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ADOPTION OF IMPROVED PRODUCTION PRACTICES IN LOW LAND RICE THROUGH COMMUNITY TRAINING

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ABSTRACT

Rice (*Oryza sativa* L.) production technology adoption requires effective farmers' training for narrowing knowledge gap. This paper assesses the result of community training on the extent of adoption of improved rice production practices in low land rice of south western Bangladesh. A total of 531 farmers were trained through community training approach and 177 farmers were randomly selected for data collection. The extent of adoption of improved rice production practices and reasons for non-adopting technologies were solicited by personal interview with the help of a semi-structured questionnaire. Collected data were analysed using descriptive and inferential techniques. The community training was suited to adopt rice production technologies. The adoption of different rice production technologies was greater by the adopters of Satkhira district compared to Khulna that resulted in significant rice yield difference. The constraints against the adoption of the selected rice production technologies show that a portion of adopters was not convinced to adopt row transplanting, skipped row planting and birds perch for controlling insects, use of appropriate K and S fertilizers due to requirement of higher labour and fertilizer and risk of reduction of rice yield. The integration of other extension methods such as method and result demonstration might enhance the rate of adoption of those rice production technologies.

Keywords: Technology Adoption, Community Training, Productivity; Rice Technology

INTRODUCTION

Rice (Oryza sativa L.) is staple food in Bangladesh. A large section of the population of the country depends on rice production and processing. Rice is grown in 72% of

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the total cropped area of the country which accounts for more than 90% of total grain production (BBS, 2018). The rapid population growth and urbanisation gradually decreased the cultivated land demanding increased output to keep pace with the population increase. To assure food security, rice production would have to be increased by 50% by 2025 as a rice consuming country (Zeng et al., 2004). Rice is grown in Bangladesh in winter, pre-monsoon and monsoon seasons covering 4.48, 1.14 and 5.59 m ha, respectively. The monsoon season rice is known as Aman rice, mainly grown under rainfed condition characterized by low productivity and income with an average yield of 3.71 t ha^{-1} (BBS, 2018). The low level of production resources, low adoption of improved agronomic practices and inadequate extension delivery system constraint its productivity which affect many farming families, particularly those who operate farming in unfavorable environments.

The success of any technology depends on its dissemination among the potential users, which ultimately is measured by the level of adoption of that technology (Reddy and Reddy, 2002). Mosher (1987) defined that adoption of an innovation is the process by which a particular farmer is exposed to, considers, and finally rejects or practices a particular innovation. Adoption decisions are mainly affected by extension related variables such as training, membership in a farmers' group, and off-farm employment (Suvedi et al., 2017). Farmers sometimes discover problems in putting a recommendation into practice, the extent of adoption, adjustment or rejection depends on farmers' behavior (Valera and Plopino, 1987). Effective farmers' training is one of the options to adopt rice production technologies (Sarma et al., 2011). Tsado et al. (2014) opined that training for rice farmers needs to be given topmost priority to improve their skills on the adoption of improved rice production packages to increase their productivity and consequently their income. However, various studies indicated that there was a wide gap between available technology and its adoption in rice cultivation under different farming situations.

Learning of community environments aided with rich training materials such as graphics, video and other media and educational materials helped learners to discover things by themselves (Deegan et al., 2016). Learners are becoming more diverse in their needs and learning styles. The instructional method prepared in terms of learners learning style act as the most effective one (Bovy, 1981). Educational literature suggests that individuals demonstrate a preference for particular information-processing styles to assimilate new information (Eastman, 2010). The integrated training course blending different methods affords flexibility that serves the learning styles of diverse learners (Albion and Redmond, 2006). Therefore, the study was conducted to: i) determine the levels of adoption of rice production technologies by the trained farmers in the study area, ii) assess the influence of rice production technology adoption on the yield of rice and iii) identify major constraints in adopting rice production technologies by the adopted farmers.

MATERIALS AND METHODS

The Study area

The study conducted in the south-western coastal region of Bangladesh belongs to the Ganges Tidal Flood Plain, Agro-Ecological Zone (AEZ) 13. This region is almost flat and is about 1 m above the sea level. The average annual rainfall of the area is 1710 mm where rainfall occurs mainly from June to September. Monthly mean minimum temperature is 12.5°C in January and the maximum is 35.5°C in May. The soils of the study area are clay loam to clay in texture.

Community training on rice production packages

A day long farmer's training on rice production was conducted at each of the 36 villages under 21 Unions of 7 Upazilas (sub-districts) of Khulna and Satkhira districts in south-western Bangladesh. Twenty-five to 30 farmers of both male and female were selected in a community for a batch of training. The small and medium farmers were selected through discussion with the community following the principle that at least 10% trainee would be female. The training was conducted before the crop growing activities i.e. during June and July 2014 which permitted for discretionary learning and successful application and bringing this into practice. The training sessions were conducted at suitable places of the community like school, Union Parishad (council or assembly) Complex, houses of some lead farmers and under the shade of big trees. The mode of training was informal. Participants were encouraged to share their experiences in rice production, processing, and storage of seeds. The facilitators tried to find out the gaps between their practices and the recommended packages of rice production. The facilitators facilitated the sessions using flip charts, real learning aid or samples like disease and insect infested rice plant, bad and good quality seeds. Practical skills such as seedling raising in a raised bed, seedling uprooting and transplanting with an optimum number of seedlings at an optimum spacing, seed production, processing and storing were demonstrated utilizing multi-media material with audio dialogue through discussing the process step-by-step guide. In order to ensure the farmer not overawed by receiving too much information at once, the video materials were delivered in a small segment.

Data collection

A total of 531 farmers were trained of which 177 farmers were selected randomly for data collection. The extent of adoption of rice production practices, grain yield obtained in the technology adopted fields was the dependent variable. Age, education, farming experiences of the sampled farmers was recorded. Some focus group-discussions were conducted in six randomly selected trained communities both in Khulna and Satkhira districts for listing the reasons against not adopting the improved practices and were included in the questionnaire for data collection from the selected respondents. Data were solicited by personal interview method with the help of a semi-structured questionnaire just after harvesting of rice during November

to December 2014. The grain yield was measured from the adopted farmer's fields, at the central part of the plot of 20 m^2 sample area and was adjusted to 14% moisture.

Data analysis

Farmers were trained on ten different rice production practices (four on fertilizer recommendations, six on other crop production practices) to adopt to their rice fields. Collected data were analyzed using both descriptive and inferential techniques. The extent of adoption of rice production practices was measured against a two-point rating scale of 1 for "adoption" and 0 for "non-adoption". In the case of adoption of the amount of fertilizer use and time of application, 5 to 10% variation was considered as adoption. The extent of adoption of agreed rice production practices was compared at the district level adopters. Data on grain yield of rice was analyzed with CROPSTAT 7.2 version. The least significant difference (LSD) was used at ($P<0.05$) to test the differences among the treatment means.

RESULTS

Characteristics of rice farmers in the study area

Among the trained farm member, the majority were in the age of 40-59 years (51.4%) followed by the group of 25-39 years old (47.5%). Farmers aged 60 and above were only 1.1% (Table 1).

Table 1. Age and level of education of the trained farmers.

Age and level of education	Trained farmers	
	Number of farmer	Percentage
Farmer's age (years)		
25-39	84	47.5
40-59	91	51.4
≥ 60	2	1.1
Total	177	100.0
Education level		
Illiterate	10	5.6
Primary	82	46.3
Secondary	76	42.9
Higher secondary	8	4.5
Graduate	1	0.7
Total	177	100.0

Farmers were mostly from the education level of primary (46.3%) and secondary (42.9%). Only 5.6 and 4.5% adopters were from the illiterate group and higher secondary level of education, respectively. Whereas, the graduate farmers were less than 1% showed in Table 1. Maximum of the adopters had the farming experiences of 6 to 20 years (63.9%). Only 11.3% farmers were from 5 years and 9.6% were from 21-25 years of farming experiences. The rest of the farmers were from 26 years to 41 years of age (Table 2).

Table 2. Farming experiences of the trained farmers.

Farming experience (years)	Trained farmers	
	Number of farmer	Percentage
≤ 5	20	11.3
6-10	38	21.5
11-15	37	20.9
16-20	38	21.5
21-25	17	9.6
26-30	14	7.9
31-35	8	4.5
36-40	4	2.3
≥ 41	1	0.5
Total	177	100.0

Rice production technology adoption

The adoption of different rice production technologies was greater by the adopters of Satkhira district as compared to Khulna district except skipped raw transplanting (Table 3). Skipped raw transplanting was slightly higher in Khulna district. However, the magnitude of difference varied among crop management practices. In general, the adoption of skipped row transplanting for seed production was lower.

Rice yield of technology adopters and constraints to adoption of rice production technology

Grain yield of trained farmers of Satkhira (5.12 t ha^{-1}) was significantly greater than those of Khulna district (4.84 t ha^{-1}). The constraints against the adoption of the selected rice production technologies showed that a portion of adopters was not convinced to adopt row transplanting, skipped row planting and birds perch for controlling insects, especially rice stem borer and rice leaf roller, use of appropriate K and S fertilizers (Tables 4 and 5). The major constraints to adoption of the raised-bed method of seedling raising that the higher cost of land preparation for raising

land followed by lack of sufficient land. They perceived that the raised bed system needed much land. Unavailability of the two-wheel tractor (power tiller) for ploughing the main field mainly constrained the adoption of seedling of optimum age. Other reasons for older seedling use were the late onset of rainfall, seedling damage due to stagnant water and unavailability of labour during transplanting. More than 27% trainees reported that they did not adopt row transplanting as it required more labourers. The trained farmers used higher number of seedlings per unit area instead of an optimum number of seedlings with a perception of lower tillering with fewer seedlings and thus grain yield might be reduced. The farmers who did not adopt skipped row for rice seed production mentioned that its adoption was not possible as the labourers were not habituated, and yield might be decreased. Birds perch, a technology for insect controlling did not convince a portion of trained farmers mainly due to its efficacy depends on the use by the whole community. Moreover, reluctant to new technology adoption also hampered the adoption of those technologies.

Table 3. Rice production technology adoption by the trained farmers of Khulna and Satkhira.

Technologies adopted	Rate of adoption (%)	
	Khulna	Satkhira
Raised bed	76.4	87.4
Younger seedling	77.6	93.5
Skipped row transplanting	59.1	55.6
Seedling per hill	55.9	91.0
Bird perch for insect management	64.2	82.3
Fertilizer dose & method of application		
Urea	82.7	88.8
TSP	84.3	92.4
MOP	79.1	92.8
Gypsum	54.3	91.3

Table 4. Constraints to adoption rice production technologies other than fertilizer by the trained farmers.

