Bangladesh J. Agric. Econs. XXXVIII, 1&2 (2016-2017) 73-83

Research Note

ADOPTION STATUS AND FACTORS INFLUENCING ADOPTION OF CONSERVATION AGRICULTURE TECHNOLOGY IN BANGLADESH

M.A. Nasrin[1]
M. Akteruzzaman[2]

ABSTRACT

Conventional tillage systems and the highprices of fuel, chemical fertilizers and labor wage that reduce farm income induced. Conservation agriculture (CA) technology is practiced for reducing cost of production and promote sustainable agriculture in Bangladesh. Thus, this study was conducted to delineate the status of adoption and thefactors influencingadoption of CA technology practice. A total of 240 farmers were randomly selected for survey of which 120 were adopter and 120 were non-adopters from Durgapur upazila of Rajshahidistrict and Baliakandiupazila of Rajbari district during February to May 2017. The evidence shows that 47.50% farmers are practicing CA technology at medium level and 36.67% were high level whilevery few of them had low level. Strip tillage (100%of VMP and PTOS farmers) found to be the most popular under VMP and PTOS in both areas compare to zero tillage and other conservation practices. By applying the logit model, it is evident that out of eight independent variables, farm size, family size, earning member, extension access and training facilities of the farmers significantly contributed the adoption of CA practice. Finally, the study suggested to make available service providers through easy credit and demonstration the benefits of CA adoption involving GO and NGOs in order to expand CA practices.

Key words: Conservation Agriculture, Adoption Status, Factors influence, Strip tillage and Zero tillage.

I. INTRODUCTION

Increasing agricultural production and productivity through sustainable intensification is not an option but could be the only feasible means to feed the alarmingly increasing world population with less detrimental effects to the environment (Tilman et al., 2002; Pretty et al., 2003; Friederich and Kassam, 2011; Friedrich et al., 2012). In this regard, the role of conservation agriculture (CA) as a means of attaining sustainable intensification and promoting productive capacity, soil health and environmental services under diverse agro ecologies with different soil types has got scientific backings (Hobbs et al., 2008; Kassam et

---

[1] * This paper is based on partial data of the 1st author's doctoral study which is funding by the Ministry of Science and Technology, GoB, Bangladesh Secretariat, Dhaka.

[1]&[2]Theauthor's are respectively doctoral student and Professor of the Department of Agricultural Economics, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh

al., 2009; Giller et al., 2009; Haque et al., 2010; Erenstein et al., 2012).CA aims to achieve sustainable and profitable agriculture and subsequently aims at improved livelihoods of farmers through the application of the three CA principles: minimal soil disturbance, permanent soil cover and crop rotations.

It is a way to combine profitable agricultural production with environmental concerns andsustainability and it has been proven to work in a variety of agro-ecological zones and farming systems (FAO, 2015). CA technology is win-win situation, as it encourages sustainable agricultural development including itself environmental, economic and social values (Pirmatovet. Al., 2016).

In northwest region of Bangladesh the International Maize and WheatImprovement Centre (CIMMYT) developed Versatile Multiple-Crop Planter (VMP) with a hope to mitigate drought with CA equipment. Initial results indicate that the VMP could be used in multiple modes for crop establishment of rice, i.e., strip tillage, minimum tillage, bed formation and conventional tillage. Regardless of the form of CA tillage treatment, about 41-43% less water was required compared to a conventional tillage system. Fuel consumption had significant variation among the treatments, with 65 % less fuel required in strip tillage treatments by VMP (Islam etal., 2010). In Bangladesh, Australian Center for International Agriculture Research (ACIAR) is pioneer in promoting CA and they are funding different organizations. International Development Enterprise (IDE) is implementing a project supported by ACIAR, 'Overcoming agronomic and mechanization constraints to development and adoption of conservation agriculture in diversified rice-based cropping in Bangladesh during 2012-2016 in Rajshahi, Mymensingh, Rajbari and Dinajpur. In Rajshahi, the experiment was conducted to evaluate appropriate planter and planting system and came out with a conclusion that strip tillage performed better than the other two minimum tillage (Zero Tillage and Bed Planting) methods compared to conventional method(Islam et al., 2013). These findings induced expansion of CA practices for rice in high Barind soils by intensified HYV rice and other crops cultivated to feed the huge population of the country (Akteruzzamanet al*.,* 2012). The consequences of this intensified rice based agriculture on soil fertility, soil microbial activity and lastly to environment are severe (Uddin and Dhar, 2016). Bangladesh is also trying to adopt CA considering its positive impact on soil health. Consequently CA techniques are practicing in the country but not on large scale (Islam et al., 2011). Farmers are accepting the concept of CA based tillage systems considering the advantages of higher yields, reduced cost of tillage operation, and minimum turnaround time between the crops (Hossainet al.,2015). Research evidence illustrates that CA techniques can give similar yields as conventional tillage with less time and energy input and better environmental sustainability (FAO, 2009; Pender et al., 2009). The other study also suggested that CA techniques may lead to higher gross margin than conventional agriculture due to higher yields and lower input costs (FAO, 2009; Pulatov et al., 2009; Tursunov, 2009). Although the benefits are higher but the adoption of CA technology is not satisfactory. Thus, the present study is undertaken to examine the status of adoption of CA techniques and find out the factors influencing on adoption of CA technology to make further recommendation to expand CA techniques in Bangladesh.

