Diversification of rice-based cropping system and their impact on energy utilization and system production

M. RAY, S. CHATTERJEE[1], M. PRAMANICK, P. K. MANI[2], K. ROY[3] AND K. SENGUPTA

Department of Agronomy
[1] Department of Agriculture Economics
[2]Department of Soil Science [3]Department Agricultural Entomology
Bidhan Chandra Krishi Viswavidyalaya, Mohanpur-741252, Nadia, West Bengal,

ABSTRACT

In an on-farm field experiment different rice (Oryza sativa) based crop sequences were tested for their performance over two consecutive years 2006-07 and 2007-08 at Haringhata, Nadia, West Bengal. The sequences were: rice – rice, rice – rapeseed (Brassica campestris) – sesame (Sesamum indicum L.), rice – potato (Solanum tuberosum L.) – sesame, rice – potato – lady's finger (Hibiscus esculentus) and rice – rapeseed – rice. Among the five cropping systems, rice-potato-lady's finger gave the highest system yield as well as net return and the rice-rice cropping system recorded lowest system yield as well as net return in both the experimental year. During the 1st year of experimentation, rice-rapeseed-rice cropping sequence was found to be the best regarding benefit cost ratio, though it is statistically at par with the rice-potato-lady's finger sequence and showed its superiority over the other sequences in the 2nd year. Highest energy productivity as well as fuel energy use efficiency was recorded with rice – potato – sesame (0.54kg/MJ and 1.97kg/MJ, respectively), followed by rice – potato – lady's finger (0.52kg/MJ and 1.66kg/MJ, respectively). Considering productivity, profitability, energy use efficiency and fossil fuel energy use efficiency rice – potato – lady's finger was the best out of the five crop sequences.

Key words: *Cropping system, energy use efficiency, net return and system yield.*

Occurrence of second generation problems, such as over-mining of soil nutrients, decline in factor productivity, reduction in profitability, lowering of ground water table and build up of pests including weeds, diseases and insects has been reported in continuous rice-rice cropping system. Diversification of rice-rice cropping system with other food crops like potato, oilseeds and vegetables is necessary for obtaining higher yield and return, maintenance of soil health, protection of environment and meeting up daily requirement of human and livestock (Samui *et al.*, 2004). A number of promising rice-based cropping systems has been emerged as alternative to the rice – rice cropping system under on-station trials for New Alluvial zone. Hence, it was felt necessary to test those cropping systems under farmers' field condition, which can utilize resources judiciously for maximization of return and to protect environment.

MATERIALS AND METHODS

An on-farm field experiment with 5 crop sequences was conducted during two consecutive years 2006-07 and 2007-08 in the same field at Haringhata (88°30' E, 22°55' N), Nadia, West Bengal. The experiment was replicated in 4 nearby farmers' field, having similar land situation. Different crops and their varieties with respective fertilizer doses were: rice (winter and summer) (IET 4094) – 60:30:30 and 120:60:60 respectively, rapeseed (B-9) – 80:40:40, sesame (B-67) – 80:40:40, potato (Kufri Jyoti) – 180:150:150 and lady's finger (Mhyco hybrid) – 80:40:40. For treatment comparison, yield of different crops in the system was converted into rice grain equivalent yield and analyzed statistically. The input energy was calculated on the basis of standard energy requirement for different operations and energy requirement for production of different inputs used in the production system Out put energy was calculated on the basis of unit energy of different produces (both main and byproduct) as per Mittal *et al*.,1985 and Devsenapati *et al.,* 2008.

RESULTS AND DISCUSSION

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 rice-equivalent yield, net return, benefit: cost ratio, system productivity and in terms of energetic. Considering environmental protection fuel energy consumption under different cropping systems was also considered while comparing the different cropping systems. In both the experimental year highest system rice-equivalent yield was recorded with rice – potato – lady's finger (23,895 kg. ha^{-1} .$year^{-1}$ and 21,598 kg. ha^{-1} .$year^{-1}$), which is closely followed by rice – potato – sesame (22,242 kg. ha^{-1} .$year^{-1}$ and 19,958 kg. ha^{-1} .$year^{-1}$). Rice – rice cropping system gave lowest system rice equivalent yield during both the experimental year. Rice – potato – lady's finger system recorded highest productivity during both the years (65.47 kg. ha^{-1} .day^{-1} and 59.18 kg. ha^{-1} .day^{-1}, respectively), followed by rice – potato – sesame. During these two consecutive years rice-

E mail : manabbckv@gmail.com

rice gave the lowest system productivity (28.39 kg. ha^{-1} .day^{-1} and 27.67 kg. ha^{-1} .day^{-1}) (Table -3).

Regarding net return significant differences existed among the different cropping systems. Rice – potato – lady's finger, rice – potato – sesame and rice – rapeseed – rice got the potentiality to give better return out of the five sequences. Analysis revealed that rice – potato – lady's finger recorded the highest net return in both the experimental years (Rs.48, 465/- and Rs.45, 450/-, respectively). Highest benefit: cost ratio was recorded with rice – rapeseed – rice sequence during 2006-07, followed by rice – potato – lady's finger and rice – potato – sesame and they were statistically at par. During 2007- 08 highest benefit: cost ratio was observed with rice – potato – lady's finger (1.48), followed by rice – potato – sesame (1.16). Lowest net return and benefit: cost ratio was recorded with rice – rice crop sequence in both experimental years. These results confirm the findings of Samui *et al.* (1995) (2004). Amount of energy harvested from a unit area of land over the year of cropping following different cropping sequences is also another important measure of the superiority of different crop sequences over the others. Crop sequences, like rice-potato – sesame (3,45,713 MJ ha^{-1} $year^{-1}$), rice – potato – lady's finger (3,01,663 MJ ha^{-1} $year^{-1}$) and rice – rapeseed – rice (4,08,936 MJ ha^{-1} $year^{-1}$), were superior to others in terms of net output energy. However, in terms of energy productivity (i.e. rice-equivalent yield in kg using MJ^{-1} of energy) and fuel energy use efficiency (i.e. rice-equivalent yield in kg using MJ^{-1} of fuel energy) rice – potato –sesame is best, closely followed by rice – potato – lady's finger. (Table. 3)

Thus, considering the productivity, economics, energy output, energy use efficiency and environmental safety rice – potato – lady's finger may be the best, followed by rice – potato –sesame under irrigated condition of New Alluvial zone of West Bengal.