Constraints to technology adoption	Technology adopted by the trained farmers (%)					
	Raised seedbed	Optimum seedling age	Row transplanting	Optimum seedling hill^{-1}	Skipped row planting	Birds perch
High land preparation cost	13.0	-†	-	-	-	-
Lack of sufficient land for seedbed	6.2	-	-	-	-	-
Not interested to change traditional practice	3.4	-	-	-	-	-
Not convinced	4.0	2.8	22.6	5.7	22.0	20.9
Unavailability of power tiller for ploughing	-	13.6	-	-	-	-
Late onset of rainfall	-	2.3	-	-	-	-
Seedling damage due to stagnant water	-	4.5	-	-	-	-
Unavailability of labour	-	2.8	-	-	-	-
Requirement of more labour	-	-	27.7	1.7	6.8	-
Difficult in higher water depth	-	-	4.0	-	-	-
Unwillingness of labour	-	-	4.0	5.1	22.0	-
Poor tillering (growth)	-	-	-	14.1	-	-
Yield reduction	-	-	-	17.5	38.4	-
Reluctant to adopt	-	-	-	-	-	15.3
Laggardness of farmer	-	-	-	-	-	9.0

†Not applicable for the specific constraints to technology adoption

The farmers who were accustomed to using the higher dose of fertilizer did not apply recommended fertilizers as they perceived that the lower dose might decrease the rice yield. On the other hand, the lower dose user did not apply the recommended fertilizer because of lack of capital. Unavailability of quality fertilizer was also reported as a constraint by some of the respondents (Table 5).

Table 5. Constraints to adoption of recommended fertilizer dose and method of application.

Constraints to technology adoption	Technology Adoption by the trained farmers (%)			
	Nitrogen fertilizer	Phosphate fertilizer	Potassium fertilizer	Sulphur fertilizer
Yield reduction (for higher dose user)	10.2	9.0	12.4	17.0
Lack of capital (for lower dose user)	6.2	6.2	5.7	13.0
Not convinced	4.5	6.2	10.7	13.6
Unavailability of quality fertilizer	-	4.5	2.8	2.8

DISCUSSION

The findings in this study highlight the effectiveness of the use of the community training for rice technology adoption. The study revealed the community training approach as the potential to adopt technologies by trained farmers. The approach could be promoted by extension providers. Conducting training in the community environment with integrated training method, the retention of the message was increased due to reinforcement that resulted in a higher rate of adoption of rice production technologies. Shanthy and Thiagarajan (2011) also revealed that by supplementing the traditional teaching environment with multimedia, the retention of the message was increased.

Training environment and trainees

Conducting training in the farmers' community environment, selecting trainees through existing farmers' group of a community and creating an opportunity to interact and exercise the practical skill by themselves within groups proved an effective way to mobilize farmers. The success of group activities observed in the present study reinforces earlier findings by Mungala and Chavangi (1996), Davis et al. (2004) and Kiptot et al. (2006) that groups are effective entry points to an extension in communities.

In the present study, the sampled farmers were mostly of middle aged. Age determines to some extent how productively an individual is carrying out agricultural activities. According to Kartasapoetra (1996), it is difficult to change the ways of thinking, working, and life by older farmers.

Technologies and training

The extent of adoption of technology is influenced by the attributes of technology, characters of adopters and extension providers and the socioeconomic, biological, and physical environment in which the technology take place (Cruz, 1987). The study

confirms that the community training combining with multiple methods are best suited to adopt rice production technologies especially easy to adopt, similar or less cost involvement and perceived higher yield and income as compared to the technologies which have higher cost involvement such as cost for higher input use or requirement of higher labour and with risk for reduction of rice yield. This is supported by the findings of Lukuyu et al. (2012) and Hossain et al. (2001). A portion of participants was not convinced to adopt some technologies like row transplanting, skipped row planting for seed production and birds perch for controlling insects, especially rice stem borer and rice leaf roller, use of appropriate K and S fertilizers. The farmers of the study area were reluctant to use their own seeds of high yielding rice varieties which might discourage to adopt this technology. Ngoc Chi and Yamada (2002) reported that the weak belief on ensuring a high yield of new technology limited the adoption of technology. Sewell et al. (2017) mentioned that barriers to learning and adoption of new technologies included issues of trialability, complexity, compatibility, and risk.

Community training might not be considered alone for adopting all sorts of crop production technologies. The crop production practices required higher farmers' confidence to adopt, the risk involved and costly have to be integrated with other extension methods such as result demonstration, field days and exposure visits and backstopping from extension personnel. McDonald et al. (2016) reported that the decision of technology adoption primarily motivated by financial considerations and were closely related to the perception of usefulness and ease-of-use of a technology.

Sustainability of the community training

Farmers' training in a distant place decreases the interest of the trainees which is further constrained by the transportation problem (Lukuyu et al., 2012). Conducting training at the real farming environment creates an opportunity to solve this problem. As female farmers have lots of on-farm and off-farm activities, they feel comfortable in their community and can join other activities just after finishing their training at the community level. The remarkable acceptance and adoption of improved rice production technologies by the farmers improve the productivity of rice and thus a significant increase in annual income, food consumption, expenditure, housing, environment and family status of the framers (Salehin et al., 2009).

CONCLUSION

The results indicate that the higher rate of technology adopters obtained higher grain yield. Therefore, informal need-based rice production training at the community level could be scaled out for successful technology adoption.

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SCENARIO OF INSECT PESTS, PREDATORS AND POLLINATORS ASSOCIATED WITH CROP PLANTS IN AN AGROFORESTRY IN BANGLADESH

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ABSTRACT

The abundance of insect pests, predators and pollinators and status of pest insects associated with citrus, mango and pineapple crops grown in an agroforestry in Bangladesh was studied during July 2015 to June 2016. Twenty five species of insects belonging to 19 families in 5 orders were found as pest of citrus and their relative abundance varied from 2.4 to 13.4%. Among the citrus pests, green leaf hopper was most abundant, but whitefly, mealy bug, lemon butterfly and leaf minor were found as major pests. Fifteen species of insects under 13 families in 6 orders were found as pests of mango and their relative abundance varied from 0.5 to 82.6%, and hopper and fruit fly were found as major pests. Four species of insects belonging to 4 families in 3 orders were found as pest of pineapple and their relative abundance varied from 12.2 to 44.9%, and all were found as minor pests. There were 20 species of predator insects belonging to 13 families in 6 orders and their abundance ranged from 0.8 to 2.5/ 40 sweeps. In total 19 species of insects belonging to 12 families in 4 orders were found as pollinators and their abundance varied from 1.7 to 5.1/40 sweeps. The ants and honeybees were most abundant as predators and pollinators, respectively.

Keywords: Agroforestry, Abundance, Insect Species, Citrus, Mango, Pineapple

INTRODUCTION

Bangladesh is a subtropical country having an area of 147570 km^2 with 160.2 million people. Agriculture has an overwhelming impact on the economy of the nation and has made significant progress in boosting national food production. However, a large part of the population still lacks access to sufficient, safe, and nutritious food. Arable land and forest areas in Bangladesh are reducing day by day due to demographic

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pressure, urbanization and industrialization. To accelerate crop production and conservation of nature, the concept of agrofrorestry has become popular here in the recent decades.

Agroforsetry is an agricultural system comprising diversity of plants, pests, predators and pollinators which are linked to crop productivity. Intensive agricultural system creates disturbance of the natural habitats, and affects species richness, abundance and community structure (Debinski and Holt, 2000). That is why the cultivated areas in Bangladesh are gaining interest for conserving tropical biodiversity.

The diversity of crop species in the agroforestry provides a variety of resources like shelter and food for predators and pollinators. The heterogeneity of the habitat in the agroforestry area thus alters the quality and quantity of bio-resources and regulates ecological niches of various species in the community (Bugg and Waddington, 1994). The composition of an agroforestry system influences its microclimatic factors such as temperature, relative humidity, light intensity, precipitation, wind, carbon dioxide and water vapor thereby affecting on the diversity and abundance of insect species (Dwivedi et al., 2003; Anitha et al., 2009).

Mango, pineapple and citrus are popular fruits in Bangladesh and these crops are widely grown throughout the country. In the agroforestry system, pineapple, citrus and mango are cultivated as lower, middle and upper storied crop, respectively, but there is limited information regarding insect abundance and their nature of interactions with these crops. Therefore, in the present study, the abundance of insect pests, predators and pollinators, status of insect pests associated with citrus, mango and pineapple were taken into investigation.

MATERIALS AND METHODS

Study site and condition

The study was conducted in the agroforestry field laboratory of Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU) at Gazipur (25°25′ North latitude and 89°5′ East longitude) in Bangladesh during July 2015 to June 2016. The study site is surrounded by sal (*Shorea robusta)* forest. The climate of this area is characterized as dry during February to May, rainy from June to September, and cold from December to January. Annual mean maximum and minimum temperatures are 36.0^{o}C and 12.7^{o}C, respectively, with 65.8% relative humidity and 237.6 cm rainfall. The agroforestry system is marked by different management intensity, grasslands, rice, fruit and vegetable crops. The area of the agroforestry is 2205 m^2, and occupied by citrus, pineapple and 45 mango trees (variety Amrapali); each 11 years old, 3-4 m high and 7m apart.

Insect collection and identification

The free-living insects on citrus, pineapple and mango plants were collected during the day using a 30 cm diameter sweep net having 1.5 mm mesh and attached with a

2.0 m long rod. Sweeping was done in between 10.00 and 11.30 hour of the day every two weeks interval and each sample consisted of 40 sweeps, encompassing an area from ground level to the top of the trees. Small and immobile insects were observed by collecting infested leaves. The collected insects and leaves were brought from the experiment field to the Entomology Laboratory of BSMRAU for counting total catch. The insects were killed by storing in a freezer for one night, then mounted on points and dried and morphotyped. During each sampling, sessile insects were observed and identified using hand lens on 40 leaves of each crop. Insects were identified by observing their morphological characteristics, compared with museum specimens and with photographs to species or genus level and also separated as pest, predator and pollinator.

Assessment of pest status

During insect collection, leaf, flower and fruit of citrus, mango and pineapple were observed for infestation (%) of different insect pests. Insects those caused less than 10% infestation were categorized as minor pest, while those with 10% or above infestation were categorized as major pests.

Calculation of relative abundance and statistical analysis

Relative abundance (%) of the pest species of citrus, mango and pineapple was calculated using the following formula.

$$\text{Abundance (\%)} = \frac{\text{Total number of individual of a species}}{\text{Total number of individual of different species}} \times 100$$

One way analysis of variance (ANOVA) followed by Tukey post hoc statistics was employed for analyzing the data of the predator and pollinator species. All the analyses were performed using IBM SPSS 21.0. (IBM SPSS statistics 21, Georgia, USA).