II. METHODOLOGY

Data Source

It was purposively decided that farm survey data would be useful for the study. To obtain data, two districts namely Rajbari and Rajshahi were selected purposively because those districts are renowned and pioneer for CA practices in Bangladesh. After selecting two districts, one upazila from each district was selected purposively. Balikandi under Rajbari district was selected considering the level of adoption CA on the basis of the previous studies and report where PTOS(Power tiller operated seeder) were used since 2000. On the other hand, Durgapur upazila under Rajshahi district was selected where VMP is practicing since 2015. From these two upazilas, a total of 12 villages were selected. The selection of the villages depended on the extent of the adoption of CA by farm households. According to the objectives, a total of 240 farmers were selected randomly of which 120 farmers are adopting CA and 120 are non-adopter covering both areas. Data were collected during the period from February 2017 to May 2017 through face to face interview. In this study, the farmers were considered as adopters of CA if they have used minimum soil disturbance tillage technology with partially crop residue retention, suitable crop rotation and weed management; otherwise, they are considered as non-adopters.

Model for Estimation Adoption of CA Technique

The adoption level was determined by calculating adoption quotient based on formula developed by Sengupta (1976) as follows :

$$\textbf{Adoption Quitent (A.Q)} = \frac{\textbf{Number of practices used}}{\textbf{Total number of practices}}\ \textbf{x100}$$

The adoption quotient was calculated for every adopter. Later on, all the respondents were classified into three categories on the basis of mean (X) and standard deviation (S.D.).

SL No	Category	Score
1	High level adopter	>mean- S.D
2	Medium level adopter	in between mean± S. D
3	Low level adopter	< mean- S. D

Estimation of Logit Regression Model

A binary logistic regression model was used to determine factors influencing adoption of CA. According to the diffusion of innovation, theoretical perspective of a farmer response towards an innovation is binary, either adopts or rejects. Hence the model for CA adoption was specified as

Logit (P(y=1)) = log(P/(1-P))= α+ β1X1+ β2X2+... + βKXK where Y is a categorical response variable with 1=adopters and 0=otherwise; α is the intercept; β1, β2.... βk are coefficients of independent variables X1 X2... XK; P is the probability of adopting CA and (1-P) is the probability that a farmer does not adopt CA. Since a farmers either had an area under CA (adopter) or no area under CA (non adopter) it was most appropriate to use a binary logistic regression model (Agresti, 2007) for the purposes of understanding factors explaining the likelihood of CA adoption.

X1=Farmer's age (year) , X2 = Education (year of schooling) , X3 = Family size (No./HH), X4= Earning person (no.), X5= Farm size (acre), X6= Household income (TK.), X7=Extension access X8 = Service provider availability, X9= Training, α=Constant,β1 β2 β3 β4 .... β9are the coefficients to be estimated.

Selection of the Variables

Adoption of CA is the dependent variable of the study. It was measured based on 3 principles of CA techniques adding weed management. The principles are: zero tillage or minimum tillage, retention of crop residues and suitable crop rotation. Farmers' age, level of education, family size, dependency ratio, farm size, household income, extension media contact, availability of service provider, and training were the independent variables assuming that these variables might influences on practicing CA techniques. These variables were measured using appropriate scales and scoring system. Both the descriptive and inferential statistical analyses were done.

