LAND PRODUCTIVITY FROM DIVERSIFIED CROPPING SYSTEM: A CASE STUDY IN BANGLADESH

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This study was undertaken to estimate the amount of energy and productivity cost required under rice (*Oryza sativa*) based diversified cropping system in selected villages of the Mymensingh district. Ten rice-based common cultivable crops were taken under the investigations. All information was collected randomly from the selected farmers on the basis of designed and pre-tested questionnaire throughout the year. Input energy and costs were calculated from human, animal, chemical fertilisers, operations of machinery and other input sources. Energy and productivity costs were calculated from crop yield and their by-products. Eight boro rice (HYV winter season rice) based cropping patterns were developed to achieve maximum land productivity in terms of energy and cost from diversified cropping system. Commercial fertilisers were the major energy and costly input sources for all field crop cultivation. Irrigated boro rice consumed the highest energy of about 19 600 MJ/ha. Boro + T. aman + Vegetable cropping patterns have resulted higher yield over Boro + T. aman cropping patterns in terms of energy outputs and financial recovery. This study revealed that the rice based diversified cropping system resulted in the highest energy and cost return.

energy inputs; productivity; returns; Boro rice; diversified crops; cropping pattern

INTRODUCTION

Rice is the major cereal crop grown widely in Bangladesh. Total rice production in Bangladesh in 1999 was 21.81 million tonnes (BBS 2001). In the seventies, due to the introduction of high yielding variety (HYV), rice seeds, modern irrigation facility, availability of chemical fertilizers and agro-chemicals, better transportation system and higher price of agricultural produces, farmers have concentrated to grow more rice in their lands during the year. Consequently, farmers have changed their traditional cropping pattern to grow only monocrop rice. Presently due to increased rice production and lower market price of rice compared to other crops, the farmers are re-thinking to introduce different crops along with rice in their lands. This has become necessary as the price of non-rice crops increased manifolds in the past few years. In the recent years, government and non-government organizations have advised the farmers to grow diversified crops to balance the overall crop production and nutrition status for food security. Maximisation of land productivity and minimisation of energy inputs are the main aim for cultivation system (Kumar, Prasad, 1999). In transition from traditional to modern farming system, the commercial energy use has increased sharply. The improved variety and adaptable technology are the key element in modern rice farming that requires commercial energy inputs (Bala, Hussain, 1992; Sarker et al., 1981). Economic analysis must be done to identify the ways and means where energy savings can be obtained without impairing grain yield (Singh et al., 1989). In this context, this research study was undertaken to find out the actual situations of energy use level and to identify the energy and land productivity, cost benefit ratio and cropping pattern from diversified cropping systems in the selected location of Bangladesh.

MATERIAL AND METHODS

The study was conducted in Kumargata village, about 15 km from Bangladesh Agricultural University under the Mymensingh district in Bangladesh. Farmers have been selected based on land ownership status, such as farm size, socio-economic conditions and accessibility of water from deep or shallow tube well. Three categories of farmers – small, medium and large – have been chosen from the village. Data were collected from 120 plots of 40 farmers covering three plots of each farmer. For collecting necessary field information four sets of questionnaire were developed. Field data on labour requirement for each farm activity from land preparation to harvesting. The energy requirement for land cleaning, land tilling, transplanting/sowing, chemical fertiliser and pesticide application, weeding and thinning, irrigation, transportation, threshing and other farm operations were considered and quantified. Energy input was calculated from individual inputs of farm activities in kg of weight and then multiplied by energy equivalent values, whereas human and animal energy were determined experimentally at Bangladesh Agricultural University Farm. Similarly, energy output was calculated from the crop yield and biomass residues. Except human and animal labour, the energetic values of input materials shown in Table 1 were determined by Standard Bomb Calorimetric method (Hussain et al., 1995; Singh et al., 1994). The energy productivity was calculated from output energy divided by input energy. Finally benefit cost ratio

Table 1. Energy equivalent sources

Source of energy	Energy equivalent (MJ)	Reference
Human labour, man/h	0.201	Hussain et al., 1995
Draught animal, pair/h	1.074	Hussain et al., 1995
Diesel, 1 litre	56.30	Singh et al., 1994
Nitrogen, 1 kg	60.00	Singh et al., 1994
P_2O_5, 1 kg	11.10	Singh et al., 1994
K_2O, 1 kg	6.70	Singh et al., 1994
Super chemical, 1 kg	120.00	Singh et al., 1994
Inferior chemical, 1 kg	10.00	Singh et al., 1994
Zinc sulphate, 1 kg	20.90	Singh et al., 1994
Rice grain, 1 kg	14.70	Singh et al., 1994
Rice straw, 1 kg	12.50	Singh et al., 1994
Wheat, 1 kg	14.70	Singh et al., 1994
Wheat straw, 1 kg	12.50	Singh et al., 1994
Farm manure (dry), 1 kg	0.30	Singh et al., 1994
Cow dung, 1 kg	1.00	Hussain et al., 1995
Ash, 1 kg	7.52	Hussain et al., 1995
Jute, 1 kg	12.76	Hussain et al., 1995
Chilli, 1 kg	2.17	Hussain et al., 1995
Cabbage, 1 kg	1.38	Hussain et al., 1995
Potato, 1 kg	4.14	Hussain et al., 1995
Brinjal, 1 kg	0.63	Hussain et al., 1995
Mosur, 1 kg	14.44	Hussain et al., 1995
Mustard, 1 kg	18.09	Hussain et al., 1995

