ISSN 0258 - 7122 (Print)
2408 - 8293 (Online)

BJAR

Volume 46 Number 2
June 2021

Bangladesh Journal of Agricultural Research

Please visit our website : www.bari.gov.bd

Volume 46 Number 2 BANGLADESH JOURNAL OF AGRICULTURAL RESEARCH June 2021

Bangladesh
Journal of
AGRICULTURAL RESEARCH
Volume 46 Number 2
June 2021

BANGLADESH JOURNAL OF AGRICULTURAL RESEARCH

Editorial Board

Bangladesh Agricultural Research Institute (BARI)
Gazipur-1701, Bangladesh

BANGLADESH JOURNAL OF AGRICULTURAL RESEARCH

Vol. 46 **June 2021** **No. 2**

C O N T E N T S

ISSN 0258-7122 (Print), 2408-8293 (Online)
Bangladesh J. Agril. Res. 46(2): 123-131, June 2021

PRODUCTION POTENTIAL OF SWEET POTATO BASED INTERCROPPING SYSTEM IN SYLHET REGION

M. I. NAZRUL[1]

Abstract

A field experiment was conducted during two consecutive years 2017-18 and 2018-19 at farming system research and development (FSRD) site, under South Surma Upazilla of Sylhet in Bangladesh to find out the suitable crop combination for increasing total productivity, return and maximizing land utilization through intercropping. Five treatments viz. T_1: Sweet potato + red amaranth, T_2: Sweet potato + leaf amaranth, T_3: Sweet potato + mustard green, T_4: Sweet potato + mustard and T_5: Sweet potato sole (100% sweet potato) were considered in the experiment. Results showed none of the intercrop-combination influenced the root yield of sweet potato. Tuberous root yield of sweet potato in 100% sweet potato + 100% mustard green combination was at per sweet potato sole cultivation. Sweet potato yield did not reduce significantly due to intercropping. The highest sweet potato equivalent yield (41.75 t ha^{-1}), land equivalent ratio (1.37), gross return (Tk. 625950 ha^{-1}), gross margin (Tk. 495500 ha^{-1}) and benefit cost ratio (4.80) were recorded from sweet potato 100% + mustard green 100% combination. On the contrary, sweet potato sole gave the lowest sweet potato equivalent yield (30.60 t ha^{-1}), gross margin (Tk.330300 ha^{-1}) and benefit cost ratio (3.57). The results revealed that sweet potato 100% + mustard green 100% intercropped combination might be suitable for higher productivity and economic return.

Keywords: Land use efficiency, production potential, sweet potato based intercropping, economic benefit.

Introduction

Sweet potato (*Ipomoea batatas*L.) is one of the most important tuber crops in Bangladesh which can be used as substitute of cereal crops to meet up the food shortage. The foliage of sweet potato has the potential for use as vegetable and animal feed (Otoo *et al*., 2001). It is the fourth important crop in Bangladesh after rice, wheat and potato (Hossain and Hakim, 2014). The orange fleshed sweet potato has significant antioxidant activity, and can potentially improve vitamin-A status in children under malnutrition (Away *et al.* 2013; Li and Mu, 2012; Burri, 2011). At present sweet potato becoming promising root crops successfully growing and disseminating in Sylhet region due to its market demand and nutritional benefits (Nazrul, 2019). Vegetables playa significant role in human nutrition, especially as sources of phytonutriceuticals: vitamins (C, A, B1, B6, B9, E), minerals and dietary fiber (Craig and Beck, 1999; Wargovich, 2000). So,

[1]Principal Scientific Officer, Bangladesh Agricultural Research Institute (BARI), Gazipur-1701, Bangladesh.

growing a high calorie food sweet potato with vegetables viz. red amaranth, leaf amaranth, mustard green, mustard and radish etc. would ensure the supply of more dietary carbohydrates, vitamins and minerals of the rural populace.

In Sylhet region, the farmers are generally growing sweet potato as a sole crop; as it is a long durated crop (150-180 days) and cultivating with maintaining the spacing of 60 cm × 30 cm. So, there is a great scope to cultivate short durated (35-40 days) leafy vegetable in the inter row space of sweet potato. Besides, multiple cropping systems ensure proper utilization of resources towards increased production per unit area and time (Ahmad *et al.*, 2007). Vegetable crop failures are common under unfavorable climate, increases of pest and disease problems are common, which are affecting the market volatility.Intercropping is one of the viable technologies to reduce the risk of biotic and abiotic stress. Considering the above facts, this trial was undertaken tofind out the suitable crop combination for intercropping with sweet potato increasing productivity, economic returnand maximize land utilization.

Materials and Methods

The field trial was carried out during two consecutive years 2017-18 and 2018-19 at farming system research and development (FSRD) site, under South Surmal Upazilla of Sylhet in Bangladesh. The soil of experimental plot was clay loam in texture and pH ranges 5.5-6.10, organic matter 1.05%, total nitrogen 0.059%, available phosphorus 10 µg/ml, available potassium 0.12 meq/100 g soils, sulphur14 µg/ml, boron 0.30 µg/ml and zinc 1.7 µg/ml.

The monthly mean maximum and minimum air temperature and rainfall during the study period (November-March) are presented in Figure 1. The highest amount of average monthly rainfall occurred in March (286.45 mm) followed by February (87.4 mm), December (60.95 mm) and November (21.5 mm). The crops received total rainfall of 456.30 mm during crop growing period. The mean monthly maximum air temperature of 33.3^0C and minimum temperature of 9.15 ^{0}C were recorded during crop season.The climatic data of Sylhet shows that the monthly average minimum temperature is 9.15 °C and the mean maximum temperature is 33.3 °C.

Five treatments combinations viz. T_1: Sweet potato + red amaranth, T_2: Sweet potato + leaf amaranth, T_3: Sweet potato + mustard green, T_4: Sweet potato + mustard and T_5: Sweet potato sole (100% sweet potato) were considered in the experiment. The experiment was setup in a randomized complete block design with three replications. The unit plot size was 8 m × 5 m.

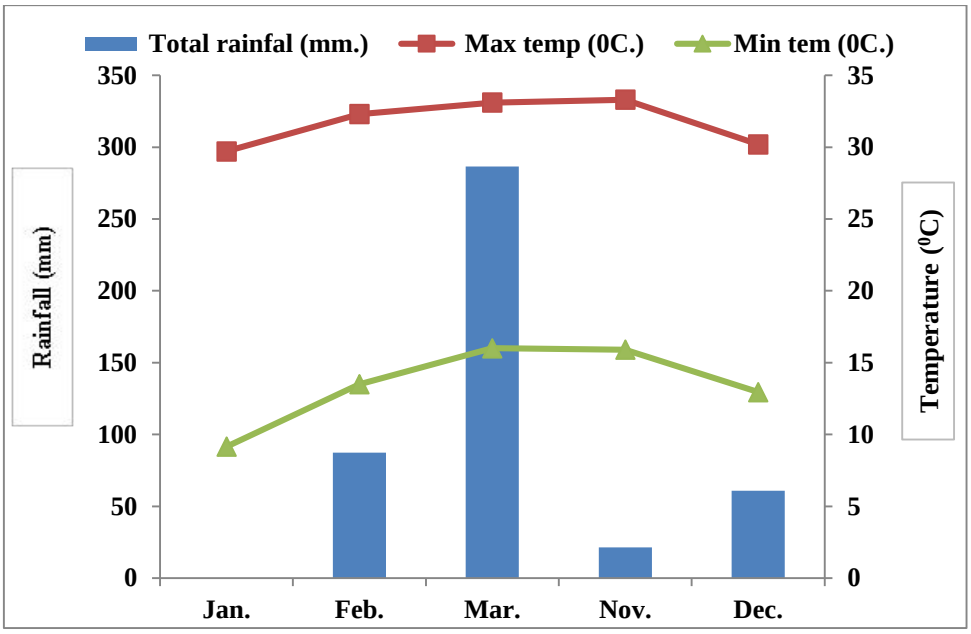


Fig. 1. Monthly total rainfall (mm), monthly meanmaximum and minimum temperature (^{0}C) during crop growing period (*Source: Metrological Department, Sylhet*)

Sweet potato (var. BARI Mishti Alu-12) as base crop, while BARI Red Amaranth-1, BARI Leaf Amaranth-1, mustard green (local cultivar) and local mustard cultivar were used as intercrops in this trial. The vine of sweet potato was planted at a spacing of 60 cm × 30 cm. The crops were fertilized with cow dung 5 t ha^{-1} and 129-34-130-12.8-4.3-1.4 kg ha^{-1} N-P-K-S-Zn-B in the form of urea, triple super phosphate (TSP), muriate of potash (MoP), gypsum, zinc sulphate and boric acid, respectively (Mondal *et al.*, 2014). Half of urea and all other fertilizers were used as basal during final land preparation. The vines of sweet potato and seeds of companion crops were planted or sown during 14-16 November in each year. Remaining N fertilizer was applied in side of the rows in two equal splits at 30 and 60 days after transplanting. Intercultural operations were done as and when required. There was no remarkable disease and pest attack. The companion crop was harvested on 15-20, December and sweet potato was harvested during 25-30 March in both the years. Mustard green and mustard were harvested as green vegetable. Data were taken from randomly selected 10 plants of sweet potato and yield data of all the crops were taken from whole plot. Collected data were pooled and means were adjusted by Least Significant Different (LSD) test at 5% level of significance. Agronomic performances, relative yield, sweet potato equivalent yield, land equivalent ratio of intercropping were calculated.

Relative yield (RY) of species was calculated (Harper, 1977) from the following formula:

$$RY = \frac{\text{Yield of a species of intercrop}}{\text{Yield of the same species in pure stand}}$$

Yield of individual crop was converted into sweet potato equivalent yield (SPEY) considering prevailing market price of the crops according to Islam *et al.,* (2014).

$$SPEY = \text{Yield of sweet potato in intercrop} + \frac{Yi \times Pi}{\text{Price of sweet potato}}$$

Where**,** Yi = yield of intercrops (vegetables) and Pi = Price of intercrop (vegetables).

Land equivalent ratio (LER) was calculated following the formula Mian (2008).

$$LER = RY_{SP} + RY_i = \frac{SP_{IY}}{SP_{SY}} + \frac{SP_{EYCC}}{SP_{SY}}$$

Where, RY_{sp}= Relative yield of sweet potato (main crop), RY_i= Relative yield of intercrops (vegetables), SP_{IY} = Yield of sweet potato in intercrop, SP_{SY} = Yield of sweet potato as sole crop, SP_{EYCC} = Sweet potato equivalent yield of component crops{(component crop yield in intercrop × price of component crop)/price of sweet potato}. Benefit cost analyses were also done.

Results and Discussion

Yield and yield contributing characters of sweet potato

Maximum vine length (80.70 cm) was recorded in T_5 (sole sweet potato). This longest vine length in T_5 than other treatment combinations might be due to no intercrop competition for light, nutrients, moisture and space. The results are in conformity with the findings of Islam (2014) and Das *et al.,* (2012). Among the intercropped, sweet potato + mustard combination (T_4) produced the highest vine length (74.90 cm) but this was not similar to that of T_1 and T_3. T_2 (sweet potato + leaf amaranth) produced the lowest vine length (Table 1). Broad leaves of mustard and mustard green might help to keep soil moisture for better soil microclimate and growth of plants. The result was consistent with the findings of Kumar *et al.,* (2010) intercrops should have either synergistic or complementary effect relative to the base crops. Maximum number of roots plant^{-1}(3.93) was obtained from T_5 (sweet potato sole) which was identical to that of T_4 (sweet potato + mustard). It was observed that number roots plant^{-1} was not influenced by any combination of intercrop (Table 1). The average weight of single root tubers was also varied with the variation of intercrop combinations. The highest weight (168.53 g) of single root tuber was found in sole sweet potato followed by sweet potato + mustard (161.57 g).

The lowest weight of single root was recorded from sweet potato + leaf amaranth combination and it was not different from sweet potato + red amaranth and sweet potato + mustard green combination (Table 1). The effect of intercropping of sweet potato with red amaranth, leaf amaranth, mustard green and mustard provided yields of tuberous root were non-significant (Table 1). Among the intercropped combinations numerically the maximum tuberous root yield (30.53 t ha^{-1}) was recorded when 100% sweet potato intercropped with 100% mustard greenthat was very close to that of sweet potato intercropped with mustard. This higher tuberous root yield of sweet potato might be due to synergetic complementary effect of broad leaves green mustard to the base crop. Generally, the tuberous root yields of sweet potato under intercropping treatments were lower than that of sweet potato sole. The reduction of sweet potato yield was possibly due to intercrop completion between two crops. However, additional yield from mustard/leafy vegetable gave extra income.

Relative yield of sweet potato

Relative yield determines competitive ability of component crops in intercropping system. Greater value of relative yield showed more competitive ability in intercrop situation compared to its monoculture (Juskiw *et al.*, 2000). The relative yields of sweet potato were 0.95, 0.96, 0.99 and 0.97 when sweet potato was intercropped with red amaranth, leaf amaranth, mustard green and mustard, respectively (Table 1). This indicates that sweet potato yield was reduced by 5, 4, 1and 3% of sole crop when it was intercropped with red amaranth, leaf amaranth, mustard green and mustard, respectively. The lower relative yield of sweet potato in intercropping indicated that the crop faced competition for space, nutrients, light, and water with component crops. The results are in agreement with the findings of Baghdadi *et al*., (2016) and Rahman (1999).

Table 1. Length of vine, roots plant^{-1}, weight of single root and yield of root tuber of sweet potato base intercropping system (pooled data of two years).

Treatments	Length of vine (cm)	Tuberous roots plant^{-1}	Weight of single root tuber (g)	Root yield (t ha^{-1})	Relative yield of sweet potato
T_1:Sweet Potato+ red amaranth	70.83	3.13	149.30	29.17	0.95
T_2:Sweet Potato+ leaf amaranth	62.97	3.10	145.83	29.50	0.96
T_3:Sweet Potato+ mustard green	74.27	3.30	154.77	30.53	0.99
T_4:Sweet Potato+ mustard	74.90	3.47	161.57	29.77	0.97
T_5:Sweet potato as sole crop	80.70	3.93	168.53	30.60	1.00
CV (%)	5.98	8.13	4.59	4.60	-
LSD $_{(0.05)}$	8.19	0.52	13.47	NS	-

NS= Not significant.

Companion crops yield

On an average, the yields of red amaranth, leaf amaranth, mustard green and mustard as vegetable under intercrops were 4.40, 5.43, 5.60 and 4.50 t ha^{-1}, respectively. Among them mustard green produced higher yield (5.60 t ha^{-1}) by T_3 and lower yield (4.40t ha^{-1}) was produced by T_1 (Table 2).

Sweet potato equivalent yield (SPEY)

The equivalent yield is expressed in total productivity of a system. Sweet potato equivalent yields were higher in all the intercrop combination (31.52 - 41.75 t ha^{-1}) than the sweet potato sole (30.60 t ha^{-1}). The maximum sweet potato equivalent yield (41.75 t ha^{-1}) was recorded in T_3 (sweet potato + mustard green) which was followed by T_4 (sweet potato + mustard), T_2 (sweet potato+ leaf amaranth) and T_1 (sweet potato+ red amaranth) combinations. On the contrary, minimum SPEY was obtained from T_5 (sweet potato as sole). The results indicate the SPEY vary mainly due to variation in yields of component crops *i. e.* combined yield of sweet potato and component crops. Contrastingly, the total productivity also increases of 14.36, 36.37, 10.59 and 3.00 % in sweet potato + mustard, sweet potato + mustard green, sweet potato + leaf amaranth and sweet potato + red amaranth combinations over sole sweet potato (Table 2) cultivation practice. This result showed that T_3 (sweet potato+ mustard green) lead to higher total productivity than sole sweet potato. The results are agreement with the findings of Ahmed *et al.,* (2013) and Khan *et al.,* (2017).

Land equivalent ratio (LER)

Land equivalent ratio was calculated to determine land use efficiency in the intercrop systems. Highest land equivalent ratio (1.37) was recorded in T_3 (sweet potato+ mustard green) intercropping system followed by T_4 (sweet potato + mustard). The lowest LER (1.03) was in T_1 (sweet potato + red amaranth) combination. LER of different crop combinations ranged from 1.03 to 1.37 indicating 103-137 % land utilize by intercropping. Total LER of all intercropping treatments was more than one, which shows an advantage over pure stands in terms of the use of environmental resources for plant growth as reported by Beyenesh *et al.,* (2017). The mean values of LER (more than one) in all intercropping treatments revealed that land was more efficiently utilized under intercropping than sole cropping of sweet potato. It also expresses that by intercropping of sweet potato with mustard green, a farmer can produce 30.53 t ha^{-1} tuberous roots of sweet potato and 5.60 t ha^{-1} yield of mustard green from one hectare of land instead of growing sweet potato sole cultivation.

Table 2. Yield of companion crops, sweet potato equivalent yield (SPEY) and land equivalent ratio (LER) under sweet potato base intercropping system (pooled data of two years).

Treatments	Yield of companion crops (t ha^{-1})	SPEY (t ha^{-1})	% increase of SPEY over sole sweet potato	LER
T_1:Sweet Potato+ red amaranth	4.40	31.52	3.00	1.03
T_2:Sweet Potato+ leaf amaranth	5.43	33.84	10.59	1.10
T_3:Sweet Potato+ mustard green	5.60	41.75	36.37	1.37
T_4:Sweet Potato+ mustard	4.50	35.17	14.93	1.15
T_5:Sweet potato as sole crop	-	30.60	-	1.00

Cost benefit analysis

Intercrop combination of sweet potato with short durated leafy vegetables showed higher monetary return over sole crop (Table 3). The highest gross return (Tk. 625950 ha^{-1}) was recorded from T_3 (sweet potato + mustard green) intercrop combination which was 36.37 % higher than sole cultivation of sweet potato. This intercropping combination also gave the higher gross margin (Tk. 495500 ha^{-1}) and benefit cost ratio (4.80) followed by T_4 (sweet potato + mustard) combination. The lowest gross return (Tk. 459000 ha^{-1}), gross margin (Tk. 330300 ha^{-1}) and BCR (3.57) were obtained from sole cultivation of sweet potato.

Table 3. Cost benefits analysis of sweet potato base vegetables intercropping system (average data of two years).

Treatments	Gross return (Tk. ha^{-1})	Cost of production (TK. ha^{-1})	Gross margin (TK. ha^{-1})	Benefit cost ratio (BCR)
T_1:Sweet Potato+ red amaranth	472800	131500	341300	3.60
T_2:Sweet Potato+ leaf amaranth	507600	131200	376400	3.87
T_3:Sweet Potato+ mustard green	625950	130450	495500	4.80
T_4:Sweet Potato+ mustard	527550	129580	397970	4.07
T_5:Sweet potato as sole crop	459000	128700	330300	3.57

Price (Tk. Kg^{-1}): Sweet potato: 15.00, Red amaranth: 8.00, Leaf amaranth: 12, Mustard green: 30.00, Mustard: 18.00

Conclusion

It appears from the results that total productivity along with crop diversification can be possible through intercropping system. However, sweet potato 100% + mustard green (Lai shak) 100% combination could be suggested to grow in Sylhet region under AEZ 20 for higher productivity and economic return.

Acknowledgement

Authors sincerely acknowledge to the farmers' of FSRD site and MLT sites under OFRD Sylhet for their co-operation regarding setup of experiment and data collection during whole experimental period. Also grateful to the Bangladesh Metrological Department, Sylhet and Soil Resource Development Institute, Sylhet for the cooperation accorded.

References

Ahmad, R., A. Jabbar, A. H. Ahmad, E. Ullah, and I. H. Bhatti. 2007. Evaluation of direct seeded upland rice-based intercropping system under strip planting geometry. *Pakistan J. Agric. Sci.* **44:**1-5

Ahmed, F., M. N. Islam, M. S. Alom, M. A. I. Sarker, and M. A. Mannaf. 2013. Study on intercropping leafy vegetables with okra (*Abelmoschusesculentus* L.). *Bangladesh J. Agril. Res.* **38**(1): 137-143.

Away, A. K., M. P. Nawiri, and H. N. Nyambaka. 2013. Nutrient variation in colored varieties of *Ipomea batatas* grown in Vihiga County, Western Kenya. *Int. Food Res. J.* **20**(2):819-825.

Baghdadi, A., R. A. Halim, R. Othman, M. M. Yusof, and A. R. M. Atashgahi. 2016. Productivity, relative yield and plant growth of forage corn intercropped with soybean under different crop combination ratio. Legume Research.

Beyenesh, Z. K., Mereseit, H. H. and Haile, T. H. 2017. Maize and Potato Intercropping: A Technology to Increase Productivity and Profitability in Tigray. *Open Agriculture. 2017.* **2:** 411–416.

Burri, B. J. 2011. Evaluating sweet potato as an intervention food to prevent vitamin-A deficiency. *Comp. Rev. Food Sci. Food Safe.* **10:**118-130.

Craig, W., and L. Beck. 1999. Phytochemicals: Health Protective Effects. *Canadian Journal of Dietetic Practice and Research.* **60**(2): 78-84.

Das, A. K., Q. A. Khaliq and M. L. Haider. 2012. Efficiency of wheat-lentil and wheat-chickpea intercropping systems at different planting configurations. *International journal of sustainable crop production.* **7:**25-33.

Harper, J. 1977. The population biology of plants: Academic press: London: pp. 892.

Hossain, K. M.Delowar and M. A. Hakim. 2014. Effect of salinity levels on the morpho-physiological characteristics and yield attributes of sweet potato genotypes. *Int. J. Sci. Res.* **3**(10): 929-934

Islam, M. N., M. Akhteruzzaman, M. S. Alom and M. Salim. 2014. Hybrid maize and sweet potato intercropping: a technology to increase productivity and profitability for poor hill farmers in Bangladesh. *SAARC J. Agri.* **12**(2): 101-11.

Islam, M. R., M. T. Rahman, M. F. Hossain and N. Ara. 2014. Feasibility of intercropping leafy vegetables and legumes with brinjal. *Bangladesh J. Agril. Res.* **39**(4): 685-692

Juskiw, P. E., J. H. Helim, and D. F. Salman. 2000. Competitive ability in mixtures of small grain cereals. *Crop Sci.* **40:** 159-164.

Khan, A. H., N. Sultana, S. Akhtar, N. Akter and M. S. Zaman. 2017. Performance of intercropping groundnut with sesame. *Bangladesh Agron. J.* **20**(1): 99-105.

Kumar, S. R., H. Kumar and S. A. Kumar. 2010. *Brassica* Based Intercropping Systems-A Review. *Agricultural Reviews, 2010.* **31**(4): 253-466.

Li, P. G, and T. H. Mu. 2012. Sweet potato: health benefits, production and utilization in China. In Potatoes: Production, Consumption and Health Benefits. C. Caprara (edn.). Nova Science Publishers. pp. 127-172.

Mian, M. A. K. 2008. Performance of maize oriented cropping patterns under different nutrient management. Ph. D. Dissertation. Dept. Agron. Bangladesh Agril. Univ., Mymensingh. Pp. 31-137

Nazrul, M. I. 2019. On-Farm Evaluation of Orange Fleshed Sweet Potato Varieties Under Acidic Soil of North-East Region in Bangladesh. Bangladesh Agronomy Journal, 21(2), 59-65. https://doi.org/10.3329/baj.v21i2.44493.

Otoo, J. A., A. Missah, and A. G. Carson. 2001. Evaluation of sweet potato for early maturity across different agro-ecological zones in Ghana. *Afr. Crop Sci. J.* **9**(1): 25-32.

Rahman, M. A. 1999. Comparative performance of intercropping in pulse and oil seeds with rainfed wheat (*Triticum aestivum*) in Bangladesh. *Indian J. Agron.* **44**(3): 504-508.

Wargovich, M. J. 2000. Anticancer properties of fruits and vegetables. *American Society for Hort. Science.* **35**(4): 573-575.

ISSN 0258-7122 (Print), 2408-8293 (Online)
Bangladesh J. Agril. Res. 46(2): 133-142, June 2021

GGE BIPLOT AND AMMI ANALYSIS OF YIELD OF PROSO MILLET (*Panicum miliaceum* L.)

H. U. Z. RAIHAN[1], M. M. BILLAH[2], M. I. RIAD[3], M. B. SARKER[4] AND M. M. ROHMAN[5]

Abstract

The experiment was conducted using seven proso millet advanced lines including one check variety, BARI Cheena-1 (BC-1) across 3 locations (Gazipur, Jamalpur and Rangpur) of Bangladesh during 2019-20. The objective of this study was to find out stable proso millet lines, and to verify the influence of the environments on the yield at different locations of Bangladesh. The mean sum of squares for the genotypes were significant for grain yield which revealed the presence of genetic variability in the material under studied. The results of the AMMI analysis indicated that the main effects due to genotype (G), environment (E) and GE interaction were significant, representing differential responses of the lines to the varied environments. Based on the AMMI stability parameter BD-1447, BD-1411 and BD-777 were the most stable lines across the environments, of which BD-777 was most stable. Biplot showed that the environment of Rangpur was poor; but that of Gazipur and Jamalpur were better for proso millet cultivation. Results also suggested that BD-1447, BD-1411 and BD-777 could be included in breeding programs due to their higher grain yield.

Keywords: GGE biplot, Yield, Stability, Proso millet, *Panicum miliaceum*.

Introduction

Proso millet (*Panicum miliaceum* L.) is an annual grass, growing from seed each year. Its origin goes back to history as far as 2000 B.C. It was first introduced to Canada in the 17th century, and was used in a limited way as a forage crop in the early 1900's. It apparently did not produce sufficiently high yield of either forage or grain to compete with the established cereals and forages of that time. Therefore, it is considered as a minor cereal of Bangladesh. Proso millet can be grown on sandy loam, slightly acidic, saline, and low-fertility soils (Riley *et al.*, 1989; Changmei and Dorothy, 2014). However, this crop grows poorly on waterlogged soils (Seghatoleslami *et al*., 2008; Hunt *et al.*, 2011) and on coarse sandy soils (Williams *et al*., 2007). Proso millet thrives in low pH soils and most of its seeds germinate well on soils with pH of 5.5 to 6.5 (Lyon *et al*., 2008). However, plants grown on soils with pH above 7.8 show symptoms of iron chlorosis. It is versatile in that it can be successfully grown on many soil types and is probably better adapted than most cultivated crops to poor land, such as land with soils having low water holding capacity and low fertility. For this

[1, 2 & 5] Plant Breeding Division, Bangladesh Agricultural Research Institute (BARI), Gazipur, [3]Regional Agricultural Research Station, BARI, Jamalpur, [4]Regional Agricultural Research Station, BARI, Rangpur, Bangladesh.

reason, it can be easily cultivated with low input in the char areas of Bangladesh. It is mainly grown for birdseed. It is also desirable for human food because it is easily digestible and gluten-free. It can be ground into flour, used to bake flatbreads, make tabbouleh or for brewing beer. Among the most commonly consumed products are ready-to-eat breakfast cereals made purely from millet flour as well as a variety of noodles and bakery products. In addition, health-promoting phenolic compounds contained in the grains are readily bio-accessible and their high calcium content favor bone strengthening and dental health. In spite of dry land and no-till farming, germination and emergence of proso millet continue throughout the season. So, it is essential for its varietal improvement to meet the challenge that will be occurred due to global warming. This is why this program is undertaken with a view to develop high yielding proso millet variety. In the recent times, we have developed some high yielding proso millet advanced lines, and their yield performances need to check over locations.

To select highly adaptive high yielding genotypes, it needs to find out the interaction between genotypes and environments. The relative performances of the genotypes can be altered with changes in the environments and these different responses are due to the genotype environment interactions (GEI), because there are environments that are either more or less favorable to certain genotypes. Numerous methods for analyzing multi environment trial data have been developed to expose the pattern of G×E interaction, joint regression (Finlay and Wilkinson, 1963, Eberhart and Russel, 1966) and currently AMMI (Gauch, 1992) and GGE biplot (Genotype main effect plus genotype by environment interaction). AMMI (additive main effects and multiplicative interactions) model combines the analysis of variance of genotypes and the environment main effect with principal component analysis of the GEI into a unified approach (Gauch and Zobel, 1996). Analysis of variance as an additive model shows only main effects and informs whether or not the GE interaction is an important source of variation. It does not, however, provide the understanding into the individual genotypes and location which are the components of the interaction (Samonte *et al.*, 2005). AMMI analysis is the combination of ANOVA and principal component analysis (PCA). PCA is used to partition AMMI analysis where the sources of variability in the genotype by environment interaction. The genotype by environment interaction results obtained from AMMI analysis is represented in a biplot which relates genotypic means to the first or some of the principal interaction components. GGE biplot analysis enables visual (graphical) presentation of interaction estimate. The biplot technique is used for the exhibition and estimation of genotypes in different environments (Gabriel, 1971). GGE biplot present the first two principal components (PC1 and PC2) which are found by decomposition of singular values of multi-location trial yield data. GGE analysis assists the identification of the genotypes with the highest yields in across environment, comparison of their performances in different environments. The objective of this study was to assess the stability of some recently developed

advanced proso millet lines to verify the influence of a sample environments at different locations of Bangladesh (Gazipur, Jamalpur and Rangpur) on the productive performance of the genotypes.

Materials and Methods

The experiment was conducted at three locations namely Gazipur (Latitude- 23° 99' N and Longitude- 90° 42' E), Jamalpur (Latitude- 24° 55' N and Longitude- 89° 57' E) and Rangpur (Latitude- 25° 74' N and Longitude- 89° 27' E) districts of Bangladesh during rabi 2019-20. Six selected proso millet germplasm (BD-768, BD-772, BD- 777, BD-780, BD-1411,BD-1447 along with one check variety BARI Cheena-1 were evaluated in this study. The trials were laid out in RCB design with three replications. Seeds of each entry were sown in 4m×3m plot at 25 cm row spacing and continuous sowing. Seeds were sown at Gazipur on 14 December, Jamalpur on 12 December and Rangpur on 10 December, 2019. Thinning was done three weeks after date of sowing. Fertilizers were applied @ 100, 60 and 40 kg/ha of N, P, and K, respectively. Irrigations were applied (2-3 times) as and when necessary. All intercultural operations were done in time to raise the crop uniformly. All the plants were considered for plot yield which later converted into t/ha.

Statistical Analysis

The analysis of variance (ANOVA) was used, and the GE interaction was estimated by the AMMI model (Zobel *et at.*,1988) to determine the genotype (G), environment (E) and genotype by environment interaction (GE) effects. The AMMI model for the yield of the ith genotype in the jth environment is (Zobel et al. 1988):

$$Yij = \mu + gi + aj + \sum \lambda k \gamma ik \alpha jk + \rho ij + eij;$$

where μ is the grand mean; gi is the main effect of the ith genotype (G); aj is the main effect of the jth environment (E).

$$GE = \sum \lambda k \gamma ik \alpha jk + \rho ij + eij$$

where λk is the eigen value of the nth interaction principal component analysis (IPCA) retained in the AMMI model; γik is the eigen vector for the ith genotype from kth IPCA, αjk is the eigen vector for the jth environment from the kth IPCA, ρij is the GE interaction residual, and eij is the random error term.

In this procedure, the contribution of each genotype and each environment to the GE interaction was assessed by use of the biplot graph display in which yield means were plotted against the scores of the first principal component of the interaction (IPCA1). The computational program for AMMI analysis was done by Duarte and Vencovsky (1999). The stability parameters, regression coefficient (bi) and deviation from regression (S^2di) were estimated according to Eberhart

and Russel (1966). All data were processed and analyzed using statistical analyzing software Crop stat 7.2 program and PB tools.

Results and Discussion

Results of combined analysis of variance for yield of 7 (seven) proso millet lines across 3 (three) environments are presented in Table 1. The mean sum of squares for the genotypes were significant for grain yield which revealed the presence of genetic variability in the material under studied. Environment mean sum of squares were also highly significant which indicated high differential genotypic response across different environments. Analysis of variance for yield at three environments indicated that the effects of genotype, environment and their interactions were significant. Environment relative magnitude was much higher than the genotypic effect, suggesting that the performances of the genotypes was influenced more by environmental factors.

