SAARC J. Agric., 20(2): 121-131 (2022) *DOI: https://doi.org/10.3329/sja.v20i2. 63571*

ASSESSMENT OF THE PROFITABILITY AND PRODUCTIVITY OF JUTE-T. AMAN-MAIZE CROPPING PATTERN AT CHAR LAND IN JAMALPUR DISTRICT OF BANGLADESH

R. Ashrafi[1*], K.U. Ahmed[2], M.R. Khan[3], ASM.M.R. Khan[4]

[1]Planning and Development Section, Bangladesh Institute of Nuclear Agriculture, Mymensingh
[2]Planning and Evaluation Division, Bangladesh Agricultural Research Council, Dhaka
[3]Soil Science Division, Bangladesh Institute of Nuclear Agriculture, Mymensingh
[4]Bangladesh Agricultural Research Council, Farmgate, Dhaka

ABSTRACT

People living in the char land area are considered the most disadvantaged group of people in Bangladesh. Considering the situation, a study was conducted to evaluate the feasibility of increasing income of char dwellers by following profitable cropping pattern. The treatments were CP_1 (Farmers' practice cropping pattern): Grass pea (BARI Khesari-1)-Jute (var. JRO 524)-T. Aman (var. Swarna) and CP_2 (Altered cropping pattern): Maize (var. Hybrid 981)-Jute (var. JRO 524)-T. Aman (var. Binadhan-11). A randomized complete block design with six dispersed replications was followed in this experiment. It was observed that the altered cropping pattern (CP_2) produced higher rice equivalent yield (avg. 25.47 t ha^{-1}), production efficiency (78.61 kgha^{-1} day^{-1}) and gross margin US$ 3056.58 ha^{-1} than those of the farmer's practice cropping pattern (CP_1) rice equivalent yield (12.97 t ha^{-1}), production efficiency (40.40 kgha^{-1} day^{-1}) and gross margin (Tk. 79,950 ha^{-1}). Gross margin increased by 206% in altered cropping pattern compared with the existing cropping pattern, revealing that rabi crop based cropping pattern including flood damage escaping rice varieties {Maize (var. Hybrid 981)-Jute (var. JRO 524)-T. Aman (var. Binadhan-11)} is appropriate for getting higher productivity and profitability by the poor char dwellers of Jamalpur district in Bangladesh.

Keywords: Bangladesh, Char land, Cropping pattern, Flood, Income, Rabi, Submergence.

INTRODUCTION

In world, about one billion people stay hungry every day due to inadequate food supply and by 2050, this will increase to two billion. For this reason, in coming decades, there

* Corresponding author: reema_ashrafi@yahoo.com

Received: 12.09.2022 *Accepted: 15.11.2022*

will be a need to increase agriculture production with more than 70% for the developing countries of Asia and Africa (Neamatollahi et al., 2017). In Bangladesh due to various development activities, the agricultural land is decreasing at about 0.73% per annum (Hasan et al., 2013) but population is increasing at a rate of 1.3% per year (BBS, 2015). Though the mainland agricultural lands are decreasing, the char lands are increasing (Rahman, 2010). So, there is need to strengthened crop production measures in unfavorable eco-systems like char areas to feed the ever-increasing population. To produce more food, there is need to increase cropping intensity by growing two or more crops on the same land round the year.

Char lands in Bangladesh are landmasses formed on and along the bank of the big rivers. About one million ha of char lands are in Bangladesh and the area is increasing in every summer due to the huge sedimentation from the Himalaya (Karim et al., 2014). In Bangladesh, approximately 4-5% of the population lives in the char area which covers almost 7200 km^2 (Paul and Islam, 2015). The char lands are prone to acute erosion and flooding, and also poorly connected to the mainland. Livelihood conditions in the char areas are very harsh which discourage people for living. In most of the chars, cropping intensity and crop yield per unit area are low. Utilization of char land on modern ground can play an important role to reduce poverty along with increase income generation of the poor char dwellers and thus can contribute substantially to the national food security.

Maize crop creates an opportunity to increase income of farmers by utilizing in poultry feed, fish feed or cattle, for chapatti. Growing season of hybrid maize in Bangladesh is dry winter (rabi) season. Compared with two rabi crops (Boro rice and wheat), maize has higher grain yield, yield stability and profitability. It also requires less water for irrigation. Maize needs irrigation only around 850 l/kg grain production compared to 1000 l/kg wheat grain and over 3000 l/kg rice grain for Boro rice (Ali et. al., 2008).