III. RESULTS AND DISCUSSION

Socioeconomic Profile of the Respondents

The socioeconomic characteristics of farmers' are shown in Table 1. The average age of the adopter farmers belongs to 43.21 years and 45.84 years respectively under VMP and PTOS tillage. On the other hand, non-adopter farmers belong to age in 49.85 and 46.72 years in the study areas. Survey report presented that adopter farmer generally younger than the non-adopter farmers in both areas. The adopter farmers' schooling years were 8.89 and 6.13 years respectively for VMP and PTOS tillage. In case of non-adopter farmers these were 5.06 and 4.37 years in both areas. Survey results showed that adopter farmers were more educated than that of non-adopter farmers. Average family size of adopter farmers are 4.4 and 4.52 under VMP and PTOS tillageand non-adopter farmers are 5.2 in both areas that is more than that of adopter farmers in both areas. Research evidence showed that average earning person of adopter and non-adopter farmers in both areas are more or less same. The farm size of adopter farmers are 1.65 and 1.13 acres under VMP and PTOS tillage. In case of non-adopter farmers, these are 0.82 and 0.80 acre respectively in both areas. Results showed that adopter farmers were larger farm size than that of non-adopter farmers in both areas. The annual household'sincome of adopter farmers is Taka 294230 and 308471 and non-adopter farmers are Taka 127174 and 128934 respectively in both areas. Report presented that households income of adopter farmers are more than that of non-adopter farmers. The results also showed that access to extension workers, local service provider's facilities and training of adopter farmers were more than that of non-adopter farmers in both areas.

Table 1. Socioeconomic profile of the respondents

Socio-economic Profile	VMP		PTOS	
	Adopter farmer (n=60)	Non-adopter farmer (n=60)	Adopter farmer (n=60)	Non-adopter farmer (n=60)
Average age (year)	43.21	49.85	45.84	46.72
Year of schooling	8.89	5.06	6.13	4.37
Average family size (no.)	4.4	5.2	4.52	5.20
Earning person (no.)	1.55	1.55	1.47	1.4
Farm size (acre)	1.65	0.82	1.13	0.80
Household income (TK.)	294230	127174	308471	128934
Extension access (score 0-3)	1.95	0.8	1.86	0.98
Service provider availability (score 0-2)	1.81	0.55	1.67	0.25
Training (no.)	2.4	0.38	2.32	0.20

Source: Field survey, 2017

Adoption Extent of CA Technology

Table 2 presents that 41.67%, 31.67% high level, 48.33%, 46.67% medium level and 10.00%, 21.66% are adopted low level under VMP and PTOS tillage. The adoption levels are categorized on the basis of Adoption Quotient (A.Q) formula which mentioned methodology section. Table 2 indicates that 47.50% farmers are practicing CA technology at medium level and 36.67% were high level whilevery few (15.83) of them had low level adoption in all areas. Previous studies also suggests that, farmers adopt retention of crop residues, crop rotation and less soil alteration (zero and minimum tillage) more than other practices (Uddinet al., 2017) and also practiced highly in Bangladesh (Akteruzzamanet al.,2012). Results presented in table 3 revealed that 10.57% and 28.17% area adoption in Kharif I season, 1.89% and 5.11% in Kharif II season and 43.06% and 34.53% in rabi season, respectively in VMP and PTOS adopters.

Table 2. Adoption level of CA technology by the location

Adoption level	VMP adopter (n=60)		PTOS adopter (n=60)		All (n=120)	
	No of HH	% of HH	No of HH	% of HH	No of HH	% of HH
High level	25	41.67	19	31.67	44	36.67
Medium level	29	48.33	28	46.67	57	47.50
Low level	06	10.00	13	21.66	19	15.83
Total	60	100	60	100	120	100

Source: Field survey, 2017

The evidence shows that large amount of area are adopted in Rabi season comparatively than that of Kharif I and Karif II season. The results also showed that very low adoption in Kharif II season, the reason is that T. aman is the main crop in that season and also zero tillage is practicing to cultivate the T. aman in some extent. On the other hand, the other two seasons(Kharif I and Rabi) mostly practiced in strip tillage under VMP and PTOS for cultivation various crops (jute, wheat, maize, lentil and mustard). Table 4 revealed that among eight cropping patterns of both areas Lentil-Boro-T.amanunder VMP and Lentil-Jute-T.amanunderPTOSCA area is comparatively more than that of others cropping patterns.