Table 1. Full joint analysis of variance including the partitioning of the G × E interaction of prosomillet advanced lines for yield

Source of variation	DF	Mean sum of square
		Yield
Genotypes(G)	6	0.23**
Environments (E)	2	0.80**
Interactions (G x E)	12	0.098*
AMMI component 1	7	0.076**
AMMI component 2	5	0.0059
G x E (Linear)	6	0.052
Pool deviation	6	0.041
Pooled error	52	0.053

*, ** indicated at 5% and 1% level of significance;

Stability parameter i.e., regression coefficient (bi) and deviation from the regression (S^2di) for yield of the proso millet lines are presented in Table 2. In Eberhart and Russel (1966) model, regression coefficient (bi) is considered as an indication of the response of the genotype to varying environments while deviation from regression (S^2di) is used as the criterion of stability. In the present study, these two criteria were considered simultaneously to identify stable genotypes. A genotype with unit regression coefficient (bi=1) is said to be average responsive to environment and suitable for all environment therefore, more adaptive.

If bi >1 it is said to be highly responsive and suitable for favorable environment. If bi<1 it is said to be less responsive and the genotype is suitable for unfavorable environment (Nadarajan and Gunasekaran, 2005).

Yield along with the value of phenotypic index (Pi,) regression coefficient (bi), deviation from the regression (S^2di) are presented in table 2. The genotypic means ranged from 1.50 t/ha (BD-768) to 2.15 t/ha (BD 777). In case of environment index, Rangpur location gave the lowest yield (1.51 t/ha) while Gazipur location gave the highest yield (2.19 (t/ha).

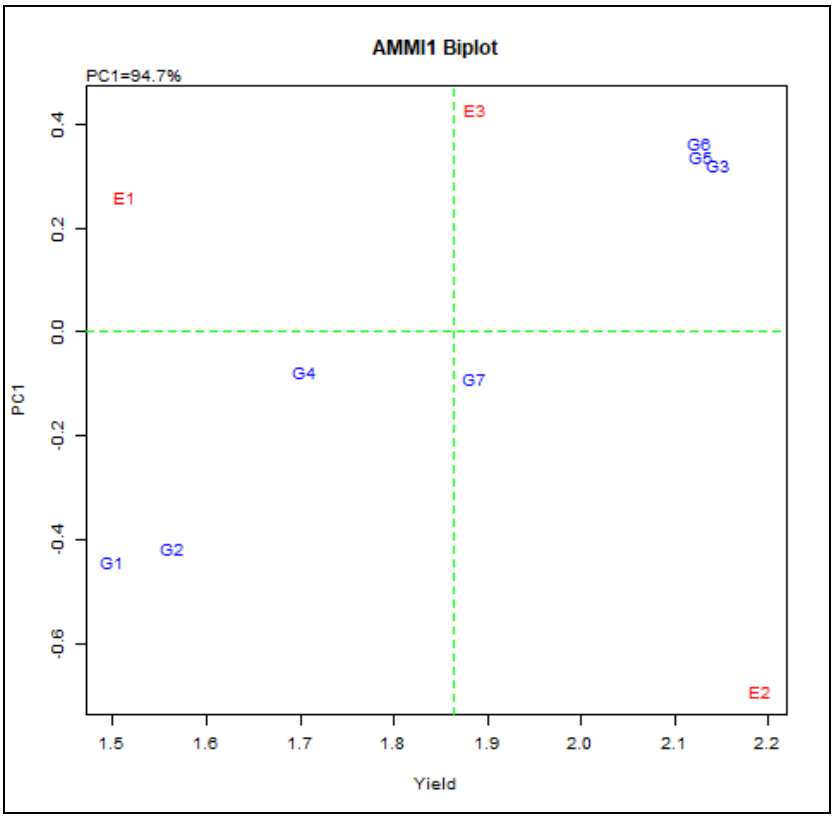
Three genotypes showed negative phenotypic index represent the low yield and the rest four showed positive Pi values representing the high yield among the genotypes. Again, positive and negative environmental index (Ij) reflects the rich or favorable and poor or unfavorable environments for this character, respectively. Thus, the environment of Rangpur and Jamalpur were poor, whereas Gazipur has positive environments for proso millet production. So Gazipur is the most favorable for proso millet cultivation followed by Jamalpur. Results also showed proso millet can be grown with minimum input in Rangpur.

The regression coefficient (bi) values of these genotypes ranged from 0.51 to 1.65. These differences in bi values indicated that all the genotypes responded differently to different environments (Table-2). Considering all the three stability parameters i.e mean, bi and S^2di, it was evident that all the genotypes were different in response of adaptability under different environmental conditions. The regression coefficient should be better considered as an indicator for genotypic responses to varying environments (Alberts, 2004) and Solomon *et al.*, 2008). Among the genotypes BD-1447, BD-777 and BD-1411exhibited higher grain yield with bi~1 and S^2di~0, which indicated that these genotypes were stable across the environment.

Table 2. Stability analysis for yield (t/ha) of proso millet over 3 environments during 2019-20

SI No.	Entry	Yield (t/ha)				Stability parameter		
		Gazipur	Jamalpur	Rangpur	Overall mean	Pi	bi	S^2di
1	BD-768	2.13	1.36	1.00	1.50	-0.36**	1.65	0.05
2	BD-772	2.17	1.40	1.11	1.56	-0.30*	1.54	0.06
3	BD-777	2.24	2.28	1.91	2.15	0.28*	0.51	0.02
4	BD-780	2.09	1.74	1.28	1.70	-0.16	1.19*	0
5	BD-1411	2.22	2.33	1.84	2.13	0.26*	0.60	0.05
6	BD-1447	2.20	2.33	1.85	2.13	0.26*	0.55	0.05
7	BC-1	2.26	1.78	1.62	1.89	0.021	0.93	0.02
Mean		2.19	1.88	1.51	1.86	-	-	-
Env. Index (Ij)		0.32**	0.02	-0.35	-	-	-	-
LSD (0.05)		0.17	0.31	0.36	-	-	-	-
CV		4.37	9.12	13.50	-	-	-	-

*, ** indicated at 5% and 1% level of significance.

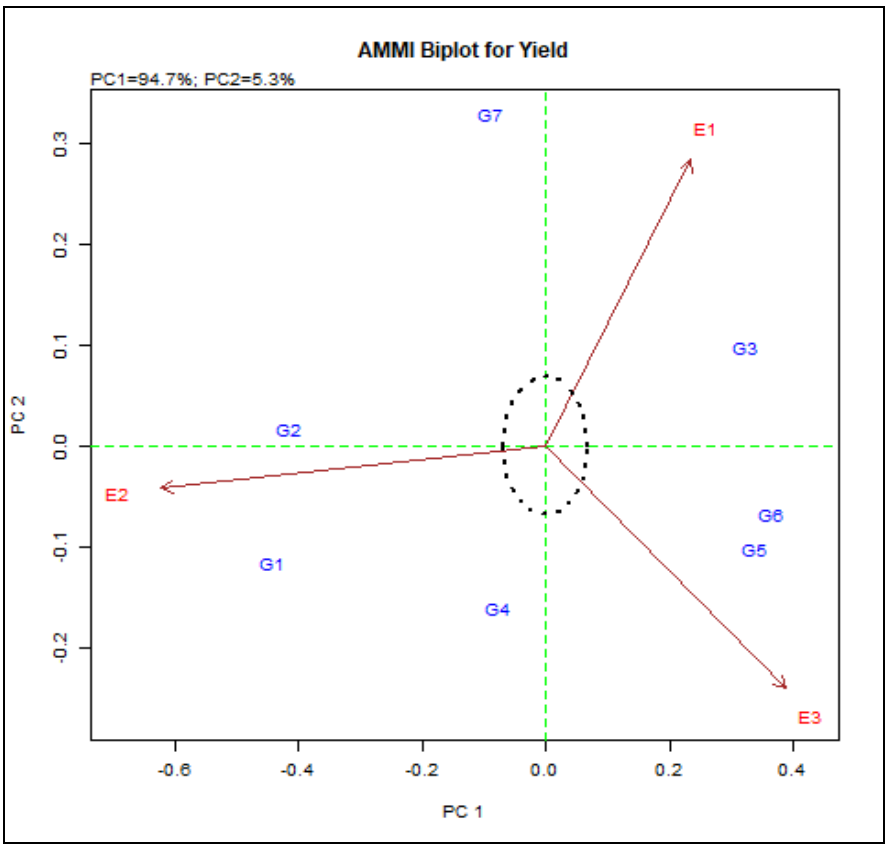


G_1=BD-768, G_2=BD-772, G_3=BD-777, G_4= BD-780, G_5= BD-1411, G_6=BD-1447, G_7=BC1(Check), E1= Gazipur, E2= Jamalpur, E3=Rangpur

Fig. 1. Biplot of the first AMMI interaction (IPCA1) score (Y–axis) plotted against mean yield (X-Axis) of seven proso millet advanced lines and three environment.

The AMMI biplot provides a visual expression of the relationship between the first interaction principal component axis (IPCA1) and means of genotypes and environments (Fig. 1) with the biplot accounting up to 94.7% of the treatment sum of squares. The IPCA1 was highly significant and explained the interaction pattern better than other interaction axes. The mean genotypes or environments in AMMI biplot located on the same parallel line, relative to the ordinate, have similar yield, while those located on the right side of the centre of the axis has higher yields than those on the left hand side (Fig.1). The biplot showed four grouping of genotypes, the 1st group was unstable and low yielding having three genotypes i.e., G_1=BD-768, G_2= BD-772 and G_4 = BD-780. The 2nd group was stable and low yielding having no genotypes, While G_6=BD-1447, G_5= BD-1411 and G_3=BD-777 are the high yielding and stable genotypes and high yielding and unstable groups having only one genotype i.e., G_7= BC-1.

The AMMI biplot (Fig. 2) illustrates that some genotypes in one environment have shown higher yield than in other, i.e., genotypes and environments have a specific interaction. Genotypes using PC values near to zero exhibit broader adaptability, and genotypes with higher PC1 values are more suitable for location with PC1 values of the same sign. For example, the genotype G7=BC-1 was suitable in Gazipur. Assessment of individual genotype performances can be based on their positions relative to the X and Y axis. The suitable advanced lines are those which have high yield with stable performances in most locations. The three high yielding genotypes (G6=BD-1447, G5=BD1411 and G3=BD777) proved to be the most desirable. Being high yielding, these are the suitable lines for all the environments.



Yield (t/ha)

Fig.2. AMMI Biplot 2 interaction (IPCA1 and IPCA2) of seven proso millet advanced lines and three environments.

IPCA2 scores also play a significant role in explaining the GEI; the IPCA1 scores were plotted against the IPCA2 scores for further exploration of adaptation (Fig. 2). Fig. 2 shows that the genotypes, G7=BC-1, G1=BD-768 and G2=BD 772 were unstable due to their dispersed position.

What -won- where biplot for yield

GGE biplot method can be used to identify superior genotypes for target sites. The biplot (Fig. 3) represents a polygon, where some of the hybrids are positioned on the vertexes, while the rest are inside the polygon. As the hybrids positioned on the vertexes have the longest distance from the biplot origin, they are supposed to be the most responsive. Responsive hybrids are either best or the poorest at one or every environment (Yan and Rajcan, 2002).

According to the biplot shown in Fig 3. The corner genotypes that are the most responsive ones can be visually determined. In this figure, Locations are divided into three sectors. The first sector represents Jamalpur and Gazipur, with genotype G_3=BD-777 as the most favorable for Jamalpur. The second sector represents Rangpur, with genotype G5= BD-1411 and G6=BD 1447 as the unfavorable. The other corner genotype G1=BD-768, G2= BD-772 and G4= BD780 were the poorest yielder. They were located far away from all of the test locations, reflecting the fact that they yielded poorly at each location.

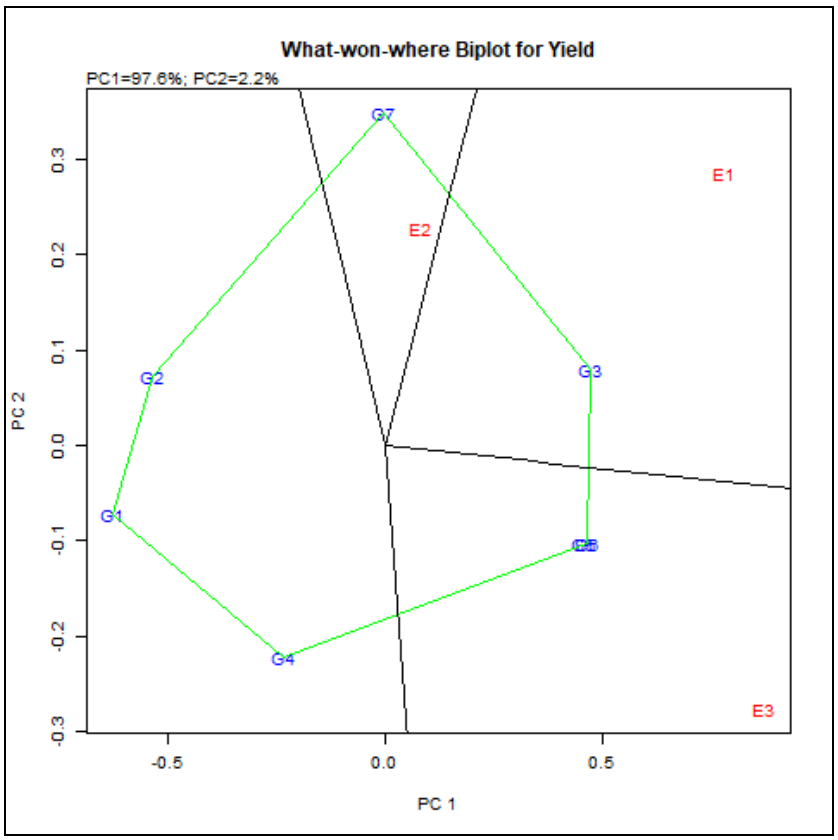


Fig.3. GGE biplot showing "What won where" of the 7 proso millet advanced lines across 3 environments

Conclusion

From the results of the study, it can be concluded that the performances of proso millet advanced lines were strongly influenced by the environments. Among the three environments, Gazipur was found most suitable for proso millet cultivation followed by Jamalpur. Among the lines BD-777 produced the highest yield followed by BD-1447 and BD-1411. Considering the yield potentiality and stability parameter, three genotypes BD-1447, BD-777 and BD-1411 were suitable for all the environments. So, these three genotypes could be selected for release as variety.

References

Alberts, M.J.A. 2004. Comparison of statistical methods to describe genotype × environment interaction and yield stability in multi-location maize trials. M. Sc. Thesis, University of the Free State.

Changmei, S., J. Dorothy. 2014. Millet-the frugal grain. *Int. J. Sci. Res.* Rev. **3**: 75–90.

Duarte, J.B. and Vencovsky, R. 1999. Interacao genotipos × ambientes: uma introducao a analise AMMI. Sociedade Brasileira de Genetica, Ribeirao Preto, 60p.

Eberhart, S. A. and Russel, W. A. 1966. Stability parameters for comparing varieties. *Crop Science*. **6**:36-40.

Finlay, K.W. and Wilkinsons ,G.N. 1963. The analysis of adaptation in a plant breeding programme. *Aust. J. Agris. Res*. **14**:742-754.

Gabriel, K.R. 1971. The biplot graphic display of matrices with application to principal component analysis. *Biometrics* **58**: 453-467

Gauch, H.G. 1992, Statistical analysis of regional yield trials: AMMI analysis of factorial designs, Elsevier, Amsterdam, 278 pp.

Gauch, H.G., Zobel, R.W. 1996. AMMI analysis of yield trials. In: Genotype by Environment Interaction, Kang, M.S. and H.G. Gauch (Eds.). Boca Raton CRC New York, USA., pp: 85-122

Hunt H. V., M. G.Campana, M. C. Lawes, Y. J. Park, M. A. Bower, C. J. Howe. 2011. Genetic diversity and phylogeography of broomcorn millet (*Panicum miliaceum* L.) across Eurasia. *Mol. Ecol.* **20**: 4756–4771.

Lyon D. J., Burgener, P. A. and DeBoer, K. 2008. EC08-137 Producing and Marketing Proso Millet in the Great Plains. Lincoln, NB: University of Nebraska-Lincoln.

Nadarajan, N. and M. Gunasekaran. 2005. Quantitative Genetics and Biometrical Techniques in Plant Breeding. Kalyani Publ., New Delhi.

Riley K. W., A. Setharam and G. Harinarayana. 1989. "Recommendations on breeding and varietal improvement. Small millets in global agriculture," in Proceedings of the First International Small Millets Workshop (New Delhi: Oxford and IBH Publishing), 29.

Samonte, S.O.P.B., Wilson, L.T., McClung, A.M., Medley, J.C. 2005. Targeting cultivars onto rice growing environments using AMMI and SREG GGE biplot analysis. *Crop Science.* **45:** 2414-2424

Solomon, A., Mandefro, N., and Habtamu, Z. 2008. Genotype-Environment Interaction and Stability Analysis for Grain Yield of Maize (*Zea mays* L.) in Ethiopia. *Asian Journal of Plant Science*. **2**:163-169.

Seghatoleslami, M. J., Kafi, M. E., Majidi. 2008. Effect of drought stress at different growth stages on yield and water use efficiency of five proso millet (*Panicum miliaceum* L.) genotypes. *Pakistan Journal of Botany*. **40**: 1427–1432.

Williams, M. M., Boydston, R. A., and Davis, A.S. 2007. Wild proso millet (*Panicum miliaceum*) suppressive ability among three sweet corn hybrids. *Weed Science.* **55**: 245–251.

Yan, W., Rajcan I. 2002. Biplot analysis of test sites and trait relations of Soyabean in Ontario. *Crop Science. J*. **42**:11-20

Zobel, R.W., M.J. Wright and H.G. Gauch. 1988. Statistical analysis of yield data. *Agronomy Journal.* **80**: 388-393.

ISSN 0258-7122 (Print), 2408-8293 (Online)
Bangladesh J. Agril. Res. 46(2): 143-151, June 2021

EFFICACY OF DIFFERENT APPROACHES TO CONTROL LITCHI FRUIT BORER

M. A. TAHER[1], M. M. UDDIN[2], K. S. ISLAM[3] AND M. A. RAHMAN[4]

Abstract

Litchi is affected by number of pests, among them litchi fruit borer (LFB)**,** *Conopomorpha sinensis* Bradley (Lepidoptera: Gracillariidae) is serious one which causes considerable yield loss. This study aimed to evaluate the efficacy of different options for the management of LFB. The research work was conducted in an orchard at Gopalpur under Tangail district of Bangladesh consecutively for two seasons to manage LFB using mosquito net, two types of bags, three botanicals and five synthetic insecticides as spray material to find out the most efficient one based on the highest reduction of fruit infestation (RFI) over control along with benefit cost ratio (BCR). White butter paper bagging showed highest RFI (100%) with 51.66% increase of fresh fruit (FF) over control and BCR 7.47:1. Neem oil was significantly effective in RFI over control (78.73%) with BCR 8.67:1. Novastar 56 EC (Bifenthrin+ Abamectin) was the most effective among the chemical treatments recording 98.08 % RFI with increase of 51.18 % FF over control and BCR 6.06:1. Based on BCR, performance of different treatments could be ranked as Neem oil > Paper bagging > Novastar. So, Paper bagging as safe technique, Neem oil at the rate of 6 ml/L of water as an eco-friendly tactic and Novastar 56 EC @ 1 ml/L of water as least harmful approach could be recommended to protect litchi from the attack of LFB and ensure higher number of fresh fruits.

Keywords: Litchi, *Conopomorpha sinensis*, mechanical, botanical, insecticide.

Introduction

Litchi (*Litchi chinensis* Sonn.) is one of the most popular fruits of Bangladesh. It is an important sub-tropical evergreen fruit crop having juicy white aril with high nutritive value, attractive colour and refreshing taste known as the queen of the fruits (Purbey and Kumar; Srivastava *et al.*, 2015). Agro-climatic condition of Bangladesh is conducive to the successful production of litchi and this popular fruit grows almost all over the country. During the recent years due to its ever increasing demand both in domestic and international market, it has risen to the status of a very important commercial fruit in Bangladesh providing livelihood opportunities to the people (Alam, 2011). But very unfortunately, the Litchi farmers are facing some problems during cultivation mainly insect pests, of which litchi fruit borer is the most common and serious pest in Bangladesh (Alam, 2004; Alam, 2011). Even in the previous century litchi fruit borer was

[1]PhD Student, Department of Entomology, Faculty of Agriculture, Bangladesh Agricultural University (BAU), Mymensingh, [2&3]Professor, Department of Entomology, Faculty of Agriculture, BAU, Mymensingh, [4]Senior Scientific Officer, Vertebrate Pest Division, Bangladesh Agricultural Research Institute (BARI), Gazipur-1701, Bangladesh.

considered to be a minor pest. But now a-days, it is regarded as a major pest of litchi, especially in Indian sub-continent (Sharma, 1985), a region of ever-changing climate scenario (Srivastava and Nath, 2015). If proper steps are not taken against this pest in time, it causes mass infestation to the fruit and farmers suffer from a huge financial loss (Alam *et al*., 2004). Annual yield loss in fruit ranges from 30%-52% due to insect pest infestation and that is one of the major causes for low production of litchi in Bangladesh (Alam, 2011). To overcome this loss, different types of insecticides are used frequently by the farmers of Bangladesh. It was evident that about hundred percent farmers in Bangladesh depends on the use of toxic insecticides in controlling fruit borer and spraying frequency of the farmers reached 20 times more during fruiting season covering the duration of 50-70 days to protect the fruits from the pest attack (Taher, 2020). Due to the absence of effective and economic control measures, the litchi growers are spraying different insecticides to control the pest without any potential benefits. The use of such type of insecticide increases the cost of production, exposes farmers and consumers to toxic residues, pollutes the environment and leads to insecticide resistance in insects. In June 2012, 14 children aged from 2 to 10, got affected with insecticides and died by consuming toxic Litchis living near the litchi orchard in Dinajpur and Thakurgaon Districts of Bangladesh (IEDCR, 2012). For avoiding these facts, management of litchi fruit borer requires strategies which should be more effective, safer and cheaper. Despite this situation, a few attempts have been made earlier to manage this serious pest by adopting different tactics. Considering all the views mentioned above, the present study was undertaken to find out the suitable management techniques for the management of LFB.

Materials and Methods

The experiment was carried out during 2014 and 2015, March to June at Gopalpur, Tangail following 11 treatments to find out the effectiveness of different management tactics (mechanical, botanical and insecticides) on litchi fruit borer, in an orchard of approximately one acre in size. Over this period of time, fruit infestations by *C. sinensis* were evaluated in this orchard (Variety: Madrazi and Bombai). The experiment was designed in Randomized Complete Block Design with 3 replications. The treatments *viz.* covering of fruit by mosquito net, bagging of fruit with mosquito net bag and white butter paper bag, Bishkatali leaf extract at the rate of 20 ml/L of water, Neem oil and Karanja oil @ 6 ml/L of water, Cypermethrin (Ripcord 10 EC) 1ml/L of water, Thiamethoxam (Actara 25 WG) 0.5g/L of water, Bifenthrin+Abamectin (Novastar 56 EC)1ml/L of water, Deltamethrin (Decis 2.5 EC) 1ml/L of water, Carbaryl (Sevin 85 SP) 2g/L of water and untreated control were evaluated. In each treatment, three trees were assigned and comprising each tree for one replication. One tree in all replication was assigned as control. All the spray

materials were applied 3 rounds; first spray was done 10 days after fruit formation and it was repeated two times at 15 days interval. The mechanical tactic was started within 10 days after fruit set. The nylon mosquito net was cut into pieces of different sizes and was used to cover litchi fruit a part of the tree (Fig. 1.a). The mosquito net was used after preparing a bag of the size of 18 inch x 14 inch. The paper bag was purchased from Dhaka, size of 12 inch x 8 inch. A few fruit bunches were tied together and then covered with Net bag and Paper bag (Fig.1. b & c). One kg of fresh Bishkatali leaves was mixed with required amount of water then boiled for 25-30 minutes, after cooling and filtration, making a volume up to 5 litres. Neem oil and Karanja oil were separately diluted into water with dish washing liquid (Trix mint) @ 0.5 ml/L of water, mixture was shaken two minutes to prepare a uniform solution and then used as botanical insecticides. The spraying was done on outer and inner canopy of the tree in all the directions with the help of foot pump sprayer. The observations of fruit infestation by *Conopomorpha sinensis* were recorded from harvested fruits. The peduncle of harvested fruit was opened and presence of larva or their excreta or entrance holes was considered as infested fruits (Fig.1. d & e). Number of fresh and infested fruits were counted and recorded from randomly selected 50 fruits per treatment and percentage of fruit infestation, reduction of infestation, percent increase of fresh fruits and benefit cost ratio (BCR) were calculated. The data of two years were used to calculate the mean and finally these were analyzed using MSTAT-C software and the means were separated by DMRT (Duncan's Multiple Range Test). Percent fresh fruit increase over control and benefit cost ratio were calculated per acre by the following formulae:

$$\% \text{ FF increase over control} = \frac{\text{No. of fresh fruit in treated tree} - \text{No.of fresh fruit in control tree}}{\text{Number of fresh fruit in treated tree}} \text{x}100$$

$$\text{Benefit-cost ratio} = \frac{\text{Value of treated fruit} - \text{Value of untreated fruit}}{\text{Cost of treatment application for each tactic}}$$

Fig.1 (a) Netting (b) Net bagging (c) Paper bagging (d) Entrance holes with excreta (e) Seed tip infested mature fruit with larva

Results and Discussion

The data of all the management approaches significantly ($p \leq 0.01$) reduced the fruit infestation in comparison to untreated control. Different management tactics showed significant effect in controlling litchi fruit infestation are described in following heads and data are presented in Table 1 and Table 2.

Efficacy of different tactics in suppressing percentages of fruit infestation

Effect of different tactics on fruit infestation was highly significant. The hundred percent protection of infestation was recorded by Paper bagging. The least infestation was found in Net bagging (0.66%) followed by Netting (2.96%). Hwang and Hung (1993) reported that the litchis with bagging could completely prevent the fruits from *C. sinensis* and did not affect the growth of fruits.

Significant variation was observed in percentage of borer infested litchi due to botanical insecticides. The lowest percentage of fruit infestation was noticed from Neem oil (10.99%) and the moderate in Bishkatali leaf extract (15.10%) followed by Karanja oil (18.83%). These findings comparable with the work of Ranjan and Singh (2003) who observed 38.0% fruit infestation when treated with neem oil. The efficacy of three botanicals was as the following order to neem leaf extract> bishkatali leaf extract>neem oil reported by Miah *et al.* (2017).

All the chemical treatments significantly ($p \leq 0.01$) reduced the fruit infestation. The minimum fruit infestation was 0.99% observed in Bifenthrin+Abamectin (Novastar 56 EC). The second lowest was registered in Thiamethoxam (Actara 25 WG) 4.03% followed by Deltamethrin (Decis 2.5 EC) 5.23%, Carbaryl (Sevin 85 SP) 6.02% and Cypermethrin (Ripcord 10 EC) 7.69%. The findings of present study are in a good agreement with Jumroenma *et al*. (2000) who found that the use of insecticides gave better performance against LFB ranging from 2.88-10.85 % at the harvesting period. Hung *et al.* (2008) reported that chemical sprays in litchi can effectively reducing the fruit damages caused by *C. sinensis* ranging from 8-16.5%.

Effect of different management approaches on percentage reduction of fruit infestation

The effect of all approaches on the reduction percentage of fruit infestation varied significantly. The hundred percent reduction of fruit infestation over control was observed in harvested fruits treated with Paper bagging, whereas 98.72% in Net bagging and 94.27% in Netting. Similarly the highest reduction of fruit infestation over control was found 96% when the litchi was bagged reported by Alam *et al.* (2004).

The effectiveness of botanical insecticides on the reduction of infestation over control was 78.73 % in Neem oil followed by Bishkatali leaf extract (70.77%) and 63.55% in Karanja oil. This results was nearer with Dong *et al.* (2006) who reported that sprayed with azadirachtin against fruit borer the reduction of infestation was 89.4% and 87.5%, respectively. Sahoo *et al.* (2007) also reported that the azadirachtin was significantly superior over the untreated control.

Due to the effect of synthetic insecticides on the reduction percentage of fruit infestation over control was the highest (98.08%) in Novastar 56 EC followed by Actara 25 WG (92.20%), Decis 2.5 EC (89.88%), Sevin 85 SP (88.35%) and the lowest was 85.11% in Ripcord10 EC (Fig.2). These results were close confirmatory with the work of Hwang and Hung (1993) who reported that insecticides were more effective against *C. sinensis* as their control rate reached above 95%. Similarly, Ping (2006) observed the efficacy of six insecticides against LFB and reported their control effects as 73.68 % to 83.41%, respectively.

Effectiveness of different approaches and their impact on the percent increase of fresh fruit

The number of fresh fruits varied between the level of pest infestation and the efficacy of applied management tactics. The percentage of fresh fruit increased over control showed significant level of success. In view of mechanical control effect, the fresh fruit was increased over control at the rate of 50.19%% in Netting, 51.34% in Net bagging and 51.66% in Paper bagging. These findings are nearly agreed with the results of Purbey and Kumar (2015) who reported that there was a 33.58% - 41.38 % healthy fruit found in all bagged fruits as compared to control.

In term of botanical treated trees, the fresh fruit was increased over control at the rate of 43.06% in Bishkatali leaf extract, Neem oil (45.69%) and Karanja oil (40.45%). Dong *et al.* (2006) reported that fresh fruit increased remarkably by spraying azadirachtin against fruit borer.

Due to the insecticidal treatments, the fresh fruit was increased over control at the rate of 47.63%, 49.63%, 51.18%, 48.99% and 48.56% by spraying of Ripcord, Actara, Novastar, Decis, and Sevin, respectively. These results are comparable to the findings of Ranjan *et al.* (2019) who reported that spraying of insecticides, recording lowest fruit damage due to litchi fruit borer and increased the maximum marketable fruit.

Economic analysis of different control measures

The benefit cost ratio (BCR) varied depending on the cost of treatment application and increasing fresh fruit with market price. In case of mechanical treated trees, the highest benefit cost ratio was 7.47:1 in Paper bagging followed by Net bagging (5.69:1) and Netting (3.17:1). It is to be noted that all the mechanical treated trees provided maximum number of fresh fruit but the higher application cost, the method brought down the profit margin and showed lower BCR. Moreover, bagging was most effective and eco-friendly management technique for controlling LFB. Similar to the present study reported by Waite and Hwang (2002).

Due to the botanical treated trees, the highest benefit cost ratio was 8.67:1 in Neem oil followed by Bishkatali leaf extract (8.50:1) and Karanja oil (6.45:1). Similar findings were reported by Gupta *et al.* (2000) to evaluate neem plant products and the maximum benefit cost ratio was found by neem oil followed by neem leaf extract.

Table1. Effect of different management approaches on fruit infestation and fresh fruit increase of litchi during 2014 and 2015 at Gopalpur, Tangail (mean)

Treatments	% fruit infestation	% reduction of fruit infestation over control	Number of fresh fruit/ acre	% fresh fruit increase over control
Netting	2.96 e	94.27	172051.90 c	50.19
Net bagging	0.66 e	98.72	176129.80 b	51.34
Paper bagging	0.00 e	100	177300.00 a	51.66
Bishkatali leaf ext.	15.10 b	70.77	150527.70 i	43.06
Neem oil	10.99 c	78.73	157814.70 h	45.69
Karanja oil	18.83 b	63.65	143914.40 j	40.45
Ripcord 10 EC	7.69 d	85.11	163665.60 g	47.63
Actara 25 WG	4.03 d	92.20	170154.80 d	49.63
Novastar 56 EC	0.99 e	98.08	175544.70 b	51.18
Decis 2.5 EC	5.23 d	89.88	168027.20 e	48.99
Sevin 85 SP	6.02 d	88.35	166626.50 f	48.56
Control	51.66 a	0.00	85706.82 k	0.00
Level of signific.	0.01	-	0.01	-
CV (%)	16.22	-	0.30	-

The values having different letter(s) in a column are significantly different at 5% level. CV (%) = Co-efficient of variation

According to chemical insecticides, the highest BCR was 6.06:1 in Novastar followed by Decis (5.66:1), Ripcord (5.15:1), Sevin (3.19:1) and Actara (3.02:1). These findings are in agreement to the works of Ranjan *et al.* (2019) who reported that spraying of insecticide, provided the maximum marketable fruit and thus highest benefit cost ratio was 10.2:1. Bhatia *et al*. (2000) conducted a study on the fruit borer control of litchi using six different insecticides and found the highest efficacy with all of the tested insecticides resulted in high returns.

