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Research Note

PRACTICES OF CONSERVATION AGRICULTURAL TECHNOLOGIES IN DIVERSE CROPPING SYSTEMS IN BANGLADESH*

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Abstract

High Yielding Varieties (HYV) along with chemical fertilizer, pesticides and irrigation had introduced in Bangladesh in the name of "Green Revolution" to feed the huge population of the country. This results degradation in soil health and reduce productivity in the long run. In this context, conservation agriculture (CA) is becoming increasingly important in overcoming the problems of declining agricultural productivity. This paper investigates the benefits and impacts of CA practiced by the farmers in Bangladesh. The study covered a range of soils and cropping systems for the evaluation of CA in Rajshahi; Mymensingh; Rajbari, and Thakurgaon districts. Data and information were gathered through focus group discussion (FGD), household survey, and case studies. A total of 458 households were interviewed considering the level of adoption of CA from different cropping systems. The results show that most of the farmers under Mymensingh and Thakurgaon districts don't have any knowledge in sowing/transplanting by machineries whereas farmers in Rajbari and Rajshahi districts have comparatively better knowledge on this. Overall 76.45% respondents know the benefits of using organic matter in soil. For tillage operation, draft power use is higher than other machineries in all cropping seasons. The retention of crop residues was found higher in Boro rice compared to Aman and Aus rice and other crops. A few farm households had a little knowledge on how to improve soil health through retention of crop residues. Only 39.30% respondents practiced crop rotations, and 30% respondents practiced mixed cropping, and most of them experienced increased production. The major constraints of adoption of CA mentioned by the respondents are low production, more weeds, low animal feed, lower cooking fuel and bothering job. Providing adequate knowledge and training of CA should be provided to the farmers for sustainable agricultural productivity.

I. INTRODUCTION

In order to feed the increasing population of Bangladesh "Green Revolution" has emerged in 1960s and priority was given to produce more food in terms of grain through intensification of land usage. As a result, immediate objectives of more grain

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production have been achieved and grain (especially rice) production has increased by manifolds. For a shorter period, Bangladesh has attained self sufficiency in food (rice) production. On the contrary a suicidal policy of over extraction of soil nutrient was followed in this rapid through the food production strategy which includes introduction of various HYVs and hybrids, and using higher doses of chemical fertilizer and pesticides. In this period of time, soil fertility conservation issue was totally ignored by the farmers. Long term use of chemical fertilizer and pesticides without any organic fertilizer resulted lack of organic matter content caused a lot of problems to the soil health, and as result productivity is decreasing day by day (Kafiluddin and Islam 2008). Since the average cropping intensity is 1.85 and rising (BBS 2005), most farms manage 2 crops per year. Soil is interconnected with other natural resources such as air, water, fauna and flora. It acts as the most important intermediate and regulating factor for the most agricultural processes and, by extension, the environmental effects of agriculture. From there it can be said that if the soil is well managed, the effects of agriculture on the environment will be acceptable and vice versa. In addition, the increased use and increased price of agricultural inputs (fertilizer, pesticides, irrigation, etc.) has made the production cost much higher day by day. The scenario is that though the grain production has been increased many times, but the farmers who produced crop became marginalized. It is the challenge of modern agriculture. In this context, conservation agriculture (CA) is becoming increasingly important in overcoming the problems of declining agricultural productivity both in developing and developed world. CA offers a powerful option for meeting future food demands and contributing in sustainability of agriculture and rural development. CA has the capacity to increase infiltration and efficient use of land, reduce water runoff and evaporation, making more water available to the crops. Moreover, CA can mitigate to some extent, the present climatic and socio-economic challenges faced by farmers.

CA is currently being practiced to varying degrees in different countries of the world. However, it is very new in Bangladesh. Economic profitability of CA in the smallholder farmer context is a crucial factor. Available literature suggest that costs of production can be cut and timeliness of sowing operations can be enhanced by a range of minimum tillage operations involving one-pass, and line sowing (Miah et al. 2010). The National Agricultural Policy (MOA 1999) suggests that the use of machinery in tilling and seeding needs to be extended further, so that efficiency of production can be achieved with increased production and reduced cost. The development of minimum tillage establishment of Aman rice is a particular challenge for CA in Bangladesh but promising technologies (direct seeding, aerobic rice, raised beds, un-puddled transplanting) have been developed elsewhere and are under evaluation in Bangladesh (Haque et al. 2010). Already considerable progress has been made in developing minimum tillage in Bangladesh using 2-WT planters (Haque et al. 2009, 2010; Hossain et al. 2009; Islam et al. 2011; Johansen et al. 2012). Similarly zero tillage planters have been developed but not yet tested under a diverse range of soil conditions (Haque et al. 2004). Finally, bed-planting machinery for making and planting on permanent beds has been developed and evaluated mostly with cereals, such as rice, maize and wheat

(Wohab et al. 2009). Based on these promising developments, pre-conditions have been established for the development and spread of conservation agriculture in Bangladesh. At this critical stage targeted research and development can lead to accelerated adoption of CA.

