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Productivity and economics of integrated farming system in irrigated agro-ecosystem of eastern Uttar Pradesh

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ABSTRACT

An experiment to identify an efficient farming system for irrigated agro-ecosystem of eastern Uttar Pradesh was carried out at Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi during 2002-03 and 2003-04. Based on the 2-year study, rice (*Oryza sativa* L.)–pea (*Pisum sativum* L. var. *arvense* Poir.)–okra (*Hibiscus esculentus* L.) was selected as the most remunerative cropping sequence, with the highest rice grain-equivalent yield (170.98 q/ha) and net return (Rs 66,079/ha) among all the sequences. Dairy produced considerably higher net return (Rs 3,17,904/ha) than poultry (Rs 39,768/ha) and fishery (Rs 21,224/ha) but had lower benefit: cost ratio (1.28) than the fish component (1.42). The poultry component was found least profitable for every rupee invested. The farming system comprising crop component [rice-pea-okra and sorghum [*Sorghum bicolor* (L.) Moench]–berseem (*Tripliam alexandrinum* L.)-maize (*Zea mays* L.)], dairy, poultry and fishery was identified as the most suitable and efficient farming system model, giving the highest system productivity, i.e. rice grain-equivalent yield of 1,237.5 q/ha and net return under irrigated agro-ecosystem of eastern Uttar Pradesh.

Key words: Yield, Economics, Integrated farming system, System productivity

Rice (*Oryza sativa* L.)-wheat (*Triticum aestivum* L. emend. Fiori & Paol.) is the predominant cropping system in irrigated areas of eastern Uttar Pradesh. The soil in this region is deep sandy loam. Average land holding of the farmers in the area is 0.4 ha and their economic condition is not good. Hence to raise the income of the farming community, it looks imperative to diversify the rice-based cropping sequence with other farming system options, viz. poultry, fishery and dairy. Integrated farming system (IFS) provides an opportunity to increase the economic yield per unit area per unit time by virtue of intensification and diversification of crops and integration of allied enterprises. It also offers enough scope for nutrient recycling within the system, to economize and sustain the system and minimize the dependence on chemical fertilizers for crop production (Rangaswami *et al.*, 1990). It may also generate more employment for the family members throughout the year. In addition, it has many ecological and economical advantages, as these integrated systems optimize the use of farm and associated resources, which encourage habitat conservation rather than destruction. Therefore, integrated farming system is the top agricultural option for achieving an upswing growth rate in agriculture on a sustainable basis. A study was hence conducted to identify the efficiency of this system for the irrigated agro-ecosystem of eastern Uttar Pradesh.

MATERIALS AND METHODS

A field investigation was carried out during 2002-03 and 2003-04 in non-replicated trials at the research farm of Institute of Agricultural Sciences, B.H.U., Varanasi to identify the most efficient farming system for irrigated agro-ecosystem of this region. Selection of the efficient farming system was based on the identification of best combination of the enterprises, i.e. dairy, poultry, fishery and crop production, which could be compatible and complementary to each other, facilitating effective recycling of resources within the system and also satisfying the needs of the farm families of the area to improve their livelihood. For this, the diversification of rice-based cropping system was done with pulses, oilseeds, vegetables as well as fodder crops. The seven cropping sequences included for economic evaluation were: rice-mustard-sorghum fodder (F); rice-table pea-onion; rice-table pea-okra; rice-wheat-fallow; rice-wheat-greengram, rice-berseem (F)-sorghum (F) and sorghum (F)-berseem (F)-maize (F). Finally, the whole farm was diversified through integration of livestock, poultry and

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fishery components with the most remunerative cropping sequence, i.e. rice-table pea-okra (S_3), along with the next best remunerative sequence sorghum-berseem-maize for fodder (S_7), and to provide green fodder to the dairy component all round the year (Table 1). The seven combinations of enterprises, viz. $S_3 + S_7$ + dairy; $S_3 + S_7$ + poultry; $S_3 + S_7$ + fishery; $S_3 + S_7$ + dairy + poultry; $S_3 + S_7$ + dairy + fishery; $S_3 + S_7$ + poultry + fishery; and $S_3 + S_7$ + dairy + poultry + fishery, were evaluated to find out the best mix of farming-system components (Table 1). The area allotted to each cropping sequence as well as the combination of enterprises was 0.25 ha. Crop varieties, doses of fertilizers and management practices used for raising crops in different cropping sequences are given in Table 2.