Table 2. Benefit cost ratio analysis in respect of effectiveness of different tactics during 2014 and 2015 (mean)

Treatments	Value of fresh fruit/acre	Value of infested fruit/acre	Total (Tk.)	Value over control (Tk.)	Application cost/ acre (Tk.)	BCR
Netting	387116.80	4198.46	391315.30	125200.40	39440	3.17:1
Net bagging	396292.10	936.14	397228.20	131113.40	23049	5.69:1
Paper bagging	398925.00	0.00	398925.00	132810.10	17784	7.47:1
Bishkat.lea. ext.	301055.40	21417.84	322473.20	56358.35	6630	8.50:1
Neem oil	315629.50	15588.20	331217.70	65102.79	7513	8.67:1
Karanja oil	287828.80	26708.47	314537.30	48422.40	7513	6.45:1
Ripcord 10 EC	286414.90	10907.50	297322.30	31207.46	6054	5.15:1
Actara 25 WG	297770.90	5716.15	303487.10	37372.18	12390	3.02:1
Novastar 56 EC	307203.30	1404.22	308607.50	42492.60	7014	6.06:1
Decis 2.5 EC	294047.60	7418.23	301465.80	35350.96	6246	5.66:1
Sevin 85 SP	291596.40	8538.77	300135.20	34020.32	10662	3.19:1
Control	192840.30	73274.54	266114.90	0.00	0.00	0.00

For calculating BCR: To use the number of fresh fruit 177300/acre obtained from the trial trees, fresh fruit market price 2.25Tk/litchi (mechanical), 2Tk/litchi (botanical),1.75Tk/litchi (insecticidal), 0.80Tk/litchi (infested), labour cost for treatment application =400Tk/day (8 hours day), sprayer rent for spraying insecticides = 50 Tk/day and treated material price.

Over all, it was found that the tested treatments in the present study showed the high efficacy in reducing fruit infestation and producing maximum fresh fruit to compare untreated control but application cost of some tactics was higher, resulted in the lower BCR than that of others. Dissimilarities in results between the previous and the present study may be due to the meteorological parameters, frequency of spray material and mode of action, application time, variety of litchi and price. The finding of this study based on different approaches hold a good promise in litchi fruit borer management. It showed that Butter paper bag, Neem oil and Novastar 56 EC (Bifenthrin+Abamectin) was the cost effective and eco-friendly technologies which may be incorporated to the farmers' field.

Conclusion

It is apparently found that infesting litchi by fruit borer elicits the greatest economic effects. From this study the results revealed that litchi fruit borer could be controlled using mechanical, botanical and chemical control tactics. It can be concluded that the use of chemical insecticides might be reduced with the increase of some promising tactics like Paper bagging as mechanical and Neem oil as

botanical treatment. Besides, new generation insecticide; Novastar 56 EC (Bifenthrin+Abamectin) may be used for the better management of LFB by maintaining the pre-harvest intervals (PHI) following the proper doses of this insecticide with optimum spray schedules.

References

Alam, S. N. 2011. Insect Pest Management for Quality Horticultural Crop Production in Bangladesh. Entomology Division, Bangladesh Agricultural Research Institute, Joydevpur, Gazipur. *Hortex Newsletter* **11(2):** pp. 7.

Alam, S. N., A. M. Z. Rahman, R. U. Mia and M. A. Sarkar. 2004. Studies on the Fruit Borer Control in Litchi. Bangladesh Agricultural Research Institute, Annual Report 2003-2004.

Bhatia, R., R. Sharma and R. P. Agnihotri. 2000. Incidence, Varietal Preference and Control of Fruit Borer, *Conopomorpha cramerella* (Lepidoptera: Gracillariidae) on Litchi *(Litchi chinensis)* in Himachal Pradesh. *Indian J. Agril. Sci.* **70(5):** 301-04.

Dong, X. J., L. G. Wen and Z. Ling. 2006. Suppressive Effect of Azadirachtin on Litchi Fruit Borer *Conopomorpha sinensis* Population. *Chinese Bull. Entom.* **43(3):** 327-330.

Gupta, M. P., S. K. Chourasia and H. S. Rai. 2000. Efficacy of Neem Plant Products Against the Budfly (*Dasineura lini*) on linseed. *Indian J. Agril. Sci.* **70(11):** 762-764.

Hung, S. C., K. Y. Ho and C. C. Chen. 2008. Investigation of Fruit Damages of Litchi Caused by *Conopomorpha sinensis* Bradley and *Bactrocera dorsalis* (Hendel) in Chiayi. *J. Taiwan Agril. Res.* **57:** 143-152.

Hwang, J. S. and C. C. Hung. 1993. Control of the Litchi Fruit Borer, *Conopomorpha sinensis* Bradley, with Bagging Method and Insecticides. *Plant Protec. Bull.* (Taichung) **35(3):** 225-238.

IEDCR. 2012. Outbreak of Illness and Deaths among Children Living Near Litchi Orch ards in Northern Bangladesh. Institute of Epidemiology, Disease Control and Research, Health and Science Bulletin. **10(4):** 15-21.

Jumroenma, K., S. S. Aromna, C. Undhawutti and W. Namruangsri. 2000. Litchi Fruit Borer and Appropriate Control. Entomology and Zoology Gazette. *Thai Agril. Res. J.* **22(1):** 2-16.

Mia, M. R. U., N. Barman, M. Z. Alam, K. Yesmin and M. Ahmad. 2017. Effectiveness of Some IPM Packages Consisting of Chemical and Non Chemical components for suppressing Pod Borer and Aphid in Summer Country Bean. *J. Environ. Sci. Nat. Resour.* **10(1):** 109-115.

Ping, C. X. 2006. Studies on the Occurrence of *Conopomorpha sinensis* Bradley and Its Key Control Techniques. http://www.disser tationto pic.net /doc /1313564

Purbey, S. K. and A. Kumar. 2015. Effect of Pre-Harvest Bagging on Quality and Yield of Litchi (*Litchi Chinensis Sonn*.) Fruits. An International Quarterly *J. Environ. Sci.* Special issue. **7:** 197-201.

Ranjan, R., U. Mukherjee and V. Kumar. 2019. Bio-rational Approaches to Manage Major Pests of Litchi (*Litchi sinensis* Sonn.). *J. Entom. Zool. Stud*. 7(2): 338-341.

Ranjan, R. and P. P. Singh. 2003. Field Efficacy of Insecticides and Plant Products Against Litchi Fruit Borer. In: Proceedings of National Symposium on Frontier Areas of Entomological Research 5-7 Nov. 2003. Indian Agricultural Research Institute, New Delhi, India. pp.105.

Sahoo, A. K., A. Roy and S. K. Ray. 2007. Comparative efficacy of insecticides and neem formulations against Litchi fruit borer, *Conopomorpha cramerella* Snellen (Gracillariidae: Lepidoptera). Department of Agricultural Entomology, Bidhan Chandra Krishi Viswavidtyalay, West Bengal, India. *Arc Journal.* **16:** 1-3.

Sharma, D. D. 1985. Major Pests of Litchi in Bihar. *Indian Farming.* **32(2):** 25-26.

Srivastava, K., S. D. Pandey, R. K. Patel, D. Sharma and V. Nath. 2015. Insect Pests Management of Fruit Crops. Chapter 7, Insect Pest Management Practices in Litchi. pp. 127-143.

Srivastava, K. and V. Nath. 2015. Keeping Emerging Litchi Pests under Changing Climate at Bay. pp. 28-30. Available online at https://www. Research gate.net /publication/ 283255079 _keeping_emerging_litchi_pests_under_changing_climate

Taher, M. A. 2020. Development of an Appropriate Management Strategy for Litchi Fruit Borer, *Conopomorpha Sinensis* Bradley using Non-Chemical and Chemical Approaches. PhD Thesis, Department of Entomology, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh.

Waite, G. K. and J. S. Hwang. 2002. Pests of Litchi and Longan. In: Peña J E, Sharp J L and Wysoki M (eds). Tropical Fruit Pests and Pollinators: Biology, Economic Importance, Natural Enemies and Control. Wallingford, UK: CABI Publishing. pp. 331-359.

ISSN 0258-7122 (Print), 2408-8293 (Online)
Bangladesh J. Agril. Res. 46(2): 153-165, June 2021

EFFECT OF SOIL AND FOLIAR APPLICATION OF PLANT NUTRIENTS ON PURPLE BLOTCH AND TIP-BURN OF ONION

M. I. FARUK[1]

Abstract

An experiment was conducted in the field of Plant Pathology Division, BARI, Cazipur, during Robi 2015-16, 2016-17 and 2017-18 cropping seasons to evaluate the efficacy of available plant nutrients against purple blotch disease and tip-burn of onion. Eight different plant nutrients viz. Potassium (ZnSO4 fertilizer), Phosphorus (TSP fertilizer), Boron (Boron fertilizer), Zinc (ZnSO4 fertilizer), Calcium ($CaSO_4$ fertilizer), Copper ($CuSO_4$), Silicon (silica gel) and Manganese ($MnSO_4$ fertilizer) were tested against purple blotch disease and tip-burn of onion. Soil and foliar application of plant nutrients viz. Potassium, Phosphorus, Boron, Zinc, Calcium, Copper, Silicon and Manganese in the formed of water solution gave appreciable reduction of purple blotch disease and tip-burn incidence and increased plant growth such as shoot and root growth as well as yield of onion. Among the nutrients solution Potassium, Phosphorus, Silicon, Zinc and Calcium were performed better for reducing purple blotch disease severity (upto 62.78%), tip-burn incidence (upto 72.22%) and increasing plant growth as well as yield of onion. Application of Boron and Manganese also performed better than control. So, soil and foliar application plant nutrients viz. Potassium, Phosphorus, Silicon, Zinc, Boron and Manganese might be recommended for tip-burn and purple blotch disease management and also for onion production in Bangladesh.

Keywords: Onion, purple blotch, *Alternaria porri*, tip burn, plant nutrients**.**

Introduction

Onion (*Allium cepa* L.) is one of the most important and familiar spices crop specially bulb onion throughout the world. It is a member of the family Alliaceae. It is also used as popular vegetable in many countries of Asia and also very common and favorable spice in Bangladesh. It ranks first in the area (419122 ha) and production (1704402 MT) (BBS, 2015). It covers almost 46% of the total areas under spices (BBS, 2015). The national average yield is only 4.07 t/ha which is quite low compared to world average of 17.27 t/ha (FAO, 1998). Onion crop is affected by a number of soil borne and foliar diseases (Munoz *et. al*., 1984; Ahmed and Hossain, 1985; Meah and Khan, 1987). Both soil borne and foliar diseases are the major constrains for low yield of onion in the country. Among the diseases, purple blotch caused by *Alternaria porri*, is noted as the major foliar disease throughout the world including Bangladesh (Meah and Khan, 1987; Bose and Som, 1986; Castellanes-Linares *et. al*., 1988). Now a day's tip-burn becomes one of the problems for onion cultivation in Bangladesh. In Bangladesh, detail and

[1]Principal Scientific Officer, Plant Pathology Division, Bangladesh Agricultural Research Institute (BARI), Gazipur-1701, Bangladesh.

comprehensive studies were done for the management of purple blotch disease but none of the informations are available about tip burn problem. Only fungicidal management is the effective means to manage the purple blotch disease. But indiscriminate use of chemicals pesticides causes environmental pollution and health hazards (Gerhardson, 2002). So, it is important to find alternative measures to control plant diseases which do not harm the environment and at the same time increase yield and improve product quality (Atkinson and McKinlay, 1997; Batish *et al*., 2007; Camprubí *et al*., 2007). Nutrients are important for growth and development of plants and also for microorganisms. In addition, nutrients can affect the development of a disease by affecting plant physiology or by affecting pathogens, or both of them. They are important factors for disease suppression (Agrios, 2005). All the essential nutrients can affect disease severity (Huber and Graham, 1999). So, it is important to manage nutrients availability through fertilizers or change the soil environment to influence nutrient availability, and in that way to control plant disease (Huber and Graham, 1999; Graham and Webb, 1991). The level of nutrients can influence the plant growth, which can affect the microclimate, therefore affecting infection and sporulation of the pathogen (Marschner, 1995). But in Bangladesh there is no available information about the effect of nutrients on the onion disease management. Therefore the present study has taken to observe the effect of plant nutrients on purple blotch disease and tip-burn of onion.

Materials and Methods

The experiment was conducted in the field of Plant Pathology Division, Bangladesh Agricultural Research Institute, Joydebpur, Gazipur during robi 2015-16, 2016-17 and 2017-18 cropping seasons. There were 9 treatments viz. T_1= Spray in the furrow soil during transplanting + Foliar spray of Potassium (MOP fertilizer @ 2% water solution), T_2= Spray in the furrow soil during transplanting + Foliar spray of Phosphorus (TSP fertilizer @ 2% water solution), T_3= Spray in the furrow soil during transplanting + Foliar spray of Zinc ($ZnSO_4$ fertilizer @ 1% water solution), T_4= Spray in the furrow soil during transplanting + Foliar spray of Silicon (Silica gel @ 2% water solution), T_5= Spray in the furrow soil during transplanting + Foliar spray of Boron (Boro fertilizer @ 1% water solution) T_6= Spray in the furrow soil during transplanting + Foliar spray of Calcium ($CaSO_4$ fertilizer @ 1% water solution), T_7= Spray in the furrow soil during transplanting + Foliar spray of Manganese ($MnSO_4$ fertilizer @ 1% water solution), T_8= Spray in the furrow soil during transplanting + Foliar spray of Copper ($CuSO_4$ @ 1% water solution) and T_9= Control (only used recommended dose of fertilizers). The unit plot size was 2 m x 2.5m. RCB design was followed with 3 replications. The treatments were applied four times viz. 1st application in the soil at the time of seedling transplanting, 2nd foliar application 40-45 days after seedling transplanting, 3rd foliar application 10-12 days after 2nd application and 4th foliar

application 10-12 days after 3rd application. Forty five days old onion seedlings of cv. BARI Piaz-1 grown on sterilized soils was transplanted in the experimental plots maintaining row to row and plant to plant distance of 15 cm and 10 cm, respectively. Standard cultivation procedures including method of fertilizer application recommended by BARI were followed to grow onion (Azad *et al*., 2019). Recommended doses of different fertilizers viz. cowdung @ 5 t/ha, Urea @ 240 kg/ha, TSP @ 260 kg/ha and MOP @ 150 kg/ha were used in all the treatment including control treatment (Azad *et al.*, 2019). During crop season necessary weeding, irrigation and other intercultural operations were done as per recommendation of the crop.

Data collection: Data were recorded on purple blotch disease severity, tip-burn incidence, plant growth parameter such as plant height, shoot weight, root length and root weight and yield per unit area. Data on plant growth parameters were recorded 65 days after seedling transplanting. Data on purple blotch disease severity and tip burn incidence were collected 10 days after 4th time treatments application. Data were calculated in terms of disease incidence and disease severity (PDI) by following formulae-

$$\text{Disease incidence} = \frac{\text{Number of infected plant}}{\text{Total number of inspected plant}} \times 100$$

$$\text{PDI} = \frac{\text{Total sum of numerical ratings}}{\text{Number of observation X Maximum disease rating in the scale}} \text{X}100$$

The 0-5 disease scoring scale was used to estimate the disease severity (PDI-Percent Disease Index) of purple blotch complex of onion for each unit plot under each treatment. The scale was followed by Islam *et al.* (1999) and Rahman and Rashid (2008) as described below:

0 = no disease symptoms in the plant

1 = a few spots towards the tip, covering less than 10% leaf area

2 = several dark purplish brown patches covering less than 20% leaf area

3 = several patches with paler outer zone, covering up to 40% leaf area

4 = long streaks covering upto 75% leaf area or breaking of leaves / stalks from the centre

5 = complete drying of the leaves/ stalks or breaking of the leaves / stalks from the base

The percent data were converted into arcsine transformation values before statistical analysis. Data were analyzed statistically by using the MSTATC program. The treatment effects were compared by applying the least significant different (LSD) test at P=0.05 level.

Results and Discussion

Plant growth: Average plant height of onion under control was 38.13 cm plant^{-1} in the first year, 40.73 cm plant^{-1} in the second year and 40.33 cm plant^{-1} in the third year. The plant height was increased to 44.73-48.73 cm plant^{-1} in the first year, 48.53-60.07 cm plant^{-1} in the second year and 46.33-64.67 cm plant^{-1} in the third year due to soil and foliar application of different plant nutrients (Table 1). In the first year, the highest plant height was obtained by the soil and foliar application MOP fertilizer followed by TSP fertilizer, $ZnSO_4$ fertilizer and Silica gel (Table 1). Lower increased of plant height over control was recorded from the treatment $CuSO_4$ followed by $CaSO_4$ fertilizer, $MnSO_4$ and Boron fertilizer. In the second year, the highest plant height was recored from Silica gel treatment followed by TSP fertilizer, MOP fertilizer, $ZnSO_4$ fertilizer, Boron fertilizer and $CaSO_4$ fertilizer (Table 1). The least effective treatment in increasing of plant height over control was recorded from $CuSO_4$ followed by $MnSO_4$ treatment. In the third year, the maximum plant height was recorded from MOP fertilizer treatment followed by TSP fertilizer, Silica gel, $ZnSO_4$ and Boron fertilizer treatment. The least effective treatment to increase plant height was $CuSO_4$ followed by $CaSO_4$ fertilizer treatment (Table 1).

Table 1. Effect of soil treatment and foliar application different nutrients on the plant growth of onion during three consecutive years

Soil and foliar application of different plant nutrient with dose	Plant height (cm)			Plant weight (gplant^{-1})		
	2016-17	2017-18	2018-19	2016-17	2017-18	2018-19
Potassium (MOP fertilizer @2%)	48.73 a	59.00 ab	64.67 a	25.67 a	68.00 a	72.67 a
Phosphorus (TSP fertilizer @2%)	48.53 ab	57.67 ab	59.33 b	23.13 b	56.20 b	68.33 b
Zinc ($ZnSO_4$ fertilizer @1%)	47.80 ab	57.13 ab	56.00 bc	22.60 bc	56.60 b	61.67 c
Silicon (Silica gel @2%)	47.67 ab	60.07 a	59.00 b	22.80 bc	56.67 b	66.00 b
Boron (Boro fertilizer @1%)	46.13 bc	56.93 ab	55.00 bc	20.33 de	51.33 c	61.33 c
Calcium ($CaSO_4$ fertilizer @1%)	45.07 c	56.73 ab	52.33 c	21.93 bc	53.40 bc	58.00 cd
Manganese ($MnSO_4$ @1%)	46.13 bc	56.27 b	55.00 bc	21.53 cd	53.67 bc	59.33 c
Copper ($CuSO_4$ @1%)	44.73 c	48.53 c	46.33 d	19.93 e	41.33 d	54.00 d
Control	38.13 d	40.73 d	40.33 e	16.33 f	40.73 d	41.00 e
LSD (P=0.05)	2.476	3.472	4.714	1.531	4.677	4.164

Values in a column having same letter did not differ significantly (P=0.05) by LSD

In first year, the plant weight of onion was 16.33 g plant^{-1} under control. It increased to 19.33-25.67 g plant^{-1} due to soil and foliar application of different nutrients (Table 1). The highest plant weight was achieved with MOP fertilizer treatment followed by TSP fertilizer, Silica gel, ZnSO4 and $CaSO_4$ fertilizer. The least effective treatment to increase plant weight was $CuSO_4$ followed by Boron fertilizer and $MnSO_4$ treatments. More or less similar trend was also observed in the second and third year trials. In second year, the lowest plant weight of onion was 40.73 g plant^{-1} recorded in the control. Soil and foliar application of MOP fertilizer gave the highest plant weight 68.00 g plant^{-1} followed by Silica gel, $ZnSO_4$ and TSP fertilizer treatments where the plant weight was 56.67, 56.60 and 56.20 g plant^{-1}, respectively (Table 1). In the third year, the highest plant weight was 72.67 g plant^{-1} recorded from MOP fertilizer treatment followed by TSP, Silica gel, $ZnSO_4$ and Boron fertilizer treatments where the plant weight was 68.33, 66.00, 61.67 and 61.33 g plant^{-1}, respectively. In second year and third year the least effective treatment was $CuSO_4$ followed by $CaSO_4$ and $MnSO_4$ treatments (Table 1).

Table 2. Effect of soil treatment and foliar application different nutrients on the root growth of onion during three consecutive years

Soil and foliar application of different plant nutrient with dose	Root length (cm)			Root weight (gplant^{-1})		
	2016-17	2017-18	2018-19	2016-17	2017-18	2018-19
Potassium (MOP fertilizer @2%)	9.20 a	8.07 a	7.20 a	2.33 a	2.50 a	2.63 a
Phosphorus (TSP fertilizer @2%)	8.67 ab	6.40 b	6.13 b	2.30 a	2.27 ab	2.33 ab
Zinc ($ZnSO_4$ fertilizer @1%)	8.47 b	5.93 bc	6.13 b	1.93 b	2.37 a	2.50 ab
Silicon (Silica gel @2%)	8.27 bc	6.07 b	6.07 b	1.87 bc	2.10 ab	2.67 a
Boron (Boro fertilizer @1%)	8.67 ab	5.80 bc	6.07 b	1.83 bcd	2.00 ab	2.17 ab
Calcium ($CaSO_4$ fertilizer @1%)	7.57 cd	5.93 bc	6.00 bc	1.73 cd	2.40 a	2.33 ab
Manganese ($MnSO_4$ fertilizer @1%)	8.27 bc	5.80 bc	6.07 b	1.87 bc	2.00 abc	2.57 ab
Copper ($CuSO_4$ @1%)	7.23 d	5.13 c	5.20 cd	1.67 d	1.80 bc	1.83 bc
Control	6.03 e	4.13 d	4.60 d	1.43 e	1.53 c	1.33 c
LSD (P=0.05)	0.709	0.830	0.821	0.189	0.504	0.76

Values in a column having same letter did not differ significantly (P=0.05) by LSD

Root growth: Soil and foliar application of different plant nutrients showed positive effects on root growth of onion as compared to control (Table 2). In first year, the maximum root length 9.20 cm was recorded from MOP fertilizer treatment followed by TSP, Silica gel and $ZnSO_4$ where the root length was 8.67, 8.67 and 8.47 cm, respectively and the minimum root length 6.03 cm was recorded from control (Table 2). More or less similar trend was observed in the second and third years. In second year, average root length under control was 4.13 cm. It was increased to 5.13-8.07 cm/plant due to application of different treatments. In the third year, the lowest root length was 4.60 $cmplant^{-1}$ recorded in control. In this year MOP fertilizer treatments gave the highest root length 7.20 cm followed by TSP, $ZnSO_4$, Silica gel, $MnSO_4$ and Boron fertilizer where the root length was 6.13, 6.13, 6.07, 6.07 and 6.07 cm, respectively. In all years the least effective treatment was $CuSO_4$ followed by $CaSO_4$ (Table 2). Root weight under control was 1.43, 1.53 and 1.33 g/plant in the first year, second year and third year, respectively. The root weight was increase to 1.67-2.33, 1.80-2.50 and 1.83-2.67 g/plant in the first year, second year and third year, respectively due application of different treatments (Table 2).

Tip burn disease incidence: In all the years, the incidence of tip burn of onion was reduced significantly over control due to soil and foliar application with different plant nutrients (Table 3). In the first year, application of MOP fertilizer gave the lowest tip-burn incidence 25% followed by TSP fertilizer, Silica gel, $ZnSO_4$ and Boron fertilizer treatments where the tip-burn incidence was 35%, 38.67%, 43.33% and 43.37%, respectively (Table 3). Application of $CuSO_4$ gave higher 56.67% tip burn incidence followed by $CaSO_4$ and $MnSO_4$ with 48.33% and 48.33 tip burn incidence, respectively. The highest tip-burn incidence 68.33% was recorded in control treatment. Application of MOP fertilizer reduced 63.41% tip-burn incidence followed by the application of TSP fertilizer, Silica gel, $ZnSO_4$ and Boron fertilizer treatments where the reduction was 48.78%, 43.41%, 36.59% and 36.53%, respectively compared to control. In the second year, all the treatments significantly reduced tip-burn incidence compared to control except $CuSO_4$ where the tip burn incidence was higher than other treatments (Table 3). The lowest tip burn incidence 16.67% was recoded from MOP fertilizer treatment followed by TSP fertilizer, $ZnSO_4$, Silica gel, $MnSO_4$, $CaSO_4$ and Boron fertilizer with tip burn incidence of 20%, 21.67%, 21.67% 23.33% , 23.33% and 25%, respectively though all the treatment were statistically similar (Table 3). The highest tip burn incidence 60% was recoded in control. Application of MOP fertilizer reduced 72.22% tip-burn incidence followed by TSP fertilizer, $ZnSO_4$, Silica gel, $MnSO_4$ and Boron fertilizer where the reduction of tip-burn incidence of onion was 66.67%, 63.88%, 63.88%, 61.12%, 61.12% and 58.33%, respectively compared to control. In the third year, application of MOP fertilizer, TSP fertilizer, Silica gel and ZnSO4 gave the significantly lower 32.33%, 32.33%, 34.33% and 36.33%, respectively tip burn incidence followed by $MnSO_4$, $CaSO_4$ and Boron fertilizer treatment. The least effective treatment was $CuSO_4$ where the tip burn

incidence was 55.00%. The highest tip burn incidence 74.67% was recoded in control. Application of MOP fertilizer and TSP fertilizer reduced 56.70% tip-burn incidence followed by Silica gel, $ZnSO_4$, $MnSO_4$, $CaSO_4$ and Boron fertilizer where the reduction of tip-burn incidence of onion was 54.02%, 51.35%, 43.75%, 43.31% and 43.31%, respectively compared to control (Table 3).

Table 3. Effect of soil treatment and foliar application of different nutrients on the incidence of tip burn of onion during three consecutive years

Soil and foliar application of different plant nutrient with dose	Tip burn incidence of onion			Reduction of tip-burn incidence (%)		
	2016-17	2017-18	2018-19	2016-17	2017-18	2018-19
Potassium (MOP fertilizer @2%)	25.00 f (29.93)	16.67 d (23.74)	32.33 d (34.64)	63.41	72.22	56.70
Phosphorus (TSP fertilizer @2%)	35.00 e (36.24)	20.00 cd (26.45)	32.33 d (34.64)	48.78	66.67	56.70
Zinc ($ZnSO_4$ fertilizer @1%)	43.33 cd (41.15)	21.67 cd (27.71)	36.33 d (37.05)	36.59	63.88	51.35
Silicon (Silica gel @2%)	38.67 de (38.43)	21.67 cd (27.71)	34.33 d (35.85)	43.41	63.88	54.02
Boron (Boro fertilizer @1%)	43.37 cd (41.16)	25.00 c (29.92)	42.33 c (40.58)	36.53	58.33	43.31
Calcium ($CaSO_4$ fertilizer @1%)	48.33 c (44.04)	23.33 cd (26.45)	42.33 c (40.58)	29.27	61.12	43.31
Manganese ($MnSO_4$ fertilizer @1%)	48.33 c (44.04)	23.33 c (28.85)	42.00 c (40.38)	29.27	61.12	43.75
Copper ($CuSO_4$ @1%)	56.67 b (48.85)	38.33 b (38.24)	55.00 b (47.87)	17.06	36.11	26.34
Control	68.33 a (55.85)	60.00 a (46.92)	74.67 a (59.83)	-	-	-
LSD (P=0.05)	4.254	4.567	3.29	-	-	-

Values in a column having same letter(s) did not differ significantly (P=0.05) by LSD; values within the parenthesis is the arcsin transformed value.

Purple blotch disease severity: All the treatments significantly reduced purple blotch disease severity over control during three consecutive years (Table 4). In the first year soil and foliar application of MOP fertilizer, TSP fertilizer, ZnSO4 and Silica gel gave significantly lower 22.33%, 22.33%, 22.67% and 22.67%, respectively purple blotch disease severity followed by Boron fertilizer, $MnSO_4$ and $CaSO_4$ fertilizer treatments where purple blotch disease severity was 24.33%, 25.33% and 28.33%, respectively (Table 4). Application of MOP fertilizer and TSP fertilizer reduced 62.78% purple blotch disease severity compared to control followed by $ZnSO_4$, Silica gel, Boron fertilizer, $MnSO_4$ and $CaSO_4$ fertilizer treatments where the reduction of disease severity was 62.21%, 62.21%, 59.45% and 57.78%, respectively (Table 4). The highest purple blotch disease severity 60% was

observed in control treatment. More or less similer trend of reduction of purple blotch disease severity was observed in the second and third year's trials. In the second year, all the treatments significantly reduced purple blotch disease severity compared to control except $CuSO_4$ where the disease severity was significantly higher than other treatments. Application of MOP fertilizer reduced 60.68% purple blotch disease severity followed by TSP fertilizer, $ZnSO_4$, Silica gel, Boron fertilizer, $CaSO_4$ and $MnSO_4$ treatments where the reduction was 58.42%, 58.42%, 56.18%, 55.05%, 52.25% and 48.31%, respectively compared to control. The highest purple blotch disease severity 59.33% was observed in control treatment. In the third year, application of MOP fertilizer reduced 60.11% disease severity followed by TSP fertilizer, Silica gel, $ZnSO_4$, $CaSO_4$, Boron fertilizer and $MnSO_4$ treatments where the reduction was 57.92%, 57.38%, 56.28%, 55.20%, 54.64% and 53.00%, respectively compared to control. The highest purple blotch disease severity 61.00% was observed in control treatment. In all the years the least effective treatment in reduction of purple disease severity was $CuSO_4$ treatment (Table 4).

Table 4. Effect of soil treatment and foliar application of different nutrients on the severity of purple blotch disease of onion during three consecutive years

Soil and foliar application of different plant nutrient with dose	Severity of purple blotch disease of onion (PDI)			Reduction of severity of purple blotch disease (%)		
	2016-17	2017-18	2018-19	2016-17	2017-18	2018-19
Potassium (MOP fertilizer @2%)	22.33 c (28.19)	23.33 d (28.87)	24.33 c (29.53)	62.78	60.68	60.11
Phosphorus (TSP fertilizer @2%)	22.33 c (28.14)	24.67 cd (29.75)	25.67 c (30.41)	62.78	58.42	57.92
Zinc ($ZnSO_4$ fertilizer @1%)	22.67 c (28.42)	24.67 cd (29.76)	26.67 c (31.09)	62.21	58.42	56.28
Silicon (Silica gel @2%)	22.67 c (28.37)	26.00 cd (30.65)	26.00 c (30.65)	62.21	56.18	57.38
Boron (Boro fertilizer @1%)	24.33 bc (29.54)	26.67 cd (31.04)	27.67 bc (31.73)	59.45	55.05	54.64
Calcium ($CaSO_4$ fertilizer @1%)	28.33 bc (32.01)	28.33 cd (31.91)	27.33 bc (31.37)	52.78	52.25	55.20
Manganese ($MnSO_4$ fertilizer @1%)	25.33 bc (30.21)	30.67 c (33.55)	28.67 bc (32.35)	57.78	48.31	53.00
Copper ($CuSO_4$ @1%)	29.33 b (32.75)	45.33 b (42.32)	30.00 b (35.24)	51.12	23.60	50.82
Control	60.00 a (50.78)	59.33 a (50.43)	61.00 a (51.37)	-	-	-
LSD (P=0.05)	3.998	4.472	4.081	-	-	-

Values in a column having same letter(s) did not differ significantly (P=0.05) by LSD; values within the parenthesis is the arcsin transformed value.