The study area Nawvanger char in Jamalpur district represented the attached chars of Brahmaputra River. The char dwellers are the poorest and most vulnerable people to flooding and riverbank erosion. Bangladesh is predominantly rice growing country and cropping pattern based to rice are mostly following all over the country. In Jamalpur, more than 50% followed cropping pattern is Rice-Fallow-Rice. In the char area among the surveyed farmer, the major cropping pattern was observed Jute - T. Aman rice (Swarna) – Grass pea whereas grass pea is produced without proper management practices just for grazing and yielded very low. As a result, a huge part remains less productive for an extensive time after the harvest of T. Aman. Again, local variety of Aman rice i.e., Swarna (Indian origin rice variety and locally adopted for more than a decade) is transplanted which sometimes damages at seedling stage due to flood, which results in low yield as compared to high yielding varieties. This cropping pattern is not profitable for the farmers of this char area. In the char areas, rabi season is a flood-free period, but end of kharif-I and starting of kharif-II seasons fall within the flooding period. So, it is very imperative to identify a profitable and productive major rabi crop-based cropping pattern and Aman rice varieties having character of flood damage escaping submergence tolerance to improve livelihood through increasing profitability and productivity of crops. Keeping in view the aforementioned fact, the present experiment was undertaken to evaluate the feasibility of increasing income through increasing cropping intensity and productivity by growing three crops in a year in the same piece of land by substituting short duration submergence tolerance Aman rice variety instead of local Aman rice variety and high yielding profitable hybrid maize variety instead of growing grass pea.

MATERIALS AND METHODS

Cropping pattern of Grass pea (BARI Khesari-1)-Jute (var. JRO 524)-T. Aman (var. Swarna) was improved by inclusion of Maize (var. Hybrid 981)-Jute (var. JRO 524)-T. Aman (var. Binadhan-11) at the FSRD site, Nawvanger char, Sadar, Jamalpur during the year 2018-19 and 2019-20.

Site selection

The experiment was conducted in farmer's field of the char land area of Nawvanger char under Sadar Upazila of Jamalpur district. This area is located under Young Brahmaputra and Jamuna Floodplain (AEZ 8). It is located between 240°42´ and 240°58' North latitudes and between 890°52' and 900°12' East longitudes.

Experimental design and treatments

The study was conducted to compare the economic value and productivity of the alternative cropping pattern against existing cropping pattern. The study was outlined with two cropping patterns viz. CP_1 (Farmer's Practice): Grass pea (BARI Khesari-1)-Jute (var. JRO 524)-T. Aman (var. Swarna) and CP_2 (Altered Cropping Pattern): Maize (var. Hybrid 981)-Jute (var. JRO 524)-T. Aman (var. Binadhan-11). The experiment was laid-out in a randomized complete block design (RCBD) with six dispersed replications. The unit plot size was 1 bigha (1335 m^2) of land.

Crop management

Dry land and wet land preparation was done for maize crop and T. Aman, respectively. The plant nutrients were supplied through urea, TSP, MoP, gypsum, zinc sulphate and boric acid for N, P, K, S, Zn and B, respectively (Table1) (Fig 1). The agronomic practices and cultural operations of crop production for two cropping patterns are presented in the Table1.

Table 1. Cultivation procedure of crops in cropping pattern

Observation	Improved cropping pattern			Existing cropping pattern		
Crop	Jute	T. Aman	Maize	Jute	T. Aman	Pulses (grass pea)
Variety	JRO 524	Binadhan-11	Hybrid 981	JRO 524	Swarna	BARI Khesari-3
Date of sowing/ Transplanting	05 April	10 July/ 05 August	08 November	05 April	10 July/ 05 August	15 November
Seed rate (kg ha^{-1})	7.5	30	20	7.5	30	40
Spacing	30cm x 5cm	20cm x 15cm	75cm x 25cm	30cm x 5cm	20cm x 15cm	-
Fertilizer dose (urea-TSP-Mop-Gyp-Zn-B (kg ha^{-1})	217-85-60-94-18-0	160-115-60-25-4-0	512-275-200-222-14-6	220-150-115-75-7.5-7.5	150-100-120-80-7.5-7.5	50-80-30
Date of harvesting	10 July	30 October	30 March	10 July	08 November	25 March
Field duration (days)	96	86	142	96	95	130
Turned around time (days)	26	9	6	26	7	11