RESULTS AND DISCUSSION

In total 25 species of insects belonging to 19 families in 5 orders (Isoptera, Thysanoptera, Hemiptera, Lepidoptera and Diptera) were found as pest of citrus (Table 1). Their relative abundance varied from 2.4 to 13.4%, and green leaf hopper was most abundant (13.4%) followed by mealy bug (9.3%), leaf miner (8.6%), fruit fly (7.4%) and lemon butter fly (7.2%). The percent abundance of the other insects was less than 5.0%. Among the insects, white fly, mealy bug, lemon butterfly and leaf minor were found as major pest as they caused more than 10% infestation, and the other insects were found as minor pest because their infestation level was less than 10%.

Table 1. Taxonomic profile, comparative abundance and status of pest insects associated with citrus plant in the agroforestry area during July 2015 to June 2016

Name	Taxonomic profile	Abundance (%)	Status
Termite	*Odontotermes obesus* Ramber (Isoptera: Termitidae)	4.5	Minor
Thrips	*Scirtothrips citri* Moulton (Thysanoptera: Thripidae)	4.8	Minor
White fly	*Dialeurodes citri* Ashmead (Hemiptera: Aleyrodidae)	5.3	Major
Black fly	*Aleurocanthus woglumi* Ashby (Hemiptera: Aleyrodidae)	2.6	Minor
Black aphid	*Toxoptera aurantii* Boyer De Fonscolombe (Hemiptera: Aphididae)	4.3	Minor
Scale insect	*Ceroplastes destructor* Newstead (Hemiptera: Coccidae) *Aonidiella aurantii* Maskell (Hemiptera: Diaspididae) *Aonidiella citrina* Coquillett (Hemiptera: Diaspididae) *Icerya purchase* Maskell (Hemiptera: Margarodidae)	5.0 - - -	Minor
Mealy bug	*Planococcus citri* Risso (Hemiptera: Pseudococcidae) *Pseudococcus citriculus* Green (Hemiptera: Pseudococcidae) *Pseudococcus filamentosus* Cockrell (Hemiptera: Pseudococcidae)	9.3 - -	Major
Spined bug	*Biprorulus bibax* Breddin (Hemiptera: Pentatomidae)	2.6	Minor
Citrus psyllid	*Diaphorina citri* Kuwayama (Hemiptera: Psyllidae)	4. 8	Minor
Green leaf hopper	*Empoasca citrusa* Theron (Hemiptera: Cicadellidae)	13.4	Minor
Leaf-footed bug	*Leptoglossus phyllopus* Linnaeus (Hemiptera: Coreidae)	2.6	Minor
Green stink bug	*Rhynchocorris humeralis* Thunberg (Hemiptera: Pentatomidae)	4.1	Minor
Bark-eating borer	*Indrabela quadrinotata* Walker (Lepidoptera: Metarbelidae)	2.6	Minor

Name	Taxonomic profile	Abundance (%)	Status
Fruit piercing moth	*Othreis cjeta* Cramer (Lepidoptera: Noctuidae)	3.4	Minor
Lemon butterfly	*Papilio demoleus* Linnaeus (Lepidoptera: Papilionidae)	7.2	Major
Swallow tail butter fly	*Papilio polytis* Linnaeus (Lepidoptera: Papilionidae)	2.6	Minor
Leaf miner	*Phyllocnistis citrella* Stainton (Lepidoptera: Gracillaridae**)**	8.6	Major
Flower moth	*Prays citri* Milliere (Lepidoptera: Yponomeutidae)	2.4	Minor
Rrind borer	*Prays endocarpa* Meyrick (Lepidoptera: Yponomeutidae)	2.4	Minor
Fruit fly	*Bactrocera dorsalis* Hendel (Diptera: Tephritidae)	7.4	Minor

Fifteen species of insects under 13 families in 6 orders (Isoptera, Thysanoptera, Hemiptera, Coleoptera, Lepidoptera and Diptera) were found as pest of mango (Table 2). Their relative abundance varied from 0.5 to 82.6%, and mango hopper was the most abundant (82.6%) followed by fruit fly (8.0%). The mango hopper and fruit fly were found as major pest because their infestation level was more than 10%.

Table 2. Taxonomic profile, comparative abundance and status of pest insects associated with mango plant in the agroforestry area during July 2015 to June 2016

Name	Taxonomic profile	Abundance (%)	Status
Termite	*Odontotermes obesus* Ramber (Isoptera: Termitidae)	0.72	Minor
Thrips	*Thrips hawaiiensis* Morgan (Thysanoptera: Thripidae)	0.8	Minor
Hopper	*Idioscopus clypealis* Lethierry (Hemiptera: Cicadellidae)	82.6	Major
	Idioscopus niveosparus Lethierry (Hemiptera: Cicadellidae)	-	
	Amritodus atkinsoni Lethierry (Hemiptera: Cicadellidae)	-	
Mealy bug	*Rostrococcus iceryoides* Green (Hemiptera: Pseudococcidae)	1.5	Minor

Name	Taxonomic profile	Abundance (%)	Status
Scale insect	*Aulacaspis tubercularis* Newstead (Hemiptera: Coccidae)	0.5	Minor
Stem borer	*Bactocera rufomaculata* De Geer (Coleoptera: Cerambycidae)	0.8	Minor
Stone weevil	*Sternochaetus mangiferae* Fabricius (Coleoptera: Curculionidae)	0.9	Minor
Mango defoliator	*Cricula trifenestrata* Helfer (Lepidoptera: Saturniidae)	0.9	Minor
Bark eating caterpillar	*Indarbella quadrinotata* Walker (Lepidoptera: Noctuidae)	0.7	Minor
Leaf webber	*Orthaga exvinacea* Hampson (Lepidoptera: Pyralidae)	1.0	Minor
Leaf eating caterpillar	*Euthalia garuda* Moore (Lepidoptera: Nymphalidae)	1.1	Minor
Fruit fly	*Daucas dorsalis* Hendel (Diptera: Tephritidae)	8.0	Major
Leaf gall	*Procontarinia matteiana* Kieffer & Cecconi (Diptera: Cecidomyiidae)	0.5	Minor

Table 3 showed that four species of insects belonging to 4 families were found as pest of pineapple. Their relative abundance varied from 12.2 to 44.9%, and the mealy bug was most abundant followed by fruit borer, black spot beetle and midget. The infestation levels of the insect species were less than 10% and all of them were termed as minor pest.

Table 3. Taxonomic profile, comparative abundance and status of pest insects associated with pineapple plant in the agroforestry area during July 2015 to June 2016

Name	Taxonomic profile	Abundance (%)	Status
Mealy bug	*Dysmicoccus brevipes* Cockerell (Hemiptera: Pseudococcidae)	44.9	Minor
Black spot beetle	*Metamasius dimidiatipennis* Jekel (Coleoptera:Curculionidae)	18.4	Minor
Fruit borer	*Strymon basilides* Geyer (Lepidoptera: Lycaenidae)	24.5	Minor
Midget	*Elaphria nucicolora* Guenee (Lepidoptera: Noctuidae)	12.2	Minor

In the agroforestry system multistoried crop plants act as secure habitat for pest, predator and pollinator insects. In the studied agroforestry area, Hemiptoriod insects were most abundant on different crops. The results agreed with Amin et al. (2015) who studied the insect abundance and diversity in a mango based agroforestry in Bangladesh and found that the Hemiptera were most abundant (59.8%). Namni et al. (2017) observed the highest abundance of hopper compared to other insects in a mango based agroforestry.

Table 4. Taxonomic profile of predator insects and their abundance in the agroforestry area during July 2015 to June 2016

Predator insect	Taxonomic profile	Abundance
Preying mantid	*Mantis religiosa* Linnaeus (Dictyoptera: Mantidae)	0.8 c
Dragon fly	*Aeshna verticalis* Hagen (Odonata: Aeshnidae)	1.6 ab
	Stylurus notatus Rambur (Odonata:Gomphidae)	-
	Orthetrum glaucum Brauer (Odonata:Libellulidae)	-
Damsel fly	*Coenagrion sp.* Kirby (Odonata: Coenagrionidae)	1.2 ab
	Lestes vidua Hagen (Odonata:Lestidae)	-
Assassin bug	*Rhinocoris segmentarius* Germar (Hemiptera: Reduviidae)	1.0 bc
	Sinea diadema Fabricius (Hemiptera: Reduviidae)	-
Pirate bug	*Orius insidiosus* Say (Hemiptera: Anthocoridae)	0.8 c
Lady bird beetle	*Coccinella septempunctata* Linnaeus (Coleoptera: Coccinellidae)	2.2 ab
	Coccinella transversalis Fabricius (Coleoptera: Coccinellidae)	-
	Menochilus sexmaculatus Fabricius (Coleoptera: Coccinellidae)	-
Ground beetle	*Calosoma scrutator* Fabricius (Coleoptera: Carabidae)	1.2 bc
Tiger beetle	*Cicindela ocellata* Klug (Coleoptera: Carabidae)	1.3 ab
Ant	*Formica rubra* Linnaeus (Hymenoptera: Formicidae)	2.5 a
	Camponotus compressus Fabricius (Hymenoptera: Formicidae)	-
	Solenopsis geminata Fabricius (Hymenoptera: Formicidae)	-
Wasp	*Polistes dominula* Christ (Hymenoptera: Vespidae)	0.8 c
	Vespula vulgaris Linnaeus (Hymenoptera: Vespidae)	-
Green lace wing	*Chrysoperla carnea* Stephens (Neuroptera: Chrysopidae)	1.1 bc

The findings indicated that the Hemipteroid pests were perhaps dominant on citrus, mango and pineapple during cooler and dry season. Our findings were in concurrence with Kaushik et al. (2012) and Kannan and Rao (2000) who observed significant abundance of hopper on mango plants. The plant species diversity in the agroforestry may have influenced the survival and abundance of insects by modifying the microclimate (Ram et al., 1989). Ram et al. (1989) reported that crop species sometimes create favorable conditions for pest incidence and damage.

There were 20 species of predator insects (Table 4) belonging to 13 families. Their abundance ranged from 0.8 to 2.5/40 sweeps and the results differed significantly ($p<0.01$). The ants were most abundant followed by lady bird beetle, dragon fly, tiger beetle, ground beetle, damsel fly, green lacewing and assassin bug. The preying mantid, pirate bug and wasp had statistically similar and lowest abundance. This finding agreed with Amin et al. (2015) who reported that ants had highest abundance compared to others in a mango based agroforestry in Bangladesh.

Data expressed as mean and means per insect group are taken from 40 sweeps per total collection. Means within a column followed by same letter(s) are not significantly different (DMRT, $P\leq0.05$). Dashes indicate no information

Nineteen species of insects under 12 families in 4 orders (Coleoptera, Lepidoptera, Hymenoptera and Diptera) were found as pollinators (Table 5). Their abundance varied from 1.7 to 5.1/40 sweeps and the results differed significantly ($p<0.001$). Honey bee and horse fly showed the highest and lowest abundance, respectively. Amin et al. (2015) found 8 species of insects belonging to 7 families in 3 orders as pollinator in a mango based agroforestry area in Bangladesh. Fajardo et al. (2008) reported 21 species in five orders as insect pollinators of mango in Philippines. Sung et al. (2006) found 39 insect species as pollinators of mango in Southern Taiwan. Uddin et al. (2012) observed five species of insects in the order Diptera and Hymenoptera as pollinator of mango in Bangladesh.