Table 5. Effect of soil treatment and foliar application of different nutrients on the yield of onion during three consecutive years

Soil and foliar application of different plant nutrient with dose	Yield (tha^{-1})			Yield increased over control (%)		
	2016-17	2017-18	2018-19	2016-17	2017-18	2018-19
Potassium (MOP fertilizer @2%)	16.75 a	16.25 ab	17.64 ab	36.84	28.18	27.55
Phosphorus (TSP fertilizer @2%)	16.75 a	17.08 a	18.19 a	36.84	31.67	29.74
Zinc ($ZnSO_4$ fertilizer @1%)	15.42ab	16.00 ab	17.64 ab	31.39	27.06	27.55
Silicon (Silica gel @2%)	16.33 a	16.00 ab	16.80 ab	35.21	27.06	23.93
Boron (Boro fertilizer @1%)	13.92bc	15.42 b	16.67 ab	23.99	24.32	23.34
Calcium ($CaSO_4$ fertilizer @1%)	15.33abc	15.42 b	15.42 bc	30.98	24.32	17.12
Manganese ($MnSO_4$ fertilizer @1%)	14.33bc	15.83 b	16.25 abc	26.17	26.28	21.35
Copper ($CuSO_4$ @1%)	13.58 c	12.08 c	14.17 cd	22.09	3.39	9.81
Control	10.58 d	11.67 c	12.78 d	-	-	-
LSD (P=0.05)	1.77	1.127	2.366	-	-	-

Values in a column having same letter(s) did not differ significantly (P=0.05) by LSD.

Crop yield: In all the years, soil and foliar application of different plant nutrients gave appreciable higher yield of onion treatment (Table 5). In first year, the lowest yield of 10.58 t/ha was found under control (Table 5). The yield was increased to 13.58-16.75 t/ha due to application of different treatments. Application of MOP and TSP fertilizer gave the higher yield 16.75 tha^{-1} followed by Silica gel, $ZnSO_4$ and $CaSO_4$ where the yield was 16.33, 15.42 and 15.33 tha^{-1}, respectively. Application of $CuSO_4$ gave lower yield 13.58 tha^{-1} followed by Boron fertilizer and $MnSO_4$ where the yield was 13.92 and 14.33 tha^{-1}, respectively compared to other treatments. The maximum yield increase of 36.84% and 36.84% over control was obtained by MOP and TSP fertilizer followed by Silica gel, $ZnSO_4$ and $CaSO_4$ where the yield was 35.21%, 31.39% and 30.98%, respectively higher (Table 5). The lowest increase was achieved with $CuSO_4$ followed by Boron fertilizer and

$MnSO_4$ where yield was 22.09%, 23.99% and 26.17%, respectively higher compared to control. In the 2nd year, average yield of onion was 11.67 t/ha under control and 12.08-17.08 t/ha under treated plots (Table 5). Application TSP fertilizer gave the highest yield 17.08 tha^{-1} followed by MOP fertilizer, $ZnSO_4$, Silica gel, $MnSO_4$, Boron fertilizer and $CaSO_4$ where the yield was 16.25, 16, 16, 15.83, 15.42 and 15.42 tha^{-1}. The lower yield of onion 11.67 and 12.08 tha^{-1} was recorded in control and $CuSO_4$ treatments. Application of TSP fertilizer gave the 31.67% higher yield compared to control which was followed by MOP fertilizer, $ZnSO_4$, Silica gel, $MnSO_4$, Boron fertilizer and $CaSO_4$ where the yield was 28.18%, 27.06%, 27.06%, 26.28%, 24.32% and 24.32%, respectively. In the 3rd year, the highest yield was 18.19 t/ha obtained with the application of TSP fertilizer followed by MOP fertilizer, $ZnSO_4$, Silica gel, Boron fertilizer, MnSO4 and $CaSO_4$ where the yield was 17.64, 17.64, 16.80, 16.67, 16.25 and 15.42 tha^{-1} (Table 5). The lowest yield of onion 12.78 tha^{-1} was recorded in control treatment which was followed by $CuSO_4$ with the yield of 14.17 tha^{-1}. Application of TSP fertilizer gave the 29.74% higher yield compared to control which was followed by MOP, $ZnSO_4$, Silica gel, Boron fertilizer, $MnSO_4$ and $CaSO_4$where the yield was 27.55%, 27.55%, 23.93%, 23.34%, 21.35%, and 17.12%, respectively.

From this study it was observed that application different plant nutrient had a significant effect on increase in plant growth, decrease of purple blotch diseases severity and tip burn incidence as well as increase yield of onion. Among the nutrients MOP fertilizer, TSP fertilizer, $ZnSO_4$, Silica gel, Boron fertilizer and $CaSO_4$ performed better than other treatments for reducing purple blotch disease severity and tip-burn as well as increasing plant growth and yield of onion. Different workers reported that the appilication of fertilizers produced a more direct means of using nutrients to reduce the severity of many diseases (Marschner, 1995; Atkinson and McKinlay, 1997; OBoron fertilizerrn *et al*., 2003; Seebold *et al*., 2000; 2004). Dordas (2008) reported that potassium fertilization could reduce the intensity of several infectious diseases of obligate and facultative parasites. A number of studies showed that application Potassium, Phosphorus, Boron, Zinc, Calcium, Silicon and Manganese could reduce fungal, bacterial and viral diseases of many crops (Potash and Phosphate Institute, 1988; Huber and Graham, 1999; Kirkegaard *et al*., 1999; Reuveni *et al*., 1998; 2000; Alvarez and Datnoff, 2001; Heckman *et al*., 2003; SeeBoron fertilizerld *et al*., 2000; 2004; Sharma and Duveiller, 2004; Sharma *et al*., 2005; Simoglou and Dordas, 2006; Zhang *et al*., 2006). Agrios (2005) reported that plant nutrients were important for growth and development of plants and also microorganisms and also important factors in disease control.

Conclusion

The present study revealed that soil and foliar application of plant nutrients viz. Potassium, Phosphorus, Boron, Zinc, Calcium, Copper, Silicon and Manganese

gave appreciable reduction of purple blotch disease and tip-burn incidence and increased plant growth parameters such as shoot and root growth as well as yield of onion. Among the nutrients Potassium, Phosphorus, Silicon, Zinc and Calcium performed better for reducing purple blotch disease severity, tip-burn disease incidence and increasing plant growth as well as yield of onion. So, soil and foliar application of plant nutrients Potassium, Phosphorus, Silicon, Zinc, Boron and Manganese might be recommended for tip-burn and purple blotch disease management as well as increase of onion production in Bangladesh.

References

Agrios, N. G. 2005. Plant Pathology, 5th ed., Elsevier-Academic Press: p. 635.

Ahmed, M. U. and M. M. Hossain. 1985. Final report of project crop disease survey and establishment of a herbarium at BARI, Plant Path. Div. BARI, Joydebpur, pp 1670.

Alvarez, J. and L. E. Datnoff. 2001. The economic potential of silicon for integrated management and sustainable rice production. *Crop Prot.* **20:** 43–48.

Atkinson, D. and R. G. McKinlay. 1997. Crop protection and its integration within sustainable farming systems, *Agr. Ecosyst. Environ.* **64:** 87–93.

Azad, A. K., M. A. Wahab, M. G. Saha, J. Nesa, M. L. Tahman, M. H. H. Rahman and M. Al-Amin. 2019, Edited: KRISHI PROJUKTI HATBOI (Handbook on Agro-Technology), 8th edition. Bangladesh Agricultural Research Institute, Gazipur, Bangladesh. pp 298-299.

Batish, D. R., H. P. Singh, N. Setia, R. K. Kohli, S. Kaur and S. S. Yadav. 2007. Alternative control of littleseed canary grass using eucalypt oil, Agron. Sustain. Dev. **27:** 171–177.

BBS. 2015. Yearbook of Agricultural Statistics, Bangladesh Bureau of Statistics, Statistics Information Division, Ministry of Planning, Government of the People's Republic of Bangladesh, Dhaka, Bangladesh. pp133

Bose, T. K. and G. M. Som. 1986. Vegetable crops in India. Naya Prokash, Calcutta, India. 567-569 pp.

Camprubí, A., V. Estaún, M. A. El Bakali, F. Garcia-Figueres and C. Calvet. 2007. Alternative strawberry production using solarization, metham sodium and beneficial soil microbes as plant protection methods, Agron. Sustain. Dev. 27: 179–184.

Castellanes-Linares, J. J., F. Auchet-Jencens and I. Garcia-Correosa. 1988. Effect of *Alternaria porri*. (EII.) Cif. On onion seed production under experimental conditions in Cuba. *In Rev. Pl. Pathol.* **67:** 2730.

Dordas, C. 2008. Role of nutrients in controlling plant diseases in sustainable agriculture: A review. *Agron. Sustain. Dev.* **28:** 33–46.

FAO. 1998. FAO Yearbook, Production 1998. Food and Agriculture Organization of United Nations, Rome, Italy. 51:135-136.

Gerhardson B. 2002. Biological substitutes for pesticides. Trends Biotechnol. **20:** 338–343.

Graham, D. R. and M. J. Webb. 1991. Micronutrients and disease resistance and tolerance in plants, in: Mortvedt J.J., F.R. Cox, L.M. Shuman and R. M. Welch (Eds.):

Micronutrients in Agriculture, 2nd ed., Soil Science Society of America, Inc. Madison, Wisconsin, USA: pp. 329–370.

Heckman, J.R., B. B. Clarke and J.A. Murphy. 2003. Optimizing manganese fertilization forthe suppression of take-all patch disease on creep-ing bentgrass. *Crop Sci.* **43:** 1395–1398.

Huber, D. M. and R. D. Graham. 1999. The role of nutrition in crop resistance and tolerance to disease, in: Rengel Z. (Ed.): Mineral nutritionof crops fundamental mechanisms and implications, Food Product Press, New York: pp. 205–226.

Islam, M. R., M. H. Ashrafuzzaman, S. K. Adhikari, M. H. Rahman and M. H. Rashid. 1999. Effect of fungicidal treatments in controlling *Alternaria porri* causing purple blotch of onion. *Progress Agric.* **10** (1&2): 43-46 pp.

Kirkegaard, J. A., R. Munns, R. A. James and S. M. Neate. 1999. Does Water and Phosphorus Uptake Limit Leaf Growth of Rhizoctonia-Infected Wheat Seedlings. *Plant Soil.* **209:** 157–166.

Marschner, H. 1995. Mineral Nutrition of Higher Plants, 2nd ed., Academic Press, London: p. 889.

Meah, B. and A. A. Khan. 1987. Checklist of vegetables and fruit diseases in Bangladesh. Dept. of plant Path. Bangladesh Agril. Univ., Mymensingh. 22pp.

Munoz, D. C. I., J. J. P. Martinez and A. P. Perez. 1984. Onion seed production under tropical conditions. Humbalst Inst. Fund. Res. Trop. Agric. Acad. Sci. **10**(2): 42-45.

OBoron fertilizerrn, I., A. C. Edwards, E. Witter, O. Oenema, K. Ivarsson, P. J. A. Withers, S. I. Nilsson and A. Richert Stinzing. 2003. Element balances as a toll for sustainable nutrient management: a critical appraisal of their merits and limitations within an agronomic and environmental context. *Eur. J. Agron.* **20:** 211–225.

Potash and Phosphate Institute (PPI). 1988. Phosphorus nutrition improves plant disease resistance, in PPI (Ed.), Better crops with plant food. Fall 1988. Atlanta, Georgia, USA: pp. 22–23.

Rahman, M. L. and M. H. Rashid. 2008. Rating scale and severity index of crop diseases-a review, Bangladesh Phytopathological Society. Plant Pathology Division, Bangladesh Agricultural Research Institute, Joydebpur, Gazipur. 44pp

Reuveni, M., D. Oppernheim and R. Reuveni. 1998. Integrated control of powdery mildew on apple trees by foliar sprays of mono-potassium phosphate fertilizer and sterol inhibiting fungicides. *Crop Prot.* **17:** 563–568.

Reuveni, R., G. Dor, M. Raviv, M. Reuveni and S. Tuzun. 2000. Systemic resistance against *Sphaerotheca fuliginea* in cucumber plants exposed to phosphate in hydroponics system, and its control by foliar spray of mono-potassium phosphate. *Crop Prot.* **19:** 355–361.

SeeBoron fertilizerld, K.W., L. E. Datnoff, F. J. Correa-Victoria, T. A. Kucharek and G. H. Snyder. 2004. Effect of silicon and fungicides on the control of leaf and neck blast in upland rice. *Plant Dis.* **88:** 253–258.

SeeBoron fertilizerld, K. W., L. E. Datnoff, F. J. Correa-Victoria T. A. Kucharek and G. H. Snyder. 2000. Effect of silicon rate and host resistance on blast, scald and yield of upland rice. *Plant Dis.* **84:** 871–876.

Seebold, K.W., L. E. Datnoff, F. J. Correa-Victoria, T. A. Kucharek and G. H. Snyder. 2000. Effect of silicon rate and host resistance on blast, scald and yield of upland rice. *Plant Dis.* **84:** 871–876.

Seebold, K.W., L. E. Datnoff, F. J. Correa-Victoria, T. A. Kucharek and G. H. Snyder. 2004. Effect of silicon and fungicides on the control of leaf and neck blast in upland rice. *Plant Dis.* **88:** 253–258.

Sharma, R. C. and E. Duveiller. 2004. Effect of helminthosporium leaf blight on performance of timely and late-seeded wheat under optimal and stressed levels of soil fertility and moisture. *Field Crop Res.* **89:** 205–218.

Sharma, S., E. Duveiller, R. Basnet, C. B. Karki and R. C. Sharma. 2005. Effect of potash fertilization on helminthosporium leaf blight sever-ity in wheat, and associated increases in grain yield and kernel weight. *Field Crop Res.* **93:** 142–150.

Simoglou, K. and C. Dordas. 2006. Effect of foliar applied boron, manganese and zinc on tan spot in winter durum wheat. *Crop Prot.* **25:** 657–663.

Zhang, Q., J. Fry, K. Lowe and N. Tisserat. 2006. Evaluation of calcium silicate for brown patch and dollar spot suppression on turfgrasses. *Crop Sci.* **46:** 1635–1643.

ISSN 0258-7122 (Print), 2408-8293 (Online)
Bangladesh J. Agril. Res. 46(2): 167-174, June 2021

PURITY LEVEL OF DIFFERENT BRANDS OF MARKETED PESTICIDES

M. AFROZE[1], M. D. H. PRODHAN[2], A. BEGUM[3]
M. S. AHMED[4] AND D. SARKER[5]

Abstract

The study was undertaken to determine the purity level of eleven selected pesticides collected from different locations of Bangladesh. In this study, Gas Chromatography coupled with Flame Ionization Detector (FID) and Electron Captured Detector (ECD) was used to determine the purity of acephate, diazinon, dimethoate, chlorpyrifos, quinalphos, malathion, fenitrothion cypermethrin, fenvalerate. High Performance Liquid Chromatography (HPLC 20A Prominence) coupled with Photo Diode Array (PDA) detector was used to determine the purity of carbofuran and carbosulfan. Results indicated that 40% of the tested pesticides have lower active ingredient (ai) than stated on the label of container. A total of 11 pesticides were tested. The purity of all tested brands of fenvalerate and fenitrothion were 100%. The purity of cypermethrin ranged from 72-100%. The purity of organocarbamate pesticide carbofuran and carbosulfan ranged from 70-100% and 95-100%, respectively. The purity of dimethoate, chlorpyrifos, malathion, quinalphos, diazinon and acephate ranged from 63-100%, 67-100%, 79-100%, 83-100% and 68-100%, respectively.

Keywords: Pesticides, purity, active ingredient.

Introduction

Pesticides are used worldwide to manage agricultural pests. Farmers use pesticides for the better production of crop. However, due to the lack of knowledge and non-availability of sustainable alternatives to pesticides farmers of Bangladesh become dependent on pesticide for crop production. The negative impact of excessive and non-judicious use of pesticide can be reflected an environment and social issues can disrupt our agricultural ecosystem.

(Handa and Walia, 1996). Over the year pesticide consumption in Bangladesh increased manifold. The Pesticide consumption in 2018 was 38691.86 metric tons (Anonymous, 2019). It is assumed that adulteration of pesticide is one of the major causes of such extensive use of pesticides Kabir *et al.* (2008) & Begum *et al.* (2016).

Due to absence or little amount of active material in the formulated pesticides, they do not work properly against targeted insect pests and diseases and thus the farmers are using more pesticides for better result. In this perspective it has become imperative to analyze the available brands of pesticides in the market for

[1-5]Entomology Division, Bangladesh Agricultural Research Institute (BARI), Gazipur-1701, Bangladesh.

their purity determination and to assure the effective, safer and non-hazardous for better protection of crops.

Materials and Methods

The percentage of active ingredient remain in acephate, carbofuran, diazinon, dimethoate, chlorpyrifos, quinalphos, malathion, carbosulfan, cypermethrin, fenvalerate and fenitrothion were tested in the Pesticide Analytical Laboratory, Entomology Division, BARI, Gazipur, Bangladesh. Sample of pesticides were collected from dealers of Rangpur, Jamalpur, Bogura, Cumilla, Gazipur, Jashore and Rajshahi where extensive usage of pesticides was recorded. Each formulated product either of granular or liquid was being dissolved in the respective solvent. described by Lehotay and Mastovska (2004).

In case of granular pesticides, the solid inert materials were removed by filtration. In case of liquid pesticides, the known concentration of the solutions was prepared directly. Methods for testing different brands with GC-FID, GC-ECD and HPLC-PDA were developed by setting the instrument parameters suitable for analyzing concerned pesticides selected on the basis of peak sharpness of the chromatogram and retention time for respective compound.

The amount of the active material present in each brand was determined by comparing with standard solution of concerned group of pesticide with the help of built-in software of GC (GC solution) and HPLC (LC solution). Percent purity was calculated from the actual amount of ai present in different marketed brands, the amount of ai actually required in the concerned group of pesticide.

Results and Discussion

Purity of Synthetic Pyrethroid Pesticides

The percentage of active ingredient presents in cypermethrin 10EC and fenvalarate 20EC are shown in Table 1. Thirteen popular marketed brands of cypermethrin were analyzed using GC-ECD. The purity of the selected tested brands of cypermethrin was ranged from 72% to 100%. Among thirteen tested brands, seven were 100% pure in terms of ai, four brands contained above 90% ai and two brands contained below 80% ai and the lowest one (RacyBk) contained only 72% ai. Four different popular marketed brands of fenvalerate were analyzed with GC-ECD. All the selected tested brands of fenvalerate were 100% pure in terms of ai presence (Table 1).

Purity of Organocarbamate Pesticides

The percentage of active ingredient presents in carbufuran 5G and carbosulfan 20EC are shown in Table 1. Sixteen brands of carbofuran were tested with HPLC

and the purity of the tested brands of carbofuran ranged from 70% to 100%. Among sixteen brands, ten contained 100% AI, four contained above 90% ai while two brands contained below 90% and the lowest AI (70%) present in GcfBf. The purity of all the selected tested brands of carbosulfan analyzed by HPLC was ranged from 95% to 100%. Among seven tested brands, six were 100% pure in terms of ai, while only one brand (RaCSAt) contained 95% ai of carbosulfan.

Purity of Organophosphorus Pesticides:

Eight different popular marketed brands of chlorpyrifos were analyzed by GC-ECD. The purity of the selected tested brands of chlorpyrifos was ranged from 67% to 100%. Among eight tested brands, five were 100% pure in terms of ai, two brands contained above 90% ai and one brand (Bochsf) contained 67% ai. Ten different popular marketed brands of diazinon were analyzed with GC-FID. The purity of the tested brands of diazinon ranged from 68% to 100%. Among ten tested brands, four contained 100% ai, another four brands contained above 90% ai while two brands contained below 90% ai. and the lowest one (GcfBf) contained 68% ai.

Ten different popular marketed brands of malathion were analyzed with GC-FID. The purity of the selected tested brands of malathion ranged from 79% to 100%. Among ten tested brands, five were 100% pure in terms of ai, three brands contained above 90% ai and two brands contained below 90% ai and one brand (ComGt) contained 79% ai of malathion. The purity of the selected tested brands of dimethoate analyzed with GC-FID ranged from 63% to 100%. Among thirteen tested brands, six were 100% pure in terms of ai, four brands contained above 90% ai and three brands contained below 90% ai and only one brand (CoDtTt) had 63% ai (Table 2.)

The percentage of active ingredient presents in the acephate 75SP, quinalphos 25 EC and fenitrothion 50EC are shown in Table 3. Five different popular marketed brands of acephate were tested with GC-FID. The purity of the selected tested brands of acephate was ranged from 93% to 100%. Among five tested brands, one was 100% pure in terms of ai, and four brands contained above 90% a.i. one brand (RaApLa) contained 93% ai. Six different popular marketed brands of quinalphos were analyzed with GC-FID. The purity of the selected tested brands of quinalphos was ranged from 83% to 100%. Among six tested brands, five were 100% pure in terms of ai while only one brand (JsQGl) contained 83% ai. Three different popular marketed brands of fenitrothion were tested with GC-FID. The purity of all the selected tested brands of fenitrothion was 100% in terms of ai presence.

Table 1. Percentage of active ingredient presents in synthetic pyrethroid & organocarmate pesticides

Cypermethrin 10EC		Fenvalerate 20EC		Carbofuran 5G		Carbosulfan 20 EC	
Brand	Purity (%)	Brand	Purity (%)	Brand	Purity (%)	Brand	Purity (%)
JacyCt	100 ± (0.012)	RjFvsd	100±(0.094)	JaCSM	100±(0.235)	JaCSM	100±(0.235)
RjcyRt	100 ± (0.051)	RjFvRf	100±(0.014)	RjCSm	100±(0.015)	RjCSm	100±(0.015)
RjcyFR	92 ±(0.816)	JeFvs	100±(0.015)	RjCSRf	100±(0.010)	RjCSRf	100±(0.010)
RjcyKt	100 ± (0.010)	RaFvs	100±(0.456)	RaCSAt	95±(0.0496)	RaCSAt	95±(0.0496)
JecyO	100 ± (0.006)			CoCSm	100±(0.834)	CoCSm	100±(0.834)
JecyJt	100 ± (0.000)			GCSM	100 (0.005)	GCSM	100 (0.005)
RacyBk	72± (0.572)			BoCSM	100±(0.161)	BoCSM	100±(0.161)
RacyRt	100± (0.010)			RacfBf	100±(0.001)		
BocyJt	75± (0.816)			Racffn	90± (1.634)		
CocyCt	96± (1.632)			CocfB	98± (0.311)		
GcyKt	95.5± (0.849)			CocFd	100± (0.012)		
GcySp	98± (0.626)			BocfK	97± (0.685)		
GcyCnt	100± (0.073)			BocfS	80± (1.06)		
				GcfKa	100± (0.00)		
				GcfBf	70± (0.188)		
				GcfRd	100± (0.015)		

Table 2. Percentage of active ingredient presents in organophosphate pesticides

Chloropyrifos 20EC		Diazinon 60 EC/10G		Malathion 57 EC		Dimethoate 40 EC	
Brand	Purity (%)	Brand	Purity (%)	Brand	Purity (%)	Brand	Purity (%)
RjchD	100± (0.00)	RjDiH	82 ± (0.005)	RjmFf	100±(0.056)	JaDtTh	95.5±(0.235)
RjchMt	100± (0.012)	JeDiDg	94.6±(0.019)	RjmKl	100±(0.841)	JaDtSt	100± (0.006)
JechHx	100± (0.235)	RaDiBg	68± (0.030)	JemDt	84± (1.632)	RjDtDt	100±(0.010)
Jechcb	100± (0.208)	RaDiDz	100± (0.177)	JemGt	98.2 (0.249)	RjDtTf	100± (0.015)
RachPf	94± (0.141)	CoDiDg	92.5±(0.335)	RamSl	100±(0.466)	RjDtSg	100± (0.008)
RachD	100± (0.094)	GDiH	100± (0.062)	GmDt	100±(0.231)	JeDtTf	93±(0.059)
BochMt	95± (0.471)	GDiBg	96± (0.816)	ComGt	79± (0.864)	JeDtSn	99± (0.086)
Bochsf	67± (0.15)	BoDiTr	100± (0.536)	ComRn	96±(0.816)	RaDtSn	86± (0.417)
		BoDimg	100± 0.0145)	BomFf	100±(0.010)	BoDtDm	100± (0.015)
		CoDiDn	98.3±(0.567)	BomRn	94±(0.0196)	BoDtsg	100± (0.471)
						CoDtTt	63± (0.817)
						CoDtDk	88± (0.435)
						GDTJy	97.5± (0.35)

The farmers of Bangladesh are using pesticides extensively to prevent the crop loss caused by insect pests infestation, Pesticide adulteration is one of the major reasons for the excessive and indiscriminate use of pesticides. Due to the adulteration, the effectiveness of pesticides is reduced and that is why, the farmers are spraying pesticides too often to control the insect-pests. As a result of frequent application of pesticides, their residues are remaining of different agricultural commodities reported by several researchers in Bangladesh (Islam *et al.,* 2019; Islam *et al.,* 2019a; Islam *et al.,* 2019b; Rahman *et al.,* 2019; Prodhan *et al.,* 2018; Prodhan *et al.,* 2018a; Prodhan *et al.,* 2018b; Hasan *et al.,* 2017; Aktar *et. al.,* 2017; Islam *et. al.,* 2014; Hossain *et al.,* 2014; Prodhan *et al.,* 2010; Prodhan *et al.*2009; Kabir *et. al.,* 2008a; Kabir *et. al.,* 2007), the insect-pests are developing resistance and due to the excessive use of pesticide insect pollinator also declined day by day (Amin *et al*., 2014). Besides, a lot of money also spends for buying pesticides. On the other hand, extensive use of pesticides disrupts the agro eco-system and also creates several adverse effects on human health and the environment.

Table 3. Percentage of active ingredient presents organophosphate pesticides

Acephate75SP		Quinalphos 25 EC		Fenitrothion 50EC	
Brand	Purity (%)	Brand	Purity (%)	Brand	Purity (%)
JaApLa	96±(1.685)	JsQGl	83±(0.235)	RjFtsm	100± (0.010)
JeApAt	100±(0.467)	RjQKls	100±(0.816)	JeFtSm	100± (0.358)
RaAppt	99± (0.010)	RjQqu	100±(0.012)	RaFtsm	100± (0.014)
RaApLa	93± (0.45)	RaQKls	100±(0.006)		
BoApAt	100±(0.012)	CoQKls	100±(0.235)		
		GQKrl	100±(0.009)		

Conclusion

The present result indicates that, around 40% marketed brands of tested pesticides contained lower active ingredient than that stated on the label of container and this results support the overusing of pesticides due to impurities. From the present study, it is recommended that the Government of Bangladesh should take necessary steps to prevent this adulteration of pesticides.

Reference

Afroza Begum, M. W. Akon, M. S. Ahmed and S. N. Alam. 2016. Purity analysis of nine pesticides collected from eight locations in Bangladesh. *Bangladesh. J. Agril. Research.* **41**(4): 685-694.

Aktar, M. A., R. Khatun, M. D. H. Prodhan. 2017. Determination of pesticide residues in eggplant using modified QuEChERS extraction and Gas Chromatography. *Int. J. Agron. Agri. R.* **11** (2): 22-31.

Amin, M. R., M. S. Hossain, S. J. Suh, and Y. J. Kwon. 2014. Conservation and utilization of insect pollinators for promotion of agricultural production in Bangladesh. *Curr. Res. Agric. Life. Sci.* **32**(4):171-174.

Anonymous. 2019. YearBook of Agricultural statistics 2019. Bangladesh Bureau of Statistics, Dhaka, Bangladesh.

Handa, S. K. and S. Walia. 1996. Pesticide residues and its implication in Integrated Pest Management, *IPM System in Agriculture Vol.1 Principles and perspectives*. Pp. 62-94.

Hasan, R., M. D. H. Prodhan, S. M. M. Rahman, R. Khanom, A. Ullah. 2017. Determination of organophosphorus insecticide residues in country bean collected from different markets of Dhaka. *J. Environ. Ana. Toxicol.* **7**: 489. doi: 10.4172/2161-0525.1000489

Hossain, M. S., M. M. Rahman, K. H. Kabir, M. R. U. Miah, M. D. H Prodhan. 2014. Determination of Pre-Harvest Interval (PHI) for cypermethrin and acephate in yard-long bean under supervised field trail. *Bangladesh J. Entomol*. **24**(1): 101-115.

Islam, M. A., A. Ullah, M. Habib, M. T. I. Chowdhury, M. S .I. Khan, A. Kaium, M. D. H. Prodhan. 2019. Determination of major organophosphate insecticide residues in cabbage samples from different markets of Dhaka. *Asia Pac. Environ. Occup. Health j.* **5** (2): 30-35.

Islam, M. S., M. D. H. Prodhan, M. K. Uddin. 2019a. Determination of major organophosphorus pesticide residues in eggplant using QuEChERS extraction and Gas Chromatography. *Int J Innov. Sci. Res. Technol*. **4**(8): 212-219.

Islam, M. S., M. D. H. Prodhan, M. K. Uddin. 2019b. Analysis of the pesticide residues in bitter gourd using midified QuEChERS extraction coupled with Gas Chromatography. *Asia Pac. Environ. Occup. Health j.* **5**(3): 6-15

Islam, M. W., K. M. Golam Dastogeer, I. Hamim, M. D. H. Prodhan, M. Ashrafuzzaman. 2014. Detection and quantification of pesticide residues in selected vegetables of Bangladesh. *J. Phytopathol. Pest Manag*. **1**(2): 17-30.

Kabir K. H., M. A. Rahman, M. S. Ahmed, M. D. H. Prodhan and M. W. Akon. 2008. Quantitative analysis of some common insecticieds used against vegetable insect pests. *Bangladesh J. Agric.* **1**(2): 259-264.

Kabir, K. H., M. A. Rahman, M. S. Ahmed, M. D. H Prodhan, M. W. Akon (2008a) Determination of residue of diazinon and carbosulfan in brinjal and quinalphos in yard long bean under supervised field trial. *Bangladesh J. Agril. Res.* **33**(3): 503-513.

Kabir, K. H., M. Abdullah, M. D. H. Prodhan, M. S. Ahmed, M. N. Alam (2007) Determination of carbofuran residue in the samples of sugarcane and soil of sugarcane field. *The Agriculturist.* **5**(1& 2):61-66.

Lehotay, S. J and K. Mastovska. 2004. Evaluation of common organic solvents for gas chromatographic analysis and stability of multiclass pesticide residues. *J. Chomatogr.* Pp. 259-272.

Prodhan, M. D. H., M. W. Akon, S. N. Alam. 2018. Determination of pre-harvest interval for quinalphos, malathion, diazinon and cypermethrin in major vegetables. *J Environ. Anal. Toxicol.* **8**: 553. doi: 10.4172/2161-0525.1000553.

Prodhan, M. D. H., S. N. Alam. 2018a. Determination of multiple organochlorine pesticide residues in shrimp using modified QuEChERS extraction and gas chromatography. *SAARC J. Agri.* **16**(1): 81-93. DOI: http://dx.doi.org/10.3329/sja.v16il.37425.

Prodhan, M. D. H., M. W. Akon, S. N. Alam. 2018b. Decontamination of organophosphorus insecticide residues from eggplant and yard long bean. *Int. J. Expt. Agric.* **8**(1): 6-9.

Prodhan, M. D. H., M. A. Rahman, M. S. Ahmed and K. H. Kabir. 2010. Pesticides residues in fish samples collected from different fish cultivation regions of Bangladesh. *SAARC J. Agri.* **8**(2):53-64.

Prodhan, M. D. H., M. A. Rahman, M. S. Ahmed and K. H. Kabir. 2009. Quantification of organophosphorous and organochlorine insecticide from fish samples using simple GC technique. *Bangladesh J. Agriculturist*. **2**(2):197-204.

Rahman, M. R., M. S. Islam, M. M. Rahman, M. D. H. Prodhan, M. K. Uddin (2019) Organochlorine pesticide residue status in dry fish of Bangladesh and their risk assessment: a review. *Int. J. Sci. Res.Pub*. **9** (10):619-639. DOI: 10.29322/IJSRP.9.10.2019.p9480.

