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The feasibility of crop diversification in rice based cropping systems in *haor* ecosystem

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Abstract

An experiment was conducted in five farmers' field in Dingaputa *haor* of Purba Tetulia village, Mohangonj Upazila in Netrakona district during the period from 20 July 2010 to 15 May 2011. The objective of the study was to determine the feasibility of growing short duration vegetable and oil crops in seasonal fallow of Boro rice-Fallow-Fallow cropping patterns in terms of both combined yields and economic performance. Six short duration vegetables such as potato, red amaranth, stem amaranth, spinach, radish and mustard were the first crops and Boro rice (var. BRRI dhan28) was the second crop. Thus there were six types of cropping patterns Potato-Boro rice- Seasonal flood, Red amaranth-Boro rice- Seasonal flood, Stem amaranth-Boro rice- Seasonal flood, Spinach-Boro rice- Seasonal flood, Radish-Boro rice- Seasonal flood and Musturd-Boro rice- Seasonal flood. The agronomic productivity (rice equivalent yield t ha^{-1}) of the cropping patterns Potato-Boro rice- Seasonal flood, Red amaranth-Boro rice- Seasonal flood, Stem amarnth-Boro rice- Seasonal flood, Spinach-Boro rice- Seasonal flood, Radish-Boro rice- Seasonal flood and Mustard-Boro rice- Seasonal flood were 22.42, 15.47, 17.04, 17.79, 22.11 and 11.56 t ha^{-1}, respectively with economic productivity (gross return Tk ha^{-1}) of 364162.50, 251712.50, 276900.00, 292012.50, 359125.00 and 187850.00, respectively and the benefit cost ratio of 1.88, 1.52, 1.65, 1.69, 1.75 and 1.12, respectively From diversification practices in Dingaputa *haor* ecosystem Potato-Boro rice- Seasonal flood and Radish-Boro rice- Seasonal flood cropping patterns were found to be the most dominant cropping patterns in economic terms.

Keywords: Crop diversification, Cropping system, *Haor*, Seasonal flood

Introduction

Haor is a bowl-shaped depression of typical low land area within the estuarine flood plain of the Surma, Kushiyara, Meghna, Dhenu and Ghorautre rivers. The *haor*s of Bangladesh cover the districts of Kishoreganj (eastern part), Netrokona, Sunamganj, Habiganj, Moulabibazar and part of Sylhet and Brahmanbaria (Haor Task Force, 1985). The *haor* area extends as many as 43 upazilas of the aforesaid districts. The area of the *haor* is about 932793 hectares (Hossain and Bhuiya, 2011). The *haor*s undergo deep flooding (5-10 m) from late May to October while it looks like a sea.

There is only one cropping season in *haor* i.e. the *Rabi*, when Boro rice, potato, groundnut, sweet potato, mustard, pulse, etc. are grown. The *haor* is highly potential area for rice production and fishery resources. It contributes over 10% to the national production of rice. An option to provide the nutritional security of the people in the *haor* area is to accommodate other crops such as vegetables, pulses, oil crops, etc. within the single rice cropping system being practiced in the area. Short duration vegetables such as red amaranth, stem amaranth, spinach, radish, potato, etc., oil crops such as mustard, groundnut, etc. and pulse crops such as black gram, lentil, etc. might be grown before cultivation of Boro rice (LIFCHASA, 2010) in land where flood water recedes fully at the end of October and first week of November. In this land type there is ample scope of crop diversification and crop intensification with the aversion of early flash flood in April. In fact such pioneering studies were done in the *haor*s of Karimganj and Itna upazila in mid 1998 to 2000 and in Austagram, Nikli, Mithamain, Ajmiriganj and Sulla upazila in 2009 to 2011 by the Bangladesh Agricultural University, Mymemsingh in the name of FSES and ART of HISAL, respectively (Hossain *et al.,* 2010a).

Crop diversification is the growing of different species of crops in a farm or area or region or nation either in succession or simultaneously or both together in the course of the year. While crop intensification is the growing of crop with intensive care and management by utilizing modern technique and technology to maximize production in a unit of land with the accommodation of more number of crops per year.

The feasibility of crop diversification and intensification of Fallow-Boro rice-Seasonal flood water grown after early potato, red amaranth, stem amaranth, spinach, radish and mustard but not sacrifing Boro rice. The study was undertaken to determine the agro-economic performance of short duration vegetables and Boro rice varieties and pattern into Potato-Boro rice- Seasonal flood water, Red amaranth-Boro rice-Seasonal flood water, Stem amaranth-Boro rice- Seasonal flood water, Spinach-Boro rice- Seasonal flood water, Radish-Boro rice- Seasonal flood water and Mustard-Boro rice- Seasonal flood water, respectively (Hossain and Kashem, 1995). The crop diversification has successfully been tried by the Action Research Team of the HISAL Project of the Ireland based NGO, the Concern Worldwide in recent years (Hossain *et al.,* 2010b). From the findings it indicates that a series of cropping can be tried. For this reason, any designing of the cropping patterns should involve rice as the base crop of the patterns.

