximize return and protect the environment.

MATERIALS AND METHODS

An experiment with 9 types of crop sequences (Table 1) was initiated during 1997 in randomized complete-block design with 4 replications in fixed plots of 7 m × 7 m area. The experiment was conducted for 4 consecutive years at the University Experimental farm at Gayespur (89°E, 23° N, 9.75 m altitude). Initially soil had organic carbon 0.964%, pH 7.6, EC 0.24 dS/m, available nitrogen 0.094%, available P_2O_5 33 kg/ha and available K_2O 137 kg/ha. Details of different treatment are given in Table 1. Different crops and their varieties with respective fertilizer doses were: rice ('IET 4094') – 80:60:40, mustard ('B 9') –60:60:40, potato ('Kufri Jyoti')– 150:100:150, wheat ('UP 262') – 100:60:40, cabbage ('Local') – 150:60:60, groundnut ('ICGS 44') – 20:60:40, sesame ('B 67') – 60:40:40, okra ('Mhyco hybrid') – 20:60:40, jute ('JRO 7835')–60:40:40 and *dhaincha* as green-manure crop. Data for different seasons and years were pooled and analysed statistically. The crop energy (K cal/g) was calculated as follows : Rice and wheat (3.46), potato (0.97), mustard (5.41), sesame (5.63), groundnut (5.67) jute (8.10), *dhaincha* (green-manure) (0.80), cabbage (0.27), okra (0.35) based on data of (IASRI, New Delhi).

RESULTS AND DISCUSSION

Rice–potato–groundnut recorded the highest yield of rainy-season rice and lowest yield of rainy-season rice in crop sequence of rice–mustard, though there was no sig-

nificant difference in yield of rice among different crop sequences (Table 1).

As the experiment was conducted with different crop sequences, consisting of crops of diverse nature, it is worthwhile to compare crop sequences on the basis of gross return, net return, benefit : cost ratio and in terms of energy production per unit area of land. Significant differences existed in pooled analysis among the crop sequences under consideration in all the years of experimentation (Table 1). Rice–potato–groundnut, rice–cabbage–rice and rice–potato–rice and rice–potato–sesame have got potentiality to give better return, depending on the market conditions of different constituent crops. Analysis revealed that rice–potato–groundnut gave maximum return. Rice–potato–groundnut also provided maximum net return, followed by rice–cabbage–rice, rice–potato–rice and rice–potato–sesame. Thus inclusion of vegetables in the crop sequences can boost the profitability of the sequences. Year-wise analysis of the benefit : cost ratio Gross return: cost of cultivation) reveals that maximum benefit can be obtained either of the 4 crop sequences, viz. rice–potato–groundnut, rice–cabbage–rice, rice–potato–rice, rice–potato–sesame. Pooled analysis showed that maximum benefit : cost ratio was obtained from the rice–cabbage–rice, followed by rice–potato–groundnut, rice–potato–rice and rice–potato–sesame. These results confirm the findings of Samui *et al.* (1995) and Roy Bardhan *et al.* (1999).

Rice–equivalent yield was the highest in rice–potato–groundnut (22.06) system, followed by rice–cabbage–rice (18.44) and lowest with rice–mustard system. (Table 2). Production efficiency and land-use efficiencies were higher in rice–potato–groundnut (60.4 and 86.8 respectively), followed by rice–cabbage–rice and lowest in rice–mustard sequence.