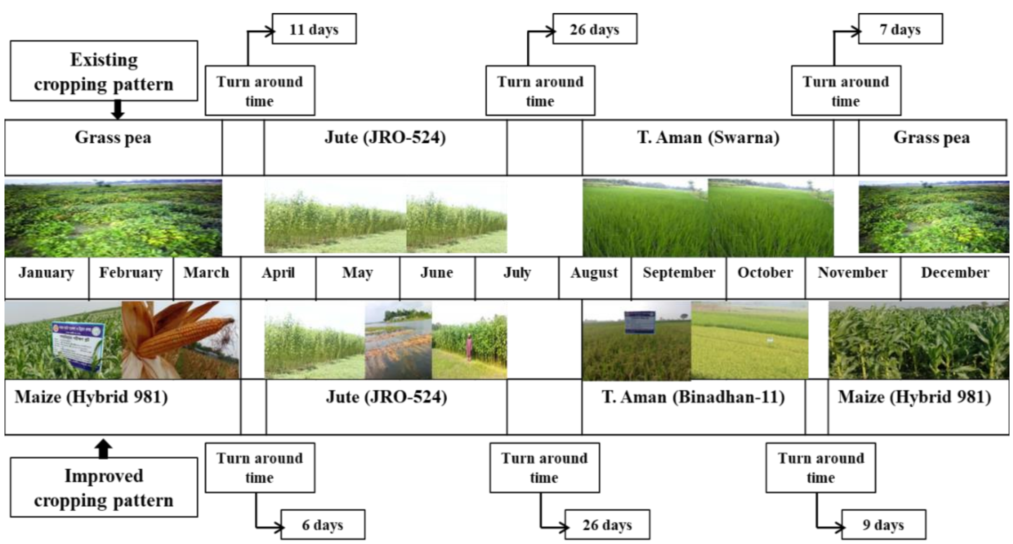

Figure 1. Existing cropping pattern with improved cropping pattern

Data collection and statistically analysis

For data collection, randomly 5 m^2 areas were selected in each plot at maturity and yield of component crops in the cropping patterns were recorded. Yield for each crop was measured an area basis (t ha^{-1}). Agronomic performance like rice equivalent yield, production efficiency and land use efficiency were calculated.

Estimation of rice equivalent yield (REY)

To compare and evaluate different cropping pattern, the yields of all non-rice crops were converted into rice equivalent. On the basis of yield and prevailed market price, rice equivalent yield was calculated (Ahlawat and Sharma, 1993) by following the below mentioned formula.

$$REY = \frac{\text{Yield of each crop (t ha}^{-1}\text{) x economic value of respective crop (Tk. t}^{-1}\text{)}}{\text{Price of rice grain (Tk. t}^{-1}\text{)}}$$

Estimation of land use efficiency

Land use efficiency (LUE) was expressed in % and calculated by formula as outlined by Jamwal (2001),

$$LUE = \frac{\sum Dc}{365} \times 100$$

Where Dc = duration of crops in the sequence

Estimation of production efficiency

Production efficiency (PE) was calculated by using formula sated by Jamwal (2001),

$$PE = \frac{REY}{\sum Dc}$$

Where REY =Rice equivalent yield in a sequence and

Dc = duration of crops in that sequence

Marginal Benefit Cost Ratio (MBCR) analyses

Costs were calculated considering the prevailed market price to determine the gross margin, total inputs (total variable cost) and outputs. The economic analysis was done following CIMMYT (1988). The MBCR is computed as the marginal value product (MVP) over the marginal value cost (MVC) where,

$$MBCR = \frac{\text{MVP (over control)}}{\text{MVC (over control)}}$$

Statistical analysis

All data were statistically analyzed following the F-test (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Yield of rabi season crop

Grain yield of crop is presented in Table 2. In rabi season, grass pea was yielded very low (0.64 t ha^{-1} during both years 2018-19 and 2019-20) whereas hybrid maize produced 10.37 t ha^{-1} during the year 2018-19 and 10.96 t ha^{-1} during the year 2019-20. Yield of maize was found statistically very high than grass pea showing thereby replacing grass pea with hybrid maize is a good option. Successful intensification of cropping systems requires selection of suitable crop varieties with high yield potential (Ali, 2008). Hybrid maize is a promising crop with higher grain yield, yield stability and profitability which can easily be grown after T. Aman harvest and requires less water for irrigation.