Although Bangladesh is nearly self-sufficient in rice production, other foods such as vegetables, pulses, oil crops etc. are still deficit to a large extent. Even rice food security has not been achieved at the household level in many poor and extreme poor farm families. Crop diversification as mentioned above will increase cropping intensity, raising the productivity of land and labour, generate income and employment which in turn will eliminate food and nutritional insecurity and poverty of farming community of the *haor* area. A study was, therefore, undertaken in Purbo Tethulia of the ecosystems of Dingaputa *haor* with the following objectives.

1. To explore the possibility of growing short duration vegetable and oil crop before Boro rice of Fallow- Boro rice - Seasonal flood water.
2. To evaluate the agro-economic performance of the designed cropping patterns.
3. To assess farmers' response on the acceptability of designed patterns of the trial.

Materials and Methods

The experiment was carried out at Purbo Tethulia situated in the eastern side of Mohangonj upazila of Netrakona district, a village and Ward of Tethulia union in Dingaputa *haor*, during the period from October 2010 to May 2011. The experimental site was a representative of flood prone *haor* area which covers 932793 ha i.e. about 6.5% area of Bangladesh. Experimental treatment consisted of six designed patterns for diversification of rice cropping systems. The patterns were designed against Fallow- Boro rice- Seasonal flood (in post flood period as shown in Fig. 1) along with crops intervened with underline. The six designed patterns were-

1. Potato-Boro rice- Seasonal flood
2. Red amaranth-Boro rice- Seasonal flood
3. Stem amaranth-Boro rice- Seasonal flood
4. Spinach-Boro rice- Seasonal flood
5. Radish-Boro rice- Seasonal flood
6. Mustard-Boro rice- Seasonal flood

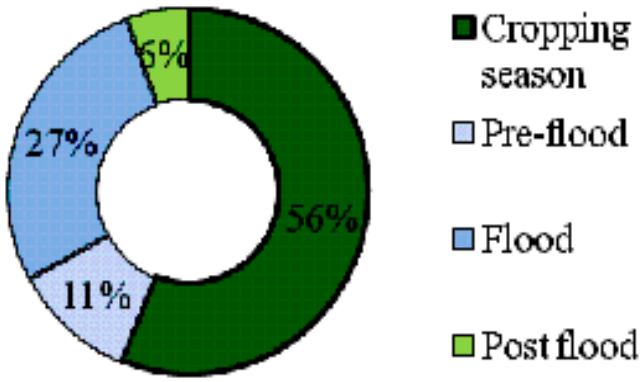

Fig. 1. Cropping season and flood in *haor* eco-system

Experiment was laid out in a randomized complete block design with five farmers' dispersed replications. Layout of the experiment was done on 20 October 2010. There were 30 unit plots of same size. Plot to plot and block to block distances were 0 .75 m and 1.00 m, respectively. The collected data were compiled and tabulated in proper form and subjected for statistical analysis. Data were analyzed using the "Analyses of variance" technique with the help of computer package MSTAT and differences among treatment means were adjudged with Duncan's Multiple Range Test (DMRT) as outlined by Gomez and Gomez (1984).

Results and Discussion

Results obtained from the present study have been presented and discussed here under different sections comprising yield and yield contributing characters of rice, vegetable yield, rice equivalent yield and economic analysis. Experimental results have been presented in Tables 1-2. *Haor* rice crop ecosystem is constrained by a number of factors such as topography, time of receeding flood water, planting and harvesting time, cold injury for rice, etc. Vegetable-Boro rice- Seasonal flood water is the single crop. Pattern practiced over there in most of the land. *Boro* rice is occasionally destroyed by early flash flood at the grain development and mature stage which generally occurs as early as last week of March. The cycle of occurrence of the flash flood is 4 years. The last flash flood occurred in the Dingaputa *Haor* on 28 March 2010 (LIFCHASA, 2010). Depending upon draining flood water from the crop field the cropping period in the *haor* area starts from last week of October and lasts up to the end of April (Fig. 1), crop growth duration for Vegetable-Boro rice- Seasonal flood water cycle is shown in (Fig. 2) and Rice equivalent grain yield are graphically represented in (Fig. 3) similar results were reported by Hossain *et al.* (2010c).