ISSN 0258-7122 (Print), 2408-8293 (Online)
Bangladesh J. Agril. Res. 46(2): 175-193, June 2021

FARMERS' ATTITUDE TOWARDS ENVIRONMENT FRIENDLY VEGETABLE CULTIVATION

P. D. PURKAYSTO[1], M. R. AMIN[2], M. A. ISLAM[3]
M. RAHMAN[4] AND F. A. NASIM[5]

Abstract

The study was conducted to determine farmers' attitude towards environment friendly vegetable cultivation and to explore the relationship of the selected characteristics with farmers' attitude. The study also identified constraints faced by farmers in relation to environment friendly vegetable cultivation. Data were collected from 100 randomly selected respondents of three selected villages under Sadar upazila of Moulvibazar district using a pre-tested interview schedule during February-March 2018. Farmers' attitude towards environment friendly vegetable cultivation (dependent variable) and was measured by 20 statements on 5-point scale and the eleven selected characteristics of the respondents. The highest proportion (40%) of the respondents had unfavorable attitude, 20% respondents had highly unfavorable attitude, 1% of them had neutral attitude, while 33% respondents had favorable attitude and 6% had highly favorable attitude towards environment friendly vegetable cultivation. The correlation analysis revealed that education, training received, time spent in vegetable cultivation, annual family income, annual income from vegetable cultivation, knowledge on environment friendly vegetable cultivation, organizational participation and credit received had significant positive relationship with the farmers' attitude towards environment friendly vegetable cultivation. The majority (70%) of the farmers faced medium constraints while 3% faced high and 27% faced low constraints during environment friendly vegetable cultivation.

Keywords: Farmers' attitude, vegetable cultivation, environment friendly.

Introduction

Vegetables are the cheapest source of vitamins, minerals and proteins which majority of people can buy easily. According to BBS (2019), vegetables are cultivated in 8.593 lakh hectares of land and annual production of vegetable is only 172.472 lakh metric tons. According to FAO, vegetable production has increased five times in the past 40 years. Bangladesh has scored 3rd in global vegetable production, next to China and India. The farmers are getting a huge profit from vegetable production which is changing their life. The farmers of Bangladesh are mostly dependent on pesticides to control the pests. Use of pesticides is expensive with some negative environmental consequences and

[1]Assistant Teacher, Goraria Government Primary School, Sylhet, [2&3]Department of Agricultural Extension Education, Sylhet Agricultural University, Sylhet, [4]Scientific Officer (Agronomy), Bangladesh Agricultural Research Institute (BARI), Daulatpur, Khulna. [5]Scientific Officer, BARI, Joydebpur, Gazipur-1701, Bangladesh.

increased health hazards to the growers and consumers of vegetables. It helps developing pest resistance to insecticides, destroys beneficial insects. To avoid such consequences and to increase the vegetable production at the same time, environment friendly practices are best for pest management. Environment friendly refers to those practices inflict minimum or no harm on the environment. The main idea behind environment-friendly vegetable cultivation has zero impact on environment. Environment- friendly practices can make major positive impact on environment. Nowadays DAE (Department of Agricultural Extension) is working with several projects all over the country. Every project has the major attention on environmental consideration in vegetable production by removal or reducing agro- chemicals. However, farmers of Bangladesh have poor knowledge on environment friendly vegetable cultivation. Most of the farmers of Bangladesh are poor. They have no enough money for buying expensive pesticides. Environment friendly practices help them to utilize the readily available source of biological control agents, tolerant genetic resource, modern cultivation practices, organic green manure and bio-fertilizer. So there is an urgent need to understand the potentiality and limits of environment friendly practices so that appropriate development choices can be made. Extension people can make new technology available to the vegetable growers through environment friendly vegetable cultivation training. However, before designing environment friendly practices training, it done for promoting sustainable production of safe vegetables.

Objectives of the Study

1. To determine farmers' attitude towards environment friendly vegetable cultivation and describe the socio-economic characteristics of the vegetable growers.
2. To find out the constraints faced by farmers in relation to environment friendly vegetable cultivation
3. To explore the relationships between farmers' attitude towards environment friendly vegetable cultivation and their selected characteristics.

Materials and Methods

The locale of the study was Durlovpur, Noldaria and Damia villages of Kanakpur union under Sadar upazila of Moulvibazar district. The selection was made on the basis of suggestions made by Upazila Agriculture Officer (UAO), Sub Assistant Agriculture Officer (SAAO), Union Parishad Member and officials of Sadar Upazila. A total number of 400 vegetable growers were listed. Out of 400, The lighted farmers 100 were was taken as randomly selected. Eleven socio-economic characteristics of the farmers viz age, education; family size, farm size,

training received, time spent in vegetable field, annual family income, annual income from vegetable cultivation, knowledge on environment friendly vegetable cultivation, organizational participation and credit received were independent variables. A interview schedule was used as data gathering instrument. Data were collected from the sample farmers through the personal interview schedule during February to March 2018.

If any respondent failed to understand any question, the researcher took utmost care explain the issue as far as possible. After completion of the interview, it was checked and editing was done in case of necessity. Data from the entire interview schedule were compiled, tabulated and analyzed according to the objectives of the study. If a respondent did not know how to read and write his literacy score was taken as zero (0). A score of 0.5 was given to that respondent who could sign his name only. Besides a respondent got actual score of one for every year of schooling i.e. '1' for class one, '2' for class two and soon. Training received score of a respondent was measured on the basis of number of days of training received from different agricultural organization. How much time a respondent spent in vegetable field was measured in hours/day considering average time spent per day. Annual income of a respondent was measured in Taka on the basis of last year total earnings from crop cultivation (without vegetables) and other sources in which the respondent as well as his family members were involved. Annual income of a respondent was measured in taka on the basis of last year total earnings from vegetable cultivation and was measured in thousand Taka and a score of 1 was assigned for each one thousand Taka. Possible scores for the knowledge on environment friendly vegetable cultivation of the respondents could range from 0 to 40, where 0 indicating no knowledge on environment friendly vegetable cultivation and40 indicate the very high knowledge on environment friendly vegetable cultivation. The organizational participation scores of a respondent could range from 0 to 30, where '0' indicated no participation and 30 indicated very high organizational participation. Credit received by farmers was expressed in Taka. A score of one (1) is given for each thousand taka. Measurement of the dependent variable was measuring the attitude of farmers a 5 point Likert scale was used. Constraints faced by the farmers in relation to environment friendly vegetable cultivation score obtained from all the constraints were added together to got the constraint confrontation score for a respondent. Score of a respondent could range from 0 to 27, while '0' indicating no constraint and 27 indicating high constraint. The procedure for categorization of data in respect of different variables will be elaborately discussed while describing those variables in chapter 4.

The data after collection were coded, compiled, tabulated and analyzed. Various statistical measures such as range, mean, percentage, standard deviation were used in categorizing and describing the dependent and the independent variables. For clarity of understanding, tables were used for presentation of

data. Pearson's Product Moment Coefficient of Correlation (r) was used to explore the relationship between the independent and the dependent variables. Throughout the study 1% and 5% level of probability was used to reject any null hypothesis.

Results and Discussion

Socio-economic characteristics of the vegetable growers

Eleven socio-economic characteristics of the vegetable growers were selected to describe and find out their relationships with attitude towards environment friendly vegetable cultivation. The characterizations are discussed in the following sections.

Age

The age score of the respondents ranged from 18 to 62 with an average of 39.4 and standard deviation of 10.30.Based on their age score, respondents were classified into three categories on the basis of their age following Hossain *et al.* (2011) as shown in Table 1.

Table 1. Distribution of the vegetable growers according to their age

Age group	Respondents		Mean	Standard deviation
	Number	Percent		
Young aged (up to 35 years)	34	34	39.4	10.30
Middle aged (36 -50 years)	53	53		
Old aged (above 50 years)	13	13		
Total	100	100		

Table 1 indicates that the middle aged category vegetable growers comprised the highest proportion (53%) followed by young aged category (34%) and the lowest proportion were made by the old aged category (13%). Data also indicate that the middle and young aged respondents constitute about 87% of the respondents. Young and middle aged people are generally receptive to new ideas and things. However, they might have valuable opinion in regard to use of environment friendly vegetable cultivation. Therefore, the extension worker should give proper attention to include the young and middle aged groups in their programs.

Education

The education score of the respondents ranged from 0-12, with an average of 4.94 and standard deviation of 3.98. Based on their education score, respondents were classified into four categories as shown in (Table 2).

Table 2. Distribution of the vegetable growers according to their education

Level of education	Respondents		Mean	Standard deviation
	Number	Percent		
Illiterate (0-0.5)	28	28	4.94	3.98
Primary education (1-5)	26	26		
Secondary education(6-10)	42	42		
Above secondary education (>10)	4	4		
Total	100	100		

Table 2 shows that vegetable growers under 'secondary education category' constitute the highest proportion 42% compared to 28% 'illiterate' category, 26% primary and 4% above secondary level category. Education broadens the horizon of outlook of vegetable growers and expands their capability to analyze any situation related to vegetable cultivation.

Family size

The family size score of the respondents ranged from 2 to 12 with the mean and standard deviation of 6.77 and 2.09 respectively. Based on their family size score, the respondents were classified into three categories as shown in (Table 3).

Table 3. Distribution of the vegetable growers according to their family size

Family size	Respondents		Mean	Standard deviation
	Number	Percent		
Small (up to 4)	15	15	6.77	2.09
Medium (5-8)	65	65		
Large (above 8)	20	20		
Total	100	100		

Table 3 shows that medium family size constituted the highest proportion 65% and the lowest 15% in small family size and 20% were large family size. The existence of traditional joint family culture, lack of awareness about family planning and lack of recreational facilities might be responsible for the highest proportion medium sized family in that area. The average family size of the vegetable growers of the study area (6.77) was higher than that of national average of 4.06 (BBS, 2016).

Farm size

The farm size score of the respondents ranged from 0.05 to 1.85 with an average of 0.39 and standard deviation of 0.36. Based on their farm size score, the

respondents were classified into three categories following (Hossain *et al.*, 2011) as shown in (Table 4).

Table 4. Distribution of the vegetable growers according to their farm size

Family size categories	Respondents		Mean	Standard deviation
	Number	Percent		
Marginal (< 0.2 ha)	39	39	0.39	0.36
Small (0.2 - <1.0 ha)	56	56		
Medium (1- 3ha)	5	5		
All	100	100		

Table 4 indicates that the small farm holder constituted the highest proportion 56% and the lowest 5% in medium farm holder and 39% had marginal farm. This was due to inheritance of little land from parents, selling of land for going foreign country; etc. The average farm size of the vegetable growers of the study area (0.39 hectares) was higher than that of national average (0.06 hectares).

Training received

The training received score of the respondents ranged from 0 to 8 with a mean and standard deviation of 2.85 and 2.24 respectively. Based on their length of training scores, the respondents were classified into three categories as shown in (Table 65).

Table 5. Distribution of the vegetable growers according to their training received

Duration/Length of training	Respondents		Mean	Standard deviation
	Number	Percent		
No training	19	19	2.85	2.24
1 -5 days	68	68		
above 5 days	13	13		
All	100	100		

Table 5 indicates that majority 68% of the respondents had low training, while 19% of them had no training and only 13% had medium training. Training makes the farmers skilled and helps them to acquire knowledge about the environment friendly vegetable cultivation. Trained farmers can face any kind of challenges about the adverse situation in their vegetable cultivation.

Time spent in vegetable field

Time spent in vegetable field score of the respondents ranged from 2 to 10 hrs/day with a mean of 5.81hrs/day and standard deviation of 1.82. Based on

their time spent in vegetable field score, the respondents were classified into three categories as shown in (Table 6).

Table 6. Distribution of the vegetable growers according to their time spent in vegetable field

Length of time	Respondents		Mean	Standard deviation
	Number	Percent		
up to 3 hrs	7	7	5.81	1.82
4-7 hrs	69	69		
above 7 hrs	24	24		
All	100	100		

Table 6 indicates that majority 69% of the respondents spent moderate time in vegetable field where24% spent long time and 7% spent short time in vegetable field. The findings of the study reveal that 93% of the farmers spent moderate to long time in their vegetable field. For that reason high income from vegetable cultivation were found. The study reveals that majority 94% of the respondents had medium to high income from vegetable cultivation. Another reason is that moderate or long time spent in the vegetable field ensures intensive care which ultimately increases the maximum production of yield.

Annual family income

The annual family income score of the respondents ranged from 62.30 to 700.00 with the mean and standard deviation of 157.08 and 81.91respectively. Based on their annual family income score, the respondents were classified into three categories as shown in (Table 7).

Table 7. Distribution of the vegetable growers according to their annual family income

Range of income	Respondents		Mean	Standard deviation
	Number	Percent		
up to 150.00	2	2	157.08	81.91
150.00-250.00	86	86		
above 250.00	12	12		
All	100	100		

Table 7 shows that majority 86% of the respondents had medium annual family income, 2% had low annual family income and 12% had high annual family income. The annual family income of the farmers of the study area was medium.

The reason might be due to the fact that most of the respondents of the study area were not only engaged in vegetable cultivation but also in other sources such as service, business etc.

Annual income from vegetable cultivation

The annual income from vegetable cultivation score of the respondents ranged from 17.70 to 247.00 with the mean and standard deviation of 45.83 and 27.95 respectively shown in (Table 8).

Table 8. Distribution of the vegetable growers according to their annual income from vegetable cultivation

Ranges of income from vegetable cultivation	Respondents		Mean	Standard deviation
	Number	Percent		
up to 18.00	6	6	45.83	27.95
19.00- 73.00	85	85		
above 73.00	9	9		
All	100	100		

Table 8 indicates that majority 85% of the respondents had medium annual income from vegetable cultivation, 9% had high annual income from vegetable cultivation and 6% had low annual income from vegetable cultivation. It also indicates that 91% of the respondents had medium to high annual income from vegetable cultivation. The average annual income from vegetable cultivation of the respondents of the study area was medium. The reason might be because they cultivate different types of vegetables in all year round.

Knowledge on environment friendly vegetable cultivation

Knowledge on environment friendly vegetable cultivation score of the respondents ranged from 7 to 32 against the possible range from 0 to 40 with a mean of 17.00 and standard deviation of 6.02 shown in (Table 9).

Table 9. Distribution of the vegetable growers according to their environment friendly vegetable cultivation

Knowledge Score	Respondents		Mean	Standard deviation
	Number	Percent		
up to 10	16	16	17.00	6.02
11 -23	66	66		
above 23	18	18		
All	100	100		

Organizational participation

The observed organizational participation score of the respondents ranged from 0 to 10 with a mean of 5.19 and standard deviation of 2.56. Based on their organizational participation score, the respondents were classified into three categories as shown in (Table 10).

Table 9 shows that majority 66% of the respondents had medium knowledge, 16% had poor knowledge and 18% of the respondents had high knowledge on environment friendly vegetable cultivation. The study showed that most of the respondents of the study area were more or less had some educational quality and they were very conscious about environmental pollution. Again most of the farmers of the study area were poor and they had little land for vegetable production. They preferred environment friendly practices as they rarely sell their vegetables at market rather they consumed it.

Table 10. Distribution of the vegetable growers according to their organizational participation

Participation Score	Respondents		Mean	Standard deviation
	Number	Percent		
up to 2.00	17	17	5.19	2.56
3.00-7.00	64	64		
above 7.00	19	19		
All	100	100		

Table 10 shows that majority 81% of the respondents had low to medium participation in different organization where 17% had low organizational participation, 64% had medium organizational participation, and another total 19% respondents had high organizational participation. Organizational participation helps an individual to find out solutions to their own problems as well as other social issues. A great majority of the farmers in the study area had less organizational participation. The study revealed that farmers felt less interest in organizational participation. Again their education level was not so high and they felt hesitate in organizational participation. They were busy in earning their livelihood, so most of the farmers were indifferent in organizational participation. More organizational participation could create coordinated capability and capacity to adopt environment friendly vegetable cultivation.

Credit received

The credit received score of the respondents ranged from 0 to 30 with the mean and standard deviation of 10.70 and 6.89 respectively shown in (Table 11).

Table 11. Distribution of the vegetable growers according to their credit received

Credit Score	Respondents		Mean	Standard deviation
	Number	Percent		
up to 3	14	14	10.70	6.89
4-17	68	68		
above 17-30	18	18		
All	100	100		

Table11 indicates that highest portion (68 %) of the respondents had received medium amount of credit, while 14 % low and 18 % received high amount of credit. Analysis of data indicates that most of the respondents (86 percent) were medium to high credit recipients and few respondents (14 percent) were supported by low credit facility. Almost all beneficiaries received credit for vegetable cultivation.

Farmers' attitude towards environment friendly vegetable cultivation

The observed scores for attitude towards environment friendly vegetable cultivation ranged from 34 to 83 against the possible range of 20 to 100 with a mean of 54.82 and standard deviation of 15.59 shown in (Table 12).

Table 12. Distribution of the vegetable growers according to their attitude towards environment friendly vegetable cultivation

Farmer attituude	Respondents		Mean	Standard deviation
	Number	Percent		
Highlyunfavorable attitude (<40)	20	20	54.82	15.59
Unfavorable attitude (40- <60)	40	40		
Neutral attitude (60)	1	1		
Favorable attitude(>60-80)	33	33		
Highly favorable attitude (>80)	6	6		
Total	100	100		

List of environment friendly vegetable cultivation practices of the respondents given below in the Table 13.

Table 13. Practice wise attitude score of the respondents towards environment friendly vegetable cultivation

Sl. no.	Environment friendly vegetable cultivation practices	Categories	Respondents		Mean	Standard deviation
			Number	Percent		
1.	Mechanical control	Strongly disagree	43	43		
		Disagree	25	25	2.28	0.78
		No opinion	16	16		
		Agree	13	13		
		Strongly agree	3	3		
2.	Biological control	Strongly disagree	19	19		
		Disagree	31	31	2.64	1.21
		No opinion	27	27		
		Agree	13	13		
		Strongly agree	10	10		
3.	Cultural control	Strongly disagree	0	0		
		Disagree	14	14	3.11	0.95
		No opinion	21	21		
		Agree	24	24		
		Strongly agree	41	41		
4.	Genetic control	Strongly disagree	28	28		
		Disagree	23	23	2.81	1.56
		No opinion	14	14		
		Agree	10	10		
		Strongly agree	25	25		

Table 12 shows that the majority (40%) of the respondents had unfavorable attitude, 20% respondents had highly unfavorable attitude, 1% of them had neutral attitude while 33% respondents had favorable attitude and 6% had highly favorable attitude towards environment friendly vegetable cultivation. The findings indicate that majority (40%) of the respondents had unfavorable attitude towards environment friendly vegetable cultivation.

Table 13 indicates that four environment friendly practices in vegetable cultivation were taken to measure responses from the respondents. Practices were mechanical control, biological control, cultural control and genetic control. Responses for these practices were measured in 5 categories. In mechanical control 43% were strongly disagree,25% were disagree,16% were no

opinion,13% were agree and 3% were strongly agree. In biological control 19% were strongly disagree,31% were disagree, 27% were no opinion,13% were agree and 10% were strongly agree. In cultural control 0% were strongly disagree,14% were disagree,21% were no opinion, 24% were agree and 41% were strongly agree. In genetic control, total 28% were strongly disagree, 23% were disagree, 14% were no opinion, 10% were agree and 25% were strongly agree. Above that it can be said that, respondents showed more favorable attitude to the cultural control and showed less favorable attitude to the mechanical control. Genetic and biological control were in 2nd and 3rd position respectively.

Relationship between selected characteristics of the vegetable growers and their attitude towards environment friendly vegetable cultivation

Pearson's product moment correlation co-efficient was computed in order to find out the extent of relationship between attitude towards environment friendly vegetable cultivation and their selected characteristics. To reject or accept the null hypothesis, 1% and 5% level of probability was used. A statistically significant and non-significant relationship was observed when the computed value or "r" was greater or smaller than the tabulated value, respectively.

The result of correlation test is shown in (Table14).

Table 14. Correlation co-efficient showing relationship of each of the selected characteristics of the vegetable growers and their attitude

Dependent variable	Independent variables	Computed value of co-efficient of correlation 'r'	Tabulated value at 98 df	
			0.05 level	0.01 level
Farmers' attitude towards environment friendly vegetable cultivation	Age	-0.028^{NS}	0.196	0.256
	Education	0.655**		
	Family size	-0.083^{NS}		
	Farm size	0.193^{NS}		
	Training received	0.234*		
	Time spent in vegetable field	0.308**		
	Annual family income	0.292**		
	Annual income from vegetable cultivation	0.324**		
	Knowledge on environment friendly practices (IPM) in vegetable cultivation	0.504**		
	Organizational participation	0.542**		
	Credit received	0.240*		

* Significant at the 0.05 level, ** Significant at the 0.01 level, ^{NS}Not significant.

Relationship between age and attitude towards environment friendly vegetable cultivation

The coefficient of correlation (r) between the concerned variables was found -0.028 (Table 14), which is non significant and thus the null hypothesis could not be rejected.

Based on the above finding, it was concluded that age of the farmers had negative and non significant relationship with the farmers' attitude towards environment friendly vegetable cultivation. This represent that age of the respondents was not an important factor to show attitude towards environment friendly vegetable cultivation. But with the increase of age of the respondents' attitude towards environment friendly vegetable cultivation also decreases. *Patel et, al.* (2007) also found similar findings in their study.

Relationship between education and attitude towards environment friendly vegetable cultivation

The coefficient of correlation (r) between the concerned variables was found 0.655 (table 14), which is significant and thus the null hypothesis was rejected. Based on the above finding, it was concluded that education of the farmers had significant and positive relationship with the farmers' attitude towards environment friendly vegetable cultivation. Thus it can be said that, education is an important factor and as the education increase or decrease, attitude towards environment friendly vegetable cultivation is also increased or decreased respectively. Patel et al. (2007), Farhad and Kashem (2004) also found similar findings in their studies.

Relationship between family size and attitude towards environment friendly vegetable cultivation

The coefficient of correlation (r) between the concerned variables was found -0.083 (table 14), which is non significant and thus the null hypothesis could not be rejected.

Based on the above findings, it was concluded that family size of the farmers had negative and non significant relationship with the farmers' attitude towards environment friendly vegetable cultivation. Thus, it can be said that farm size of the farmers had shown no impact on their attitude towards environment friendly vegetable cultivation. Rahman (2010) and Parvez (2007) also found non significant relationship between family size and attitude towards environment friendly vegetable cultivation.

Relationship between farm size and attitude towards environment friendly vegetable cultivation

The coefficient of correlation (r) between the concerned variables was found 0.193 (table 14), which is non significant and thus the null hypothesis could not be rejected.

Based on the above findings, it was concluded that farm size of the farmers had positive and non significant relationship with the farmers' attitude towards environment friendly vegetable cultivation .Thus, it can be said that farm size of the farmers had shown no impact on their attitude towards environment friendly vegetable cultivation. Rahman (2010) and Parvez (2007) also found non significant relationship between farm size and attitude towards environment friendly vegetable cultivation.

Relationship between training received and attitude towards environment friendly vegetable cultivation

The coefficient of correlation (r) between the concerned variables was found 0.234 (table 14), which is significant and thus the null hypothesis was rejected. Based on the above finding, it was concluded that training received had significant positive relationship with the farmers' attitude towards environment friendly vegetable cultivation. Environment friendly practices require the manipulation of local natural resources for conservation and augmentation of natural enemies which can be achieved by successful participation of farmers in training. It means that, the farmers with more training received had favorable attitude towards environment friendly vegetable cultivation. Sarker (2002) and Rahman (2010) also found similar significant positive relationship in their studies.

Relationship between time spent in vegetable field and attitude towards environment friendly vegetable cultivation

The coefficient of correlation (r) between the concerned variables was found 0.308 (table 14), which is significant and thus the null hypothesis was rejected.

Based on the above finding, it was concluded that time spent in vegetable field had significant positive relationship with the farmers' attitude towards environment friendly vegetable cultivation. It means that, with the increase or decrease of time spent in vegetable field, the favorable attitude towards environment friendly vegetable cultivation by the farmers is also increased or decreased. Roy (2014) found similar significant positive relationship in his study.

Relationship between annual family income and attitude towards environment friendly vegetable cultivation

The coefficient of correlation (r) between the concerned variables was found 0.292(table 14), which is significant and thus the null hypothesis was rejected.

Based on the above finding, it was concluded that annual family income of the farmers had significant and positive relationship with the farmers' attitude towards environment friendly vegetable cultivation. Thus it can be said that, annual family income of farmers had effect on attitude of farmers. If annual

family income increase or decrease, farmers' attitude towards environment friendly vegetable cultivation will also respectively increased or decreased. Parvez (2007) and Rahman (2010) also found significant relationship between annual income of the farmers and their attitude towards environment friendly vegetable cultivation.

Relationship between annual income from vegetable cultivation and attitude towards environment friendly vegetable cultivation

The coefficient of correlation (r) between the concerned variables was found 0.324 (table 14), which is significant and thus the null hypothesis was rejected.

Based on the above finding, it was concluded that annual income from vegetable cultivation had positive significant relationship with the attitude of the farmers towards environment friendly vegetable cultivation. The positive relation implies that attitude towards environment friendly vegetable cultivation was observed favorable among those farmers who had high annual income from vegetable cultivation. Haider (2005) also found significant relationship between annual income of the farmers from vegetable cultivation and their attitude towards environment friendly vegetable cultivation.

Relationship between Knowledge on environment friendly vegetable cultivation and attitude towards environment friendly vegetable cultivation

The coefficient of correlation (r) between the concerned variables was found 0.504 (table 14), which is significant and thus the null hypothesis was rejected.

Based on the above finding, it was concluded that knowledge on environment friendly vegetable cultivation had significant positive relationship with the farmers' attitude towards environment friendly vegetable cultivation. It means that, with the increase of knowledge on environment friendly vegetable cultivation, favorable attitude towards environment friendly vegetable cultivation is also increased. Farhad (2004) and Rahman (2010) also found similar findings in their study.

Relationship between organizational participation and attitude towards environment friendly vegetable cultivation

The coefficient of correlation (r) between the concerned variables was found 0.542 (table 14), which is significant and thus the null hypothesis was rejected.

Based on the above finding, it was concluded that organizational participation had significant positive relationship with the farmers' attitude towards environment friendly vegetable cultivation. Higher the participation in different organization, higher is the scope of exchanging information that leads to higher the level of attitude towards environment friendly vegetable cultivation. Rahman (2010) found similar findings in his study.

Relationship between credit received and attitude towards environment friendly vegetable cultivation

The coefficient of correlation (r) between the concerned variables was found 0.240 (table 14), which is significant and thus the null hypothesis was rejected.

The finding indicates that the attitude of the farmers increased with the increase of credit availability. This seems to be logical, because high amount of credit leads to high amount of investment and subsequently high profit and high favorable attitude. So, it could be concluded that loan or credit play a significant and vital role in enhancing attitude towards environment friendly vegetable cultivation. Farhad (2003) and Rahman (2010) also found similar findings in their study.

Ranking of the constraints faced by the farmers in using environment friendly vegetable cultivation

In order to ascertain the extent of severity of constraint faced by the farmers in using environment friendly vegetable cultivation, constraint facing index (CFI) was computed. The CFI of any constraint could range from 0 to 300, where 0 indicated no constraint and 300 indicated high constraint. However, the computed Constraint facing index (CFI) of the 9 constraints ranged from 67 to 195 and has been arranged in rank order according to their constraint indices which appears in table 4.17.

Table 15. Ranking of the constraints faced by the farmers in using environment friendly vegetable cultivation

Sl No.	Constraints	Frequency of extent of constraint faced (N=100)					
		H	M	L	N	CFI	Rank
1.	Lack of resistant variety	35	34	22	9	195	1
2.	Lack of quality seed	33	28	28	11	183	2
3.	Expensive in using light trap	20	32	20	28	144	5
4.	Time consuming in mechanical control to the pests	29	24	22	25	157	4
5.	Lack of pesticides with short residual effect	38	18	16	28	166	3
6.	Lack of knowledge about the beneficial insects and harmful insects	12	29	25	34	119	6
7.	Unavailability of organic farming practices	9	23	35	33	108	7
8.	Lack of cooperation among the farmers	9	16	45	30	104	8
9.	Criticize to other farmers for use of environment friendly practices	4	9	37	50	67	9

Elaborations:

H = High, M = Medium, L = Low, N = Not at all, CFI = Constraint facing Index

Data contained in (Table 15) indicate that the farmers faced highest constraint in "lack of resistant variety "as indicated by its CFI of 195. This is the main constraint faced by the farmers in relation to environment friendly vegetable cultivation. The second and third constraints faced by them are "lack of quality seed "(CFI 183) and "lack of pesticides with short residual effect" (CFI 166) respectively. The fourth constraint was "time consuming in mechanical control to the pests" (CFI 157). Fifth constraint was "expensive in using light trap" (CFI 144). Sixth constraint was "lack of knowledge about the beneficial insects and harmful insects" (CFI 119). Seventh constraint was "unavailability of organic farming practices" (CFI 108). Eighth constraint was "lack of cooperation among the farmers" (CFI 104). In this way, comparatively less constraint (ninth) faced by the fanners is "criticize to other farmers for use of environment friendly practices" (CFI 67) that means it is not a serious constraint for the farmers in using environment friendly vegetable cultivation.

Conclusions

Majority (40%) of the respondents had unfavorable attitude towards environment friendly vegetable cultivation. Unfavorable attitude should be changed into favorable attitude towards environment friendly vegetable cultivation through increasing their educational level, organizational participation, training received, credit received etc. In this study (28%) of the respondents were illiterate and rests of all were literate. Training received had significant positive relationship with their attitude towards environment friendly vegetable cultivation. 87% of the respondents had no to low training. 76% of the respondents were short to moderate time spender in their vegetable field. It also showed that 86% of the respondents had medium family income. It plays a vital role in any socio-economic development of the farmers. 82% of the respondents had poor to medium knowledge on environment friendly vegetable cultivation. 81% of the respondents was low to medium organizational participation. 82% of the respondents were low to medium credit recipient. So, it can be concluded that increase of credit availability may improve their situation and more favorable attitude towards environment friendly vegetable cultivation can be seen.

References

Adeola, R. G. 2012. Perceptions of Environmental Effects of Pesticides Use in Vegetable Production by Farmers in Ogbomoso, Nigeria. *Global J. of Sci Frontier Res Agri & Biology.* **12**(4).

BBS. 2016. Bangladesh Bureau of Statistics, Statistical Division, Ministry of Planning, Government of the People's Republic of Bangladesh.

BBS. 2019. Bangladesh Bureau of Statistics, Statistical Division, Ministry of Planning, Government of the People's Republic of Bangladesh.

BER. 2015. Bangladesh Economic Review, Report on agricultural, 2015. Finance Division, Ministry of Finance, Government of the People's Republic of Bangladesh.

Chaudhary, F. K. and G. M. Patel. 2008. An integrated approach of male annihilation and bait application technique for fruit fly management in pumpkin. *J. of Pest Manag and Eco Zoology*. **16**(1): 57- 61.

FAO. 2017. Food and Agriculture Organization.The future of food and agriculture – Trends and challenges, Rome.

Farhad, A. K. M and M. A. Kashem. 2004. Attitude of Rural Women towards Using IPM Practices in vegetable Cultivation. *Bangladesh J. of Ext. Education*. **16**(2):75-83.

Hossain, K. Z., M. R. Islam, M. H. Bhuiyan, M. A. Wazad and M.M. Rahman. 2011. Farmers' Communication Behavior in Receiving Information on Improved Rice Production Technologies. *J. Innov Dev. Strategy.* **5**(1): 28-33

Haider, M. L. 2005. Farmer's Response to Integrated Pest Management for Increasing Vegetable Production. M.S. Thesis, Department of Agricultural Extension and Rural Development, Bangaabandhu Sheikh MujiburRahman Agricultural University, Gazipur.

Islam, Z. 2007. Attitude of Farmers towards Modern Jute Cultivation in BaliakandiUpazilaUnderRajbari District. M.S. (Ag. Ext. Ed.) Thesis.Department of Agricultural Extension and Information System, Sher-e- Bangla Agricultural University, Dhaka.

Kabir, M. H. and R. Rainis. 2012. Farmers' Perception on the Adverse Effects of Pesticides on Environment: The Case of Bangladesh. *International J. of Sustain* Agric **4**(2): 25-32.

Kadam, P. 2016. Attitude of the farmers towards integrated pest management technology programme on cotton. *Internat. J. agric. Sci.,* **12** (2): 294-297.

Patel, M. C. 2007. Consequence of Farmers' Attributes on their Attitude Towards Integrated Pest Management Strategy. *Karnatak J. of Agri Sci.* **20**(4): 797-799.