Table 5. Taxonomic profile of pollinator insects along with their abundance in the agroforestry area during July 2015 to June 2016

Insect pollinator	Taxonomic profile	Abundance
Epilachna beetle	*Epilachna dodecastigma* Wied (Coleoptera: Coccinellidae)	2.6 be
	Epilachna vigintioctopunctata Fabricius (Coleoptera: Coccinellidae)	-
Red pumpkin beetle	*Aulacophora foveicollis* Lucas (Coleoptera: Galerucidae)	2.7 be
Lemon butterfly	*Papilio demoleus* Linnaeus (Lepidoptera: Papilionidae)	3.7 ad
Swallow tail	*Papilio polytis* Linnaeus (Lepidoptera: Papilionidae)	2.5 be

Insect pollinator	Taxonomic profile	Abundance
butter fly		
Four footed butter fly	*Junonia sp.* Hubner (Lepidoptera: Nymphalidae)	2.2 de
Monarch butterfly	*Danus plexippus* Linnaeus (Lepidoptera: Nymphalidae)	1.9 de
Sulphur butter fly	*Colias eurytheme* Boisduval (Lepidoptera: Pieridae)	4.1 ac
Honey bee	*Apis mellifera* Linnaeus (Hymenoptera: Apidae)	5.1 a
	Apis cerana Fabricius (Hymenoptera: Apidae)	-
	Apis dorsata Fabricius (Hymenoptera: Apidae)	-
Carpenter bee	*Xylocopa pubescens* Spinola (Hymenoptera: Apidae)	2.6 be
Wasp	*Polistes dominula* Christ (Hymenoptera: Vespidae)	1.9 de
	Vespula vulgaris Linnaeus (Hymenoptera: Vespidae)	-
House fly	*Musca domestica* Linnaeus (Diptera: Muscidae)	2.9 be
Horse fly	*Tabanus sp.* Linnaeus (Diptera: Tabanidae)	1.7 e
Blow fly	*Calliphora erythrocephala* Meigen (Diptera: Calliphoridae)	2.6 be
Syrphid fly	*Syrphid sp*. Linnaeus (Diptera: Syrphidae)	4.3 ab
Fruit fly	*Bactrocera dorsalis* Hendel (Diptera: Tephritidae)	2.3 ce

Data expressed as mean and means per insect group are taken from 40 sweeps per total collection. Means within a column followed by same letter(s) are not significantly different (DMRT, $P \leq 0.05$). Dashes indicate no information.

The variation of the insect species abundance among pest, predator and pollinator in different countries and different regions of a country is due to climatic conditions, host plants and habitat management. In the present study, relative abundance of the insect pest species on citrus, mango and pineapple showed variation, and the abundance of predator and pollinator insect species also differed significantly. The predator and pollinator insects may have got secure habitat because of the presence of different plant species in the agroforestry system and they showed adequate abundance. Expansion of agroforestry technology could provide habitat for restoration of the beneficial insects, but information on the abundance and damage threshold of the insect pest species is very important prior to expand this technology in any locality (Epila, 1988). So, plant species combinations must be on the basis of least favorable conditions for the survival and multiplication of major pest species.

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PHYLOGENETIC ANALYSIS OF BLACK BENGAL AND JAMUNAPARI GOATS IN BANGLADESH BASED ON PARTIAL SEQUENCE OF *CYTOCHROME B* GENE

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ABSTRACT

Goats, among the livestock species, are considered the most prolific ruminant especially under callous climatic conditions. The aim of the present study was to depict the current phylogenetic status and genetic diversities of Black Bengal (BBG) and *Jamunapari* goat of Bangladesh and the world. *Cytochrome b (cytb)* gene (1140 bp) of mitochondrial DNA of Black Bengal goats (*Capra hircus*) was amplified by Polymerase Chain Reaction (PCR) for the first time in Bangladesh. The sequence from BBG had no nucleotide (nt) difference and 100% homology with the BBG (*C. hircus*) of India and also the goats (*C. hircus*) from China (Yangtze River Delta White Goat), Thailand (Wild Cervidae), Japan (Bezoar goat) and South Africa (Domestic goat). The sequence had 1-5 nt differences and 99% homology with the goats (*C. hircus*) from China, Thailand and Japan (other goats), and also with the goats (*C. hircus*) from Malaysia, South Korea, France, Italy, Pakistan, Slovenia, Switzerland and USA. Phylogenetic tree constructed with Black Bengal Goat (BBG-K-2) and *Jamunapari* goats (SG-1) of Bangladesh with cytochrome b nucleotide sequences were closely related to China-HM7. China-YP xj46, Pakistan-Lineage C1, Pakistan-Lineage C2, Slovenia-ChSo1, Switzerland-ChTo2992 and shared 98.8% to 99% and 98.3% to 98.6% similarity, respectively and 1-1.2% and 1.4 to 1.7% genetic distance, respectively. Based on Ctb gene Sequence collected from Bangladeshi Black Bengal Goats (BBG-K-2) and Jamunapari goats (SG-1) that were closely related and shared with the same genetic lineage of China HM18 and India-BBG-DQ073048, respectively, suggesting a common origin.

Keywords: Domestic Goats, Genetic Diversity, mtDNA, cytb Gene, Phylogenetic Analysis

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INTRODUCTION

Archaeological evidences indicated that goats were the first ruminant animal to be domesticated 10,500 years ago around the Fertile Crescent (Fernández et al., 2006; Zeder, 2008). There were two suggested wild species of the genus *Capra* (*C. aegagrus* and *C. falconari*), with the closest candidate *C. aegagrus*, which domestic goat gene pool was derived from (Mannen et al., 2001). Analyses of the control region (the displacement-loop) of mitochondrial DNA (mtDNA) and nuclear DNA are most useful examinations and are informative genomic elements for explicating the origin, diversity, genetic relationship and diversification of livestock including goat (Dorji et al., 2010).

In Bangladesh, the rearing of goats is a profitable household enterprise for rural populations due to the animal's prolific breeding potential, survivability and consumption of locally collected feed (Islam et al., 2011). Economy of Bangladesh is mainly driven by agricultural product and livestock is the most viable sector. Livestock is contributing about 2.73% of overall Gross Domestic Products (GDP) and 4.31% export earnings from leather and leather goods of total export, 20% of the population is directly and 50% is partly dependent on this sector (Draft Sixth Five Year Plan, 2010). Goat (66.6 million) and Sheep (29.1 million) in Bangladesh have valuable contributions to the economy of the country (DLS, 2018).

Recently, molecular studies of goats based on mitochondrial DNA (mtDNA) sequences have been carried out to investigate the origin and phylogeny of goats (Mannen et al., 2001). Mitochondrial DNA is very useful for its multiple presences in cells. The most of animal mtDNA is coding 37 genes (Avise, 1994). One of them, *Cytochrome b* (*Cyt b*) is one of the genes encoded by mitochondrial deoxyribonucleic acid (mtDNA). The mtDNA sequence has been used extensively in the study of genetic evolution because it is easy to obtain, has a high value in evolution, and generally follows a pattern of inheritance compatible with phylogenetic reconstruction (Jain et al., 2007). The uniqueness of *Cyt b* is one of the protein-coding genes involved in the transport of electrons in the respiratory chain; it can be determined as a target for evolutionary analysis and species identification, particularly useful for comparing species within the same genus or the same family and also can be used to study genetic diversity through mtDNA sequences (Manceau et al., 1999; Castresana, 2001; Mohammadi et al., 2018). Amino acid sequence on *Cyt b* gene can be used to clarify Kejobong goat phylogenetic status among several Asian local goats (Lestari et al., 2018).

Characterize and molecular sequencing of *Cytochrome b* gene of Mitochondrial DNA in Bangladeshi goat genome was evident in our previous endeavor (Chowdhury et al., 2011). The present study was investigated to current phylogenetic status and genetic diversities of *Black Bengal* and *Jamnapari* goat of Bangladesh and the world in order to understand the genetic basis of this breed.

MATREIALS AND METHODS

Breed selection

There were two different local breeds *Black Bengal* and *Jamnapari* goats of Bangladesh selected for this research study.

Study area

This study was conducted in three different goat farms located in semi-urban area of Savar region of Dhaka and Khulna for Black Bengal goats, Gazipur area for *Jamnapari* goats in Bangladesh during the period 2010 to 2011. Three goat farms are designated as farm code A, B, and C. The samples were collected from the three goats of selected farms and brought to the Department of Microbiology and Hygiene, Bangladesh Agricultural University, for laboratory analysis.

Sample collection

A total of 3 blood samples from individual goats of 2.5 years of age were collected from jugular vein each from three selected goat farms. Blood samples of *Black Bengal* goat were taken from Khulna (BBG-K-2), Dhaka and Jamunapari goats from Sardagonj of Gazipur (SG-1) area of Bangladesh. All blood samples (5ml in EDTA Containing tubes) were aseptically collected and stored at -20°C until used at Microbiology laboratory. The goat samples were unrelated genetically based on the information of the owners and local breeding data. Processing of blood samples was followed by Chowdhury et al. (2011).

DNA extraction, amplification, and sequencing of *cyt b* gene

DNA was extracted from whole blood using the method as described by Chowdhury et al (2011) for sequence analysis *Cyt b* gene in mtDNA. All DNA samples were brought to the final concentration of 50 ng/µL and stored at -80°C. The forward primer (5′-ATG ACC AAC ATC CGA AAG ACC C-3′ (nt 1-22)) and reverse primer (5′-TCT TCA TTT TAG AAG GTT GTT TCC-3′ (nt 1140-1117) that generated 1140 bp polymerase chain reaction (PCR) product were used to amplify 1140 bp of *Cytb* gene as described by Takada et al (1997) and Chowdhury et al (2011).

Sequence Alignment and identification

Partial sequences, obtained using forward and reverse primers of mtDNA *Cyt b* sequences were combined to full length sequences (420 bp for Black Bengal) via the SeqMan Genome Assembler (DNAstar, USA) and were compared to the Gene Bank database of the National Center for Biotechnology Information (NCBI) (http://www.ncbi.nlm.nih.gov/GenBank) by means of the basic local alignment search tool (BLAST) to identify close phylogenetic relatives. The nucleotide sequences then were translated into amino acids form by mitochondrial vertebrate genetic code. All mtDNA *Cyt b* sequences were analyzed using Molecular Evolutionary Genetics Analysis 6 program (Tamura et al., 2013) and aligned by ClustalW (Thompson et al., 1994).