Table1. Productivity of Vegetable-Boro rice-Fallow cropping pattern in Dingaputa *haor* ecosystem

Cropping pattern	Vegetable yield (t ha^{-1})		Rice equivalent yield t ha^{-1} (vegetable)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Rice equivalent yield (t ha^{-1})	Total grain yield (t ha^{-1})	Total rice equivalent yield (t ha^{-1})
	Product	By product						
	1	2	3	4	5	6	4+6	3+7
Potato-Boro rice-Fallow	18.00	-	13.29	8.51	9.98	0.61	9.13	22.42a*
Red amaranth-Boro rice-Fallow	10.30	-	6.33	8.54	9.89	0.60	9.14	15.47d
Stem amaranth-Boro riceFallow	22.00	-	8.12	8.32	9.66	0.59	8.92	17.04c
Spinach-Boro rice-Fallow	12.00	-	8.86	8.51	9.82	0.60	9.11	17.97b
Radish-Boro rice-Fallow	52.00	-	12.79	8.71	9.82	0.61	9.32	22.11a
Mustard-Boro rice-Fallow	1.01	2.55	2.49	8.47	9.82	0.60	9.07	11.56e
Level of significance	NS	NS	NS	NS	NS	NS	NS	0.01
$S\bar{X}$	0.22	-	-	0.18	0.18	-	-	0.19
CV (%)	2.65	-	-	4.92	4.04	-	-	2.44

*Figures in column bearing dissimilar letters differ significantly whereas figures bearing similar letter(s) do not differ significantly at 1% level of probability. By product is not substantial and not included in the calculation.
NS = Not significant

Table 2. Duration of cropping patterns and occurrence of the flash flood

Cropping pattern	Planting time of first crop	Duration of the first crop (Day)	Turn around period (Day)	Planting time of second crop	Duration of the second crop (Day)	Duration of the pattern (first crop+ turn around period+ second crop)	Possibility avoiding early flash flood (before last 28 March) an estimation				
							Shifting planting/ transplanting date to	Curtailing duration of turn around period for *Boro* rice	Earliness advantage obtained for rice	Probable harvesting date	Probability of risk prone to flash flood *
1	2	3	4	5	6	7	8	9	10(8+9)	11	12
P_1	4 Nov.	71	10	25 Jan.	93	174	20 Oct.	7	17	11April	Risk prone
P_2	9 Nov.	26	50	25 Jan.	93	169	20 Oct.	25	34	24March	Risk aversive
P_3	9 Nov.	53	23	25 Jan.	93	169	20 Oct.	15	27	1April	Risk prone
P_4	9 Nov.	30	46	25 Jan.	93	169	20 Oct.	25	40	18March	Risk aversive
P_5	4 Nov.	71	10	25 Jan.	93	174	20 Oct.	7	22	6Apri	Risk prone
P_6	4 Nov.	76	5	25 Jan.	93	174	20 Oct.	Too short to shorten	14	14April	Risk prone

P_1=Potato-Boro rice-Fallow, P_2=Red amaranth-Boro rice-Fallow, P_3=Stem amaranth-Boro rice-Fallow, P_4=Spinach-Boro rice-Fallow, P_5=Radish-Boro rice-Fallow, P_6=Mustard-Boro rice-Fallow
*Latest flash flood occurred in Dingaputa *haor* area on 28 March, 2010 based upon this flash flood occurrence the possibility avoiding early flash flood as shown in the table has been prepared