Parvez, A. K. M. K. 2007. Farmers‟ Knowledge, Attitude and Practices in Using IPM for High Value Crops Production (unpublished master‟s thesis). Department of Agricultural Extension Education, Bangladesh Agricultural University, Mymensingh.

Rahman, M. 2010. Variables contributing to farmers' attitude towards ipm practices in rice cultivation in godagari, rajshahi. *J. Life Earth Sci.* **5**: 11-15

Ram S. and S. Singh. 2010. Effect of intercropping of spices, cereal and root crops on the incidence of Helicoverpaarmigera (Hub.) in tomato. Vegetable Science **37** (2): 164-166.

Rana, S., H. M. Hasan, M. S. Alam, M. S. Islam. 2017. Farmer attitude towards organic vegetable cultivation in RanguniaUpazila, Chittagong, Bangladesh. *J. of Biosci and Agri Res.* **14**(01): 1151-1156.

Roy. 2014 Farmers' Attitude Towards Integrated Pest Management (Ipm) Practices In Vegetable Cultivation. M.S. (Ag.Ext.Ed.) Thesis, Department Of Agricultural Extension And Information System, Sher-E-Bangla Agricultural University,Dhaka.

Sasane, G. K., U. D. Jagdale, and R. P. Khule. 2010. Knowledge and adoption of brinjal management practices by the farmers.Agriculture. **5**: 495-497

Sattar, M. A. 1994. Impact of Agro-chemicals in the Environment.In : M.H. Ali, (ed.) Proceeding of the Workshop on Environmental Issues. GTI, Bangladesh Agricultural University, Mymensingh. Pub.No. 99.

Wahab, M. A. 2006. "BRAC Beneficiaries' Attitude towards Poultry Rearing". M.S. (Ag. Ext. Ed.) Thesis.Department of Agricultural Extension and Information System, Sher-e-Bangla Agricultural University, Dhaka.

ISSN 0258-7122 (Print), 2408-8293 (Online)
Bangladesh J. Agril. Res. 46(2): 195-202, June 2021

GENETIC VARIABILITY IN YIELD CONTRIBUTING CHARACTERS OF TOSSA JUTE (*Corchorus capsularis* L.)

A. GHOSH[1], B. K. BISWAS[2] AND M. ARIFUZZAMAN[3]

Abstract

Fifty-six hybrids of Tossa jute (*Corchorus olitorius* L.) were raised at Hajee Mohammad Danesh Science and Technology University, Dinajpur from the parental lines O-9897, O-795, JRO-524, Acc.-2381, Acc.-3423, Acc.-3438, Acc.-3533 and Acc.-3860 and studied. Maximum 24 genotypes were in cluster II followed by 11 in I, 9 in IV, 6 in VI, 4 in V and only 2 in cluster IV and the minimum (2.871) was between the clusters IV and V. Cluster VI produced the highest mean values for all the characters indicated the higher potential. Intra-cluster distances were lower than inter-cluster distances, suggested less diversity within a cluster. Mahalanobis D^2-statistics for genetic divergent classified those 56 genotypes into six clusters. Cluster VI showed the highest intercluster distance (23.565) with cluster I. Therefore, jute breeders may consider the hybrids having desirable trait of cluster I and VI for further improvement of Tossa jute.

Keywords: Tossa jute (*Corchorus capsularis*), inter-cluster distance, Eigen values, Yield Contributing Character, Mahalanobis D^2.

Introduction

Jute is a natural fibre popularly known as the golden fibre of Bangladesh. It is an important traditional cash crop of the country. In fact, jute is the second most important natural fibre in terms of global consumption after cotton. The global awareness for the environmental protection creates the opportunity of exploring jute (Chowdhury and Rashed, 2015). Jute has the priority over the synthetic fiber as this contains quality of biodegradability and recycling (Islam and Ahmed, 2012). Considering the impacts that it creates to the environment and recycling nature, jute is considered as 'sustainable'. Still there is potential prospect to revive jute industry. By this time, with the help of technology, jute gets new dimension. The future of jute fiber is very greatly depending on its quality. The breeders gather deep knowledge on the genetic diversity and variability, genetic architecture for fiber yield, and yield-related anatomical traits of jute germplasm for varietal improvement of jute (Ngomuo *et al.*, 2017). The plants are sometimes selected on the basis of some morphological traits which is actually unable to give any accurate

[1]MS Student, Department of Genetics and Plant Breeding, Hajee Mohammad Danesh Science and Technology University, Dinajpur, [2 & 3]Professor, Department of Genetics and Plant Breeding, Hajee Mohammad Danesh Science and Technology University, Dinajpur, Bangladesh.

information on fiber quality. So, the breeders need to do anatomical studies of jute plants for accurate information on fiber improvements (Majumdar, 2002). Correlations between jute fiber quality and other yield attributing anatomical characters are helpful to improve desired characters as well as to select good germplasm for breeding purpose (Kumar *et. al.*, 2007; Mati and Satya, 2009). Multivariate methods such as cluster analysis and principal component analysis (PCA) have proven to be useful for characterizing, evaluating, and classifying germplasm for diversity when a large number of accessions or genotypes to be assessed for several characteristics of anatomical importance (Badenes *et al*., 2000).

Improvement of varieties is required to have more productivity from the cultivation. Generally, the success of any crop improvement program largely depends on the magnitude of genetic variability, genetic advance, character association, direct and indirect effects on yield and its attributes. The selected sergeants can be used in advancing the generation to develop diverse genotypes in segregating generations. In this context, the present investigation was undertaken to assess and also to explain the nature and magnitude of genetic variability of 56 hybrids of Tossa Jute of O-9897, O-795, JRO-524, Acc.-2381, Acc.-3423 Acc.-3438, Acc.-3533, and Acc.-3860 parents.

Materials and Methods

A set of 56 experimental hybrid of the Tossa jute generated and maintained by the Department of Genetics and Plant Breeding of Hajee Mohammad Danesh Science and Technology University, Dinajpur were used in this study. The experiment was laid out in Randomized Complete Block Design with three replications. The seeds of each genotype were sown in 3 rows of 3 meter long plot. The rows were 30 cm apart with planting space of 5-7 cm. The replication blocks were interspaced with 60 cm. Manures and fertilizers were applied as per recommended dose. Seeds were sown on 30 April 2018. After 120 days of sowing, the sample plants of individual plots were harvested for fibre yield. The data on fibre yield and its attributes as plant height (m), base diameter (mm), green bark thickness (mm), green wight without leaves (g), fibre weight (g), stick weight (g), fibre strength (MPa), days to flowering and days to maturity were recorded from 5 randomly selected plant of each genotype from each replication. The data obtained for different characters were recorded first on MS excel sheet. Afterwards, the data were analyzed using the software package R of version 3.4.2 and Statistical Tool for Agricultural Research (STAR) Version: 2.0.1. Genetic divergence analysis was concurrently performed by using Mahalanobis D^2-statistics and based on the unique D^2- values 56 hybrids were classified

purposefully into 6 groups. Multivariate analysis named clustering analysis and Principal Component Analysis (PCA) were performed with the help of GENSTAT 5 program in computer.

Table 1. Characteristics of eight selected genotypes of Tossa jute

Sl. No.	Accessions/ Varieties	Origin	Parental symbol	Other characteristics
01.	O-9897	O-5 x BZ-5	P1	Plant full green, leaves ovate lanceolate, fruit indehiscence in nature, seed bluish green in colour, less photosensitive and late maturing.
02.	O-795	Uganda red x O-4	P2	Plant reddish, leaves ovate lanceolate, fruit indehiscence in nature, seed bluish green in colour, less photosensitive and late maturing
03.	JRO-524	Indian origin	P3	Plant full green, leaves ovate lanceolate, fruit indehiscence and sticky in nature, seed bluish green in colour, less photosensitive and late maturing.
04.	Acc. 2381	Local collection	P4	Plant reddish, leaves ovate lanceolate, seed bluish green in colour.
05.	Acc. 3423	Local collection	P5	Plant full green, leaves ovate lanceolate, seed bluish green in colour.
06.	Acc. 3438	Local collection	P6	Plant reddish, leaves ovate lanceolate seed bluish green in colour.
07.	Acc. 3533	Local collection	P7	Plant full green, leaves ovate lanceolate, seed bluish green in colour.
08.	Acc. 3860	Local collection	P8	Plant reddish, leaves ovate lanceolate, seed bluish green in colour.

Results and discussion

Principal Component Analysis (PCA)

The first two principal components having eigen values for plant height (5.798) and base diameter (1.753) accounted for 69% of the total variation among ten characters of Tossa jute for 56 genotypes studied. Similar kind of results were reported by Ghosh *et al*., (2014) in jute. Sawarkar *et al.*, (2015) reported the highest contribution (12.63%) was exerted by plant height of total divergence, which supports the current findings. Alam *et al.*, (2016) calculated Eigen values and percentage of variation in respect of eleven characters in white jute (*C. capsularis* L.) germplasm and found four of these Eigen values above unity accounted for 90.81%.

Table 2. Eigen values and percentages of variation in respect of ten characters in 56 hybrids of Tossa jute

Parameters	Eigen values	Percentage of total variation accounted for individual characters	Cumulative percentage
Plant Height (m)	5.798	52.74	52.74
Base Diameter (mm)	1.753	15.94	68.68
Green Bark Thickness (mm)	0.901	8.19	76.88
Green Wight Without Leaves (g)	0.802	7.29	84.17
Fibre Weigh (g)	0.542	4.93	89.10
Stick Weight (g)	0.510	4.64	93.74
Fibre Strength (MPa)	0.314	2.86	96.60
Days to Flowering	0.228	2.08	98.68
Days to Maturity	0.085	0.77	99.45
Fibre Weight/ Stick Weight	0.061	0.55	100.00

Cluster analysis

On the basis of Mahalanobis D^2 analysis 56 genotypes were grouped into 6 clusters. The grouping of materials of same origin into different clusters was an indication of broad genetic base of the genotypes belonging to that origin or vice-versa. All members of cluster VI were from P8 origin. Table 3 represent the composition of different clusters with their corresponding genotypes. Maximum 24 genotypes were in cluster II followed by 11 in I, 9 in III, 6 in VI, 4 in V and only 2 in cluster IV.

Table 3. Distribution of 56 hybrids of Tossa jute in 6 clusters

Cluster	Number of hybrids	Hybrids
I	11	P1 x P2, P1 x P5, P3 x P4, P4 x P6, P2 x P1, P3 x P1, P3 x P2, P6 x P3, P7 x P1, P8 x P1, P5 x P7
II	24	P1 x P3, P1 x P7, P1 x P8, P2 x P3, P2 x P5, P2 x P6, P2 x P7, P3 x P5, P3 x P6, P3 x P7, P3 x P8, P4 x P7, P4 x P8, P5 x P6, P5 x P8, P6 x P7, P7 x P8, P4 x P2, P4 x P3, P5 x P1, P5 x P3, P5 x P4, P7 x P2, P7 x P6
III	9	P1 x P4, P1 x P6, P2 x P4, P2 x P8, P4 x P5, P4 x P1, P5 x P2, P6 x P4, P7 x P4
IV	2	P6 x P8, P7 x P5
V	4	P6 x P1, P6 x P2, P6 x P5, P7 x P3
VI	6	P8 x P2, P8 x P3, P8 x P4, P8 x P5, P8 x P6, P8 x P7

The Inter and intra-cluster distance (D^2) of 56 genotypes of Tossa jute were shown in Table 4. The maximum inter-cluster distance (23.565) between the cluster I and cluster VI followed by cluster I and cluster V (20.616), cluster I and cluster IV (18.405), cluster I and cluster III (14.857), cluster II and cluster V (10.984) clearly indicating the presence of high genetic diversity between the clusters. Similar kind of results in Tossa jute were found by Akter *et al*., (2005), Roy *et al*., (2011), Jatothu *et al.*, (2018) and Biswas *et al.*, (2018). Selecting tossa jute genotypes from high inter cluster distances with high mean values for fibre yielding characters will help in developing high heterotic hybrids and also useful in selecting better recombinants in the segregating generations for higher fibre yield (Jatothu *et al.*, 2018).

Table 4. Inter and intra-cluster distance of 56 genotypes of Tossa jute

Cluster	Cluster Distance					
	I	II	III	IV	V	VI
I	**0.1837**					
II	10.277	**0.2843**				
III	14.857	4.5840	**0.3297**			
IV	18.405	8.4250	4.2960	**0.3376**		
V	20.616	10.984	7.1290	2.8710	**0.2971**	
VI	23.565	14.05	10.72	5.4220	3.37051	**0.37051**

In the present study, the maximum intra cluster distance was found in cluster VI (0.37051) revealing high genetic diversity and minimum in cluster I (0.1837) revealing less variation among genotypes in this cluster. In general, intra cluster distances were lower than inter cluster distances suggesting less diversity within a cluster but the genotypes under a cluster were far away from the genotypes of other clusters.

Cluster mean analysis

Table 4 shows the comparison of cluster means for different characters. Cluster VI produced the highest mean values for total plant height, base diameter, green bark thickness, green wight without leaves, fibre weigh, stick weight, fibre strength and days to maturity compared to the rest of the cluster indicated the higher potentials of the genotypes in the population. The cluster means for the selected characters determined the potential of a cluster for a character that might help in selection of genotypes for further breeding programme for amelioration of this important cash and fiber crop.

Table 5. Cluster mean value for yield and yield contributing characters of Tossa jute

Characters	Cluster mean					
	I	II	III	IV	V	VI
Plant Height (m)	3.36	3.36	3.36	3.21	3.07	3.42
Base Diameter (mm)	15.89	15.88	15.88	15.97	16.31	17.35
Green Bark Thickness (mm)	15.22	15.23	15.18	15.05	14.34	16.99
Green Wight Without Leaves (g)	2.94	2.95	2.93	2.80	2.56	4.17
Fibre Weigh (g)	555.92	558.17	555.67	508.47	486.27	851.29
Stick Weight (g)	247.78	247.97	245.87	233.41	224.50	407.59
Fibre Strength (MPa)	590.10	591.68	592.78	589.61	576.29	617.22
Days to Flowering	77.05	76.98	76.96	77.15	77.13	76.61
Days to Maturity	112.31	112.44	112.43	112.06	111.67	113.06
Fibre Weight/ Stick Weight	2.24	2.25	2.26	2.18	2.17	2.09

Conclusion

The selected 10 characters showed wide range of variability among 56 hybrids of Tossa jute. Plant height, base diameter, green bark thickness and green weight without leaves, fibre weight and fibre weight/stick weight are the fibre yield enhancing characters. Therefore, jute breeders might exploit these characters for improving fibre yield in Tossa jute. Genetically distant parents have the potential to develop useful recombinants for obtaining heteroblastic programming. Considering the inter and intra-cluster distance, the inter genotypic crosses between the genotypes from cluster I (P1 x P2, P1 x P5, P3 x P4, P4 x P6, P2 x

P1, P3 x P1, P3 x P2, P6 x P3, P7 x P1, P8 x P1, P5 x P7) and cluster VI (P8 x P2, P8 x P3, P8 x P4, P8 x P5, P8 x P6, P8 x P7) may be suggested to proceed further selection.

Acknowledgement

The authors are grateful to the Department of Genetics and Plant Breeding, Hajee Mohammad Danesh Science and Technology University, Dinajpur for supporting the research work with farm and laboratory facilities.

References

Akter, N., M. A. K. Mian, M. M. Islam, M. A. Alim and M. N. Islam. 2005. Estimation of genetic parameters, character association and path analysis in jute (*Corchorus olitorius* L.). germplasm. *Bangladesh J. Pl. Breed. Genet.* **18(1)**: 35-38.

Alam, M. J., M. E. A. Pramanik, Jannatul Ferdous and M. M. Islam. 2016. Assessment of Genetic Variation in Selected Germplasm of White Jute (*Corchorus capsularis* L.). *Pertanika J. Trop. Agric. Sci.*, **39(1)**: 41-54.

Badenes, M., J. Martínez-Calvo, and G. Llácer. 2000. Analysis of a germplasm collection of loquat (*Eriobotrya japonica* Lindl.). *Euphytica*. **114(3)**: 187-194.

Biswas, S. K., M. R. Debnath, M. Moniruzzaman, S. N. Islam and M. Z. Tareq. 2018. Genetic Variability Study of Tossa Jute (*Corchorus olitorius*) Genotypes. *Int. J. Bus. Soc. Sci. Res*., **6(3)**: 52-55.

Chowdhury, I. U. A. and M. S. Rashed. 2015. Market Access of Bangladesh's Jute in the Global Market: Present Status and Future Prospects. *J. Econ. and Sustainable Dev.*, **6**(3).

Ghosh, R. K., A. Wongkaew, T. Sreewongchai, S. Nakasathien and C. Phumichai. 2014. Assessment of genetic diversity and population structure in jute (*Corchorus* spp.) using simple sequence repeat (SSR) and amplified fragment length polymorphism (AFLP) markers. *Kasetsart J. Nat. Sci.*, **48**: 83-94.

Islam, M. S. and S. K. Ahmed. 2012. The impacts of jute on environment: An analytical review of Bangladesh. *J. Env. and Earth Sci.*, **2(5)**: 24-31.

Jatothu, J. L., A. A. Kumar, S. B. Choudhury, H. K. Sharma, R. T. Maruthi, Kar, C. S. and J. Mitra. 2018. Genetic diversity analysis in tossa jute (*Corchorus olitorius* L.) germplasm lines. *J. Applied and Nat. Sci.* **10(1)**: 1-3.

Karmkar, K., S. C. Bhattacharya, and A. Bakshi. 2007. A comparative study on simple correlation coefficient value in capsularis Jute at different population level. *J. Crop and Weed*, **3**:30-32.

Maiti R. K. and P. Satya. 2009. Fiber bundle anatomy determines the yield potentials, and fiber quality of bast fiber (Long Fiber): A hypothesis. *Int. J. Agriculture Env. and Biotech.*, **2**(4): 41- 46.

Majumdar, S. 2002. Prediction of fiber qualities from anatomical studies in jute stem: part-I prediction of fineness. *Indian J. Fibre and Textile Research*, **27**: 248-253

Ngomuo, M., T. Stoilova, T. Feyissa, and A. N. Patrick. 2017. Characterization of morphological diversity of Jute Mallow (*Corchorus* spp.). *Int. J. of Agronomy*, vol. 2017, Article ID 6460498

Roy, S. K., B. Das, V. A. Kale and S. Haque. 2011. Genetic divergence study for yield and quality traits in tossa jute. *J. Crop and Weed*, **7**(1):130-132 (2011)

Sarker, S. R., M. A. H. Chowdhury, K. M. Mohiuddin, and B. K. Saha. 1995. Influence of different levels of potassium on yield and fibre strength of jute. *J. Agroforestry and Env.*, **6**(1): 39-42, 2012.

ISSN 0258-7122 (Print), 2408-8293 (Online)
Bangladesh J. Agril. Res. 46(2): 203-209, June 2021

SUITABILITY OF MEDIUM DENSITY FIBER BOARD MADE FROM RUBBER WOOD FOR HOUSEHOLD AND INDUSTRIAL USE

M. M. RAHAMAN[1], S. HOSSAIN[2], M. R. ISLAM[3] AND M. M. UDDIN[4]

Abstract

The use of fiber board is increasing due to limited supply of timer wood. This study investigated the suitability of medium density fiber board (MDF) made from rubber wood for household and industrial use. Rubber wood was collected from Bangladesh Forest Development Corporation (BFIDC), Chattogram. Single layer fiber boards were fabricated by five different densities, such as 700, 725, 750, 775 and 800 kgm^{-3}. The mechanical and physical properties of medium density fireboards fabricated by rubber wood fiber as a raw material and urea formaldehyde as a resin were studied. The performance of composite was evaluated by its mechanical and physical properties. Experimental investigation indicated that the mechanical strength of medium density fiber board such as modulus of rupture (MOR) and tensile strength increased with increasing board density. The bending strength (188-234$kgcm^{-2}$) passed the Indian, German and British standard while the tensile strength (4.20-4.70$kgcm^{-2}$) passed the German and British Standard specification. The research concluded that 800kgm^{-3} fiber board made from rubber wood had the best modulus of rupture (234 $kgcm^{-2}$) and the highest tensile strength (4.70 $kgcm^{-2}$) among all other single layer medium density fiber boards.

Keywords: Medium density fiber board (MDF), rubber wood, modulus of rupture (MOR), thickness swelling.

Introduction

The Food and Agricultural Organization (FAO) of the United Nations estimates that the production of industrial wood from plantations will be an increasingly important source of industrial fiber throughout the world (Evans,1998). Wood composite panels are a type of construction material used extensively as a raw material in furniture, shelving, cabinetmaking and other non-load-bearing construction applications. Two types of composite panels, such as particle board and fiber board are typically made using different techniques and materials. Fiber board is a type of engineered wood product that is made from wood fibers. There are three types of fiber board such as low-density fiber board (LDF), medium-density fiber board (MDF), and high-density fiber board (HDF).In general fiber board is considered as higher quality than particle board.

Medium density fiber board (MDF) is one of the most widely used wood-based panels to manufacture building and housing components such as furniture units for interior applications. In recent years, production of MDF has significantly

[1]Senior Research Officer, Veneer & Composite Wood Products Division, BFRI, Chattogram, [2]Research Officer, Veneer & Composite Wood Products BFRI, Chattogram, [3]Fild Investigator, Veneer & Composite Wood Products Division, BFRI, Chattogram, [4]Fild Investigator, Pulp & Paper Division, BFRI, Chattogram, Bangladesh.

increased and has a major market share in the wood composites industry **(**Julson*etal.*,2007, Akgul *et al.*,2008).

The demand for composite wood products, such as plywood, oriented strand board (OSB), hardboard, particle board, medium-density fiber board, and veneer board products has been recently increased substantially throughout the world (Youngquist,1999; Sellers, 2000).

The first MDF was made in a particle board plant in Deposit, New York in 1965.MDF capacity has grown rapidly. From the first production in 1965, world capacity is now estimated at $36x10^6 m^3 yr^{-1}$while in New Zealand capacity is some 900,000 $m^3 yr^{-1}$(Chapman,2004). Production of this product has increased dramatically and new plants are planned worldwide. In 1996, MDF shipments from U.S. plants set another annual record in an unbroken series, totaling 2.1 million m^3, which was forecasted to be 3 million m^3 in 1997.In 1996, European production of MDF jumped 18 percent to 4.5 million m^3, continuing an unbroken upward trend in Europe **(**Krzysik *et al,* 2001).

Rubber **(***Hevea brasiliensis***)** plantations are being raised in Bangladesh since the early sixteen for the production of latex. The wood of old trees whose latex production has declined can be used as rubber wood on a continuous basis (Hasnin *et al*, 1992). The present study was undertaken for finding out the suitability of fiber board from rubber wood. The shortage of the raw material for the forest industry is the main problem. To overcome the shortage of raw material this study aimed to examine the feasibility of using unusable rubber wood.

Materials and Methods

Fiber preparation

Rubber woods were collected from Bangladesh Forest Industries Development Corporation (BFIDC), Chattogram. Then woods were cut into pieces of shorter length in Veneer and Composite Wood Products Division, Bangladesh Forest Research Institute, Chattogram. The pieces were hammer milled to chips using screen of 0.63cm diameter. The chips were then sieved through 20-mesh screen to remove dust and fines and dried in the batch oven at 70ºC temperatures to 4 to 5% moisture content. The chips were cooked by direct steaming 120ºCin a stainless-steel rotary digester of 0.02 m^3 capacity under 10 $kgcm^{-2}$ digester pressures for one hour. They were then refined in a single-rotating disk attrition mill to obtain fiber of different freeness from each of the above cooks.

Fiber board manufacture

Five single layer fiber boards (MDF)were prepared under five treatments (T_1=700, T_2=725, T_3=750, T_4=775 and T_5=800 kgm^{-3}) in the laboratory hot press using the rubber wood fiber which followed by Latin Square Design (LSD). The dimension of the fiber board was 50 cm x 50 cm x 1.20 cm having a target density. The

temperature of the platens of the hot press was maintained at 160°C. Liquid urea formaldehyde (UF) adhesive (50% solid content) was used on oven dry fiber for fiber board preparation. The liquid urea formaldehyde was catalyzed with 2% hardener (ammonium chloride) for hot pressing. No water repellent was used in this preparation. The mats of the board were formed manually in wooden fabricated bordered frame. Then the mats were pressed initially at 500psi specific pressure for 6 minutes. The pressure was then lowered in two steps, firstly 150psifor 4 minutes and then 50psifor 2 minutes according to the experimental condition shown in Table 1. The boards were then conditioned at 65 ±2% relative humidity and 20±2°C temperature before they were put to tests.

Table 1. Experimental condition

UF - solid content (%)	Board thickness (mm)	Board density (kg/m^3)	Pressing temperature (°C)	Mat moisture (%)	Specific Pressure (psi)	Pressure time(minute)
50	12	700-800	160	12	500	6
					150	4
					50	2

Test samples preparation

The fiber boards were cut into various test samples sizes such as (35.00cmx7.50cm x1.20cm) for modulus of rupture and (5.08cm x5.08cm x1.20cm) for tensile strength. The tests were carried out according to specification of IS: 2380 (Anon, 1977) with a constant loading speed of the testing machine at 12mmmin^{-1}.

The parameters of modulus of rupture are as follows:

The modulus of rupture (equn.1), R can be found by substituting the maximum load, P for the load at the proportional limit

$$R = \frac{3Pl}{2b\mathrm{h}^2} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

Where, R=modulus of rupture in kgcm^{-2}

P=maximum load in kg

l=length of span in cm

b=width of specimen in cm

h=depth of specimen in cm

The tensile strength perpendicular to the surface was also carried out according to the specification of IS: 2380 (Anon,1977) with the exception that wooden blocks of 7.62cm x 5.08cm x 2.54cm were glued in cold press with the test specimens.

To determine thickness swelling and water absorption the specimens of size 10.16 cmx 10.16 x1.20 cm were taken from each board.

$$(\%)\ \text{Water absorption} = \frac{increaseofweightwithwater}{Ovendryweight} \times 100$$

The thickness of the specimens was measured with the platform type thickness gauze with an accuracy of 0.01 mm and immersed in 25 mm depth of coolwater.

$$(\%)\ \text{Swelling} = \frac{increaseindimensionorvolume}{originaldimensionorvolume} \times 100$$

At the end of 2 hours and 24 hours, the test specimens were withdrawn from water, wiped with a damp cloth, reweighed and re-measured the thickness as before. The percentage of water absorption and thickness swelling were then calculated. The test results were then compared with standard results given inTable2 and Table 3.

Statistical analysis

Analysis of variance (ANOVA) for the randomized complete block design was performed with the SPSS software package using the Least Significant Difference (LSD) method to compare the mean values of MOR,IB, TS and WA of the boards under various refining density at the 95% confidence level.

Table 2. Some standards specifications for strength property

Requirements/specification of some standards	Thickness of board (mm)	Density of board (kgm^{-3})	Modulus of rupture (MOR) ($kgcm^{-2}$)	Tensile Strength ($kgcm^{-2}$)
IS Specification 3087(Anon,1985b)	6-40	500 - 900	112.00	8.00
German Standard Din 68761 (Verkor, 1975)	13-20	600 -750	180.00	3.50
BS Specification 5669 (Anon, 1979b)	6-19	-	140.00	3.40

Table 3. Some standards specifications for dimensional stability (Thickness SwellingandWater Absorption)

Requirements/specification of some standards	Thickness of board (mm)	Density of board (kgm^{-3})	Thickness Swelling ((%))		Water Absorption ((%))	
			2hrs	24hrs	2hrs	24hrs
IS Specification 3087(Anon.,1985b)	6-40	500 - 900	10	25	-	50
German Standard Din 68761 (Verkor, 1975)	13-20	600 -750	6	-		-
BS Specification 5669 (Anon.,1979b)	6-19	-	12 (for 1hr soaking)	-		-

Results and Discussion

The results of analysis of variance (ANOVA) show that the effects of five different densities (T1=700, T2=725, T3=750, T4=775 and T5=800 kgm-3) have significant effects ($p \leq 0.01$) towards the modulus of rupter (MOR), thickness swelling (TS) and water absorption (WA). Tensile strength is higher significant than all other parameters and the significant ($p \geq 0.05$) value was 0.441259. The mean values according to least significant difference (LSD) of MOR,IB,TS and WA are given in Table4.

Measurements of modulus of rupture in static bending (MOR) and the tensile strength (internal bondIB perpendicular to face properties are presented in Table 4. The data in Table 4 revealed that the bending and tensile strength values have increased with increasing fiber board density, which are not proportional across the treatments.

Fiber boards containing density $800kgm^{-3}$hadsignificantly ($p \geq 0.01$) the highest values of modulus of rupture among all other medium densities (Table 4). The value is$234.00kg/cm^2$ (Table4),which superseded the Indian- ($112.00kgcm^{-2}$), British- ($140.00kgcm^{-2}$) and German- ($180.00kgcm^{-2}$) Standard(Table 2).

All density boards tensile strength values were insignificant at 0.01% level (Table4). Fiber board made from different densities meet the requirement of German Standard Din:68761 (Verkor and Ledune,1975) and British Standard, BS:5669(Anon.,1979b) but did not fulfill the requirement Indian Standard Specification IS:3087 (Anon.,1985b). The higher density MDF makes it stronger and more resistant to breaking when under heavy loads. Franz *et al.* (1975) pointed out that modulus of rupture is the most important mechanical property of particle board with respects their particle application as structural elements.

Table 4. Strength property and dimensional stability of MDF made from rubber (*Heveabrasiliensis*)Wood

	Board density (kgm^{-3})	Modulus of rupture (MOR) ($kgcm^{-2}$)	Tensile Strength ($kgcm^{-2}$)	Thickness Swelling (%)		WaterAbsorption (%)	
				2hrs	24hrs	2hrs	24hrs
	700	188	4.20	6.22	11.08	34.63	45.45
	725	190	4.40	7.30	11.73	39.81	48.68
	750	197	4.50	7.50	11.92	43.44	52.62
	775	200	4.60	9.09	12.76	53.34	53.95
	800	234	4.70	9.10	12.87	54.42	63.22
F-value		28.23	1.02	69.52	8.43	1882.52	1892.76
Significant value		1.99E-05	0.441259	2.94E-07	0.003029	2.46E-14	2.39E-14

The observed thickness swellings of the different types of boards were 6.22 - 9.10% after 2 hours and 11.08-12.87% after 24 hours water soaking (Table 4). The average values of thickness swelling and water absorption for 24 hours immersion are greater than 2 hours immersion. Thickness swelling and water absorption values were significant at 0.01% level. It was found that, 2 hours thickness swelling of 800 kgm^{-3} density board satisfied the values of Indian Standard IS: 3087 (Anon., 1985b) and German Standard (Verkor and Ledune, 1975) specification. However, less water absorption is better than more absorption and less thickness swelling is better than more swelling. The table (4) revealed that the physical properties (thickness swelling and water absorption) increased with the increase of the board density. Density 800$kgm^{-3}$was very significant at 0.01% level and had better performances among all other parameters.

MDF boards are commonly used as interior for household purposes. Since household furniture is kept at a safe distance from water, it is less prone to water absorption and thickness swelling. Kollman *et al. (*1975) reported that the highest thickness swelling after two hours immersion in water should not exceed 6-10% of the original thickness. Addition of additives may improve the properties of the particle boards.

Conclusion

According to the test results it can be concluded that higher mechanical properties were obtained for denser panels of medium density fiber board made from rubber wood fiber. The results revealed that the 800 kgm^{-3} density rubber wood fiber board had the highest values for all the parameters and comparable to other rubber wood fiber boards. Other medium density fiber boards (700 kgm^{-3}, 725 kgm^{-3}, 750 kgm^{-3} and 775 kgm^{-3}) made from rubber wood can also be used conventionally.

References

Anonymous. 1977. Methods of test for particle board and boards from other lignocellulosic materials (First revision) IS: 2380(Parts I to XXI). Indian Standard Institution, New Delhi.66pp.

Anonymous. 1979 (b). Specifications for wood chip board and methods of test for particle board,BS: 5669.British Standard Institution, 28pp.

Anonymous. 1985 (b). Specification for wood particle boards (medium density) for general purposes (First revision) IS:3087-1985 Indian Standard Institution, New Delhi 19 pp.