Amount of energy harvested from a unit area of land over the year of cropping following different crop sequences is also another important measure of the superiority of different crop sequences over others. Crop sequences rice–cabbage–rice, rice–potato–rice and rice–potato–sesame were superior to the other sequences (Table 3). Maximum amount of energy (196,980 MJ/ha/year) was harvested from crop sequence of rice–potato–ground-

Table 1. Evaluation of different crop sequences tested for New Alluvial Zone of West Bengal (Pooled data 1997–2000)

Treatment	Seasons and crops			System duration (days)	Rainy-season rice yield (tonnes/ha)	Gross return (Rs/ha)	Net return (Rs/ha)	Benefit : cost ratio
	Rainy season	Winter season	Summer boro					
T_1	Rice	Rice	Green manure	280	4.046	38,665	20,807	1.184
T_2	Rice	Rice		240	4.268	39,855	23,299	1.419
T_3	Rice	Mustard	Okra	270	4.246	84,954	50,922	1.664
T_4	Rice	Potato	Sesame	300	4.187	90,024	55,321	1.731
T_5	Rice	Potato	Groundnut	330	4.282	105,177	68,019	1.833
T_6	Rice	Potato	Rice	330	4.184	91,316	56,985	1.732
T_7	Rice	Wheat	Jute	335	4.235	52,771	28,217	1.166
T_8	Rice	Cabbage	Rice	310	4.120	97,088	60,777	1.855
T_9	Rice	Mustard		210	3.879	26,334	10,991	0.754
CD(P=0.05)					NS	4,651	2,746	0.077

Table 2. Yield data and production efficiency of different crop sequences tested for New Alluvial Zone of West Bengal

Treatment	Crop sequence			Yield (tonnes/ha)			Rice equivalent (tonnes/ha)	Production efficiency (kg/ha/day)	Land-use efficiency (kg/day/ha)
	Rainy season	Winter season	Summer/ boro	Rainy season	Winter season	Summer/ boro			
T_1	Rice	Rice	Green manure	4.05	4.15		8.2	22.500	29.2
T_2	Rice	Rice		4.27	4.12		8.39	23.00	34.9
T_3	Rice	Mustard	Okra	4.25	0.82	18.45	16.08	44.000	59.6
T_4	Rice	Potato	Sesame	4.19	22.19	0.95	14.87	40.700	49.5
T_5	Rice	Potato	Groundnut	4.28	20.28	2.19	22.06	60.400	86.8
T_6	Rice	Potato	Rice	4.18	21.28	2.84	16.84	46.100	51.0
T_7	Rice	Wheat	Jute	4.23	2.92	2.52	10.35	28.400	30.9
T_8	Rice	Cabbage	Rice	4.12	25.99	2.33	18.44	50.500	59.4
T_9	Rice	Mustard		3.88	0.72		5.53	15.100	26.3

Table 3. Energy efficiency of different crop sequences for New Alluvial Zone of West Bengal

Treatment	Seasons and crops			System energy input (MJ/ha)	System energy output (MJ/ha)	System net energy return (MJ/ha)	System energy-use efficiency (MJ/ha/day
	Rainy season	Winter seasons	Summer/ boro				
T_1	Rice	Rice	Green manure	36,884	1,19,280	82,396	426
T_2	Rice	Rice		33,276	1,21,923	88,647	508
T_3	Rice	Mustard	Okra	40,751	1,07,520	66,769	398
T_4	Rice	Potato	Sesame	41,342	1,73,460	1,32,118	578
T_5	Rice	Potato	Groundnut	40,842	1,96,980	1,56,137	597
T_6	Rice	Potato	Rice	50,698	1,88,580	1,37,881	571
T_7	Rice	Wheat	Jute	37,540	1,49,940	1,12,400	448
T_8	Rice	Cabbage	Rice	48,028	1,23,060	75,032	397
T_9	Rice	Mustard		26,151	72,660	46,509	346

nut, confirming the results of Parihar *et al.* (1999), followed by rice–potato–rice and rice–cabbage–rice sequence respectively. System net energy return (156,137 MJ/ha/year) and energy-use efficiency (597 MJ/ha/day) were highest in rice–potato–groundnut sequence (Table 3). Rice–potato–sesame (578 MJ/ha/day) and rice–potato–rice (571 MJ/ha/day) proved efficient crop sequence in terms of energy-use efficiency, while rice–mustard system had lowest (346 MJ/ha/day) energy-use efficiency.

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