Partial *cyt b* gene sequence (N-terminal part) of mtDNA of *Jamnapari* goat from Gazipur was published (Chowdhury et al., 2011). Based on the resulted partial *cyt b* gene sequence (N-terminal part) of mitochondrial DNA of *Black Bengal* goat (Bangladesh-BBG-K-2) of Khulna district, similar sized sequence was taken from that of *Jamnapari* goat (Bangladesh-*Jamnapari*-SG) and that of 42 other goats of different countries from Gene Bank Databases. Multiple alignment was carried out using Lasergene MgAlign program of DNASTAR Software (http://www.dnastar.com, Product Key: NXRAY-GQ8NJ-EKJW7). Sequence distances were obtained using MgAlign Distance ClustalW.

Construction of Phylogenetic tree

The multiple sequence alignment of the retrieved reference sequences from NCBI, EMBL or DDBJ and representative isolates' sequences were performed with the ClustalW (Larkin, Blackshields et al., 2007) software. Aligned sequences were exported to the GeneDoc software for sequence trimming and conserved region identification. Refined sequences were further exported to the Molecular Evolutionary Genetic Analysis (MEGA) (Tamura and Dudley, 2007) software for phylogenetic tree construction using the Neighbor joining algorithm and selecting 1000 bootstrap replication. Further analysis of the genes was carried out using the Distance and Pattern analysis tool in the MEGA software. The phylogenetic tree was inferred using the Neighbor-Joining method (Saitou and Nei, 1987). A bootstrap consensus tree was inferred from 1000 replicates (Felsenstein, 1985).

Nucleotide sequence accession numbers

The partial mtDNA Cytochrome B gene sequences obtained in this study have been deposited in the GenBank database under the accession numbers MN066604 for Black Bengal goat (BBG-K-2) and MN066605 for Jamunapari goat (SG-1). The mtDNA *Cytb gene* sequences were displayed within the phylogenetic tree and the accession numbers are listed in Table 1. Isolates name have been abbreviated using the following format: country/organization/location/isolate no.

Table 1. List of *Cyt b gene* sequences of goats used in phylogenetic analysis

Serial no.	Goat Species	Country	Accession No.
1.	Capra hircus (Isolate: BBG-K-2)	Bangladesh	MN066604
2.	Capra hircus (Isolate: SG-1)	Bangladesh	MN066605
3.	Capra hircus (Isolate:D-LK18)	China	GU229281
4.	Capra hircus (Isolate: G32, breed: Yangtze River Delta White Goat)	China	EU130773
5.	Capra hircus (Isolate: G45, breed: Yangtze River Delta White Goat)	China	EU130774
6.	Capra hircus (Isolate: HM7, breed:	China	EU130780

Serial no.	Goat Species	Country	Accession No.
	Yangtze River Delta White Goat)		
7.	Capra hircus (Isolate: HM13, breed: Yangtze River Delta White Goat)	China	EU130775
8.	C. hircus (Isolate: HM18, breed: Yangtze River Delta White Goat)	China	EU130776
9.	C. hircus (Specimen_voucher:YP xj46)	China	DQ089480
10.	C. cylindricornis (East caucasian tur)	France	AF034737
11.	C. caucasica (West caucasian tur)	France	AF034738
12.	C. ibex (Ibex)	France	AF034735
13.	C. falconeri (Markhor)	France	AF034736
14.	C. nubiana (Nubian ibex)	France	AF034740
15.	Capra hircus (Isolate: V07-146)	France	GU295658
16.	C. aegagrus (wild goat)	France	AF034739
17.	Capra hircus (breed: black Bengal)	India	DQ073048
18.	C. hircus	India	EF056502
19.	C. aegagrus cretica (subspecies-cretica)	Israel	AF217255
20.	Capra hircus (Strain- breed Baladi)	Israel	AF217254
21.	C. hircus	Italy	AF533441
22.	C. hircus	Japan	AB004073
23.	C. hircus	Japan	AB004074
24.	C. hircus	Japan	D84201
25.	C. hircus (Strain: Laos native, Isolate: Laos-1)	Japan	AB044307
26.	C. hircus (Strain : Laos native, Isolate: Laos-5)	Japan	AB044308
27.	C. falconeri (Markhor)	Japan	AB044309
28.	C. hircus (haplotype: ChMy50)	Malaysia	DQ514545
29.	C. hircus (Strain: Lineage C1)	Pakistan	AB110594
30.	C. hircus (Strain: Lineage C2)	Pakistan	AB110595
31.	C. hircus (Strain: Lineage D1)	Pakistan	AB110596
32.	C. hircus (Strain: Lineage D2)	Pakistan	AB110597
33.	C. aegagrus blythi (Strain: Sindh Ibex 1)	Pakistan	AB110592
34.	C. aegagrus blythi (Strain: Sindh Ibex 2)	Pakistan	AB110593

Serial no.	Goat Species	Country	Accession No.
35.	C. hircus (haplotype ChGr642)	South Africa	DQ514544
36.	Capra hircus (Isolate: a-105)	South Korea	EU259119
37.	Capra hircus (Isolate: b-109)	South Korea	EU259120
38.	Capra hircus (Isolate: e-139)	South Korea	EU259132
39.	C. hircus (haplotype: ChSo1)	Slovenia	DQ514547
40.	C. hircus (haplotype: ChTo2992)	Switzerland	DQ514548
41.	Capra hircus (Isolate:Goat01)	Thailand	FJ556564
42.	Capra hircus (Isolate:Goat03)	Thailand	FJ556557
43.	C. hircus	USA	X56289
44.	C. aegagrus (wild goat)	Japan	AB004069

RESULTS AND DISCUSSION

We analyzed cytochrome b sequences to identify Bangladeshi goat phylogeny as well as to discern the genetic diversity of goat breeds/populations. Two different goat breeds, *Black Bengal* (MN066604) and *Jamunapari* (MN066605) goats, were detected in Bangladesh. Two sequencing reactions (forward and reverse) for each sample gave 606 bp sequence for a *Jamunapari* goat (Chowdhury et al., 2011) and 420 bp sequence (Fig. 1) for a BBG from Khulna those after analysis were confirmed as partial cyt b gene sequence (N-terminal part) of goat mtDNA. Nuclcotide (nt) differences and percentage homologies of the genome fragment sequence (420 bp) of a BBG with the concerned sequences of goats of other countries are given in Table 1.

1 ATTGTAAACA ACGCATTTAT TGACCTCCCA ACCCCATCAA ACATCTCATC
ATGATGAAAC TTTGGATCCC TCCTAGGAAT TTGCCTAATC TTACAAATCC
TGACAGGCCT ATTCCTAGCA ATACACTATA CATCCGACAC AATAACAGCA
TTTTCCTCTG TAACTCACAT TTGTCGAGAT GTAAATTATG GCTGAATCAT
CCGATACATA CACGCAAACG GAGCATCAAT ATTCTTTATC TGCCTATTCA **420**
TACATATCGG ACGAGGTCTA TATTATGGAT CATATACCTT TCTAGAAACA
TGAAACATTG GAGTAATCCT CCTGCTCGCG ACAATGGCCA CAGCATTCAT
AGGCTATGTT TTACCATGAG GACAAATATC ATTTTGAGGG
GCAACAGTCA TCACTAATCT TCTTTCAGCA

Figure 1. Partial Cytochrome b (CYTB) gene sequence (420 bp, N-terminal part) of itochondrial DNA from a *Black Bengal* goat (*Capra hircus*) (Bangladesh-BBG-K-2) of Khulna district.

Phylogenic analysis of the *Cyt b* region of mtDNA has been used extensively to identify and characterize goat species, and investigate the molecular distribution of the goat worldwide (Lestari et al., 2018). mtDNA is an important tool for phylogenetic studies and has been widely used to study genetic differentiation, genetic complexity, evolutionary relationships and origins of many domestic animals

(Wilson et al., 1985; Carmela et al., 2000) including cattle (Loftus et al., 1994), buffalo (Babar et al., 2011a), sheep (Loehr et al., 2006) and goats (Joshi et al., 2004; Babar et al., 2011b). Sequence data from the BLRI isolates of different goat breeds in this study indicated that the two goat breeds existing during the period of 2010–2011 were closely related to native breeds of Bangladesh and surrounding countries.

Jamunapari (MN066605) and *Black Bengal* (MN066604) goats are compared with 22 different goat breeds from different countries by drawing phylogenetic (Table 2). The phylogeny tree shows two main clusters which in each cluster there were several subclusters (Fig. 3). Almost all of *Jamunapari* goats in this study were in the first cluster together with India, Pakistan, China, Japan, Thailand, Malaysia, Japan, France, S. Africa and BBG-K-2 goats, but some of them (S. Korea-a-105, S. Korea-b-109, S. Korea-e-139) formed separate subcluster with most of the other *Jamunapari* (MN066605) and *Black Bengal* (MN066604) goats. On the other hand, the second cluster was filled by goats from Israel, Italy, USA Switzerland, Slovenia, France, Japan, China and Pakistan. Two sequencing reactions (forward and reverse) for each sample gave 606 bp sequence for a *Jamunapari* goat (Chowdhury et al. 2011) and 420 bp sequence for a BBG from Khulna those after analysis were confirmed as partial cytb gene sequence (N-terminal part) of goat mitochondrial DNA. The sequence from BBG had no nucleotide (nt) difference and 100% homology with the BBG (*C. hircus*) of India and also the goats from China, Thailand, Japan and South Africa. The sequence had 1-5 nt differences and 99% homology with the goats from China, Thailand and Japan (other goats), and also with the goats from Malaysia, South Korea, France, Italy, Pakistan, Slovenia, Switzerland and USA. Same similarity (99%) with only 1 nt difference was found with a Japanese wild goat (Bezoar *C. aegagrus*), with 2 nt difference was found with a Bangladeshi *Jamunapari* (MN066605) goat , and with 3 nt difference was found with Israeli goats (*Capra hircus* and *C. aegagrus cretica*) (Table 2). The sequence had 12-13 nt difference (97% homology) with Sindh Ibex goats (*C. aegagrus blythi*) from Pakistan, and with other Indian goat (*C. hircus*). Sixteen nt difference (96% homology) was found with Markhor goats (*C. falconeri*) of Japan and France. Eighteen to 28 nt difference (96%-93% homology) was found (Table 2) with other goats of France (*C. caucasica*, *C. cylindricornis*, *C. aegagrus*, *C. nubiana* and *C. ibex*). This is possible because of geographical distance and distribution. Chowdhury *et al*., 2011 reported sequencing of Bangladeshi *Jamunapari* (MN066605) goat has unique at positions 17 and 21 containing G and G, respectively. For this reason, *Jamunapari* goat phenotypically has been showed more height, weight and milk production in relation to BBG of Bangladesh. In our present study, BBG of Bangladesh showed unique at positions 17 and 21 containing T and T, respectively, which may be considered as nucleotide markers of *Black Bengal* goats. Since these differences BBG gives at least triplet numbers of kid at six months interval of reproduction period.