Farmers (CA adopters) and other stakeholders who are new or are at the initial stages of converting to CA require tangible evidence on the benefits and impacts of CA. It is necessary to know - whether CA significantly increases productivity and food security for their families or not. Conservation agriculture should also lead to improvements in soil fertility in intensive cropping systems (Hobbs, 2007). It is also a crucial question to the CA adopters whether CA helps them to save production costs and generate income or not. Based on the above discussion, the main objective of this paper is to investigate the present status of CA practiced by the farmers in Bangladesh. The specific objectives are (i)to investigate the present status of tillage operations with respective costs, weed control, and usage of various crop rotations in different parts of Bangladesh, (ii) to identify the constraints and opportunities to adoption of CA in diversified rice-based cropping systems and (iii) to suggest some policy guidelines for popularizing CA in Bangladesh.

The reminder of this paper has been organized as follows: Section II discusses the research methods applied in this study. Section III describes the results and discussions based on the study. Finally, some concluding observation and policy implication are made in section IV.

II. RESEARCH METHODS

To get a complete picture of the conservation agriculture that is practicing in Bangladesh, the study covered a range of soils and cropping systems in Bangladesh. Therefore, four different regions namely Rajshahi, Mymensingh, Rajbari, and Thakurgaon districts which are different in soils and cropping systems were purposively selected for the present study. Data and information were gathered through focus group discussion (FGD), household survey, and case studies. Each focus group was consisted of different sections of people such as Sub-Assistant Agricultural Officer (SAAO), 2 wheel power tillers, machineries and spare parts sellers, owners, operators, and few conscious local community people. On the other hand, quantitative and qualitative data and information were gathered from the randomly selected users and service providers of machineries through conducting household survey using pre-tested interview schedules, some suitable case studies of successful service providers were also conducted to supplement the study.

A multistage sample technique was applied to gather the required data and information. Firstly, districts (Thakugaon, Rajshahi, Rajbari and Mymensingh) were selected purposively considering different soil types and cropping systems. Secondly, the households were selected through FGD considering the level of adoption of CA such as cultivation by minimum tillage, retention of crop residues and crop rotations. Thirdly,

the households were categorized by cropping systems, mostly rice based (rice-pulses or rice-oilseed) cropping systems. Finally, the former CA research sites and new research sites were categorized for a better understanding of CA techniques used such as cultivation by minimum tillage, retention of crop residues and crop rotations. Thus, a total of 458 farms were selected followed by a field reconnaissance and key informants interview with different stakeholders for baseline survey (Table 1).

To ensure the quality of information, the interview schedule was checked to ensure that information to each of the items had been correctly recorded. Data were collected during October to December 2012. All the collected data were processed and analyzed in accordance with the objectives of the study.

Table 1: Sample Respondents in the Study Area

Major cropping systems	Farm HHs	Service provider and related parti
Rajshahi		
Rice-lentil-mung bean	60	
Rice-wheat-mung bean	60	
Sub-total	120	30
Mymensingh		
Rice-mustard-mung bean	40	
Rice- wheat-mung bean	40	
Rice-lentil-Aus rice	38	
Sub-total	118	30
Rajbari		
Rice-lentil-mung bean	80	
Rice-lentil-jute	80	
Sub-total	160	30
Thakurgoan		
Rice-wheat-mung bean	60	
Sub-total	60	30
GRAND TOTAL	458	120

III. RESULTS AND DISCUSSIONS

i) Socio-economic profile of the selected households

Table 2 shows the socioeconomic profile of the respondents in the study areas. The average family size of the households (HHs) is 5.80 whereas the average age of the respondents is 40.23 years. Among the respondents, around 40% have above primary level educational and about 90% are dependent on agriculture. In Rajshahi district, annual income (BDT 123,571) is less than the other three districts. Average operated land area is 2.61 acres per HHs which is quite small and cropping intensity is 214% implies production of two crops in a year.