Table 3. Intensity of area adoption of CA technology by cropping season

Season	VMP adopter (area in acre)			PTOS adopter (area in acre)		
	Total Area	CA Area	% of CA area	Total Area	CA Area	% of CA area
Kharif I	65.84	6.96	10.57	60.73	17.11	28.17
Kharif II	60.96	1.15	1.89	5.9	3.04	5.11
Rabi	60.01	25.84	43.06	59.68	20.61	34.53

Source: Field survey data, 2017

Table 4. Intensity of area under CA technology according to cropping pattern

Cropping pattern	Tillage technology VMP=1, PTOS=2	No. of HH	Cultivable land (acre)	Area under CA (acre)	% of CA area
Lentil- Boro-T. aman	1	15	45.39	9.21	20.28
Wheat-Jute- T. aman	1	15	33.65	6.70	19.91
Mustard- Boro-T.aman	1	15	45.00	7.09	15.76
Maize-Maize-T. aman	1	15	62.77	10.95	17.45
Lentil-Jute-T.aman	2	15	37.74	13.40	35.51
Wheat-Jute-T.aman	2	15	62.75	13.86	22.09
Mustard-Jute-T.aman	2	15	44.94	8.28	18.42
Onion-Jute-T. aman	2	15	34.46	5.22	15.15
All		**120**	**366.71**	**74.71**	**20.37**

Source: Field survey, 2017

Table 5 revealed that 100% adopterfarmer'sof VMP and PTOS practices strip tillage on CA plots. In contrast zero tillage practices 20% and 16.87%; bed planting practices 8.33% and 0%; retention of crop residue 100% (one season in a year) and crop rotation practices 60% and 85% adopter farmers of VMP and PTOS respectively. In addition study results showed that (table 5) 70.83% and 58.33% non-adopter farmers practices retention of crop residue and crop rotation respectively. In the case of weed control 100% of VMP and PTOS farmers control weeds by hand and applying weedicide. On the other hands non adopter farmers control weeds by hand and applying weedicide 100% and 66.67% respectively.Some sampled farmers (adopters and non-adopters) also thought that suitable crop rotations can reduce the incidence of insects and diseases.

Table 5. CA practices by the Selected CA Farmers

CA practices	VMP adopter (n=60)		PTOS adopter (n=60)		Non adopter (n=120)	
	No. of HH (N=60)	% of HH	No. of HH (N=60)	% of HH	No. of HH (N=120)	% of HH
Tillage						
Traditional tillage (non-CA plot)	60	100	60	100	120	100
Traditional tillage (CA plot)	0	0	0	0	-	-
Zero tillage (CA plot)	12	20	10	16.67	-	-
Strip tillage(CA plot)	60	100	60	100	-	-
Bed planting (CA plot)	05	8.33	0	0	-	-
Retention of crop residues(non-CA plot)	52	86.67	45	75	85	70.83
Retention of crop residues(CA plot)	60	100	60	100	-	-
Crop rotation (non-CA plot)	15	25	45	75	70	58.33
Crop rotation (CA plot)	36	60	51	85	-	-
Weed control						
Weeding by hand	60	100	60	100	120	100
Applying weedicide	60	100	60	100	80	66.67