Table 2. Nuclcotide (nt) differences and percentage homologies of the sequence (mitochondrial cytb gene partial sequence, 420 bp) of Black Bengal (Accession No.: MN066604) goat (BBG-K-2) with that of other goats

Serial no.	Accession No. /Identity	Country	No. of nt differences	Percentage homology (%)
1.	MN066605	Bangladesh	2	99
2.	GU229281	China	3	99
3.	EU130773	China	2	99
4.	EU130774	China	1	99
5.	EU130780	China	4	99
6.	EU130775	China	0	100
7.	EU130776	China	0	100
8.	DQ089480	China	5	99
9.	AF034737	France	21	95
10.	AF034738	France	18	96
11.	AF034735	France	28	93
12.	AF034736	France	16	96
13.	AF034740	France	27	94
14.	GU295658	France	1	99
15.	AF034739	France	21	95
16.	DQ073048	India	0	100
17.	EF056502	India	13	97
18.	AF217255	Israel	3	99
19.	AF217254	Israel	3	99
20.	AF533441	Italy	1	99
21.	AB004073	Japan	0	100
22.	AB004074	Japan	1	99
23.	D84201	Japan	5	99
24.	AB044307	Japan	0	100
25.	AB044308	Japan	1	99
26.	AB044309	Japan	16	96
27.	DQ514545	Malaysia	1	99
28.	AB110594	Pakistan	4	99
29.	AB110595	Pakistan	4	99
30.	AB110596	Pakistan	3	99

Serial no.	Accession No. /Identity	Country	No. of nt differences	Percentage homology (%)
31.	AB110597	Pakistan	2	99
32.	AB110592	Pakistan	12	97
33.	AB110593	Pakistan	12	97
34.	DQ514544	South Africa	0	100
35.	EU259119	South Korea	2	99
36.	EU259120	South Korea	1	99
37.	EU259132	South Korea	1	99
38.	DQ514547	Slovenia	4	99
39.	DQ514548	Switzerland	5	99
40.	FJ556564	Thailand	0	100
41.	FJ556557	Thailand	1	99
42.	X56289	USA	5	99
43.	AB004069	Japan	1	99

Our results were in general agreement with the pattern described in previous studies (Liu et al., 2007; Wang et al., 2008). From NCBI BLAST search of the GenBank, EMBL, DDBJ and PDB databases, no sequence of Jamunapari goat was available. However, unpublished Gene Bank sequences of cytochrome b gene of mitochondrial DNA of Black Bengal goats (BBG) in India (Accession nos. DQ093614 and DQ 073048) had only 3-4 nt differences (Table 2) with high homology (99%) with the present Jamunapari goat sequence (Chowdhury et al., 2011). Results of sequence analysis of cytochrome b gene of mitochondrial DNA revealed that China-HM13 were closely related to Black Bengal goat (BBG-K-2) of Bangladesh, China-HM18, Japan-AB004073, S. Korea-a-105, S. Korea-b-109, S. Korea-e-139, Thailand-Goat01, Japan-AB004069 and also shared 99.5% to 100% similarity at the nucleotide level. Significant divergence rates (0 to 0.5%) observed among the goats of above countries. Black Bengal Goat (MN066604) of Bangladesh showed that S. Korea-a-105, S. Korea-b-109, S. Korea-e-139, Japan-AB004069 with 99.5% to 99.8% identity were most closely related to BBG-K-2 collected from the Khulna area of Bangladesh. Moreover, it revealed that there was slight divergence (0.2% to 0.5%) of those countries (Fig. 2). Whereas analyses of cytochrome b gene sequences suggested that Jamunapari goats (SG-1) have maximum identity of 99.5% to 99.8%, and were most closely related to BBG-K-2, China-D-LK18, China-G32, China-HM13, China-HM18, India-BBG-DQ073048, Japan-AB004073, Japan-AB004074, Pakistan-Lineage D1, Pakistan-Lineage D2, S. Africa-ChGr642, S. Korea-a-105, S. Korea-b-109, S. Korea-e-139, Thailand-Goat01, Japan-AB004069 (Fig. 2). The slight divergence rate (0.5% to 1.2%) was also found (Fig. 3).

Genetic relationships of *Black Bengal* (MN066604) Goat (BBG-K-2) and *Jamunapari* (MN066605) goats (SG-1) of Bangladesh with cytochrome b nucleotide sequences were closely related to China-HM7, China-YP xj46, Pakistan-Lineage C1, Pakistan-Lineage C2, Slovenia- ChSo1, Switzerland-ChTo2992 and shared 98.8% to 99% and 98.3% to 98.6% similarity, respectively and 1-1.2% and 1.4 to 1.7% genetic distance (Fig. 2), respectively. China-HM7 showed 98.8% to 100% similarities with China-YP xj46, Pakistan-Lineage C1, Pakistan-Lineage C2, Slovenia- ChSo1, Switzerland-ChTo2992 and slight divergence rate (0% to 0.2%).

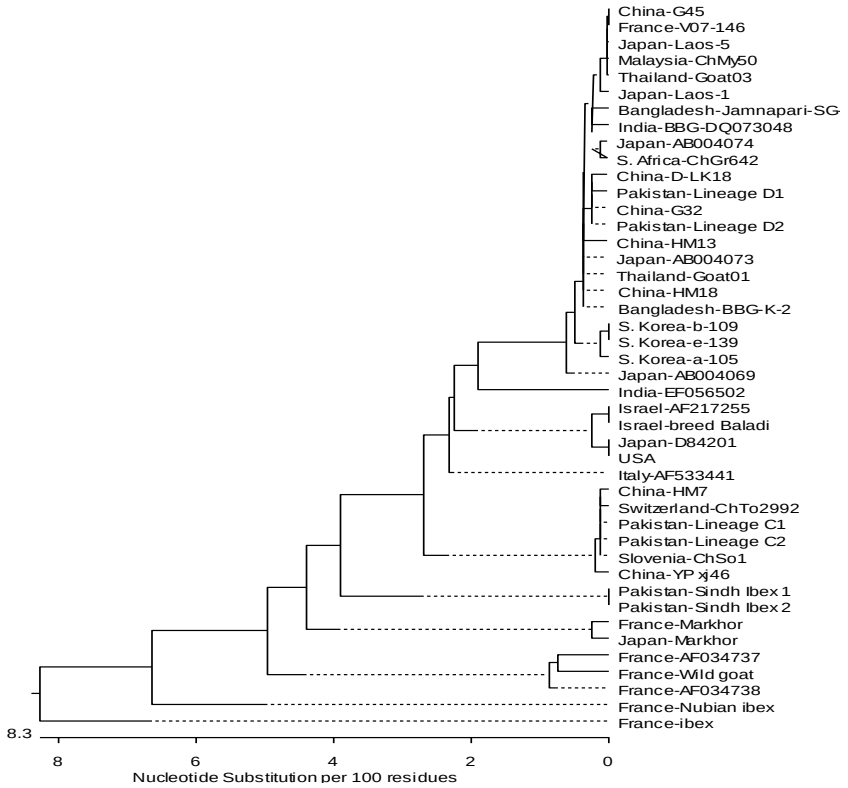

Figure 3. Phylogenetic tree showing the relationships of Black Bengal (BBG-K-2) and Jamunapari goats (SG-1) of Bangladesh with other goats based on partial cytochrome b gene (420 bp seq) sequence

There was 99% to 100% similarity observed for France-V07-146 and Japan-Laos-5 goat in relation to goats of Bangladesh-BBG-K-2, Bangladesh-Jamnapari-SG-1, China-D-LK18, China-G32, China-HM13, China-HM18, India-BBG-DQ073048, Japan-AB004073, Japan-AB004074, Japan-Laos-1, Malaysia-ChMy50, Pakistan-Lineage D1, Pakistan-Lineage D2, S. Africa-ChGr642, S. Korea-a-105, S. Korea-b-109, S. Korea-e-139, Thailand-Goat01, Thailand-Goat03, Japan-AB004069 and significant divergence rates (0% to 1%) observed. There was high divergence showed

(7.1% to 7.6% and 6.8% to 7.2%) from the sequencing of cytochrome b gene of France-ibex goat and France-Nubian ibex with Black Bengal Goat (BBG-K-2) and Jamnapari goats (SG-1) of Bangladesh (Fig. 2). Sequenced Cytb gene collected from Bangladeshi goat Black Bengal (BBG-K-2) were closely related and shared with the same genetic lineage of India (DQ073048), China HM18, respectively, suggesting a common origin whereas Bangladeshi Jamnapari goat (SG-1) showed 99.5% similarity with India (DQ073048) and BBG-K-2 (MN066604) of Bangladesh (Fig. 3).

CONCLUSIONS

Black Bengal and *Jamunapari* goats of Bangladesh have a close genetic relationship to several local goats in Southeast Asia. We speculated that gene flow among goat populations facilitated by the traditional seasonal pastoralism and annual long-distance migrations in history as well as trade would account for the pattern discerned in regional goat pools.

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Conflicts of interest

Authors have no financial and other conflicts of interest to declare.

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IMPROVEMENT IN ANAEROBIC GERMINATION POTENTIAL AND GRAIN YIELD OF RICE (ORYZA SATIVA) THROUGH SEED PRIMING

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ABSTRACT

A field experiment was conducted during the dry season of 2014 and 2015 at National Rice Research Institute (NRRI), Orissa, India, (20.5°N, 86°E, and 23.5 meters above mean sea level). Seed priming was employed to enhance the anaerobic germination potential in two near isogenic rice lines (IR64 and IR64-Sub1). Under natural field condition, oxygen concentration in floodwater never dropped to zero. It varied from 3.0 to 5.2 mg L^{-1}. Seed priming with calcium peroxide and seed soaking with water followed by sun drying showed greater beneficial effects as compared to potassium nitrate. Seed priming with sodium peroxide found deleterious. Cultivar IR64-Sub1 responded well due to seed priming as compared to cultivar IR64 under submergence. To improve anaerobic germination potential in rice, seed soaking with water followed by sun drying found economicalas compared to other methods of seed priming as this technique was not linked with additional investment in chemicals and was more environments friendly.

Keywords: Germination, Oxygen Deficiency Tolerance, Plant Stand, Rice, Seed Priming

INTRODUCTION

Rice is grown at different ecosystems starting from rainfed lowland flood prone to aerobic to irrigate ecology. Under irrigate ecology, transplanting is the main means of rice cultivation whereas under aerobic condition, direct seeding is the only way. Under rainfed lowland, both direct seeding and transplanting methods are followed. Direct seeding reduces the cost of cultivation under irrigated condition whereas in addition of reduction of cost of cultivation in rainfed lowland, it imparts robustness in seedlings enabling them to withstand complete submergence during flooding (Sarkar, 1998). Direct seeding has several advantages, yet it needs a paradigm shift in the process of cultivation to realize the full potential of the method (Mamun, 2014).