Table 2. Productivity of season wised component crops (rabi season) in different cropping patterns

Cropping pattern	Cropping year 2018-19	Cropping year 2019-20
	Rabi 2018-19	Rabi 2019-20
	Yield of maize/grasspea	Yield of maize/grasspea
	Product (grain/seed) yield (t ha^{-1})	Product (grain/seed) yield (t ha^{-1})
CP_1 (FP): Grass pea-Jute-T. Aman	0.64	0.64
CP_2 (IP): Maize-Jute-T. Aman	10.37	10.96
Level of significance	**	**
SE (±)	0.664	0.183
CV (%)	14.81	7.37

* = Significant at 5% level of probability ($P<0.05$); ** = Significant at 1% level of probability($P<0.01$)
NS = Not significant ($P>0.05$)

Yield of kharif-I season crop

Jute was the second crop of the cropping pattern which was grown both in the cropping pattern. Fibre and stick yield of kharif-I season crop is presented in Table 3. Significant difference among jute fiber yield between two cropping patterns was not found.

Table 3. Productivity of season wised component crops (Kharif-I season) in different cropping patterns

Cropping pattern	Cropping year 2018-19		Cropping year 2019-20	
	Kharif-I 2018-19		Kharif-I 2019-20	
	Yield of Jute		Yield of Jute	
	Product (fibre) yield ($t\ ha^{-1}$)	By-product (stick) yield ($t\ ha^{-1}$)	Product (fibre) yield ($t\ ha^{-1}$)	By-product (stick) yield ($t\ ha^{-1}$)
CP_1 (FP): Grass pea-Jute-T. Aman	2.5	1.5	2.5	1.45
CP_2 (IP): Maize-Jute-T. Aman	3.0	1.8	3.08	1.19
Level of significance	NS	**	*	**
SE (±)	0.252	0.012	0.075	0.008
CV (%)	18.25	6.64	9.83	6.9

* = Significant at 5% level of probability (P<0.05), ** = Significant at 1% level of probability(P<0.01)

NS = Not significant (P>0.05)

Yield of kharif-II season crop

Grain or straw yield of kharif-II season crop is presented in Table 4. The results revealed that T. Aman in the farmer's practice pattern (CP_1) was yielded low (grain yield 3.8 $t\ ha^{-1}$ and straw yield 4.0 $t\ ha^{-1}$ during the year 2018-19 and grain yield 3.9 $t\ ha^{-1}$ and straw yield 4.6 $t\ ha^{-1}$ during in the year 2019-20) and in the altered cropping pattern (CP_1) was yielded high (grain yield 4.8 $t\ ha^{-1}$ and straw yield 5.0 $t\ ha^{-1}$ in the year 2018-19 and grain yield 5.0 $t\ ha^{-1}$ and straw yield 5.2 $t\ ha^{-1}$ in the year 2019-20). Farmers cultivated Swarna variety T. Aman yielded low. In this area, flood is regular phenomena which damages rice seedling at early stage. Bangladesh falls in the region with heavy rainfall. About 80% of the rainfall occurs in May-September (Ahmed and Falk, 2008). The char-lands are affected by the massive floods repeatedly with concomitant riverbank erosion (Hasan et. al., 1999). To get higher yield and escaping flood damage, submergence tolerance short duration T. Aman rice variety Binadhan-11 was included in the altered pattern (CP_2) instead of growing local T. Aman rice variety. Selection of this variety has reduced the risk of damaging the rice seedling by flood water.

Table 4. Productivity of season wised component crops (Kharif-II season) in different cropping patterns

Cropping pattern	Cropping year 2018-19 Kharif-II 2018-19 Yield of T. Aman		Cropping year 2019-20 Kharif-II 2019-20 Yield of T. Aman	
	Product (grain) yield (t ha^{-1})	By-product (straw) yield (t ha^{-1})	Product (grain) yield (t ha^{-1})	By-product (straw) yield (t ha^{-1})
CP_1 (FP): Grasspea-Jute-T.Aman	3.8	4.0	3.9	4.6
CP_2 (IP): Maize-Jute-T. Aman	4.8	5.0	5.0	5.2
Level of significance	**	**	**	**
SE (±)	0.074	0.045	0.052	0.005
CV (%)	5.21	4.44	5.12	2.29

* = Significant at 5% level of probability (P<0.05); ** = Significant at 1% level of probability(P<0.01)
NS = Not significant (P>0.05)

In Kharif-II season, grain yield of aman rice increased by 27% due to inclusion of modern variety instead of local rice variety. As a result, higher rice yield was recorded both during both years 2018-19 and 2019-20 in altered cropping patterns over farmer's practice.