Source: Field survey data, 2017

Factors influencing adoption CA technology

The results of the logistic regression model were summarized in the Table 6. Five independent variables among eight have been statistically significant at 5% level. Significant variables are: farm size, family size, earning member, extension access and training. The age and farming experience have negativelyinfluenced though insignificant; it means that the probability of adoption of the CA technologies increases with the decrease of farmers' age and farming experience. It may be concluded that young farmers are the most adopters of CA technologies.In this study education had positive but insignificant impact on the adoption of CA practices indicating that the probability of adoption of CA technologies increases with the increase of the year of schooling. It means that high educated farmers are the most adopters of CA technologies compared to lower educated farmers in the study areas. Many studies also supported that the education had positive influence on new technology adoption (Miah et al., 2010 and Islam, 2010). Research shows that farming experience had insignificant negative impact on CA practices means that farmers who have more experience are traditional minded and reject in new technology than that of farmers who have less farming experience. The study revealed that farm size had positive significant relation on adoption of CA practices implying that large farmers are more adopter than that of small farmers. Small farm size is observed here feel at risk to try new things like CA techniques. So they need some assurance to give trial to some new practices. The study revealed that family size had significant and negative relation on adoption of CA practices.The farmers who have large family size, they have more family labor for that reason they are practicing in traditional agriculture. In this study the family had more earning member they are more adopter than that of family have less earning member. When extension media contact increases farmers get that assertion from different extension agent. Organizational participation also plays similar kind of role like extension media contact can also learn from them about the benefits of CA techniques. In the study, it also revealed that the farmers who have attended more training had a positive and highly significant relationship with the probability of adopting CA practices,thus,concluded that providing farmers training on CA can be important tools to better adoption of CA techniques.The adjusted R^2 was found to be 0.83, thus, the above mentioned variables can explained 83% of the factorsinfluences adoption of CA practices.

Table 6. Factors influencing adoption of Conservation Agriculture Technology

Factors	Coefficient	S. E	t-value
Constant	-8.84	3.05	-2.90
Age	-0.07	0.08	-0.78
Education	0.11	0.11	1
Farming Experience	-0.15	0.10	-1.51
Farm size	0.05	0.02	2.92*
Family size	-1.11	0.31	-3.60*
Earning member	2.81	1.00	2.82*
Extension access	2.22	0.78	2.84*
Training	3.17	0.59	5.39*
Adjusted R^2	0.83		

Note: *Significant at 5% level.

The marginal effects of the factors determining adoption of CA technology are presented in Table 7. Farmers age had significantnegatively influence on the adoption of CA technology implying that the probability of adoption of the CA technologyincreases with the decrease of farmers' age. In this study, education had significantpositive impact on the adoption of CA technology implying that the probability of adoptionof CA technologyincreases with the increase of the year of schooling. It means thateducated farmers are the most adopters of CA technology compared to illiterate/or lower educatedfarmers in the study areas. Marginal coefficient reveals that if the year of schooling increasesby 100%, the probability of adopting CA technologies would be increased by 1.59% (Table 7).Education has positive influence on new technology adoption (Miah et al., 2015). In the study areas more farming experienced farmers are less likely to adopt CA technology than that of fewfarming experienced farmers. Marginal coefficient reveals that if the farming experiencedecreasesby 100%, the probability of adopting CA technologies would be increased by 1.50% (Table 7). The evidence shows that large farmer's are more likely to adopt CA technology than that of small farmers implying that the farm sizeincreasesby 100%, the probability of adopting CA technologies would be increased by 0.74% (Table 7). Inthis study family size had significant negative influence on the adoption of CA technology. Marginal coefficient reveals that if the familysizedecreasesby 100%, the probability of adopting CA technologies would be increased by 17.33%(Table 7). On the other hand earning person had the significant positive influence on the adoption of CA technology. If the earning member increases by 100%, the probability of adopting CA technologies would be increased by 45.88%(Table 7). Finally, extension access and training had also significant positively influence on the adoption of CA technology. Marginal coefficient also shows that if the extension contact and training on different CA practices increases by 100%, CA adoption likely to be increased by 37.55% and 52.87% respectively (Table 7).

Table7. Marginal effect of the factors determining adoption of Conservation Agriculture Technology

Factors	dy/dx	S. E	t-value
Age	-0.0051	0.0023	-2.22*
Education	0.01595	0.0211	0.76
Farming Experience	-0.0150	0.0075	-2.00
Farm size	0.0074	0.0017	4.35*
Family size	-0.1733	0.0738	-2.35*
Earning member	0.4588	0.2053	2.23*
Extension access	0.3755	0.0957	3.92*
Training	0.5287	0.1584	3.34*

Note: *Significant at 5% level.