was estimated from total output and input costs. Field activities were recorded during January to December of 2000 and analysed using computer. Land taxation value and solar energy inputs were not considered in the above calculations.

RESULTS AND DISCUSSION

The activity wise relationship between energy input and output for ten different crops are presented in Table 2. The total values are rounded off to the nearest figures and therefore may not give the exact added totals.

Energy input and output status of 10 important crops that are mainly grown by the farmers in the selected location are presented in Table 2. Farm activities, such as tillage, irrigation, fertilizer, weeding, seed, pesticide, planting and harvesting, were considered for estimating input energies. Energy productivity for grain crops was higher than the other crops except the brinjal. Yields of grain crops were higher than the other crops, which gave the higher energy productivity.

Cost of production and output from producing rice together with other diversified crops are presented in Table 3. Total values are the rounded off figures of the columns.

Transplanted aman (T. aman) rice requires less fertilizer application and less irrigation. Farmers showed keen interest to grow more boro (winter HYV rice) and transplanted aman rice as the both the rice crops together ensured their food security. The favourable climatic condition and multipurpose use of rice straw were also promoting rice cultivation among the farmers.

Less irrigation was required for potato cultivation but this crop was very sensitive to fogy and foul weather condition. The brinjal cultivation was profitable to the farmers in terms of yield and the cost-benefit ratio. Insect attack in brinjal cultivation is very high and the farmer needs to spray insecticides frequently. The cultivation of chilli was also profitable in terms of benefit-cost ratio or productivity level. This chilli can be cultivated throughout the year, where flood water does not come. Pesticide is not applied in chilli field but fertilizer and tillage cost is comparatively high. The cultivation of cabbage was profitable and farmers showed keen interest to grow more vegetables crops for own consumption and commercial purpose. Vegetable cultivation and consumption rates were increasing among the farmers level due to awareness of good health. Farmers have realized that they can produce vegetable in any homestead areas.

The net return from the cultivation of mustard was not very high due to late planting. During the harvesting period the market price of mustard was low as compared with other months. Mosur also resulted in highest benefit

Table 2. Energy input for different crop production (MJ/ha)

Farm activity	Boro	Jute	Wheat	T. aman	Potato	Brinjal	Cabbage	Chilli	Mustard	Mosur
Tillage	1315	1263	1134	997	1142	863	1456	746	821	425
Irrigation	7817	0	413	337	283	195	3893	1018	0	0
Fertilizer	8721	5680	5314	5128	7634	5973	9692	3875	5653	3047
Weeding	114	263	39	65	57	237	109	83	0	0
Seed	1328	256	1936	1032	1273	42	133	27	164	194
Pesticide	68	0	13	69	51	162	19	0	0	0
Planting	133	23	3	92	69	71	73	3	3	3
Harvesting	86	1374	81	70	255	125	109	123	61	59
Total input	19 580	8760	8930	7790	10 760	7670	15 480	5880	6700	3730
Total output	113 450	37 510	43 810	76 230	23 100	49 560	64 600	14 430	23 250	15 690
Energy productivity	5.80	4.30	4.90	9.80	2.20	6.50	4.20	2.50	3.50	4.20

Table 3. Input cost distribution for different crop production in Taka, 1 US $ = Tk. 57.00

Farm activity	Boro	Jute	Wheat	T. aman	Potato	Brinjal	Cabbage	Chilli	Mustard	Mosur
Tillage	3938	2038	2195	3645	4135	3503	3332	3775	2750	2182
Irrigation	3060	0	750	315	750	850	849	650	0	0
Fertilizer	2479	1678	1564	1120	2205	1925	2631	1746	3297	1234
Weeding	2189	1979	551	1072	1331	2756	3544	1064	0	0
Seed	1560	650	2065	1141	3042	476	202	570	227	781
Pesticide	600	0	0	123	235	375	450	0	0	0
Planting	2167	200	200	1497	2662	1168	886	250	219	250
Harvesting	2411	3493	1870	1152	3149	2046	1772	1996	1007	962
Total input	18 400	10 000	9200	10 100	17 500	13 100	13 700	10 100	7500	5400
Total output	35 600	15 800	1900	21 300	26 200	34 400	34 100	24 700	8850	19 200
Benefit cost ratio (BCR)	1.94	1.57	1.06	2.12	1.41	3.00	2.50	2.45	1.18	3.56