Rice equivalent yield (REY)

Rice equivalent yield differed significantly between the cropping patterns. Data on total REY of component crops of two cropping patterns are presented in Table 5.

Table 5. Rice equivalent yield (REY) of component crops in different cropping patterns

Cropping pattern	System REY (t ha^{-1})	
	2018-19	2019-20
CP_1 (FP): Grass pea-Jute-T. Aman	12.79	13.14
CP_2 (IP): Maize-Jute-T. Aman	25.02	25.92
Level of significance	**	**
SE (±)	0.009	0.219
CV (%)	3.51	2.40

* = Significant at 5% level of probability (P<0.05); ** = Significant at 1% level of probability(P<0.01)
NS = Not significant (P>0.05)

It was observed that the altered cropping pattern (CP_2) produced the higher REY (25.02 t ha^{-1} in the year 2018-19 and 25.92 t ha^{-1} in the year 2019-20) than that of the farmer's practice cropping pattern (CP_1) REY (12.79 t ha^{-1} in the year 2018-19 and 13.14 t ha^{-1} in the year 2019-20). Rice equivalent yield was increased in the altered cropping pattern due to inclusion of high yielding hybrid maize variety in the rabi season and high yielding rice variety Binadhan-11 in the kharif-II season instead of growing grass pea in the rabi season and local Aman rice variety Swarna in kharif-II season. Rice equivalent yield was higher in the altered cropping pattern due to higher yield and superior market price of maize (Sarker et. al., 2020). The lower rice equivalent was also observed by Rahman et al. (2015) in the farmer's pattern with three crops, local variety of crop and traditional management practices.

Production efficiency (PE)

Variation on production efficiency was also found in the cropping patterns (Table 6). Higher production efficiency (78.61 $kgha^{-1}$ day^{-1}) was observed in CP_2 than the CP_1 (40.4 $kgha^{-1}$ day^{-1}). The result showed that the crops in the farmer's practice pattern (CP_1) took shorter time in the field and lower yields leading to lower production per day (Sarker et al., 2020). On the contrary, crops in the improved cropping pattern (CP_2) took longer time in the field and higher yield leading to higher production efficiency (production per day). This is due to the production of high yielding rice varieties in kharif-II season and hybrid maize in the rabi season.

Table 6. Field crop duration, production efficiency and land use efficiency as influenced by cropping patterns

Cropping pattern	Mean REY (t ha^{-1})	Field duration of crop sequence (day)	Production efficiency ($kgha^{-1}day^{-1}$)	Land use efficiency (%)
CP_1 (FP): Grasspea-Jute-T.Aman	12.97	321	40.40	87.95
CP_2 (IP): Maize-Jute-T. Aman	25.47	324	78.61	88.77

Land use efficiency (LUE)

Land use efficiency depends on crop duration. The land use efficiency was observed 87.95 in CP_1 and 88.77 in CP_2 (Table 6). The crop duration difference among two cropping pattern was observed less due to 3 crops in both cropping patterns. After that, land use efficiency as well as crop duration was observed higher in CP_2 than CP_1 due to cultivation of maize.

Economic performance

Economic performance of the pattern is presented in Table 7. Submergence tolerance high yielding short duration rice variety Binadhan-11 and maize hybrid variety tremendously increased the system productivity and economic return of the pattern.

Average gross margin US$ 3056.58 ha^{-1} was observed in altered cropping pattern which was higher than existing cropping pattern (Tk. 79,950 ha^{-1}). Gross margin increased by 206% in altered cropping pattern compared to existing cropping pattern. Altered cropping pattern CP_2 showed a maximum gross return (Tk. 471427 ha^{-1}) along with higher cultivation cost (Tk. 226901ha^{-1}) and contributed to higher marginal return (Tk. 231977ha^{-1}) and MBCR (3.37) than the farmer's practice CP_1. In the char area, rabi season is very important for getting higher yield as well as higher income. Inclusion of maize in the rabi season enhanced both the cultivation cost and the return. Maize tremendously increased the system productivity and economic return of the three crop-based cropping patterns. Maize gives higher profit and provides an opportunity to the char land farmers to come out of poverty.