IV. CONCLUSIONS AND POLICY RECOMMENDATIONS

CA adoption is still on-going in the study areas. The evidence showed that maximum adopters were medium level adopter in both areas. Conservation tillage (strip) using VMP and PTOS is largely used for different crop establishment than that of other conservation tillage (zero and bed planting) technology in the study areas. It is also clear that among different CA practices strip tillage is more popular in both areas. Traditionally, a good number of the non-CA farmers retain crop residues in the field and practice suitable crop rotations over the year. The determinants such as younger age, educated farmers, large farmers, farmers who have more earning persons, extension contact of the farmers and training have significantly positive influenced them to adopt CA practices. Study revealed that young farmers are the most adopters of CA technology. The respondents contact with different extension personnel such as Agriculture Officer, Sub Assistant Agriculture Officer, BARI scientist and lead farmers and getting access to agriculture fair, booklet, leaflet, field day, radio, television had a positive and highly significant relationship with the probability of adopting CA technologies. The findings revealed that extension media contact has the strongest relationship with the practice of conservation agriculture. Training is another crucial factor that influences farmers to adopt the technology to a great extent. Finally it can be concluded that to expand CA practices, organize more training, make available extension accessinvolving GO and NGO extension workers and demonstration the benefits of CA adoption aswell as strengthening research-extension-farmers collaboration are strongly suggested.

REFERENCES

Akteruzzaman, M., Jahan, H.andHaque, M.E. 2012.Practices of conservation agricultural technologies in diverse cropping systems in Bangladesh. *Bangladesh Journal of Agricultural Economics*, 35 (1 & 2), 143-153.

Agresti, A. 2007.*An Introduction to Categorical Data Analysis* (2 ed.). Hoboken, New Jersey: JohnWiley& Sons, Inc. (Chapter 4). http://dx.doi.org/10.1002/0470114754

Erenstein, O., Sayre, K.,Wall,P.,Hellin, J. and Dixon.J. 2012. Conservation agriculture in maize-and wheat-based systems in the (sub) tropics: lessons from adaptation initiatives in South Asia, Mexico, and Southern Africa. *Journal of Sustainable Agriculture*, 36:180– 206, 2012

Food and Agricultural Organization, FAO. 2015. Conservation agriculture. Retrieved December 24, 2015,
from http://www.fao.org/ag/ca/1a.html

FAO. 2009. Conservation agriculture in Uzbekistan. Food and Agriculture Organization of the United Nations, Rome, 2009, pp. 23 –25; pp. 29–30

Friedrich, T., Derpsch, R. and KassamA. 2012.Overview of the global spread of conservation agriculture.*Field Actions Science Reports*.Special Issue 6. September 12, 2012. http://factsreports.revues.org/1941

Friedrich T., and Kassam,A. 2011. Conservation agriculture: concepts, worldwide experience, andlessons for success of CA-based systems in the semi-arid Mediterranean environments. In:Bouzerzour H. (ed.), Irekti H. (ed.), Vadon B. (ed.). 4. RencontresMéditerranéennes du Semis Direct.Zaragoza : CIHEAM / ATU-PAM / INRAA / ITGC / FERT, 2011. p. 11-51 (Options Méditerranéennes :Série A. SéminairesMéditerranéens; n. 96.

Haque, M.E., Esdaile,R.J.,Kabir,E., Vance, W., Bell,R.W.,Musa,A. M.,Shahidullah, A.K.M. Mia,M.N.N., Maruffuzaman,M. and Johansen, C. 2010. Minimum tillage, mechanized sowing of pulses with two-wheel tractors. 19th World Congress of Soil Science, Soil Solutions for a Changing World.1-6 August 2010, Brisbane, Australia.

Hobbs, P.R., Sayre,K. andGupta, R. 2008. Role of CA in sustainable agriculture. *Philosophical Transactions of the Royal Biological Science Society,*363:543–555

Hossain, M.I., Sarker, M.J.U., Haque, M.A. 2015.Status of conservation agriculture based tillage technology for crop production in Bangladesh. *Bangladesh Journal of Agricultural Research,* 40(2): 235-248.

Knowler, D. and Bradshaw, B. 2007. Farmers' adoption of conservation agriculture: a review and synthesis of recent research. *Food Policy,* 32(1): 25-48.

Islam, A.K.M.S., Hossain, M.M.; Saleque. 2013.Evaluation of direct seeded rice planter under minimum tillage practices. *The Agriculturists,* 11(2): 87-95.