Table 2: Socioeconomic Profile of the Selected Households

Parameters	Mymensingh (n=118)	Rajbari (n=160)	Rajshahi (n=120)	Thakurgaon (n=60)	Total (N=458)
Family size (no.)	5.63	6.23	4.64	7.30	5.80
Age of the respondents (years)	38.63	41.21	40.15	40.89	40.23
Education above primary level	46.67	36.25	33.33	28.33	37.11
Agriculture as primary occupation	81.36	86.88	92.50	95.00	88.93
Annual income (BDT)	209,409.75	270,912.76	123,571.15	268,352.46	216,240.58
Operated land area (Acr	2.80	1.79	2.70	3.16	2.61
Cropping intensity (%)	196.43	282.12	223.33	153.16	213.76

Source: Field Survey, 2012.

ii) Knowledge on CA technologies of the respondent households

The present study examined the knowledge of CA technologies based on eight CA technology levels which are information of land preparation through CA, knowledge on harmful of excessive tillage, sowing by hand, sowing by machineries, sowing by both, knowledge on the benefit of organic use, use of organic fertilizer and knowledge on the danger of excessive use of chemical fertilizer.

Table 3: Knowledge of Conservation Agriculture by the Respondents

Data	Mymensingh (n=118)	Rajbari (n=160)	Rajshahi (n=120)	Thakurgaon (n=60)	Total (N=458)
Information of land preparation through CA	0	30.63	37.50	6.67	21.40
Knowledge on harmfulness of excessive tillage	59.32	64.38	22.50	48.33	50.66
Sowing/ Transplanting by hand	98.31	66.88	66.67	81.67	77.51
Sowing/ Transplanting by machineries	0	0	0	1.67	0.22
Sowing/ Transplanting by both	0.85	33.13	32.50	16.67	22.49
Knowledge on the benefit of orga use	86.44	51.88	75.83	91.67	76.45
Use of organic fertilizer	68.64	40.63	72.50	70.00	62.94
Knowledge on the danger of excessive use of chemical fertiliz	31.36	44.38	48.33	30.00	38.43

Table 3 shows that farmers in Mymensingh district do not know the information of land preparation through CA, and only 7% farmers in Thakurgaon district are aware about this. But about 60% farmers in Mymensingh district have the knowledge on harmfulness of excessive tillage. Most of the respondents mentioned that they planted or seeded manually (by hand). Only 2% farmers in Thakurgaon district use machineries for sowing seeds. Most of the farmers know the benefit of using organic materials though they are not much aware of the danger of using chemical fertilizers.

iii) Cost of tillage operation by season

Both draft power and machineries are used for tillage operation in three crop seasons. The main cropping seasons are Rabi (mid October to mid March), Kharif I (mid March to mid July) and Kharif II (mid July to mid October). The respective costs for five tillage operations have been presented in Table 4. Still now farmers are mostly using draft power for tillage operation and the cost is also high compared to other tillage practices for all seasons. Table 5 shows the cost of tillage practices by districts. In all districts, usage and cost is higher for country plough followed by power tiller and tractor.

Table 4: Cost of Tillage Operations by Season

Types of tillage	Rabi		Kharif I		Kharif II	
	No. of tillage	Cost in BDT/acre	No. of tillage	Cost in BDT/acre	No. of tillage	Cost in BDT/acre
Draft Power	3.04	1724	3.55	1550	3.13	1212
Power tiller	1.55	480	1.75	556	1.80	573
Tractor	1.38	433	1.67	533	1.89	677
Seeder machine	1.70	555	1.86	490	1.83	495
Other machineries	1.00	506	1.50	600	1.00	400

Table 5: Cost of Tillage Operations by Districts

Locations	Country plough		Power tiller		4W Tractor		Seeder machine		Other machine
	No.	Cost	No.	Cost	No.	Cost	No.	Cost	No.
Mymensingh	3.04	1724.00	2.85	977	-	-	-	-	-
Rajbari	3.50	1550.00	1.38	500	2.00	533	1.84	593	-
Rajshahi	3.00	1800.00	2.36	950	1.20	373	1.00	400	1
Thakurgaon	2.67	1542.00	2.82	900	1.33	533	1.00	365	-
All locations	2.84	1,671.00	2.35	831.75	1.51	479.67	1.28	452.67	1.00

iv) Weed control operation

Table 6 shows the methods of weed control operation by the respondent households. In the study area, the main cultivated crops were rice, wheat, maize, jute, pulses, oilseed, vegetables and others. The maximum framers have grown rice followed by wheat, jute, vegetables, maize and pulses. The rice and other crop growers mostly have followed traditional practices of weed control.