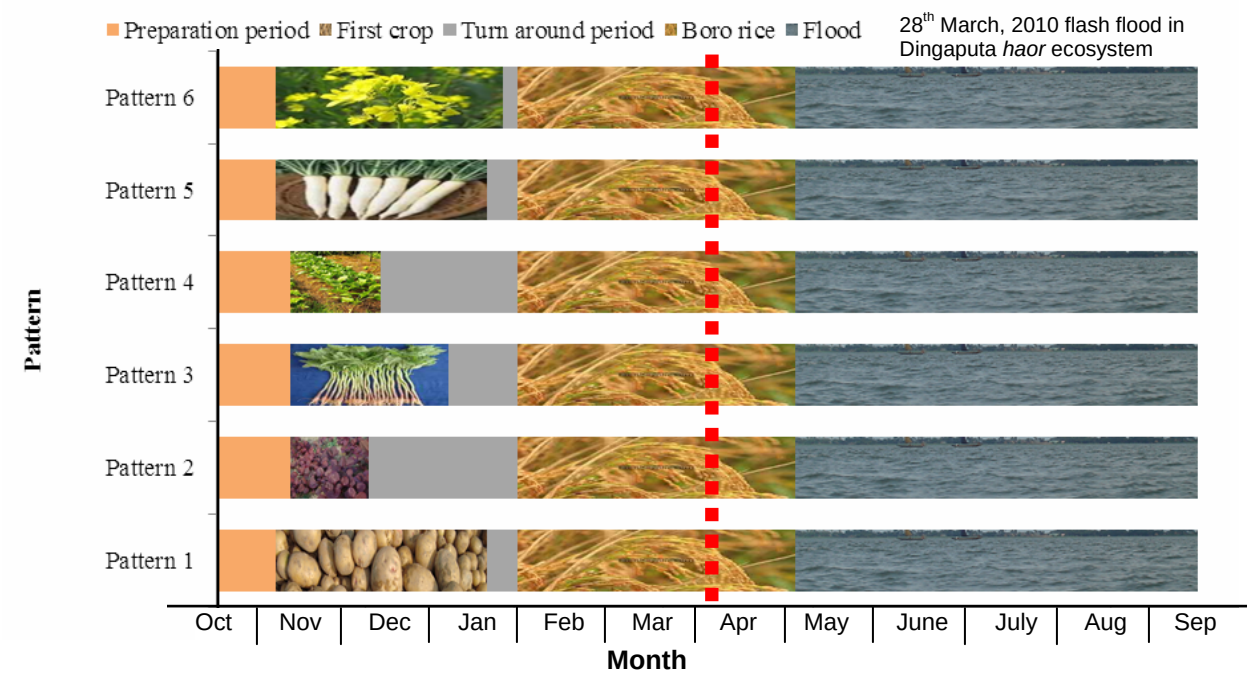

Fig. 2. Crop growth duration for Vegetable-Boro rice- Seasonal flood water pattern occurrence in Dingaputa *haor* ecosystem

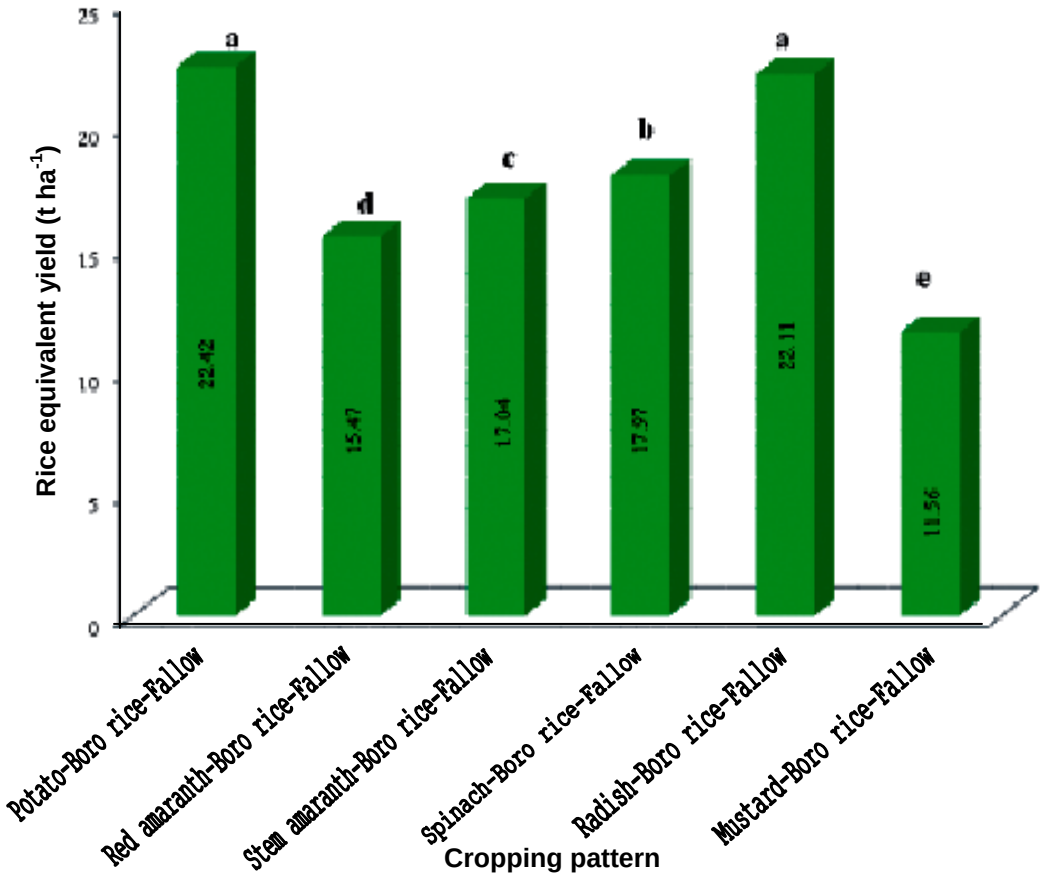

Fig. 3. Rice equivalent grain yield with cropping patterns in Dingaputa *haor* ecosystem