Islam, A.K.M.S.; Hossain, M.M.; Saleque, M.A.; Rahman, M.A.; Karmakar, B.; Haque, M.E. 2012.Effect of minimumtillage on soil properties, crop growth and yield of aman rice in drought prone Northwest Bangladesh.*Bangladesh Agronomic Journal,*15, 43–51.

Islam, A.K.M., Haque, S., Hossain, M.E.,Saleque, M.M., and Bell, R.W. 2011.Evaluation of versatile multi-crop planter to establish the sprouted direct seeded rice. 5th World Congress of Conservation Agriculture incorporating 3rd Farming Systems Design Conference, 2011, Australia.

Islam, A.K.M.S, Haque, M.E., Hossain, M.M.,Saleque, M.A. and Bell, R. W. 2010. Water and fuel saving technologies: un-puddled bed and strip tillage for wet season rice cultivation in Bangladesh. In *Proceedings of the 19th World Congress of Soil Science, Soil Solutions for a Changing World.*1 – 6 August 2010, Brisbane, Australia.Eds R.J. Gilkes Published on DVD. pp. 169-172.

Kassam, A., Friedrich, T., Shaxson, F. and Pretty, J. 2009. The spread of conservation agriculture: justification, sustainability and uptake. *International Journal of Agricultural Sustainability*, 7: 292-320.

Giller, K.E., Witter, E., Corbeels, M., Tittonell , P. 2009.Conservation agriculture and smallholder farming in Africa: the heretics' view.*Field Crop Research*., 114, pp. 23-34.

Miah, M.M.A., Haque, M.E., Baksh, M.E. and Hossain, M.I. 2010. Economic analysis of power tiller operated seeder operation at farm level. *Journal of Agricultural Engineering*, 1**:** 19-24.

Miah, M.M.A.,Afroze, S., Rashid, M. A., and Shiblee, S.A.M. 2015. Factorsaffectingtheadoptionofimprovedvarieties of mustardcultivationin some selectedsitesof Bangladesh.*Bangladesh Journal of Agricultural Research*, 40(3): 363-379.

Hobbs, P.R.,Sayre,K. and GuptaR. 2008.The role of conservation agriculture in sustainable agriculture*Philosophical Transactions of the Royal Society B*, 363 pp. 543-555

Pender, J.Mirzabaev, A.Kato, E. 2009. Economic analysis of sustainable land managementoptions in Central Asia. In Asian Development Bank, 2009, pp. 13–14.

Pirmatov, K. Pulatov, A.Horská, E. 2016.Comparative analysis of conventional and conservation agriculture, doi:http://dx.doi.org/10.15414/isd2016.s2.07

Pulatov, A.Umurzakov, U.P. Hudaynazarov, J.K. 2009.Experience and economic analysis of no-tillage system implementation in wheat production. In Muradov, S.O. Wietsma, E. Pulatov, A. (Eds.), Ecological education, monitoring and management quality of environment. Tempus Project Team, Karshi,Uzbekistan, 2009, pp. 104–109.

Pretty, J.N., Morison,J.I.L. andHine, R.E. 2003.Reducing food poverty by increasing agricultural sustainability in developing countries. A*griculture, Ecosystems and Environment*, 95:217–234.

Sengupta, T**.** 1976. A simple adoption scale used for farmers for high yielding programme of rice. *Indian Journal of Extension Education,* 3(3):107-115.

Tilman, D., Cassman, K.G.,Matson, P.A.,Naylor,R. andPolasky, S. 2002. Agricultural sustainability and intensive production practices. *Nature*, 418.

Tursunov, M. 2009. Potential of conservation agriculture for irrigated cotton and winter wheat production in Khorezm, Aral Sea Basin Rheinischen. Bonn : Friedrich-Wilhelms-Universitätzu Bonn, 2009, p. 106.

Uddin, M.T., Dhar, A.R., and Rahman, M.H. 2017. Improving farmers' income and soil environmental quality through conservation agriculture practice in Bangladesh. *American Journal of Agricultural and Biological Sciences,* 12(1): 55.65.

Uddin, M.T. and Dhar, A.R. 2016. Conservation agriculture practice and its impact on farmer's livelihood status in Bangladesh. *SAARC Journal of Agriculture*, 14(1), 119-140.