Table 4. Energy and cost of productivity for different cropping patterns model

Cropping patterns of the selected location	Energy (MJ/ha)			Cost (Taka)		
	output (000)	input (000)	output/input ratio	output (000)	input (000)	output/input ratio
Boro + T. aman	190	27	6.93	56	28	1.99
Boro + T. aman + Potato	213	38	5.58	83	47	1.77
Boro + T. aman + Brinjal	239	35	6.83	91	42	2.20
Boro + T. aman + Cabbage	254	43	5.93	91	42	2.16
Boro + T. aman + Chilli	204	33	6.14	82	39	2.12
Boro + T. aman + Mustard	213	34	6.25	66	36	1.83
Boro + T. aman + Musur	205	31	6.60	76	34	2.25
Wheat + Jute + T. aman	158	25	6.18	47	29	1.60

cost ratio from the land productivity. According to the farmers the cultivation of wheat was not profitable and the benefit-cost ratio was low due to lower market price of wheat during harvesting time. Moreover, rodents seriously affected wheat cultivation. Farmers could not take proper plant protection measures due to the unavailability of appropriate agro-chemicals. Farmers in the study area had no idea regarding the actual dose of fertilizer use with irrigation schedule, which hampered the whole wheat cultivation system. But in terms of energy ratio the cultivation of wheat would be justifiable.

The cultivation of jute was profitable but in comparison to paddy cultivation it was less profitable. The harvesting cost including land preparation, weeding, cutting, carrying, dipping into water, rating, washing and drying was high. Farmers grew jute for his domestic consumption, such as for making jute rope, fuel purpose, scaffolding for vegetable production and making fencing for houses. The energy input-output cost for the major cropping patterns practiced in the study area is shown in Table 4.

In general farmers of study area follow the above mentioned cropping patterns.

CONCLUSION

The highest energy input is required for winter season irrigated HYV rice (boro rice) followed by wheat and transplanted rain fed aman rice among the cereal crops. Among the vegetables cabbage required the highest energy inputs followed by potato. The major contribution comes from chemical fertilisers and irrigation components. Non-irrigated pulses consumed least energy. HYV rice produced 150% more total output energy than rain fed transplanted aman. Similarly, energy output from cabbage is 250% higher than potato and 130% more than brinjal. On the other hand, energy productivity is highest for rain fed transplanted aman followed by brinjal, HYV boro rice, wheat and cabbage. Rain fed rice requires much less irrigation and fertiliser energy inputs than irrigated rice. Benefit costs ratio is highest for transplanted aman followed by boro rice and wheat in cereal crops, whereas this is the highest for brinjal followed by cabbage and potato among the vegetables grown in the selected locality. In terms of energy productivity (output to input ratio) Boro + T. aman + Brinjal cropping pattern gives highest result followed by Boro + T. aman + Musur and Boro + T. aman + Brinjal.

Based on the findings of the study farmers may be advised that cropping pattern like Boro rice + Transplanted aman + winter vegetable will give them maximum energy productivity and economic return.

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Produktivita půdy u diverzifikovaných pěstebních systémů: Případová studie v Bangladéši

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Cílem práce bylo výpočítat množství energie a produkčních nákladů potřebných při pěstování rýže (*Oryza sativa*) pomocí diverzifikovaného pěstebního systému ve vybraných vesnicích distriktu Mymensingh. Zkoumalo se deset běžně pěstovaných plodin se základem rýže. Veškeré informace od vybraných zemědělců byly shromážděny nahodile pomocí vypracovaného a během roku předem otestovaného dotazníku. Vstupní energie a náklady se vypočítaly z lidských a živočišných zdrojů, spotřeby organických a anorganických hnojiv, nákladů na provoz zemědělských strojů a z dalších vstupních zdrojů. Náklady na energii a produktivitu se vypočítaly z výnosu plodin a jejich vedlejších produktů. Bylo připraveno osm pěstebních systémů, ve kterých byla použita odrůda rýže boro (zimní odrůda rýže HYV) k dosažení maximální produktivity půdy při odpovídající spotřebě energie a nákladech diverzifikovaného pěstebního systému. Průmyslová hnojiva byla hlavním zdrojem energie a vstupních nákladů pro všechny pěstované plodiny. Zavlažovaná rýže boro spotřebovala nejvíce energie, asi 19 600 MJ/ha. Pěstební systémy rýže boro – T. aman (transplantovaná rýže aman) + zelenina poskytly vyšší výnosy ve výstupech energie a finanční návratnosti než rýže boro + T. aman. Bylo zjištěno, že u rýže vypěstované v diverzifikovaném systému bylo dosaženo nejvyšší návratnosti energie a nákladů.

vstupy energie; produktivita; návratnost; rýže boro; diverzifikované plodiny; pěstební systém

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