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Greater weeds menace, germination failure due to stagnation of water on soil surface vis-à-vis improper plant stand are some of the concern to adapt direct seeding practice of rice cultivation. Sowing of seeds on the surface of soil surface is too risky compared to seed sown below the soil surface. Problem of direct seeding is greatly decreased if anaerobic seeding is practiced (Ray et al., 2016). In this process, seeds are sown below soil surface and shallow soil flooding with 5-10 cm is imposed. Under such condition, the growth of plumule is minimal while the growth of radicle is severely inhibited. Most of the rice varieties fail to establish due to lack of oxygen near seeds (Vijayan et al., 2018).Improving germination potential of rice under Oxygen deficiency can alleviate the flooding stress at early emergence stage.

Submergence tolerant gene / QTL – '*SUB1*' has been introduced in several mega rice varieties. *SUB1* imparts tolerance to complete submergence. Importantly, these introgression lines can also replace some of the low-yielding traditional landraces currently being used by farmers in submergence-prone areas, augmenting yields in typically marginalized fields. Farmers are now greatly adopting the rice cultivar possessing *SUB1* (Dar et al., 2013). It was observed that cultivars with *SUB1* failed measurably at farmer's field under direct seeding condition due to untimely rain at germination stage. Stagnation of 5-10 cm of water on the surface of the field for 10 days or more severely restricted the establishment (Das et al., 2004; Ismail et al., 2009). Seed priming, an old age practice, was applied to improve the germination capacity in rice to encounter the abiotic stresses (Farooq et al., 2011; Sarkar, 2012). Therefore, in the present investigation, an attempt has been made to assess the effectiveness of seed priming and seed coating in improving germination potential of rice under submerge condition with two near isogenic lines IR64 and IR64-Sub1 in relation to yield and yield attributing parameters under direct sown field condition.

MATERIALS AND METHODS

Plant materials and growth condition

Two near isogenic rice (*Oryza sativa* L.) cultivars i.e. IR64, susceptible to complete submergence and IR64-Sub1, tolerant to complete submergence, were used to investigate the effects of seed priming on seed germination and yield under early flooding and non-flooding conditions. The experiment was conducted during the dry season of 2014 and 2015 at National Rice Research Institute (NRRI), Orissa, India, (20.5^{o}N, 86^{o} E, and 23.5 meters above mean sea level).

Seed priming with water

Seeds were soaked in tap water for 17 hours at room temperature (25-33^{o}C) in dark (16:00-09:00 h). The soaked seeds were spread on a concrete floor and dried under the Sun till the moisture content reached 10 – 12%. The dried seeds were kept in plastic bags under normal ambient condition. The seed lot was prepared 10 days before sowing.

Seed coating with different chemicals

Seed coating were done with calcium peroxide (65%, HIMEDIA, India), potassium nitrate (99%, HIMEDIA, India) and sodium peroxide (78%, HIMEDIA, India). One hundred gram of each chemical was properly mixed with four hundred gram of dried fine farm soil. 500 gm of mixture was used to coat one kg of paddy. The seeds were treated with the specific chemical and farm soil mixture by simultaneous shaking and spraying with water mist in a tray. Stirring and spraying continued until all the powder was attached to the seed. Coated seed were kept at room temperature (27–31°C) to dry and harden the coat. The duration from pelleting to seeding was 20 hours.

Experiment-I during the year 2014 dry season

The primed and non-primed seeds were directly sown beneath (1 – 2 cm) the puddled soil surface in an experimental field tank (L x B x H = 40m x 8m x 0.8m). Field bunds approximately 15 cm in height from soil surface were raised with mud. Seed (4 – 5 in numbers) were sown 15 cm apart in each line. Line to line distance was 20 cm. The experiment was conducted under factorial randomised block design with three replications. Flooding was done after sowing with 10 cm depth of water, which was continuedtill 20 days of sowing. There was no stagnation of water in control plot. Similar water level (0 – 10 cm) was maintained in all plots after 21 days of sowing. Chemical fertilizers were added @ 80:40:40 NPK kg ha^{-1}. All P and ⅔ K were applied as basal dose before sowing. Nitrogen was added in 3 splits as basal (½ part) and at 30 (¼ part) and 60 (¼ part) days after sowing. Rest amount of K was applied along with N after 60 days of sowing. Weeding was done once after 35 days of sowing.

Experiment-II during the year 2015 dry season

The experiment was conducted under bigger field condition. Mud bund was raised to provide the desired level of flooding during germination stage. Seeing the performances of each treatment in the previous year, three seed treatments such as non-priming and priming with water were taken. Crops were raised under direct seeding with and without soil flooding and under transplanting. Two seedlings were sown 15 cm apart in each line. The distance between lines was 20 cm. All other operations were similar as described in experiment I.

Flood water characterisitcs

Temperature and oxygen concentration of flood water were determined at 07:00 hrs (model Simplair-F-5, Syland Scientific, Heppenheim, Germany). A portable pH meter was used to determine the pH of the flood-water.

Plant establishment, growth and yield parameters

Emergence of leaf tips were noted regularly after 3 days of submergence up to 21 days of sowing. Considering final emergence as 100% days to emergence was

calculated. Under submergence, 100% emergence occurred within 9-15 days of sowing whereas under control, the emergence time was 3-4 days. Final stand (%) was calculated as;

$$\text{Final Stand} = \frac{\text{Number of hills with plant}}{\text{Total number of hills}} \text{ X } 100$$

Hill with at least one seedling was considered as hill with plant. To determine the seedling length and dry matter accumulation, ten plants was randomly harvested from different hills after 21 days ofsowing. Five hills were taken at flowering stage whereas twenty hills were taken at harvest to determine different growth and yield attributing parameters. Data on leaf mass:leaf area ratio, leaf, stem and panicle dry mass was taken at flowering. The harvested sample was oven dried at 65 ± 2^0C for 72 h to determine dry mass. Harvest index (%) was calculated as;

$$\text{Harvest Index} = \frac{\text{Grain Yield}}{\text{Biological Yield}} \text{ X } 100$$

Data on yield were taken on per plot basis and then converted into t ha^{-1}.

Statistical analysis

Differences between different treatments were compared using *CropStat* (International Rice Research Institute, Philippines) software's least significant difference (LSD, $p<0.05$).

RESULTS

EXPERIMENT-I DURING THE YEAR 2014 DRY SEASON

Flood-water characteristics

The temperature of floodwater ranged from 27.5 to 29.2°C throughout the period of the experiment (Fig. 1). The concentration of Oxygen was 3.0 mg L^{-1} just after 1 day of submergence whereas it increased gradually and after 15 days of submergence, the concentration Oxygen of floodwater was 5.2 mg L^{-1}. There was an upward trend of pH of floodwater. After one day of submergence, the pH of the floodwater was 7.8, which became 8.2 after 15 days of submergence.

Emergence, plant stand and seedling growth

Flooding at germination stage had negative impact on plant establishment (Fig. 2A). Seed priming with sodium peroxide (P3) showed greater negative effect as compared to non-primed seed (P1). Days to 100% emergence was more in P3 followed by P1, P4 (potassium nitrate coating) and P2 (calcium peroxide coating) and P5 (water priming with soaking and drying). Plant stand was significantly greater under submergence in P2 and P5 followed by P4, P1 and P3 (Fig. 2B). The performances of cultivar in respect of plant establishment were significantly better in cultivar with IR64-Sub1 as compared to the cultivar IR64. Plant establishment was 87%, 84% and 68% in IR64-Sub1 under P2, P5 and P4 treatment whereas in IR64, it was 68%, 73% and 61%, respectively.

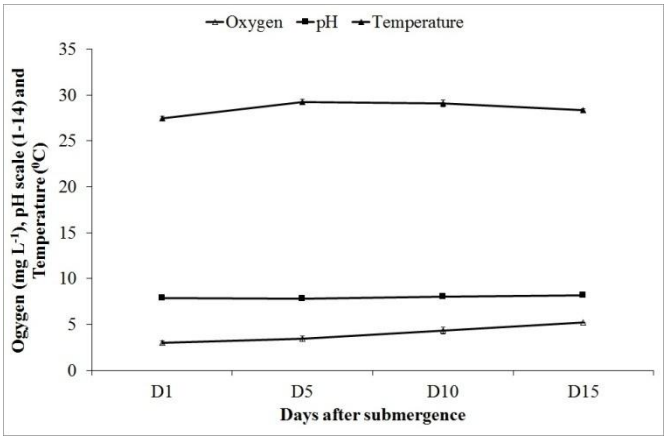

Figure 1. Concentrations of oxygen, temperature and pH of flood water at different days of submergence. D1, D5, D10 and D15 represent 1, 5, 10 and 15 days after sowing. Bar represents standard deviation.

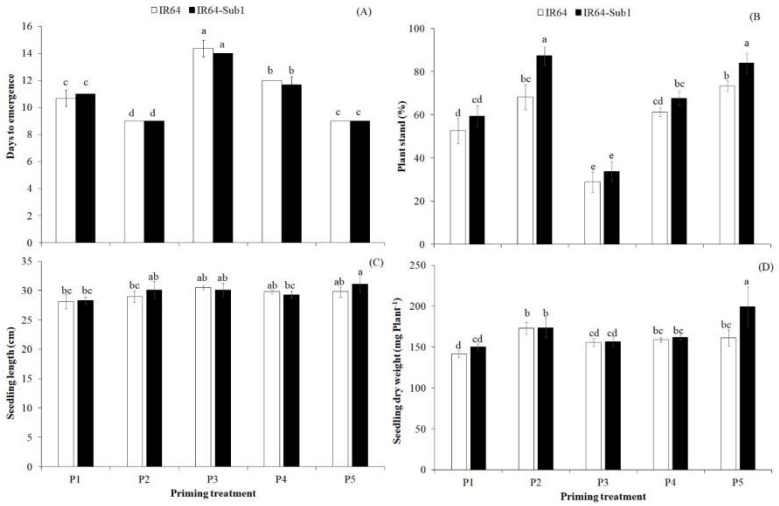

Figure 2. (A)Days to 100% emergence of coleoptiles tip above the water surface. (B) Final plant stands (%) after 21 days of submergence. (C) Seedling length and (D) dry mass of non-primed and primed seed under submergence after 21 days of sowing [P1 = control, non-primed; P2 = calcium peroxide coated; P3 = sodium peroxide coated; P4 = potassium nitrate coated; P5 = seed soaking with water followed by sun drying]. Bar represents standard deviation. The same small case did not differ significantly.

Seed priming increased both seedling length and dry matter accumulation (Fig. 2C, 2D). Cultivar differences in seedling length were non-significant. The seedlings emerged out from the water surface grew well and attained the length more than 25

cm in all the treatments. Cultivar with IR64-Sub1 accumulated greater amount of dry matter under various seed priming treatments as compared to cultivar IR64. Cultivar differences in dry matter accumulation were highly significant. Both cultivar and seed priming treatments together influenced the dry matter accumulation at early stage of plant growth.