Dairy component, consisting of five Jersey crossbred cows, was maintained in signle-row cow-rear system. A cowshed of 0.005 ha was constructed for this purpose to suit the requirement of 0.25 ha of integrated farming system. Consequently to work out the milk production and economics, four cows were converted to 16 for 1 ha of integrated farming system. Considering 300 kg body weight and 10 litres milk of each cow, 32.5 kg ration was given, which constituted 10.8 kg concentrated feed and 21.7 kg roughage The roughage included 7.22 kg green fodder and 14.44 kg dry fodder.

A poultry-shed of 0.005 ha was constructed to accommodate the 150 chicks of broilers purchased every third month. After completion of 8 weeks of growth, the produce was sold in the market. Deep litter system was used for rearing the birds. Due to the extreme weather conditions, only three cycles could be completed in both the years. The amount of feed given to the chicks or birds from the first to the eighth weeks was 6.5, 14.0, 17.0, 26.0, 36.0, 42.0, 45.0 and 54.0 g/day, respectively. The composition of feed was: rice bran 35 per cent, maize flour 25 per cent, mustard cake 18 per cent, dried molasses 5 per cent, fish-meal 12 per cent and mineral mixture 5 per cent.

One fish-pond of 0.05 ha with 2 m depth was taken and divided into two parts. Polyculture fingerlings, 10-15 days old, of three species, viz. rohu, catla and mrigal, in 3:3:4 proportions were released in both the ponds in August during both the years. The stocking density was 10,000 fingerlings/ha of the ponded water. Farming-system waste, i.e. cowdung and poultry droppings, was used for feeding the fishes in ponds I and II, respectively. In addition to 2 kg crushed foodgrains and oilcake in 4:1 ratio, either 20 kg cowdung manure or 5 kg poultry manure was applied to each pond at fortnightly intervals. Both cowdung and poultry manure were partially digested. Staggered harvesting was done at an interval of 15 days starting from 300 days after stocking, with a net. After final harvesting, the pond silt was collected and applied to the field. The nutrients added through manure and pond silt were adjusted with the recommended fertilizer dose of rice in each sequence.

Economic parameters like cost of cultivation, gross return, net return, component productivity (0.25/ha) and system productivity (kg/ha) were worked out for each component. For better comparison, the productivity of each component was converted into rice grain-equivalent yield (RGEY) using prevailing local market prices of different commodities during the period of experimentation. Labour requirement for crops, dairy, poultry and fishery were computed and the economics was worked out. The amount of power generated in integrated farming system was also worked out in terms of kilowatt (KW) and horsepower (HP) as per the method described by

Table 1. Area under different farming-system components

Cropping sequence and farming system	Area (ha)
Cropping sequence	
S_1: Rice-mustard-sorghum (F)*	0.25
S_2: Rice-table pea-onion	0.25
S_3: Rice-table pea-okra	0.25
S_4: Rice-wheat-fallow	0.25
S_5: Rice-wheat-greengram	0.25
S_6: Rice-berseem-sorghum (F)	0.25
S_7: Sorghum (F)-berseem (F)-maize (F)	0.25
Integrated farming system	(0.25)
S_3 (MRS**) + S_7 + dairy (d)	0.125+0.12+0.005
$S_3 + S_7$ + poultry (P)	0.125+0.12+0.005
$S_3 + S_7$ + fishery (F)	0.125+0.075+0.05
$S_3 + S_7$ + (D + P)	0.125+0.115+(0.005 each)
$S_3 + S_7$ + (D + F)	0.125+0.07+(0.05 each)
$S_3 + S_7$ + (P + F)	0.125+0.07+(0.05 each)
$S_3 + S_7$ + (D + P + F)	0.125+0.065+(0.05 each)

*F = Fodder; **MRS = most remunerative sequence

Table 2. Details of crop variety and cultural practices in different cropping sequences

Crop	Variety	Seed rate (kg/ha)	Spacing (cm)	Fertiliser schedule N–P–K (kg/ha)
Rice (hybrid)	'Suruchi'	25	20×10	150–60–60
Mustard	'Pusa Bold'	5	45×15	80–40–40
Pea	'Early Apurva'	125	20×10	50–60–60
Onion	'Pusa Dark Red'	1	15×10	125–60–60
Okra	'Hybrid No 10'	20	25×10	100–60–60
Wheat	'HUW 234'	100	22×10	120–40–40
Greengram	'Jyoti'	25	30×10	40–60–60
Berseem	'Prabhat'	30		40–90–40
Sorghum	'Sudan Grass'	25		120–40–40
Maize	'Jaunpur Local'	30		120–40–40

Sriram *et al.* (1991).