Table 7. Profitability of the improved cropping pattern over the existing cropping pattern

Cropping pattern	Gross return (Tk. ha^{-1})	Cultivation cost (TVC) (Tk. ha^{-1})	Marginal value (MVP (Tk. ha^{-1}))	Marginal cost (MVC) (Tk. ha^{-1})	MBCR*
CP_2 (IP): Maize-Jute-T. Aman	471427	226901	233477	68901	3.37
CP_1 (FP):Grass pea-Jute-T.Aman	237950	158000	-	-	-

*Marginal benefit cost ratio, Price (Tk. kg^{-1}): Jute-47.5, Jute stick-5, T.Aman rice- 18.5, Straw-2, Maize-20.5, khesari-50

Rice equivalent yield of the improved cropping pattern was found 25.47 t ha^{-1}. The gross margin was found 206% higher than the existing cropping pattern. The marginal benefit cost ratio of the altered cropping pattern is 3.4. Considering systems REY, LUE, PE and economic performances of the two year crop cycle, it is revealed that the altered cropping pattern is the better option for greater productivity and profitability over farmer's practice cropping pattern Grass pea-Jute-T. Aman and could be suggested for the char area. Submergence tolerant short duration T. Aman rice variety will reduce the risk of damaging transplanted Aman rice during flood. Again, this short duration variety also ensures sowing of maize in time. As flood comes in the area within July to August, farmers can utilize water entered in the canal during flood for retting jute. Farmers can also get higher yield by growing maize in soil enriched with silt carried by flood water. The technology is suitable for char land area.

ACKNOWLEDGEMENTS

This study was planned and implemented as a part of a coordinated project between Planning and Evaluation Division, Bangladesh Agricultural Research Council (BARC) and Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh. This work was financially supported by the Project Implementation Unit of BARC, National Agricultural Technology Program-Phase II (NATP-2).

REFERENCES

Ali M.Y., Waddington, Hodson, D., Timsina, J. and Dixon J. (2008). Maize-rice cropping systems in Bangladesh: Status and research opportunities. Mexico, D.F.: CIMMYT.

Ahlawat, I.P.S. and Sharma, R.P. (1993). Agronomid Terminology. Indian Society of Agronomy, New Delhi, India, 3rd edition.

Ahmed, R. and Falk, G.C. (2008). Bangladesh: environment under pressure. GeographischeRundschau International Edition 4(1): 13-19.

Baqee, M.A. (1993). Barga and Bargadar, the case of the char-lands of Bangladesh. Oriental Geographer, 37(2): 1-17.

BBS. (2015). Statistical Yearbook of Bangladesh. Bangladesh Bureau of Statistics, Ministry of Planning, Dhaka, Bangladesh.

CIMMYT. (1988). From Agronomic Data to Farmer Recommendations: An Economic Training Manual, International Maize and Wheat Improvement Center, EI Batan, MEX, Mexico.

Gomez, K.A. and Gomez, A.A. (1984). Statistical Procedures for Agricultural Research. An International Rice Research Institute Book, John Wiley and Sons, New York, NY, USA, 2nd edition.

Hasan, R., Rahman M.A. and Roy I.B. (1999). Farmer’s indigenous knowledge: lessons from participation research in Bangladesh. Grassroots voice: *A Journal of Resources and Development*, II (II-II): 38-41.

Hasan, N.M., Hossain, M.S., Islam, M.R. and Bari, M.A. (2013). Trend in availability of agricultural land in Bangladesh. National food policy capacity strengthening programme (NFPC-SP), FAO (Rome) pp. 1-72.

Jamwal, J.S. (2001). Productivity and economics of different maize (Zea mays) based crop sequences under dry land conditions. *Indian Journal of Agronomy*, 46(4): 601-604.

Karim, M.A., Haque, M.M. and Hamid, A. (2014). Concern, opportunity and strategic research in crop sector under climate change context in Bangladesh. In: Rising atmospheric CO2 and crop response. A compendium of published works at BSMRAU, Bangabandhu SMR agricultural University (Gazipur), 1-64.

Neamatollahi, E., Vafabakhshi, J., Jahansuz, M.R. and Sharifzadeh, F. (2017). Agricultural optimal cropping pattern determination based on fuzzy system. *Fuzzy information and engineering*, 9: 479-491.

Paul, S. and Islam, M.R. (2015). Ultra-poor char people’s rights to development and accessibility to public services: a case of Bangladesh. *Habitat International*, 48:113-21.

Rahman, S. (2010). Six decades of agricultural land use change in Bangladesh: effects on crop diversity, productivity, food availability and the environment, 1948-2006. *Singapore Journal of Tropical Geography*, 31: 245-269.

Sarker, U.K., Monira, S. and Uddin, M.R. (2020). On-farm evaluation and system productivity of Wheat-Jute-T. Aman rice cropping pattern in char area of Bangladesh. *Agricultural Science*, 2(1): 39-46.