REFERENCES

Baishya, Ajit and Sharma, G.L. 1990. Energy budgeting of rice – wheat cropping system. *Indian Journal of Agronomy* **35** :167-77.

Devsenapathy, P., Senthil Kumar, G., and Gill, M.S. 2008. Energy In Crop Production. AICRP on Cropping Sysystems, Tamil Nadu Agriculture University.

Gangwar, B. and Prasad, K., 2005. Cropping system management for mitigation of second-generation problems in agriculture. Indian Journal of Agricultural Sciences **75**:65-78.

Mittal, V.K., Mittal, J.P. and Dhawan, K. C. 1985. Research digest on energy requirements in agriculture sector, Coordinated cell, AICRP on Energy requirement in Agricultural Sector. Punjab Agricultural University.

Samui, R.C., Hazarika, B., Maity, S. and Roy, A.1995. Fertilizer management in rice based crop sequences for sustained production in sub-humid zone. (In) *Proceedings of National Symposium on Sustainable Agriculture in Sub-humid Zone*, 3-5 March, pp.130-32.

Samui, R.C., Kundu, A.L., Majumder, D., Mani, P.K. and Sahu, P. K.2004. Diversification of rice (*Oryzae sativa*)-based cropping system in new alluvial zone of West Bengal. *Indian J. Agronomy* **49**:71-73.

Annexure 1: Economic yield (average) of different component crops during different season in 2006-07 and 2007-08

Cropping System	Yield ($kg.ha^{-1}$)					
	2006-07 ($kg.ha^{-1}$)			Yield 2007-08 ($kg.ha^{-1}$)		
	Rainy	Winter	Summer	Rainy	Winter	Summer
Paddy-Paddy	3712		6324	3718		6098
Paddy-Rapeseed-Sesame	3457	1378	1190	3607	1476	1326
Paddy-Potato-Sesame	3564	16760	1256	3814	14968	1428
Paddy-Potato-Lady's finger	4041	15147	5229	3866	16839	5034
Paddy-Rapeseed-Paddy	3876	1629	6434	3908	1642	6286

Table 1: Energy equivalent for direct and indirect sources of energy

Sl No.	Particulars	Unit	Energy equivalent (MJ)	Remarks
A.	**Inputs**			
1.	Human labour	Man-hr	1.96	
2.	Bullocks	Pair-hr	10.10	
3.	Diesel	Litre	56.31	
4.	Farm Machinery	kg/hr	62.70	Weight of machine distributed equally over total life span (hours)
5.	Chemical Fertilizer			
	(i) N	kg	60.60	
	(ii) P_2O_5	kg	11.10	
	(iii)	kg	6.70	
6.	Chemicals	kg	120.00	
7.	Seed			
	(i) Rice	kg	14.70	
	(ii)Rapeseed	kg	25.00	
	(iii)Sesame	kg	25.00	
	(iv)Potato	kg	5.60	
	(v)Lady's finger	kg	25.60	
B.	**Output**			
1.	**Main product**			
	(i) Rice/Rapeseed/Sesame/Potato	Same as seed		
	(ii)Lady's finger	kg	1.60	
2.	**By product**			
	(i)Rice straw (dry mass)	kg	12.50	
	(ii)Rapeseed/Sesame/ Lady's finger straw(dry mass)	kg	18.00	

(Mittal *et al.,* 1985and Devsenapati *et al.,* 2008)

Table 2: Effect of cropping sequences on yield, net return, B: C ratio and productivity in the system during 2006-07 and 2007-08

Cropping system	System yield (Kg. ha^{-1})		System net return (Rs. ha^{-1})		System B: C ratio		System productivity (Kg. ha^{-1}.day^{-1})	
	2006-07	2007-08	2006-07	2007-08	2006-07	2007-08	2006-07	2007-08
Rice - Rice	10363	10099	13001	15041	1.27	1.30	28.39	27.67
Rice – Rapeseed - Sesame	11492	11058	19805	20775	1.42	1.41	31.48	30.30
Rice - Potato - Sesame	22242	19958	44763	40440	1.53	1.46	60.94	54.68
Rice - Potato - Lady's finger	23895	21598	48465	45450	1.53	1.48	65.47	59.18
Rice – Rapeseed - Rice	15461	14858	34936	21732	1.56	1.43	42.36	40.69
LSD (P=0.05)	**1135**	**644**	**5234**	**3222**	**0.06**	**0.04**		

Table 3: Energy efficiency of different crop sequences

Cropping system	System energy input (MJ/ha)	System energy output (MJ/ha)	System net energy return (MJ/ha)	Energy productivity(kg/MJ)	Fuel energy use efficiency (kg/MJ)
Paddy-Paddy	34657	277668	243010	0.30	0.75
Paddy-Rapeseed-Sesame	30986	263855	232868	0.36	1.35
Paddy-Potato-Sesame	39205	345713	306508	0.54	1.97
Paddy-Potato-Lady's finger	43793	301663	257870	0.52	1.66
Paddy-Rapeseed-Paddy	45191	408936	363745	0.34	0.94