RESULTS AND DISCUSSION

Productivity

Among the various cropping systems, rice-pea-okra (S_3) recorded the highest RGEY of and net return of among the cropping sequences due to better price of vegetable crops in the market (Table 3). Therefore it was selected as the most remunerative sequence. The next profitable sequence was sorghum-berseem-maize (S_7) for fodder. However, the lowest RGEY of 86.44 q/ha was obtained in rice-wheat sequence. The intensification of sequence with greengram (rice-wheat-greengram) resulted in higher yield of rice in the second year due to improvement of soil-fertility status and soil condition, facilitating better crop growth and development. Among other components, dairy was found highly productive, which recorded 678.2 and 1,469.3 per cent higher RGEY than poultry and fishery, respectively.

The most remunerative cropping sequences, i.e. rice-pea-okra and sorghum-berseem-maize, taken to meet the fodder requirement of the milch animals throughout the calender year, were integrated with the different farming system enterprises like dairy, poultry and fishery to find out the best mix of farming-system components. The integration of cropping with the other enterprises (dairy, poultry and fishery) resulted in markedly higher system productivity than the cropping alone (Table 5). Thus integrated farming system provided an opportunity to increase the economic yield per unit area per unit time due to intensification and diversification of cropping and integration of allied enterprises, and thereby efficient use of resources. The farming system constituting crop + dairy + poultry + fishery resulted in the highest system productivity of

Table 3. Yield and economics of proposed cropping system (mean data of 2002-03 and 2003-04)

Cropping system	Cost of cultivation (Rs/ha)	Yield (q/ha)	Net return (Rs/ha)	B:C ratio of crops
Rice-mustard-sorghum				
Rice	14,817	47.04	13,407	0.90
Mustard	12,880	12.45	10,775	0.84
Sorghum	7,070	452.56	11,032	1.56
System performance	34,767	116.64*	35,214	1.01
Rice-pea-onion				
Rice	14,817	46.12	12,855	0.87
Pea	11,290	41.92	11,766	1.04
Onion	14,523	37.09	7,731	0.53
System performance	40,630	121.64*	32,352	0.80
Rice-pea-okra				
Rice	14,817	46.76	13,239	0.89
Pea	11,290	43.19	12,465	1.10
Okra	10,340	101.43	40,375	3.90
System performance	36,447	170.88*	66,079	1.81
Rice-wheat-greengram				
Rice	14,817	48.17	14,085	0.95
Wheat	13,412	34.02	12,103	0.90
Greengram	7,846	8.06	9,886	1.26
System performance	36,075	120.24*	36,074	1.00
Rice-wheat				
Rice	14,817	45.57	12,525	0.85
Wheat	13,412	32.70	11,113	0.83
System performance	28,229	86.44*	23,638	0.84
Rice-berseem-sorghum				
Rice	14,817	46.14	12,867	0.87
Berseem	6,287	294.76	14,346	2.28
Sorghum	7,070	408.86	9,284	1.31
System performance	28,174	107.78*	36,497	1.30
Sorghum-berseem-maize				
Sorghum	7,070	398.57	8,873	1.11
Berseem	6,287	341.47	17,616	2.80
Maize	7,166	188.50	10,699	1.49
System performance	20,523	96.19*	37,188	1.76

*RGEY

1,237.5 q RGEY/ha (Table 5), which was 1331.6 and 624.2 per cent higher than the traditional (rice-wheat) and most remunerative cropping sequence, respectively. This could be attributed to better management, inclusion of profitable enterprises and efficient recycling of resources from one system to another, which reduced the total input requirement, lowering the cost of production.