The period seems to be sufficient for *Boro* rice raising one crop in sequence of Fallow- Boro rice-Seasonal flood water pattern. But early planting of rice may cause cold injury to rice plant resulting in anther deformation destroying the crop. In order to accommodate another crop in the Fallow-Boro rice-Seasonal flood water pattern, short duration vegetable and short duration rice varieties might be possibility for crop diversification in the pattern (Fig. 1, 2 and Table 3).

From the findings of the study it reveals that all the experimental crops were safely harvested due to favourable weather and no occurrence of flash flood indicating that in favourable cropping season, there is an excellent possibility of crop diversification through inclusion of sequential short duration vegetable crops before Boro rice pre-flood and post flood period cropping pattern. The designed cropping patterns tried in the experiments except Mustard-Boro rice- Seasonal flood water the agro-economic productivity was lucrative and farmers' response was very positive to adopt them. The risk of flash flood and cold injury may be avoided by developing appropriate duration of cropping patterns harvestable before the risk period of early flash flood (as occurred on 28 March, 2010) and cold injury for Boro rice during winter.

The designed cropping patterns Potato-Boro rice- Seasonal flood water, Red amaranth-Boro rice-Seasonal flood water, Stem amaranth-Boro rice- Seasonal flood water, Spinach-Boro rice- Seasonal flood water, Radish-Boro rice- Seasonal flood water and Mustard-Boro rice- Seasonal flood water in addition to their very high agro-economic productivity may be sustainable one as they can generate more income and employment opportunity for the farming, poor and extreme poor households of the area.

Duration of crops in the main field is the major determinant of number to be accommodated in the sequential cropping pattern. It may be mentioned that this duration does not include the seedling raising period in the nursery. Turn around period, another important determinant when land is prepared in between two crops. The possibility to introduce one crop of vegetable/oil crop in Fallow-Boro rice-Seasonal flood water (post flood period) pattern in the context of early flash flood (as on 28 March 2010) has been critically analyzed below.

From Table 2 it is evident that planting/transplanting time followed in the present experiment with sufficient period of turn around period in patterns like Red amaranth-Boro rice- Seasonal flood water and Spinach-Boro rice- Seasonal flood water, there is ample scope of adjustment/manipulation of planting/ transplanting time particularly shifting from 9 November to 20 October and manipulating turn around period from 50 to 25 and 46 to 25 days in the case of Red amaranth-Boro rice- Seasonal flood water and Spinach-Boro rice- Seasonal flood water, respectively which may be considered as risk aversive and the rest four patterns had small turn around period may fall under risk prone period. But except Mustard-Boro rice- Seasonal flood water pattern the performance of all other patterns were excellent in favourable years. In early flash flood affected as on 28 March, 2010. Red amaranth-Boro rice- Seasonal flood water and Spinach-Boro rice- Seasonal flood water however would be aversive of flash flood. Potato- Boro rice-Seasonal flood water and Radish- Boro rice- Seasonal flood water would give additional produce of potato and radish, respectively.

Conclusion

The highest rice equivalent yield (REY) of 22.42 t ha^{-1} was recorded in the pattern Potato-Boro rice-Seasonal flood water and the next highest REY (22.11 t ha^{-1}) was found in pattern Radish-Boro rice-Seasonal flood. In rice based vegetable cultivation the highest gross return (Tk.187850.00 ha^{-1}), gross margin (Tk. 170459.04 ha^{-1}) and benefit cost ratio (1.88) were obtained from Red amaranth-Boro rice-Seasonal flood, and Potato-Boro rice- Seasonal flood, respectively. In all rice based cropping patterns in terms of rice equivalent grain yield, gross return, and gross margin and BCR values. Among the different designed patterns Potato-Boro rice- Seasonal flood gave the performance in terms of rice equivalent grain yield, gross return, gross margin and BCR values.

In early flash flood affected years, the patterns Red amaranth-Boro rice- Seasonal flood and Spinach-Boro rice- Seasonal flood would be risk aversive due to their shorter durations for which they may be sustainable ones. Further agronomic trials are needed to refine the proposed shifting of Boro rice to earlier dates along with the use of turn around period to package the generated information into technology.

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