It was evident that 81.66% rice growers, 39.96% wheat growers, 35.67% jute growers and 31.66% vegetables growers practiced weed control by traditional methods. Few rice growers and vegetables growers practiced CA in case of weeding.

The costs of weed control under different methods are presented in Table 7. Farmers mostly use hand for weed control, and cost is also high in this method. The cost of weeding is higher for vegetable production both for weeding by hand and by machine. Weed control by machine is practiced in a limited scale only for rice, wheat, and

vegetables. It is also evident that cost of weed control by medicines is cheaper than by hand and by machine.

Table 6: Methods of Weed Control Operation by the Respondent Households

Crops	Methods of weed control practiced by HHs under			
	By traditional practices		By CA practices	
	No. of HH	% of HH	No. of HH	% of HH
Rice	374	81.66	131	28.60
Wheat	183	39.96	12	2.62
Maize	55	12.01	1	0.22
Jute	162	35.37	12	2.62
Pulses	46	10.04	7	1.53
Oilseeds	19	4.15	10	2.18
Vegetables	145	31.66	47	10.26
Others	12	2.62	2	0.44

Table 7: Area under Different Methods of Weed Control by the Respondent Households

Crops	Area in acre	No. of farm grown	By hand		By weed machine		By medicines	
			No. of weed control	Costs	No. of weed control	Costs	No. of weed control	Costs
Rice	2.72	343	2.07	3082	1.20	2590	1.25	610
Wheat	1.31	163	1.53	1725	2.00	700	1.45	204
Maize	1.02	55	2.00	1286	-	-	3.00	300
Jute	1.95	162	2.50	5492	-	-	1.42	320
Pulses	1.49	46	1.87	1736	-	-	1.57	372
Oilseeds	0.90	29	1.72	1353			2.70	1060
Vegetables	3.21	145	2.28	7780	3.00	3600	1.35	951

The main reasons for practicing CA technologies in relation to weed control by the respondent are: require less labor, economically profitable, weed can't grow quickly, increase production, require less fertilizer, reduce production cost, and protect pest & insects. On the other hand, the farmers who are not using CA weed control method (11.35%) claimed that destruction of environment was the main cause for not practicing the CA technologies.

v) Pattern of crop rotation

The number and percentage of households that are practicing and not practicing crop rotation in the sample districts are presented in Table 8. Table 8 indicates that 55.08%, 39.38%, 43.33% households practiced crop rotation in Mymensingh, Rajbari and Rajshahi regions respectively. But in Thakurgaon region no household practiced crop

rotation. For all households, 39.30% practiced crop rotation while 60.70% didn't practice it.

Table 8: Crop Rotation Practices by the Respondent Households

Area	Crop Rotation (Yes)		Crop Rotation (No)	
	No. of HH	% of HH	No. of HH	% of HH
Mymensingh	65	55.08	53	44.92
Rajbari	63	39.38	97	60.63
Rajshahi	52	43.33	68	56.67
Thakurgaon	0	-	60	100.00
Total	180	39.30	278	60.70

The reasons for using crop rotation stated by the farmers are: limited requirement of land for practicing it, being economically profitable, requirement of less fertilizer, better production and maintaining of soil fertility. But the stated perceptions varied over the study areas in number and in percentage.

Table 9 represents the crop rotation systems that were followed by the respondent HHs in the study areas. To have an idea about the crop rotation systems, the years 2010 and 2012 were used. Alternatively, the table also represents the cropping patterns followed by the respondent households for two years. In Boro season, the crop rotations that followed by the farmers were Boro rice-Pulses/Mustard, Maize-Wheat, Mustard-Pulses/Wheat, Pulses-Mustard/Wheat, Vegetables-Wheat/Maize, Wheat-Vegetables and fallow-Boro Rice. In Kharif I season, Jute-Aus Rice, Aus rice-Jute and Vegetables-Vegetables were followed, and in Kharif II season, Jute-Aman rice and Aman rice-Pulses were followed respectively. On the other hand, the cropping patterns followed in 2010 were Boro rice-Jute-Jute, Maize-Maize- **Table 9: Crop Rotations by the Respondent Households**