Economics of different components

Choice of a cropping system in an area is guided mainly by the profitability. Among the different cropping sequences tested, rice-pea-okra gave the highest net return (Table 3). This is attributed to higher productivity and better market price of pea and okra, which fetched higher return, followed by sorghum-berseem-maize and rice-berseem-sorghum sequences, recording net returns of Rs 37,188 and Rs 35,497/ha respectively. However, rice-wheat sequence recorded the lowest net return of Rs 23,638/ha and proved the most inefficient. This indicates that diversification and intensification of rice-wheat system resulted in higher profitability.

Dairy component produced considerably higher net return (Rs 79,476) than poultry (Rs 9,942) and fishery (Rs 5,306) (Table 4). However, the dairy component had lower benefit: cost ratio (1.28) than fish component (1.42), as the cost of production and maintenance of milch animal was high. The poultry component was found the least profitable per rupee invested, recording the lowest benefit:cost ratio (1.20). This can be ascribed to low survival percentage of birds during winter season and the rearing of fewer birds in the system. On the whole the integration of cropping components with different farming system components was able to generate more income and increase the profitability through recycling of wastes of one component into another. This also reduced the dependence on external inputs (Singh *et al.*, 2004).

Employment generation

The integration of crop with other farming system components increased the employment opportunities and generated enough scope to employ family labourers round the year (data not reported). This model was developed for small and marginal farmers and the labour engaged in crop production was used also for taking care of the dairy, poultry and fishery components, hence they had common value. The data of 2 years of experiment show that 731

Table 4. Yield and economics of different components of farming system unit of 0.25 ha (mean data of 2002-03 and 2003-04)

Component	Cost of production	Yield (q) Economics*	Manure silt**	RGEY	Net return** (Rs)	B:C ratio
Dairy	62,325	100.66	87.7	236.30	79,476 (3,17,904)	1.28
Poultry	8,279	4.15	22.6	30.37	9,942 (39,768)	1.20
Fishery	3,739	1.89	15.1	15.06	5,306 (21,224)	1.42

*Dairy: Milk, poultry and fish (live body weight); **Dairy and poultry: manure, fishery, pond silt; ***Figure in parentheses show the net return in Rs/ha

Table 5. Productivity (rice grain-equivalent yield) of integrated farming system (mean data of 2002-03 and 2003-04)

Farming system	Component productivity (q)					System productivity (q/ha*)
	Crop	Dairy	Poultry	Fish	Total	Total
Rice-mustard-sorghum	29.16				29.16	116.64
Rice-pea-onion	35.41				35.41	121.64
Rice-pea-okra*	42.72				42.72	170.88
Rice-wheat-greengram	30.06				30.06	120.24
Rice-wheat	21.61				21.61	86.44
Rice-berseem-sorghum	26.95				26.95	107.80
Sorghum-berseem-maize	24.05				24.05	96.19
MRS + sorghum-berseem-maize + dairy	32.70	236.33			269.03	1,076.12
MRS + sorghum-berseem-maize + poultry	32.70		30.37		63.07	252.28
MRS + sorghum-berseem-maize + fish	28.57			15.06	43.63	174.52
MRS + sorghum-berseem-maize + dairy + poultry	32.42	236.33	30.37		299.12	1,196.48
MRS + sorghum-berseem-maize + dairy + fish	28.09	236.33		15.06	279.48	1,117.92
MRS + sorghum-berseem-maize + fish + poultry	28.09		30.37	15.06	73.52	294.08
MRS + sorghum-berseem-maize + dairy + fish + poultry	27.61	236.33	30.37	15.06	309.37	1,237.48