Akgul, M. and C¸amlibel, O. 2008. Manufacture of Medium Density Fiber board (MDF) Panels from Rhododendron (R. ponticum L.) Biomass, Building and Environment, 43: 438443.Properties of MDF Based on Bagasse Fibers, 1933

Krzysik, A. M., James H. Muehl J A; Youngquist; Fabio Spina Franca. 2001. Medium density fiber board made from *Eucalyptus Saligna*, Forest Products Jourmnal, USDA, Vol. 51, NO .10. 47-50 pp.

Evans, J. 1998. The sustainability of wood production in plantation forestry. Unasylva **49**(192): 47-52.

Franz, F.P.; E.W.; Kollman; A.J.; Kuenzi and Stamm.1975. Principles of wood science and technology, wood based materials, Springer verlag, New York. Volume -11. 457- 505 pp.

Hasnin, S. M, D. Biswas, M. W. Sheikh and M.M. Ali. 1992.Assessment of Rubber wood (*Heveabrasiliensis)* for Plywood and Particle board manufacture. Bulletin-6,*Composite Wood Products Series*, Bangladesh Forest Research Institute, Chittagong, 8 pp.

Kollman, F. P Franz, E. W Kunzi and A. J. Stamn. 1975. *Principles of Wood Science and technology*, Wood based materials, Volume-II, Springer Verlag, NewYork.457-505pp.

Chapman, K. M. 2004. A study of two aspects of medium density fiber board manufacture, Doctor of Philosophy in Chemical and Process Engineering University of Canterbury, March 2004.

Sellers, T. 2000. Growing markets for engineered products spurs research. Wood Tech. **127** (3): 40–43.

Verkor, S.A and G. Ledune. 1975. *German standard* DIN 68761.*Cited in FAO port folio of small scale wood based panel plants*. Koningin, Astridlaan. B-8520-Lauwe/Belgium. 54 pp.

Youngquist, J.A. 1999. Wood-based composites and panel products. In: Wood Handbook: Wood as an Engineering Material. Gen.Tech.Rept.FPL-GRT-113. USDA Forest Serv., Forest Prod. Lab., Madison, WI, pp. 1–31 (Chapter 10).

Julson, J., X.P Ye, M. Kuo, A. Womac and D. Myers. 2007. Properties of Medium Density Fiber boards Made from Renewable biomass, Bio-resource Technology. **98**(5): 10771084.

ISSN 0258-7122 (Print), 2408-8293 (Online)
Bangladesh J. Agril. Res. 46(2): 211-226, June 2021

IMPACT OF BROWN PLANT HOPPER (BPH) MANAGEMENT TRAINING ON BORO RICE CULTIVATION IN SERAJGANJ DISTRICT

M. A. QUAYUM[1], M. M. HOSSAIN[2] AND T. SHARMIN[3]

Abstract

A study was conducted under the project areas of Tarash Upazila at Sirajganj district. The objectives were to assess the improvement of farmers' knowledge and perception on different factors of BPH incidence and its management to examine the economic impact on rice and to determine the profitability of Boro rice cultivation among the different groups of farms. Out of 850 samples listed, 170 representative farmers among which 16 target, 54 trained and 100 non-trained farmers were selected respectively by stratified random sampling technique. Rice plants are affected by 20-33 major insect pests. Among them, BPH is considered as most damaging one. Eighty eight, 83 and 93% target, trained and non trained farmers reported that the project needs to continue while 100% farmers of each group reported that the project is beneficial to control BPH to increase rice production. Eighty seven, 56 and 51 % farmers of the target, trained and non-trained group used double nozzle for spraying insecticides to control BPH in their field. In boro season, 2073 kg/ha and 1209 kg/ha yield loss of BRRI dhan29 were found before and after the project, respectively. The lower yield loss was due to proper management taken by the farmers who got training and acquired sufficient knowledge for controlling BPH. The study revealed that 37% higher cost and 47% higher time is required by single nozzle sprayer than double nozzle sprayer. Therefore, farmers of all categories prefer double nozzle sprayer as it is good for health and saves money and time. They also reported that use of double nozzle sprayer is more profitable than single nozzle sprayer. Benefit cost analysis indicated that the gross return, net return and BCR were found higher in case of the target farmers and these were Tk.171107/ha, Tk.73735/ha and 1.76 respectively, but the cost of production per kg was lower (Tk.10.27) than those of the other two groups due to more knowledge gathered by the target farmers on management practices for rice production. Partial budgeting analysis indicated that the double nozzle users were more benefited by Tk 7287/ha than the single nozzle users for boro rice cultivation. Thus, after the project the farmers of all categories of the project area were socio-economically benefited learning how to use double nozzle for controlling BPH.

Keywords: Rice, Brown plant hopper management, Bangladesh.

Introduction

Pest problem in Bangladesh is becoming severe because of intensive rice cultivation. Every year 15% and 18% yield losses occurred due to disease

[1]Ex Principal Scientific Officer, Agril. Economics Division, [2]Chief Scientific Officer, Entomology Division, Bangladesh Rice Research Institute (BRRI), Gazipur -1701, [3]MS Student, Department of Zoology, Dhaka University, Bangladesh.

infection and insect pests infestation respectively (Haq *et al.*, 2006). Therefore, it is essential to save the crops from this huge loss by using BRRI developed different pest management technologies. Studies (Haq *et al.*, 2006) revealed that 13% rice yield could be increased by adopting these technologies. For environmental safety it is necessary to reduce the use of pesticides. It is quite possible to protect the crop from the damage of insects and diseases by using eco-friendly management practices such as use of resistant to moderately resistant rice varieties, different cultural, mechanical and biological, cultivation methods, fertilizer management, water management, rice based cropping systems, use of botanicals etc (Haq *et al.*, 2006). It is revealed that trained farmers could easily differentiate between harmful and beneficial insects through integrated pest management practice which is long lasting, inexpensive and environmentally safe (Pathak and Khan, 1994). The use of pesticides has been reduced remarkably after training at Farmer Field School (FFS) in different areas of the country. Farmers obtained 12% more yield than before as result of training in Bangladesh (Islam *et al.*, 2004; Haq *et al.*, 2006). Thus, farmers of the country should practice this method to increase the rice production reducing the damage by insects. Insect control is an important constraint limiting yields of modern rice in all rice growing seasons. Research has firmly established that insects cause considerable yield losses on rice crops in the tropics. It is also established that those losses can often be prevented through the application of appropriate insecticides. However, most insecticides are more expensive especially at the high rate used for complete protection. There is also evidence that yield losses can be reduced considerably through one or two applications of insecticides (Islam *et al.*, 2004). Also insects do not always appear in sufficient numbers to warrant the use of high levels of application. On the contrary, sometimes there are some types of insects appeared in the field and damage rice crops in a large scale. Thus, there is a real economic problem of determining the optimal method of controlling insect pests to get the maximum net return from their rice crops.

Benefit cost analysis by Gomez *et al.* (1979) indicated that the findings helped emphasize the importance of IRRI's objective to develop cheaper and cost-effective methods of insect management in rice (IRRI 1979). Litsinger *et al.* (1978) and Carbonell (1980) have examined farmers' insect management practices in Central Luzon, Philippines, in some detail to report on the design of superior, farmer-applicable methods of pest management in rice in Laguna.

A number of sets of data have been examined showing yield losses due to insects and the economics of insect control in fairly intensive rice growing areas in the Philippines and found that if farmers cultivate modern insect resistant varieties and apply no insecticides, they may lose between 0 and 2 t/ha to insects averaging 1 t/ha. If they apply one treatment, costing less than peso 200/ha in 1979, the yield loss due to insects will be cut to about 0.5 t/ha (Herdt and Jayasuriya, 1981). The implementation of pest control methods require a

substantial increase in farmers' technical knowledge about insects and identification of insects as well as insecticides to be used to control them. Rice is subject to attack from dozens of insects, and the damage to the plant can be severe. Some of the more common and widely distributed rice insects in Asia are rice stem borers, brown planthopper (BPH), green leafhoppers, white-backed planthopper, the gall midge and whorl maggot. The use of insecticides was sometimes uneconomical because of the high cost of the chemicals. As a result, it needs the insecticide industry as well as to devise ways of reducing the amounts needed for effective insect control (Chandler, 1979).

Entomologists and agricultural economists are testing numerous methods of increasing the efficiency and reducing the cost of insecticide use. Integrated pest management- the combination of resistant varieties, different management practices and insecticides are becoming most widely recognized as the most effective and efficient way of keeping insect populations at low levels. For instance, BPH outbreaks are common only where two or more rice crops are grown consecutively in a single year. Thus, planting some other crops between rice crops significantly reduces the BPH populations, because the insect has an extremely narrow host range. BPH damage to the rice crop undoubtedly can be kept at low levels and yields and profits can be increased by using resistant varieties and by employing such practices as multiple cropping and insecticide placement (Chandler,. 1979). The BPH was first officially recorded in Bangladesh in 1969, but there are earlier records using synonyms of *N. lugens* in 1957 and in 1917. Catches in light traps near Dhaka showed that the insect population has gradually increased since 1970. The first confirmed case of hopper-burn, due to the BPH in Bangladesh was in 1976 found near Dhaka (Alam and Karim, 1977). The BPH has become a serious threat to rice production throughout Asia. The increase in severity of the insect appears to be associated with the technology used in modern rice culture. The BPH recently increased in abundance and caused severe yield losses in several tropical countries of Asia. It damages the rice plant by directly feeding on it and by transmitting the grassy stunt and ragget stunt disease. Losses from the insect alone are more than one million tons of rice valuing US $100 million in Japan and US$ 50 million in Taiwan. (Dyck and Thomus, 1979). The ecology of the BPH involves the relationship between the insect and its biotic and abiotic environments. The most important factors of the biotic environment are host plants, and natural enemy fauna, those of the abiotic environment are climate (temperature, relative humidity, solar radiation, rainfall, wind) and agricultural chemicals such as fertilizers, insecticides etc.(Dyck *et al.*, 1979).

Boro rice contributes the lion's share in the rice production in Bangladesh. Bangladesh needs 2.7% increase of rice production per year (Alam et al, 2004). It is clear from the table A that the area and yield as well as production of boro rice gradually increase which indicates the importance of growing this crop to feed

the increased population. On the other hand, BPH is a major pest which affects tremendously in this season. This is why this study was undertaken.

Table A. Area (000 ha), yield (ton/ha) and production (000 tons) of boro rice from 1971-76 to 2011-16 in Bangladesh.

Year	Area (000 ha)	Yield (t/ha)	Production (000 tons)
1971-76	1080.16	1.97	2113.00
1976-81	1065.62	2.03	2175.00
1981-86	1448.66	2.43	3526.00
1986-91	2206.82	2.42	5392.40
1991-96	2646.34	2.56	6784.80
1996-01	3322.31	2.94	9819.00
2001-06	3937.86	3.28	12927.40
2006-11	4681.68	3.80	17952.00
2011-16	4777.20	3.78	18947.60

Source: BBS,different issues from 1974 to 2014., DAE, 2014 and DAE, 2016

Rown planthopper causes severe damage in rice production in Bangladesh. The insect passes a considerable time (about 2.5 months) in the respective field unnoticed-before causing any visible damage required to cause hopper burn. Unfortunately, the rice farmers fail to identify the pest at that time mostly due to ignorance and unawareness which in turn allow the insects to develop a huge population required to cause hopper burn. To combat the situation it is necessary to make farmers aware through training about BPH management. Therefore, this study has been undertaken with the following objectives to solve this serious problem in BPH endemic areas of Sirajganj district.

Specific Objectives:

1. To assess the improvement of farmers' knowledge and perception on different factors of BPH incidence and its management;
2. To determine the farmers' perceptions on the merits and demerits of the BPH management technology (nozzle) selected through the project activities;
3. To examine the economic impact of harmful insects infestation on rice cultivation; and
4. To determine and compare the profitability of Boro rice cultivation among different groups of farms.

Methodology

Sampling Procedure and sample size:

Five villages named Humkuria, Dobila, Ghargram, Washin and Kanchenswar under the project areas of Tarash upazila at Sirajganj district were selected for the study. Three types of farmers were recognized in those villages such as target, trained and non-trained farmers. Target farmers were also called participating farmers. Participating farmers/target farmers were those farmers who were trained and plots of those farmers were selected for the project. Trained farmers were those who got only training and they did not give land for the project, while non-trained farmers were those who neither got training nor gave land for the project. Farmers were listed first and found 850 farmers. Then, the representative farmers were selected by stratified random sampling technique. Total number of sample farmers was 170 for the study taking proportionate number, 20% from each of the above category. Among the selected samples, 16, 54 and 100 were target, trained and non- trained farmers, respectively.

Data Collection and Analysis:

Survey was conducted during October 2016 to January, 2017. Data were collected by trained enumerators interviewing the sample farmers through structured questionnaire and finalized after pre-testing. Descriptive statistics as well as profitability analysis were done for analyzing the collected data based on target farmer, trained farmer and non trained farmers. In addition, partial budgeting analysis was done to find out the economic benefits of using double nozzle compared to single nozzle in spraying insecticides.

Results and Discussion

Farmers knowledge and perception on BPH:

Eighty eight, 83 and 93 % of target, trained and non trained farmers reported that the project needs to continue while 100% farmers of each group reported that the project is beneficial to control BPH to increase rice production (Table 1). Ninety four, 74 and 96% farmers of target, trained and non trained farmers reported that the BPH attack was comparatively higher in the boro season, while on an average of all samples 89% farmers reported it. But only 6, 4 and 3% farmers of target, trained and non- trained farmers reported that the BPH attack was higher in the aman season. On an average of all groups of farmers 29 and 69 % farmers respectively reported that the BPH attack was found in the nymph and adult stages.

Table 1. BPH related information given by the different categories of farmers (% respondents) in the study area

Items	Group			Average
	Target farmers	Trained farmers	Non trained farmers	
Project needs to continue	88	83	93	89
Project is beneficial	100	100	100	100
Plant damage due to more attack	94	96	67	79
BPH attack shown	94	93	70	79
Badly affected season: Boro season	94	74	96	89
Aman season	6	4	3	4
Know about the BRRI Project	100	100	90	94
Know about resistant variety	13	6	13	11
Control measure taken	94	83	53	66
BPH attacks in Nymph stage	6	83	3	29
BPH attacks in adult stage	88	24	90	69
Use same insecticides as before	25	83	40	52
Methods of insecticides application:				
Apply after drying field	75	65	47	55
Apply making furrow	75	50	30	41
Apply mixing kerosene and water	13	24	13	16
Transplant in Line for easy application	31	24	10	16
Apply mixing with fertilizer	60	11	8	14
Apply after removing water	6	17	7	10
Type of nozzle used:				
Single nozzle	13	44	49	44
Double nozzle	87	56	51	56

Farmers in the project area adopted different methods of insecticides application for controlling BPH such as apply after drying field, apply making furrow, mixing kerosene and water, transplant in line for easy application, mixing with fertilizer and apply after removing water from the crop field (Table 1). On an average, 55, 41, 16, 16 and 14% farmers respectively applied insecticides in their field after drying field, making furrow, mixing kerosene and water, transplant in line for easy application and apply mixing with fertilizer. Eighty seven, 56 and 51 % farmers of the target, trained and non- trained group used double nozzle for spraying insecticides to control BPH in their rice crop field.

Impact on BPH management options:

Farmers in the project area adopt different types of BPH management practices of which use of resistant variety, use of balanced fertilizer, regularly insect monitoring, use of high organic fertilizer, use of light trap, insecticide use at economic threshold level and draining out of water from the field are the most important ones (Table 2) . Before the project, the control measure taken by the different categories of farmers was poor, but after the project farmers of all categories were more careful about the management practices for controlling BPH. On an average, before the project, 14, 18, 68 and 6 % farmers used balanced fertilizers, used high organic fertilizers, insecticide used insecticides at economic threshold level, and drained out of water from the field to control insects/BPH respectively, while after the project the corresponding figures were 81, 32, 89 and 85%.

Table 2. Brown plant hopper management options of different categories of farmers (% of respondents) before and after the project

Management option	Before the project (2016)				After the project (2017)			
	Target farmers	Trained farmers	Non-trained farmers	Average	Target farmers	Trained farmers	Non-trained farmers	Average
Use of resistant variety	6	-	-	1	19	19	27	24
Use of balanced fertilizers	6	9	17	14	14	93	74	81
Regular insect monitoring	6	7	2	4	44	74	23	41
Use of high organic fertilizer	13	28	13	18	50	48	20	32
Use of light trap	6	4	4	4	31	11	6	10
Use of Neem extract	6	9	2	5	13	6	7	7
Use of beneficial insects	-	4	3	3	44	48	17	29
Insecticide use at economic threshold level	75	65	69	68	100	91	87	89
Draining out of water from the field	6	6	6	**6**	88	76	90	**85**

Farmers' perceptions on BPH:

Table 3 shows the general perceptions of farmers about BPH before and after the project. It can be assumed from the table that the maximum farmers in the study area did not know much about BPH before the project. But after the project most of the farmers' response on different aspects of BPH was correct. This indicates that after the project farmers gathered sufficient knowledge regarding BPH.

Table 3. Farmers perceptions on different aspects of BPH control before and after the project

Aspects	Respondent farmers (%)					
	Before the project (2015)			After the project (2017)		
	Yes	No	Don't know	Yes	No	Don't know
BPH eats other insects	2	-	98	4	26	70
BPH eats eggs of other insects	1	-	99	2	27	71
BPH sucks sap of leaves	29	-	71	50	29	21
BPH sucks stem	49	1	50	77	8	15
BPH eats spider	1	11	88	4	39	57
Spider eats BPH	19	16	65	80	3	17
BPH increased due to insecticide use	2	70	28	4	93	3
BPH decreased due to insecticide use	82	2	16	93	7	-

Table 4. Farmers' response about the impact of harmful insects on rice in different seasons before and after the project in the study areas

Insects	% respondents			
	Before the project		After the project	
	Boro season	Aman season	Boro season	Aman season
Brown plant hopper(BPH)	99	14	80	11
White backed planthopper (WBPH)	87	10	82	13
Stem borer (SB)	92	14	70	8
Leaf roller (LR)	40	3	54	8
Rice hispa (RH)	2	1	2	3
Rice bug (RB)	64	9	61	6
Green leafhopper (GLH)	65	1	42	2
Ear cutting caterpillar (ECC)	23	2	11	3
Mealy bug (MB)	2	-	1	-
Thrips	56	-	35	7

Impact on infestation of harmful insects:

Ninety nine percent and 87 % farmers reported that BPH and WBPH respectively attacked boro rice before the project while 80 and 82% farmers reported that these insects attacked in this season after the project (Table 4). Similar findings were obtained in case of stem borer, rice bug, GLH, ECC and thrips. This indicates that the infestation of different harmful insects reduced to a great extent during post-adoption period. After the project in the Aman season the findings were quite opposite except BPH due lack of knowledge of farmers about the insects.

Impact on rice yield loss:

Before the project in the boro season 2073kg/ha yield loss of variety BRRI dhan 29 affecting about 20% area while after the project only 1209 kg/ha yield loss of this variety was found affecting only 6.5% area (Table 5). Similar results were found in case of other varieties both in the boro season and aman season before and after the project. Therefore, the benefit in case of yield loss in the Boro season was found 42, 91, 15 and 37% for BRRI dhan 29, hybrid, miniket and pajam respectively, The yield loss was found less after the project due to proper management taken by the farmers after training and acquiring knowledge for controlling BPH.

Table 5. Yield loss (kg/ha) and BPH affected area (%) in different seasons before and after the project

Season	Variety	Before the project (2015)		After the project (2017)		% benefit in case of yield
		Yield loss (kg/ha)	Affected area (% of total)	Yield loss (kg/ha)	Affected area (% of total)	
Boro	BRRI dhan 29	2073	20.00	1209	6.50	42
	Hybrid	676	7.10	61	0.12	91
	Miniket	59	4.00	50	4.20	15
	Pajam	63	5.20	40	3.5	37
Aman	BR11	143	2.76	122	0.22	15
	BRRI dhan 32	40	2.00	32	2.40	20
	Ranjit	93	14.00	60	1.00	35
	Bina-7	52	3.00	43	2.20	17

Farmers perception on spraying nozzle:

The most important advantage of double nozzle sprayer is that it covers more land in less time reported by 100% farmers of target, trained and non- trained farmers (Table 6). Ninety percent and 72% of target farmers respectively reported that less labour cost and physically and environmentally helpful in case

of double nozzle. The disadvantages of double nozzle machine are needs furrow and needs more money reported by 50 and 75% target farmers respectively, while 37 and 54% trained farmers reported these disadvantages. However, on an average, 41, 60 and 67 % farmers reported that double nozzle spraying needs furrow, needs more money and line planting respectively. On an average of all farmers, 18 and 32 % farmers respectively reported that easy walking and spraying, and needs less money are the advantages of single nozzle sprayer. On the other hand, 54 and 31 % farmers respectively reported that single nozzle sprayer needs more time and high labour cost which are the most important disadvantages of this sprayer. The other most important disadvantage of single nozzle sprayer is that it sprays only one way reported by 84% farmers.

Table 6. Advantages and disadvantages of double and single nozzle sprayer as opined by the different categories of farmers in the project area

Advantages of double nozzle:	Categories of farmers (% of farmers)			
	Target farmers	Trained farmers	Non trained farmers	Average
Covers more land in less time	100	100	100	100
Spray covers in the base of the plant	9	10	8	9
Uniformity in coverage	60	20	10	18
Good yield	64	45	16	30
Easy walking and spraying	70	30	28	33
Less labour cost	90	65	46	56
Physically and environmentally helpful	72	25	26	30
Disadvantages of double nozzle:				
Needs furrow	50	37	42	41
Needs more money	75	54	61	60
Furrowing dries water	25	22	14	18
Needs line planting	75	78	60	67
Advantages of single nozzle:				
Needs less money	31	37	30	32
Spraying covers base of the plant	63	30	20	27
Uniformity in coverage	13	7	14	12
Good yield	-	4	5	4
Easy walking and spraying	-	19	20	18
Physically and environmentally sound	-	4	4	4
Disadvantages of single nozzle:				
Needs furrow	27	30	33	31
Needs more time	88	65	43	54
Furrowing dries water	36	4	7	9
Needs line planting	18	12	40	29
Needs frequent tank loading	18	6	4	6
High labour cost	40	35	27	31
Sprays only one way	90	80	86	84

The average cost per hectare for applying insecticides by single nozzle sprayer was Tk 1542 and time required is 21.12 hr/ha, but the average cost and time required by double nozzle sprayer were Tk 964 and 11.12 hr/ha respectively (Table 7). This indicates that 37% higher cost and 47% higher time is required by single nozzle sprayer than double nozzle sprayer. Therefore, farmers of all categories prefer double nozzle sprayer as it is good for health and saves both money and valuable time.

Table 7. Comparative cost (Tk./ha) of spraying by single and double nozzle sprayer

Items	Single nozzle	Double nozzle	Difference over double nozzle
Cost (Tk./ha)	1542	964	578 (37)
Time required (hr/ha)	21.12	11.12	10.00 (47)
Times/season	1.70	1.22	0.48 (28)

Note: Cost: Cost of pesticides and labour. Figures in the parentheses indicate percentages

Table 8 showed that 100% farmers reported that they prefer double nozzle sprayer to single nozzle sprayer. Eighty eight, 93 and 60% farmers of target, trained and non- trained group respectively reported that double nozzle sprayer is hygienic to use. On an average, 62% farmers in the survey area informed others about double nozzle sprayer.

Table 8. Preference of type of nozzle by the different categories of farmers

Items	Categories of farmers (%)			
	Target farmers	Trained farmers	Non- trained farmers	Average
Prefers single nozzle	-	-	-	-
Prefers double nozzle	100	100	100	100
Double nozzle-healthy	88	93	60	73
Double nozzle not healthy	-	9	20	25
Inform others about double nozzle	100	93	40	62
Farmers informed about double nozzle (no.)	25	37	8	19

Farmers perceptions on the use of Double Nozzle:

Table 9 shows the opinions of different categories of farmers about double nozzle sprayer for controlling BPH. On an average, hundred percent farmers of the three categories of farmers reported that less time is required by double nozzle sprayer to spray and improved technology. They also reported that use of double nozzle sprayer is more profitable than single nozzle sprayer. On an average, 96, 98 and 97 % farmers respectively reported that double nozzle sprayer are good for small and poor farmers, more yield giving and very satisfactory solution.

Table 9. Farmers' opinion on double nozzle sprayer for controlling BPH

Opinion	Categories of farmers (%)			
	Target farmers	Trained farmers	Non trained farmers	Average
Right solution in case of insecticide use	100	100	93	96
Good for small and poor farmers	100	100	93	96
Environment-friendly technology	100	93	57	72
Difficult and needs knowledge acquiring for application	88	83	83	84
Less time needed	100	100	100	100
More time needed	31	22	46	37
Need more capital	50	74	50	58
More yield	100	100	97	98
Very suitable for this locality	100	96	93	95
Very satisfactory solution	100	96	97	97
Technically very easy	94	56	57	60
Improved and profitable	100	100	100	100

Impact of using Double Nozzle on Boro rice production:

Table 10 showed the comparative cost of Boro rice cultivation by single nozzle users and double nozzle users in the study area. The land preparation cost for single nozzle users and double nozzle users were Tk.15782/ha and Tk.17341/ha respectively. The fertilizer cost and irrigation cost were more or less same for both the groups. However, the human labour cost was found higher for the single nozzle users (Tk.55580/ha) compared to double nozzle users (Tk.48985/ha) due to higher seedbed preparation cost and insecticide cost as well as difference in management practices. The cost for insecticides was 19.12 % higher for the single nozzle users compared to the double nozzle users due to less amount of insecticide use by the double nozzle users. The total cost was found higher (4.23%) for the single nozzle users than the double nozzle users. The yield, gross return, net return and BCR were higher for the double nozzle users compared to the single nozzle users. Therefore, the cost of cultivation was found higher for the single nozzle users (Tk 13.37/kg) compared to the double nozzle users (Tk.12.40/kg) indicating 7.22% higher cost of cultivation for the single nozzle users for Boro rice cultivation

Table 10. Comparative cost and returns (Tk/ha) of MV Boro rice cultivation for double nozzle and single nozzle users

Cost items	Double nozzle users	Single nozzle users	Difference
Land preparation	17341	15782	1559 (9.88)
Seedbed cost	2266	2970	-704 (23.70)
Seeds	1418	1287	131 (10.17)
Fertilizer	8256	8221	35 (0.43)
Irrigation	13225	12644	581(4.60)
Insecticides	440	544	-104 (19.12)
Human labour	48985	55580	-6595 (11.87)
Land rent	22264	22214	50 (0.2)
Total Cost	114195	119242	-5047(4.23)
Yield (kg/ha)	9206	8920	286 (3.21)
Gross returns	168150	165910	2240 (1.35)
Net returns	53955	46668	7287(15.61)
BCR	1.47	1.39	0.08 (5.93)
Cost of cultivation (Tk./kg)	12.40	13.37	-0.97 (7.22)

Note: Figures in the parentheses indicate percentages. Plus sign means higher and minus sign means lower cost and returns of the double nozzle users than those of the single nozzle users.

Partial budgeting analysis indicates that the double nozzle users are benefited by Tk 7287/ha than the single nozzle users for using double nozzle sprayer for Boro rice cultivation in the study area (Table 11). Therefore, double nozzle is more economically advantageous than single nozzle.

Table 11. Partial budgeting, single nozzle versus double nozzle users

Debit (Tk/ha)		Credit (Tk/ha)	
Single Nozzle users		Double nozzle users	
1. Cost of single nozzle users plot	119242	1. Returns from single nozzle users plot	165910
2. Revenue forgone for not practicing double nozzle	168150	2. Cost saved for not practicing double nozzle	114195
3. Profit/loss	- 7287	3. -------	-------
	280105		280105

Impact on profitability of Boro rice cultivation:

Most of the cost items were found higher for the non- trained farmers as shown in the table 12. The cost for land preparation, fertilizer, irrigation and human labour were Tk.18631/ha, Tk.8913/ha, Tk.14062/ha and Tk.57599/ha respectively in case of non-trained farmers, while the corresponding figures for the trained farmers were Tk.15514/ha, Tk.7504/ha, Tk11853/ha and Tk.44634/ha. The total cost for Boro rice cultivation in case of the target, trained and non-trained farmers were Tk. 97372/ha, Tk.103901/ha and Tk.126226/ha respectively. The yield was found higher for the target farmers (9480 kg/ha) compared to the trained (9200 kg/ha) and non-trained farmers (8973 kg/ha) due to better management practices. The gross return, net return and BCR were found higher in case of the target farmers and these were Tk.171107/ha, Tk.73735/ha and 1.76 respectively, but the cost of production per kg was lower (Tk.10.27) than those of the other two groups. This is due to more knowledge gathered by the target farmers on management practices for crop production.

Table 12. Cost and returns (Tk/ha) of MV Boro rice cultivation of different farmers group in relation to training status

Cost item	Farmers group according to Training obtained		
	Target Farmer	Trained Farmer	Non-Trained Farmer
Land preparation	15565	13314	18631
Seedbed cost	1310	2553	2792
Seeds	857	1322	1460
Fertilizer	6516	7504	8913
Irrigation	9906	11853	14062
Insecticides	469	415	526
Human labour	40744	44634	57599
Land rent/season	22007	22308	22239
Total Cost	97372	103901	126226
Yield (kg/ha)	9480	9200	8973
Gross returns	171107	169590	164740
Net returns	73735	65689	38514
BCR	1.76	1.63	1.31
Cost of cultivation (Tk./kg)	10.27	11.29	14.07

Conclusions and Recommendations

After the project the farmers of all categories of the project area were financially benefited by using improved BPH management techniques. They had gathered sufficient knowledge regarding BPH control, use of balanced fertilizer dose and

insecticides application. Farmers became aware of harmful insects which were a threat to increase crop production because they got training on different aspects of pest management. They could increase higher yield and income from rice production using right management practices and applying proper inputs. They learned how to use double nozzle for controlling BPH and reported that use of double nozzle is better than single nozzle use because it has more advantages than that of single nozzle. Double nozzle sprayer can be disseminated among the farmers through the personnel of department of agricultural extension and research institutes. Thus rice growing farmers need necessary training on improved insecticides application and its proper management to gain adequate knowledge to increase rice production. Therefore, sufficient credit should be provided to the farmers in time to purchase high cost inputs. At the same time policy should be made to subsidize on agricultural implements like double nozzle sprayers so that farmers can use these with minimum cost to grow rice profitably. So the more the training of farmers on improved BPH management techniques for rice cultivation the more benefit they obtain.

References

Alam, S., and A.N.M.R.Karim, 1977. Brown Planthopper (Nilavarvata lugens)- a probable threat to rice cultivation in Bangladesh. Paper presented at Second Annual Bangladesh Science Conference, January 1977. Bangladesh Agricultural University, Mymensingh.

BBS, different issues from 1974 to 2014. Statistical Yearbook of Bangladesh. Bangladesh Bureau of Statistics. Statistics Division, Ministry of Planning, Government of the People's Republic of Bangladesh, Dhaka, Bangladesh.

Carbonel, P.U.1980. Pest control practices and costs for irrigated and rainfed farmers in Nueva Ecija. Paper presented at the 11 th Annual Scientific Meeting of the Crop Science Society of the Philippines, VISCA, Baybay, Leyte, April 27-28 (mimeo).

Chandler, Robert F. Jr. 1979.Rice in the Tropics: A Guide to the Development of National Programs. Westview Press/ Boulder, Colorado, USA.

DAE. 2014. Department of Agricultural Extension. Field services wing. Khamarbari, Farmgate, Dhaka, Bangladesh.

DAE. 2016. Department of Agricultural Extension. Field services wing. Khamarbari, Farmgate, Dhaka, Bangladesh.

Dyck, V.A.,and B.Thomus, 1979. Brown planthopper: Threat to Rice Production in Asia. The Brown Planthopper Prblem. International Rice Research Institute, Los Banos, Laguna, Philippines.

Dyck, V.A., B.C.Mista, S.Alam, C.N.Chan, C.Y.Hsich and R.S.Rejesus,. 1979. Ecology of the Brown planthopper in the Tropics. International Rice Research Institute, Los Banos, Laguna, Philippines.