2010			2012		
Rabi	Kharif I	Kharif II	Rabi	Kharif I	Kharif II
Boro Rice	Jute	Jute	Pulse/Mustard	Aus Rice	Aman Rice
Maize	Maize	Aman Rice	Wheat	Aus Rice	Pulses
Mustard	Aus Rice		Pulse/Wheat	Jute	
Pulses	Vegetables		Mustard/Wheat	Vegetables	
Vegetables			Wheat/Maize		
Wheat			Vegetables		
Fallow			Boro Rice		

. Aman rice, Mustard-Aus rice, Pulses-Vegetables and the single cropping pattern was Vegetables, Wheat and Fallow. In 2012, the cropping patterns have changed which were Pulse/Mustard- Aus Rice- Aman Rice, Wheat- Aus Rice- Pulses, Pulse/Wheat-Jute, Mustard/Wheat-Vegetables and the single cropping pattern was Wheat/Maize, Vegetables and Boro rice. Farmers change their crop rotation behaviour mostly in rabi season, and least in kharif II season.

vi) Constraints and opportunities to adoption of CA technologies

Table 10 describes the constraints to the adoption of CA in the studied households. The constraints have been classified into three categories as high, medium and low. Further, a rank of 1-5 has been given to the constraints, where rank 1 indicates the highest perception about a constraint while rank 5 indicates the lowest perception about a constraint. The highest perception was given to the constraint of low production at minimum tillage (47.66%) and growing of more weed (47.38%). The other constraints are: lower level of animal feed, lower level of cooking fuel, and bothering job.

Table 11, on the other hand, describes the opportunities to adoption of CA in the studied households. Similar to table 10, the opportunities have been identified and a rank of 1-5 has been given to those. Rank 1 has been given to the opportunity of low cost of labour for seeding, weeding and harvesting which occupied 43.27% of the total households while rank 5 has been given to the opportunity of setting up mind for alternative sources of cooking fuel which occupied 2.88% of the total households. They have ranked 2, 3 and 4 to the opportunities of increased soil fertility through crop rotation, herbicides can be used for control weeds and, crop residues can be handled easily to procure animal feed which occupied 30.77%, 14.42% and, 8.65% respectively. Therefore, it can be concluded that conservation agriculture system can be efficient to the respondents if the respondents used it by considering the above opportunities.

Table 10: Constraints to Adoption of CA in the Studied Households

Constraints	All HHs (%)			All HHs (	Ranks
	High	Medium	Low		
Low production at minimum tillage	9.61	18.12	19.43	47.66	1
Grow more weeds	8.08	28.82	10.48	47.38	2
Lower level of animal feed	25.55	5.68	4.80	36.03	3
Lower level of cooking fuel	15.94	12.88	6.33	35.15	4
Bothering job	2.62	11.35	15.94	29.91	5

Table 11: Opportunities to Adoption of CA in the Studied Households

Items	No. of H	% of total	Rank
Less cost of labor for seeding, weeding & harvesting	45	43.27	1
Increased soil fertility through crop rotation	32	30.77	2
Herbicides can be used for control weeds	15	14.42	3
Crop residues can be handled easily to procure animal feed	8	8.65	4
Set up mind for alternative sources for cooking fuel	3	2.88	5

IV. CONCLUSION AND POLICY IMPLICATION

This study concluded that higher CA practices induced higher cropping intensity and farm income. The widely use of rented power tillers are inducing farmers to adopt CA technologies. CA adopters' are practicing diversified tillage operations and among them strip tillage was mostly established. Traditional methods of weeding were also largely practiced in the rice crop field than the other crops (i.e. wheat, maize, jute, pulsed, oilseeds, vegetables and other crops). Among the 458 households, most of the households have not practiced crop rotation. But the households in Mymensingh region have practiced this method more than other regions. Some constraints and opportunities of CA have been reported by the farmers in the study areas. If these issues are taken into consideration, CA can be adopted more extensively in Bangladesh.

On the basis of the findings, promotion of knowledge on the benefits of CA technologies should be ensured through training by DAE and local NGOs. In addition, government should come forward to provide agro-machineries through local workshop at reasonable price. Finally, the research on the crop rotation and cropping patterns for harvesting the benefits of CA technologies is also suggested.

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