*MRS = Most remunerative sequence

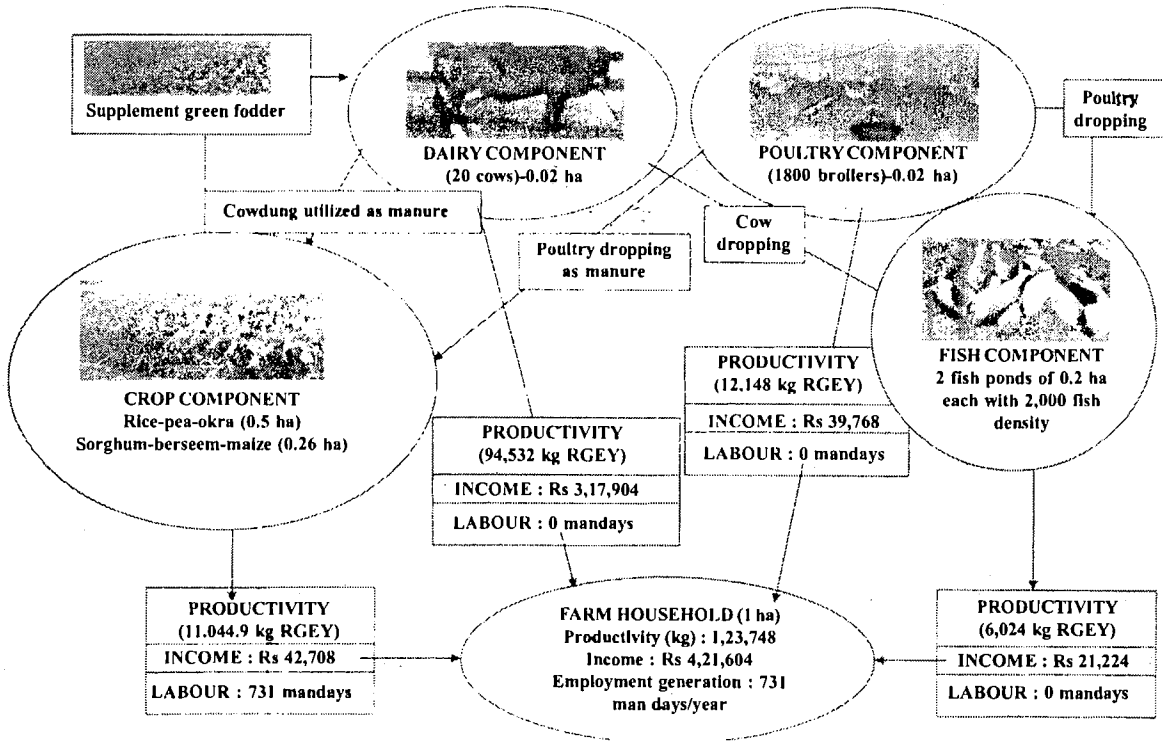

Fig. 1. Sustainable farming system model for irrigated agro-ecosystem of Varanasi and Chanduli region of NEPZ of Uttar Pradesh

mandays/ha were required for the crop component and the integration of crop with dairy, poultry and fishery in various combinations including crop + dairy + poultry + fishery, managed with the same labourers. This was equivalent to 365.5 kilowatt (KW) or 478.4 horespower (HP) in a year. Therefore the integration of different farming system components resulted in efficient utilization of labour, as the labour engaged in crop components managed the dairy, poultry and fishery components, reducing the cost of production with increased profitability.

Farming-system model

Based on the findings, a model was developed for marginal and small farmers of NEPZ of Uttar Pradesh with 1 ha land (Fig. 1). The chart shows the area allocated to each component, recycling of resources, production potential and income generated by the farm household. It reveals that integrated farming system provides an opportunity to increase the economic yield per unit time by intensification of cropping and integration of allied enterprises. It also offers enough scope to increase the profitability, employment generation and nutrient recycling within the system to improve the livelihood of the farmers and sustainability of eco-system. An area of 0.5 ha was allocated to rice-pea-okra sequence, the most remunerative sequence. Sorghum-berseem-maize in 0.26 ha was taken to meet the green-fodder requirement of dairy component round the year. The feed requirement of fingerlings in fishponds was met from cow and poultry units. The surplus of cowdung, poultry droppings as well as the silt obtained from fish-pond was utilized as valuable organic manure to the crop component.

REFERENCES

Rangaswami, A., Manicksundaram, P. and Vidhya, G. 1990. Integrated farming system: a variable approach. *Farming System News Letter* **1**(2): 11–13.

Singh, K., Singh, A.K., Singh, K.K. and Singh, C.S. 2004 A. Analysis of farming systems in north eastern plain zone of Uttar Pradesh. *Journal of Farming Systems Research and Development* **10**(1,2): 1–6.

Sriram, C., Thyagraj, C.R., Mayande, V.M. and Srinivas Rao, P. 1991. *Indo-US Project on Research on Mechanization of Dryland Agriculture (Operation Search)*. Central Research Institute for Dryland Agriculture, Hyderabad, India (Annexure I).