Gomez, K.A..,L.Lopez, M.J.Novenario, R.W.Herdt, and V.P. Marciano. 1979. Constraints to high yields, Laguna, Philippines. In IRRI, Farm level Constraints to High Rice Yields in Asia: 1974-77, Los Banos, Philippines.

Haq, M.,M.A.Hossain, N.R.Sharma, M.A.T.Mia, and M.N.Bari. 2006. Role of Pest Management in Minimizing Yield Gap in Rice. Twenty first BRRI-DAE Joint Workshop. Theme: Bridging the Rice Yield Gap for Food Security. Organized by Bangladesh Rice Research Institute and Department of Agricultural Extension. Bangladesh Rice Research Institute, Gazipur 1701.

Herdt, R.W. 1979. An overview project results. In IRRI, Farm level Constraints to High Rice Yields in Asia: 1974-77, Los Banos, Philippines.

Herdt, R.W and S.K. Jayasuriya. 1981. The economics of insect control on rice in the Philippines. Paper prepared for the Annual meeting of the Pest Control Council of the Philippines, Los Banos, May 16, 1981. IRRI Ag. Econ. Dept. Paper No. 81-10.

IRRI (International Rice Research Institute). 1979a. Farm level Constraints to High Rice Yields in Asia: 1974-77, Los Banos, Philippines.

Islam, M.R., Mustafi,B.A.A. and Haq,M. 2004. Impact assessment of the IPM training of farmers during Boro 2003. Agril. Econ. Division, BRRI, 30p.

Litsinger, J.A., E.C. Price, and R.T. Herrera. 1978. Small farmer pest control practices for rainfed rice, corn, and grain legumes in three Philippine provinces. Philippine Entomologist **4**(1-2):65-68.

Pathak, M.D. and Khan,Z.R. 1994. Insect pests of rice, IRRI-ICIPE, 89p.

ISSN 0258-7122 (Print), 2408-8293 (Online)
Bangladesh J. Agril. Res. 46(2): 227-240, June 2021

STUDY ON LIVELIHOOD OF *HAOR* COMMUNITY IN BANGLADESH

M. KHATUN[1] AND M. S. RAHMAN[2]

Abstract

This paper is an endeavor to depict the picture of farming life and livelihoods of *Haor* community in two districts namely Netrokona and Kishoreganj of Bangladesh. It assessed the socioeconomic condition, livelihood patterns, risk and uncertainty of *Haor* farming. Primary data were collected from 120 farm households. A simple random sampling technique was followed to select the households. Overall, 33% of the households head had no formal education which was 31% and 34% in Kiahoreganj and Netrokona respectively. About 9% of the farmer belonged to large farm category while 12% of them were marginal. The half of the households in Netrokona belonged to small farm category which was accounted for 32% in Kishoreganj. At the same time, the percentages of landless households in Netrokona and Kishoreganj were 30% and 27% respectively. Crop production was the primary means of livelihood of 80% of the surveyed households. Besides, business, labour, public and private service, fishery etc. were some of other livelihood sources of the surveyed households. Boro (rice) – fallow – fallow was the most dominant cropping pattern. The causes of single dominant cropping pattern was the intrusion of flood or *Haor* water, low land, lack of knowledge about new crop variety and production technology and lack of flood resistant crop varieties. Flash flood was the main cause of vulnerability of *Haor* people in both the districts. In order to reduce the vulnerability, most of the respondents construct barriers to stop floodwater. Households mostly depend on borrowing or taking loan and government support to lead their family livelihood during and after flash flood. Establishing new cropping patterns along with managing alternate sources of income might be the options to improve the livelihood of *Haor* people.

Keywords: *Haor*, Livelihoods, Cropping pattern, Vulnerability, Bangladesh.

Introduction

Haor, a back swamp or bowl-shaped large tectonic depressions located north-eastern region of Bangladesh between the natural levees of rivers and may comprise a number of *Beels* (Rana et al., 2010). Large areas of Sunamganj, Sylhet, Habiganj, Maulvibazar, Netrakona, Kishoreganj and Brahmanbaria districts of Bangladesh are covered by many *Haor*s. There are 373 *Haor*s which cover an area of about 1.99 million ha and accommodate about 19.37 millions of people covering around 43% of the total area of *Haor* (Jakariya and Islam, 2017; Abuodha and Woodroffe, 2006; BHWDB, 2012).

[1]Assistant Professor, Department of Agricultural Finance and Banking, Bangladesh Agricultural University (BAU), Mymensingh-2202, [2]Scientific Officer, Agricultural Economics Division, BARI, Gazipur-1701, Bangladesh.

*Haor*s are basin like structures where water remains stagnant or flash flooding condition during the months of June to November (Sarif et al., 2016). These basins also act as a natural reservoir by regulating water flows of the Meghna river system (Rahman et al., 2016). Heavy rainfalls and onrush of water from the upstream Meghalaya hills in India causes inundation of *Haor* crop lands each year. Surface runoff by canals and rivers makes basins an extensive water body in the monsoon but dry up mostly in the post-monsoon period (Bevanger and Broseth, 2001; Adger et al., 2003; Abedin et al., 2013). Annual rainfall ranges from 2200 mm along the western boundary to 5800 mm in its north east corner and is as high as 12000 mm in the headwaters of some catchments extending to India (BHWDB, 2012).

The *Haor* region has long been lagging behind mainstream national development although the economic development of Bangladesh is moving steadily at a moderate pace (BHWDB, 2012). As this region covers a major part of the country and population so it deserves special development initiatives. But it has the lowest categories of living standard and high population density. Having one of the poorest road communication networks in terms of connectivity with the main land, 11 *Haor* upazillas are not connected with roads network (BHWDB, 2012). The *Haor*s are the source of livelihoods of millions of rural people who depend on *Haor* for fishing, rice farming, boating, hunting, wage laboring in sand and stone mines (Planning Commission, 2016). Farmers of *Haor* areas depend on crop land where almost 80% areas are covered by the boro rice production (Hossain et al., 2017) and remain fallow in during Kharif-1 and Kharif-2 season as inundated by flood water. Only 10% of the *Haor* area is covered by T. Aman rice. Pre-monsoon flash flood, hailstorm and drought are the main constraints to grow modern boro rice in the *Haor* region (Alam et al., 2010).

Despite geographical isolation, *Haor* areas have huge potentials. Though development potentials are huge in *Haor* areas, there is a lack of integrated approach for maximizing the utilization of resources (both human and natural resources) for the sustainable development of *Haor* (Planning Commission, 2016). Crop production techniques, people's livelihood and economic activities are quite different from those of the other parts of Bangladesh (Alam et al., 2010). So, it is necessary to demonstrate the real picture of life and livelihood of *Haor* dwellers for mainstreaming them in the journey towards national progress of Bangladesh. In line with this view the present study was designed to fulfill the following specific objectives:

i. To assess the socioeconomic condition and livelihood pattern of *Haor* community,

ii. To evaluate the cropping patterns, land utilization pattern and risk of *Haor* farming and

iii. To demonstrate the vulnerability of *Haor* dwellers and their adaptation strategies against vulnerability.

Materials and Methods

Study area and sampling procedure

Based on the existence of *Haor* and *Haor* based ecosystem, two districts namely Netrokona and Kishoreganj were selected for the study. Farmers were selected based on the information provided by DAE to ensure that the farmers of this area well exposed by the impact of *Haor* related hazards. On consultation with DAE personnel, a list of households was prepared from Dingapota *Haor* in Mohanganj Upazila along with Digar *Haor* and Jaherpur *Haor* at Khaliajuri Upazila under Netrokona district, and Bonpur *Haor* and Meherpur *Haor* of Kishoreganj district. From the individual list, 60 households were randomly selected from each district. They were different in land holding size and also indifferent in different socioeconomic attributes. Thus, a total of 120 households were finally selected for the survey.

Sources of data and data collection procedure

The study is based on primary data. Besides, secondary data was also collected from the Department of Agricultural Extension (DAE), Bangladesh Bureau of Statistics (BBS), different published and unpublished reports, presentations, related websites, and individual experts. An interview schedule was used to collect field level primary data. Before finalizing the interview schedule it was pre-tested in the survey areas. The researcher along with two assistants collected field level data from the selected respondents. Data collection was started in 1st February 2018 and completed in 30 April 2018.

Results and Discussions

Socioeconomic profile: It is evident that the highest percentages (31%) of household's head of Netrokona district were in between 30-39 years while 37% household's head of Kishoreganj district were in 50-59 years (Table-1). The level of education of the household's head demonstrates that 33% had no formal education (Table-1). Moreover, the highest year of schooling was found up to 1-5 years of schooling which means that most of the respondents did not complete the primary level of education. Distribution of households by family size (Table-1) indicated that 22% of the households in all areas belonged to small family (1-4 persons/hh), 52% belonged to medium family (5-7 person/hh) and 27% belonged to large family (above 7 person/hh).

The 50% of the households of Netrokona were small farmer followed by 31% medium farmer and 6% large farmer (Table-1). At the same time, 13% of the households of this district fell under marginal farm categories. Besides, the

highest percentages of respondents (46%) of Kishoreganj district were medium farmers followed by 32% small and 10% marginal. Only 12% of the households were large farm categories in this district (Table-1). A number of primary occupations were found in which 80% of the head of the households occupation was crop production (Table-1). Besides business, labour, public or private service, and fishery were also primary income sources of the respondents. Table-1highlights the family status of the households where 69% of the family belonged to nuclear family following by 31% joint family.

Table 1. Socioeconomic profile of the sample respondents

Demographic variables	% of respondents		
	Netrokona district	Kishoreganj district	All areas
Age (years)			
20-29	13	2	8
30-39	31	17	24
40-49	29	17	23
50-59	19	37	28
≥60	8	27	18
Education (year of schooling)			
No formal education	31	34	33
1-5	51	58	55
6-10	18	8	13
11-12	0	0	0
>12	0	0	0
Family Size (No. of family member			
Small family (1-4)	33	10	22
Medium family (5-7)	48	56	52
Large family (above 7)	19	34	27
Farm size			
Marginal farmers (<0.19 ha)	13	10	12
Small farmers (0.19-1.0 ha)	50	32	41
Medium farmers (1-3.03 ha)	31	46	39
Large farmers (>3.03 ha)	6	12	9
Family status			
Male Headed HHs	93	95	94
Male female ratio	95	110	103
Nuclear family	65	73	69
Joint family	35	27	31

Demographic variables	% of respondents		
	Netrokona district	Kishoreganj district	All areas
Occupational status			
A. Main Occupation			
Agriculture	81	78	80
Business	8	19	24
Labour	2	1	2
Service	1	0	1
Fishery	2	2	2
Others	6	0	3
B. Secondary Occupation			
No profession	10	41	26
Agriculture	17	19	18
Business	12	22	17
Labour	10	3	7
Service	6	0	3
Fishery	41	14	28
Others	4	1	3

Source: Field survey, 2018

Monthly income and expenditure: Monthly income and expenditure of the households showed that 40% of the respondents belonged to less than Tk. 5000 per month followed by 37% whose monthly income was between Tk. 5000-10000 (Table-2). Only 7% of the households in the survey area had their monthly income more than Tk. 30000. Proportion of households based on expenditure groups did not match to their income group. Highest percentage (29%) of the households' monthly expenditure was below Tk. 5000. There were no household whose monthly expenditure belonged to more than Tk. 30000.

Table 2. Distribution of farms according to income and expenditure

Items	Percent of farms as per income and expenditure (Tk./month)					
	≤5000	5001-10000	10001-15000	15001-20000	20001-25000	>25000
Income	40	37	9	3	4	7
Expenditure	29	8	23	18	22	0

Source: Field survey, 2018

Land utilization pattern and sharing agreements: Table-3 shows distribution of sample households based on land holdings. It is evident that 70% of the respondents of Netrokona district cultivated their own land whereas it was 73% in Kishoreganj district. The percentage of landless farmers among the survey respondents were 30% and 27% in Netrokona and Kishoreganj district respectively. About 77% of the survey respondent's crop land was under two crops in a year where it was 70% in Kishoreganj district (Table-3).

Table 3. Percent distribution of households according to land holdings

Pattern of land holdings	Farmer responded (%)	
	Netrokona	Kishoreganj
Owner cultivator	70	73
Share cropper	13	9
Renting in land (Tenant)	37	48
Renting out land (landlord)	8	3
Landless	30	27
Land under one crop in a year	77	70
Land under two crop	4	20

Source: Field survey, 2018

Table 4. Sharing agreements practiced among the survey tenant farmers

Tenure arrangements	Farmer responded (%)	
	Netrokona	Kishoreganj
1. Owner received half of the crop produced (without by product) but not providing any part of cost of production.	48	31
2. Owner received half of the crop produced (without by product) and provides some portion of the cost of fertilizer and irrigation.	32	29
3. Owner provided half of the cost of fertilizer and irrigation and receives half of the crop produced and by product.	1	3
4. Owner shared half of the total cost of cultivation and receives half of the crop produced and by product.	1	7
5. Owner gave just irrigation cost and receives half of the crop produced and by product.	1	2
6. Owner gave just seed cost and receives half of the crop produced (without by product).	1	1
7. No part of the cost is shared by the owner and receives predefined part of the crop such as 40Kg per 33 decimal.	14	22
8. Owner received one third of the crop produced (without by product) but not providing any part of the cost of production.	2	5

Source: Field survey, 2018

Land sharing agreements are demonstrated in Table-4 where eight different agreements were found among the survey tenant farmers. The most practiced tenure system was owner of the land receive half of the crop produced without by product but not sharing any of the cost of production and this was found 48% and 31% of the tenant farmer from Netrokona and Kishoreganj district respectively. At the same time 32% and 29% of the survey tenants of this district were in another agreements where owner of the land receives half of the crop produced (without by product) and provides some portion of the cost of fertilizer and irrigation. It is also evident from Table-4 that 14% from Netrokona district and 22% from Kishoreganj district were in another agreement where no part of the cost is shared by the owner and receives predefined part of the crop such as 40Kg per 33 decimal (Table-4).

Cropping pattern practicing in the survey areas: The study intended to find out the present variation of cropping pattern among its survey areas (Table-5). In Itna upazila of Kishoreganj, 93.34% of the land used for growing only *Boro* rice. Keeping the other two seasons fallow. Besides, about 7% of the land in this upazila were under two other cropping pattern i.e., chilly-fallow-fallow and vegetables-fallow-fallow. But in Mithamoin upazila of Kishoreganj the highest 46.67% of land occupied by *Boro* rice-fallow-fallow following by 13.33% in groundnut- B. Aman-fallow and vegetables-fallow-fallow. On the other hand, the respondents of Khaliajuri upazila under Netrokona practiced *Boro* rice–fallow–fallow cropping pattern whereas it was followed by 87.33% at Mohanganj upazila (Table-5). Overall, it can be concluded that *Boro* rice–fallow-fallow was the primary and most practiced cropping pattern among the respondents under this study.

Table 5. Cropping pattern practiced by the respondents

Cropping pattern	Farmer responded (%)	Cropping pattern	Farmer responded (%)
Kishoreganj			
Itna upazila		Mithamoin upazila	
Boro rice– Fallow–Fallow	93.34	Boro rice–Fallow–Fallow	46.67
Chilly–Fallow–Fallow	3.33	Groundnut–B. *Aman*–Fallow	13.33
		Potato–Vegetables–Fallow	10.00
Vegetables– Fallow–Fallow	3.33	Mashcolai–Fallow–Fallow	6.66
		Jute- Fallow–Fallow	10.00
		Vegetables–Fallow–Fallow	13.33
Netrokona			
Khaliajuri upazila		Mohanganj upazila	
		Boro rice–Fallow–Fallow	87.33
Boro rice– Fallow–Fallow	100	Chilly–Fallow–Fallow	6.00
		Jute–Fallow–Fallow	6.60

Source: Field survey, 2018

Causes of static cropping pattern: Most of the respondents opined that intrusion of flood water (30% in Netrokona and 39.4% in Kishoreganj) was the prime reason for practicing the same pattern of crop production year after year (Table-6). Besides, low crop land (18.33% from Netrokona and 28.33% from Kishoreganj) was another important reason for static cropping pattern. During the rainy season, these low lands have easily drowned under water for about six months in a year. They also told that if someone want to cultivate in other than *boro* rice than it was damaged by local people through their livestock. It needs farmer's combined efforts to cultivate in the fallow land with a number of off season crops.

Table 6. Causes of static cropping pattern in the study areas

Causes	Farmer responded (%)	
	Netrokona	Kishoreganj
Intrusion of flood or *Haor* water	30.00	39.4
Low land	18.33	28.33
Lack of knowledge	16.67	8.33
Lack of flood resistant variety	10.00	-
Long habit of rice production	8.33	-
Disturbance by livestock during fodder shortage	6.67	5.00
Small amount of land	5.00	6.67
Shortage of manpower	5.00	6.67

Source: Field survey, 2018

Possible cropping pattern in the survey areas: Table-7 refers that vegetables, potato, groundnut, wheat and mustard have the possibility to grow in relatively less low land which is locally called "Kanda". As for example, Kishoreganj district, *Boro* rice-fallow-fallow pattern is practiced by more than 70% of the respondents; but about 65% of land may be brought under groundnut-B. aman rice-fallow pattern. This will be an added option over the existing cropping pattern for the farmers of this area. At the same time, 25% of the land of Netrokona may be brought under mustard-*Boro* rice-fallow pattern.

Table 7. Possible cropping patterns in the *Haor* areas

Study upazila	Possible cropping pattern	Exploitable area under pattern (%)
Itna and Mithamain	Groundnut-b. aman rice-fallow	65
	Potato-vegetables-fallow	15
	Wheat-b. aman-fallow	20
Mohanganj and Khaliajuri	Mustard-*boro* rice-fallow	25
	Boro rice-fallow-t. aman rice	20

Source: DAE and Field survey, 2018

Disaster in the *Haor:* The Table-8 enumerates a number of natural disasters experienced by the *Haor* inhabitants during the last few years. Almost all of the disasters were the sources of significant damages in *Haor* areas. Among them hill

pitch and flash flood are the most common one. Flash flood starts from April and continues until September. Due to climate change there is no definite time for raining in the *Haor* areas. Inundation from heavy rainfall or frequent rainfall is also a regular occurrence in the study area. During the last few years' damages of livestock or death of human has increased considerably due to frequent occurring of hailstorm and thunderstorm in the *Haor* areas.

Table 8. Extent of disasters in the *Haor* areas

Nature of disaster	Extent of occurance
Hill pitch and flash flood	April to September
Heavy rainfall and inundation	April to May
Thoroughly rainfall	July to September
Hailstorm and thunderstorm	April to may
Siltation in land	April to July

Source: DAE and field survey, 2018

Vulnerability of households in the survey areas: Vulnerability index was prepared to find out the causes of vulnerability of *Haor* people. Flash flood was the main causes of vulnerability in both the districts (Table-9). Beside this poor marketing system, health hazard, land slide, inadequate financial support was ranked as 2nd, 3rd, 4th respectively for the *Haor* people of Kishoreganj district. On the contrary, land slide, poor marketing system, food insecurity, sanitation and nutrition were ranked as 2nd, 3rd, 4th respectively for the *Haor* people of Netrokona district.

Table 9. Vulnerability index

Causes of Vulnerability	No. of respondents			No. of respondents			Vulnerability Index		Rank	
	Kishoreganj			Netrokona			Kishoreganj	Netrokona	Kishoreganj	Netrokona
	1	2	3	1	2	3				
Land slide	19	3	38	35	7	18	101	137	4	2
Flash Flood	48	12	0	60	0	0	168	180	1	1
Sanitation and nutrition	8	12	40	10	20	30	88	100	7	5
Migration	7	15	38	11	15	34	89	97	8	6
Health hazard	18	21	21	6	14	40	117	86	3	8
Food insecurity	6	18	36	15	16	29	90	106	6	4
Inadequate financial support	9	18	33	13	16	21	96	92	5	7
Poor marketing system	21	23	16	19	25	16	125	123	2	3

Note: 1=Low, 2=Moderate and 3 =High, Source: Field survey, 2018

Risk factor in crop production: A number of risk factors in crop production were identified in the survey areas (Table-10). The most risk that the farmers have to face is flood which may be occurred due to flash flood or heavy rainfall. The way it happened caused enormous damages to the rice crop. Lack of labour during harvesting and planting period is the most common problem. Hail storm and uncertain rain are other two common hazards on which the farmer had nothing to do. They were not so frequent in the past but farmers told that during the last few years the magnitude of hail storm and uncertain rain were very frequent. At the same time, 16.67% of the respondents in Kishoreganj and 20% in Netrokona told that they suffered from drought problem (Table-10).

Table 10. Risk factors in crop production in the study areas

Types of Risk	Farmer responded (%)		
	Kishoreganj District	Netrokona District	All areas
Flash flood	100	100	100.00
Crisis of labor	86.00	76.00	81.00
Hail storm	23.33	41.66	32.50
Pest and disease in crops	21.67	38.33	30.00
Uncertain rain	18.33	28.33	23.33
Drought	16.67	20.00	18.34
Lack of crop production inputs	11.67	11.67	11.67

Source: Field survey, 2018

Adaptation strategies in before, during and after flooding: A number of measures were considered and taken by the respondents of the selected *Haor* areas before the flooding (Table-11). One of the common tasks of the inhabitants of *Haor* areas is to construct different barriers to stop floodwater from entering into home (89%). Besides this 64% of them construct their dwelling households above flood level. The 72% of the respondents told that they always monitor the situations of floods and surroundings to become update about the flood. At the same time 47% of the respondents listen to the local or national radio stations or surfing television channel to take updates about the upcoming flooding.

During a flood, affected people try to decrease their degree of damages and losses. Monitoring the surroundings (92%) and listen to the local radio stations or television for information (78%) were the most important tasks during the flood time. Beside this they kept their children and other family member out of the water (57%), and left the low areas (34%) which are subject to flooding. Again, when a flood occurred, the family who left the dwelling places back to that place just immediately after the flood (61%).

Table 11. Steps practicing before, during and after flooding

Steps	Farmer responded (%)
Before	
Construct barriers to stop floodwater from entering into home	89
Monitoring the surroundings	72
Construct buildings above flood level	64
Take protection of the property	63
Listen to the local or national radio stations or television for information	47
Fixing the places to go	39
Get out of housing subject to flooding	27
Assemble disaster supplies for leaving quickly	19
During	
Monitoring the surroundings	92
Listen to the local radio stations or television for information	78
Keep children and other family member out of the water	57
Leave the low areas that may be subject to flooding	34
Move to safe area before access is denied due to rising water	19
Contact with the emergency response authority	16
After	
Return to the flooded areas immediately after flooding	61
Contact with the emergency response authority	17

Source: Field survey, 2018

Alternate livelihood during and after flooding: In Netrokona, 65% of the respondents were laid on loan or credit whereas it was 40% for Kishoreganj. Besides this borrowing was an important source to manage their daily necessities accounted for 69% in Netrokona and 38% in Kishoregaj (Table-12). The 89% from Netrokona and 56% from Kishoreganj opined that they received different amount of loan to meet their daily necessities. At the same time government support considered a very important source of livelihood during the flood time. The 74% from Netrokona and 68% from Kishoreganj opined that government support were one of their major sources to lead their life after flood period (Table-12).

Table 11. Sources of alternative livelihood during and after flooding

Sources	Farmer responded (%)	
	Netrokona	Kishoreganj
During flood time		
Selling the previous year food stock	22	25
Consuming the previous year food stock	32	32
Savings	32	37
Selling livestock	37	20
By loan/credit	65	40
Government support	32	55
Paid labour	40	27
Through borrowing	69	38
Eating one time in a day	5	2
Fishing	33	25
Business	9	29
Garments	0	10
After flood time		
Selling the previous year food stock	17	39
Consuming the previous year food stock	30	46
Savings	47	49
Selling livestock	45	22
By loan/credit	89	56
Government support	74	68
Paid labour	51	12
Fishing	19	27
Business	13	19

Source: Field survey, 2018

Conclusion

Overriding challenge of *Haor* inhabitants is perhaps the fact that they have limited livelihood options. This restricts their educational attainment. No respondents were found above secondary level of education in the survey areas. Besides, they have to depend on one cropping pattern Boro-Fallow-Fallow. As crop production is the main occupation of the survey areas, so it is necessary to diversify their cropping pattern. For this groundnut-B. aman rice-fallow, mustard-*boro* rice-fallow can be the alternate pattern. Flash flood, lack of labour, hail storm etc. were the main risk factor of crop production. *Haor* dwellers

follow a number of adaptation strategies to mitigate their losses such as constructing barriers to stop floodwater, monitoring the situations, construct dwelling places above flood level etc. Besides, borrowing or taking loan and government support were the primary means of livelihood during risk time. Establishing new prospecting cropping pattern and managing alternative income sources might be the possible options for improving the life and livelihood of *Haor* dwellers in Bangladesh.

Acknowledgement

Authors are grateful to the Ministry of Science and Technology, Government of the Peoples' Republic of Bangladesh for providing fund. Special thanks to Director (BAURES), Bangladesh Agricultural University and respective Upazila Agricultural Officer of Kishoreganj and Netrokona for their cooperation.

References

Abedin, M. A., U. Habiba and R. Shaw. 2013. Gender and climate change: impacts and coping mechanism of women and special vulnerable groups. In: Shaw R, Mallick F, Rahman A (eds) Climate change adaptation actions in Bangladesh. Springer, Tokyo.

Abuodha, P. A., C. D. Woodroffe. 2006. International assessments of the vulnerability of the coastal zone to climate change, including an Australian perspective. School of Earth and Environmental Sciences, University of Wollongong for the Australian Greenhouse Office, Department of the Environment and Heritage, Australia.

Adger, W. N., S. Huq, K. Brown, D. Conway and M. Hulme. 2003. Adaptation to climate change in the developing world. *Progress in Development Studies.* **3**(3):179–195.

Alam M. S., M. A. Quayum and M. A. Islam. 2010. Crop Production in the Haor Areas of Bangladesh: Insights from Farm Level Survey, *The Agriculturists.* **8**(2): 88 – 97.

Bevanger, K. and H. Brøseth. 2001. Bird collisions with power lines - an experiment with ptarmigan (Lagopus spp.). *Biological Conservation.* **99:** 341–346.

BHWDB. 2012. Master plan of Haor area: Volume I, Summary report. Ministry of Water Resources, Government of Bangladesh, Dhaka.

Hossain, M. S., A. A. Nayeem and A. K. Majumder. 2017. Impact of Flash Flood on Agriculture Land in TanguarHaor Basin. I*nternational Journal of Research in Environmental Science.* **3**(4): 42-45.

Jakariya, M. and M. N. Islam. 2017. Evaluation of climate change induced vulnerability and adaptation strategies at Haor areas in Bangladesh by integrating GIS and DIVA model. *Model. Earth Syst. Environ. Springer International Publishing.* DOI 10.1007/s40808-017-0378-9.

Planning Commission. 2016. Environment and Climate Change Policy Gap Analysis in Haor Areas. Workshop outcome document. Support to Sustainable and Inclusive Planning (SSIP) Project, General Economics Division (GED), Planning Commission, Government of the Peoples' Republic of Bangladesh.

Rahman, M. M., K. I. Sajib and I. Alam. 2016. Impacts of Climate Change on the Livelihoods of The People in TanguarHaor, *Bangladesh Journal of Water Resource Engineering and Management.* **3**(1): 1-9.

Rana, M. P., M. S. I Sohel, S. Akhter and M. S. Alam. 2010. Haor based livelihood dependency of a Rural Community: A Study on Hakaluki Haor in Bangladesh. *Proceedings of the Pakistan Academy of Sciences*. **47** (1): 1-10.

Sarif, S. M. K., M. H. Kabir, S. Sultana, M. S. Mahmud and S. Mahjabun. 2016. Socioeconomic Conditions, Agricultural Practices and Communication Status of the Vulnerable *Haor* People in Bangladesh. *American Journal of Rural Development*. **4**(5): 100-104.

Guidelines for Contributors

Bangladesh Journal of Agricultural Research (BJAR) is a quarterly Journal highlighting original contributions on all disciplines of crop agricultural research conducted in any part of the globe. The full text of the Journal is visible in www.banglajol.info and www.bari.gov.bd websites. Contributors are requested to note the following points while preparing paper for the Journal.

- Paper submitted for publication must contain original unpublished material.
- Papers in the Journal are published on the entire responsibility of the contributors.
- Paper must be in English and type-written in Times New Roman (font size 12) with double space on one side of A4 size 80g paper.
- Margin should be 2.50 cm (1 inch) in all sides.
- Manuscript should be submitted in duplicate along with a soft copy.
- The manuscript should contain the following sub-titles in sequence: Title, Abstract, Key words, Introduction, Materials and Methods, Results and Discussion, Conclusion, Acknowledgements (if any) and References. In case of 'Short Communication' no sub-titles are necessary except Abstract and References.
- **Title:** It should be brief and specific and typed in capital letters. The manuscript will have a separate title page giving title of the paper, author(s) name and address.
- **Abstract:** It should not exceed 150 words containing the highlights of the study, but in case of short communication if should not exceed 70 words.
- **Key words: S**hould not exceed 6 words and it should be below the Abstract.
- **Text:** The text of the article should be clear and precise. Introduction should be precise and relevant to the study. Methods already published should be indicated by references. In case of modification of a method it needs explicit description. Results should be stated concisely and presented referring to Tables and Figures. Data of Tables and Figures should not be repeated in the text. Each result should be followed by discussion or interpretation with appropriate reference(s).
- **Tables and Figures:** Number of Tables and Figures should be minimum. The figures and graphs should be properly drawn with bold and solid lines. The photographs should be submitted on glossy paper or in JPG format. Black and white and colored photographs are acceptable.
- All quantitative data must be in metric units.
- Abbreviations should be as per style "Manual for Biological Editors".

- **References:** The references and scientific names are important. The authors must be sure about the correctness of citations and spellings. In the text, references should be cited within brackets quoting author's surname and the year of publication in the appropriate place e.g. (Bhuiyan, 1964), Khan and Rahman (1970). Two or more references when put within the same bracket should be separated by a semicolon.

For more than two authors the reference should be cited with the surname of the first author and then *et al*. (year), for example Ahmed *et al.* (1999).

References should be arranged alphabetically according to author's surname, to be followed by year of publication and full title of the paper. Name of the Journal and Book should be in italics, to be followed by volume, number and page range.

Ahmed, F. and M. Z. Alam. 1993. Mango leaf consumption by *Cricula trifenestrata* Heifer (Lepidoptera: Saturnide) larvae under field conditions. *Bangladesh J. Entomol.* **31:** 9-17.

Cano, H., N. Gabas and J. P. Canselier. 2001. Experimental study on the ibuprofen crystal growth morphology in solution. *J. Crystal Growth* **224:** 335.

De Beer, G. R.1940. Embryology and Taxonomy. *In: The New Systematics.* (Ed. Huxely, J.). Oxford Univ. Press, London. pp. 365-393.

Dockery, D. J. and C. A. Pope, 1994. Acute respiratory effects of particulate air pollution. *Ann. Rev. Public Health* **15:** 107-110.

Edmonds, J. and K. M. Karp. 1997. Theoretical improvements in Algorithmic Efficiency for network flow problems. *J. Assoc. Comput. Mach.* **19:** 248-264.

- A full paper exceeding 12 typed pages and a short communication exceeding six typed pages will not be entertained.
- Principal author should take consent of the co-author(s) while including the name(s) in the article.
- The article prepared from M.S/Ph.D. thesis should be mentioned in the foot note of the article.
- Authors get no complimentary copy of the Journal. Twenty copies of reprints are supplied free of cost to the author(s).

FOR SUBMISSION OR CONTACT

Editor (Technical)
Bangladesh Journal of Agricultural Research
Bangladesh Agricultural Research Institute (BARI)
Joydebpur, Gazipur-1701
Phone: 02-49270038
E-mail: editor.bjar@gmail.com

BANGLADESH JOURNAL OF AGRICULTURAL RESEARCH

Vol. 46 **June 2021** **No. 2**

Published by the Director General, Bangladesh Agricultural Research Institute (BARI), Gazipur-1701, Bangladesh. **Printed at** Baishakhi Mudrayan, 49/6, Ram Krishna Mission Road, Wari, Dhaka-1203, Mobile: 01782559244.

Published: January 2022