Seed priming and its impact on biomass accumulation at flowering

Dry mass differed greatly at flowering stage (Table 1). Leaf mass and leaf area ratio greatly influenced by seed priming. The differences due to cultivar were non-significant. Leaf and stem dry mass at flowering were significantly greater in IR64-Sub1 as compared to IR64. Biomass accumulation was significantly greater in P2 and P5 as compared to non-priming and other seed priming treatments. Seed priming with sodium peroxide (P3) negatively influenced the dry matter accumulation. Cultivar and seed priming interaction significantly changed the stem and panicle dry mass accumulation at flowering.

Table 1. Seed priming and its impact on dry matter production at flowering stage during the year 2014 dry season

Cultivar	Treatment	Leaf mass: leaf area ratio	Leaf dry mass (g m^{-2})	Stem dry mass (g m^{-2})	Panicle dry mass (g m^{-2})
IR64	P1	6.66^{b}	91.3^{e}	191.0^{e}	60.2^{e}
	P2	6.25^{c}	116.9^{d}	279.4^{c}	74.0^{c}
	P3	7.43^{a}	74.3^{f}	176.5^{ef}	48.2^{f}
	P4	6.67^{b}	112.9^{d}	276.6^{c}	64.7^{d}
	P5	6.22^{c}	137.6^{bc}	307.4^{b}	73.9^{c}
Mean		**6.65^{A}**	**106.6^{B}**	**246.2^{B}**	**64.2^{A}**
IR64-Sub1	P1	7.17^{a}	94.7^{e}	237.7^{d}	48.7^{f}
	P2	6.10^{c}	150.0^{ab}	378.1^{a}	95.0^{a}
	P3	7.31^{a}	70.9^{f}	170.1^{f}	40.7^{e}
	P4	6.41^{bc}	127.6^{cd}	301.8^{b}	70.5^{cd}
	P5	6.40^{bc}	157.7^{a}	367.2^{a}	85.6^{b}
Mean		**6.68^{A}**	**120.2^{A}**	**290.9^{A}**	**68.1^{A}**

P1, control, non-treated; P2, calcium peroxide coated; P3, sodium peroxide coated; P4, potassium nitrate treated; P5, seed soaking with water followed by sun drying. NS, non-significant; In a column the same small and upper-case letter do not differ significantly.

Yield and yield attributes

Seed priming differently influenced the grain yield. Seed priming treatment P2 (calcium peroxide coating) and P5 (water priming with soaking and drying) had greater positive effect whereas seed priming treatment P3 (Seed priming with sodium peroxide) had negative effect (Table 1). Grain yield production was significantly higher in P2 and P5 as compared to other priming and non-priming treatments both under control and germination stage submergence. Seed coating with potassium nitrate (P4) had neither negative nor positive effect on yield. Submergence at germination stage decreased the panicle numbers; however, the reduction was checked in P2 and P5. Yield attributing parameters such as panicle numbers per unit of land and harvest index significantly improved in P2 and P5.

Experiment I during the year 2015 dry season

Plant height was significantly greater under transplanting as compared to direct seeding, yet numbers of panicle per unit leaf area was less under transplanting as compared to direct seeding (Table 3). Single panicle weight was, however, higher under transplanting as compared to direct seeding. Fertile spikelet (%) and harvest index did not change statistically under priming and different methods of crop raising. Seed priming improved the straw and grain yield both under transplanting and direct seeding compared with non-priming conditions and checked the yield reduction under germination stage submergence.

DISCUSSION

Direct seeding is crucial during both wet season in coastal deltas as well as in rainfed lowland areas because of lower cost and additional benefits, improve drought and submergence tolerance and earlier harvests (Sarkar and Das, 2003). Direct seeding is now facing innumerable problems due to irregular and unpredictable rainfall and climate change. Rainfall is now more uncertain with more frequencies of extreme events (Ismail et al., 2009). It is known that shallow flooding suppresses weed growth. Yet, the knowledge is not in practice due to poor germination and failure of plant establishment of rice under such condition. Sowing of seeds beneath the flooded surface was termed as anaerobic seeding (Yamauchi and Choung, 1995). Cultivar tolerant to oxygen deficiency at germination stage is successful in such situation (Ray et al., 2016; Vijayan et al., 2018). The level of oxygen of flood water varied between 3.0 and 5.2 mg L^{-1} after 1 day of submergence to 15 days after submergence (Fig. 1). It showed that flood water was always hypoxic, neither anoxic nor normoxic (Setter et al., 1995). Once the coleoptiles reached the water zone, it started to get oxygen from the surrounding floodwater and started to grow fast and pushed the tip of the coleoptile above the water surface. The pH and the temperature were not so harsh, which could restrict coleoptiles growth (Fig. 1). Seed coating with calcium peroxide (P2) and water priming with soaking and drying treatment (P5) enabled the seedlings to pierce through water early as against non-priming and other

treatments (Fig. 2A). Sodium peroxide (P3) coating extended date of emergence as well as final plant stand (Fig. 2B).The negative effect was noticed in respect seedling vigour (Fig. 2D). Dry matter accumulation was significantly better under P2 and P5 than other treatments. No such trend was observed with respect to seedling length (Fig. 2C). Sodium peroxide (Na_2O_2) upon contact with water produces NaOH and H_2O_2, which might destroy the germinating embryo and thereby action of Na_2O_2 found to be negative. Potassium nitrate (KNO_3), which has soil oxidizing power but does not generated oxygen by itself was not so effective in cutting the emergence time and improving the plant stand. Soaking of seeds at around 30^0C for 17 hours initiated the germination process. Enzymes associated with germination process were synthesized during imbibitions (Sarkar, 2012). When such seeds are dried upon, the metabolites / enzymes needed for germination go for hibernation (Farooq et al., 2011). While re-moisturizing of such seeds (P5), the germination process became fast. In a less span of time, seedlings pierced the soil surface and entered flood water environment. Upon reach on the water zone, coleoptiles got needed oxygen from the flooded water and continued to grow (Sarkar, 2012). Each seed priming agent except sodium peroxide impacted favourably. The order of effect was P1 < P4 < P2 = P5.

Submergence at germination stage greatly influenced the biomass accumulation even at flowering stage per unit land area. Dry biomass at flowering was significantly greater in IR64-Sub1 than that of IR64 (Table 1). Sarkar (2012) reported that Swarna-Sub1 was able to accumulate greater biomass as compared to Swarna under direct sown submerge conditions. There was no significant difference of leaf mass/leaf area ratio between these two cultivars. Seed coating with Na_2O_2 though improved the leaf mass and leaf area ratio, yet it failed to produce enough biomass per unit area at flowering. The two cultivars such as IR64 and IR64-Sub1 are near-isogenic lines (NILs). Panda and Sarkar (2012) reported that NILs were identical in terms of growth and yield under stress free environment. The differences in biomass accumulation per unit land area were due to greater plant number per unit land in IR64-Sub1 compared to IR64 (Fig. 2B). The seed priming treatments improved the biomass accumulation at flowering showed positive effect on grain yield production at harvest (Table 2). Maintaining greater plant stand under different abiotic stresses is an uphill task to get maximum return from a unit of land, where plant stand decreased, the values of yield and yield attributing parameters perturbed. Plant stand decreased tremendously under P3. Due to poor plant stand, individual plant got more space to grow and became stout. Under P3 plant growth per hill basis was greater at flowering as well at harvest (data not provided) whereas per unit land basis was less (Table 1, 2).

Table 2. Seed priming and its impact on yield and yield attributes during the year 2014 dry season

Variety	Treatment	Grain yield (tha^{-1})		Single panicle weight (g)		Panicle (number m^{-2})		Fertile spikelet (%)		Straw ($t\ ha^{-1}$)		Harvest Index	
		C	AG	C	AG	C	AG	C	AG	C	AG	C	AG
IR64	P1	3.53^{bA}	2.39^{dB}	1.47^{bA}	1.23^{abcB}	309^{abA}	245^{eB}	72^{abcA}	73^{abcA}	5.31^{abA}	3.09^{cB}	0.40^{abA}	0.41^{abcA}
	P2	3.88^{aA}	3.28^{bB}	1.55^{abA}	1.21^{abcB}	321^{aA}	333^{bcA}	76^{aA}	73^{abcA}	5.08^{abA}	4.31^{bB}	0.43^{abA}	0.43^{aA}
	P3	2.83^{cdA}	1.36^{eB}	1.37^{cA}	1.22^{abcB}	275^{bcdA}	138^{fB}	72^{abcA}	64^{dB}	4.25^{bcA}	2.16^{dB}	0.40^{abA}	0.37^{bcA}
	P4	3.41^{bcA}	2.36^{cB}	1.48^{bcA}	1.19^{abcB}	295^{abcA}	293^{cdA}	72^{abcA}	69^{bcA}	5.12^{abA}	4.01^{bB}	0.40^{abA}	0.38^{bcA}
	P5	3.80^{abA}	3.08^{bB}	1.56^{abA}	1.26^{abcB}	324^{aA}	341^{bcA}	71^{bcA}	73^{abcA}	5.04^{abA}	3.84^{bB}	0.43^{abB}	0.44^{aA}
IR64-Sub1	P1	3.45^{bA}	2.55^{cdB}	1.48^{bcA}	1.16^{bcB}	304^{abB}	340^{bcA}	73^{abcA}	71^{bcA}	5.48^{abcA}	4.30^{bB}	0.39^{bA}	0.37^{bcA}
	P2	3.85^{aA}	3.65^{aA}	1.58^{abA}	1.29^{aB}	322^{aA}	345^{bcA}	72^{abcA}	76^{aA}	5.18^{abA}	4.97^{aA}	0.43^{abA}	0.43^{aA}
	P3	2.58^{dA}	1.44^{eB}	1.38^{bcA}	1.27^{abA}	257^{bcdA}	161^{fB}	70^{bcA}	62^{dB}	4.16^{cA}	2.49^{dB}	0.38^{bA}	0.37^{bA}
	P4	3.12^{cA}	2.75^{cB}	1.49^{bA}	1.15^{bcB}	285^{bcdB}	319^{cdA}	75^{abA}	72^{abcA}	4.61^{bcA}	4.06^{bA}	0.40^{abA}	0.40^{abcA}
	P5	3.77^{abA}	3.55^{abB}	1.61^{aA}	1.17^{bcB}	321^{aB}	393^{aA}	76^{aA}	73^{abcA}	4.80^{bA}	4.59^{abA}	0.44^{aA}	0.41^{abcA}

P1, control, non-treated; P2, calcium peroxide coated; P3, sodium peroxide coated; P4, potassium nitrate treated; P5, seed soaking with water followed by sun drying. NS, non-significant; In a specific treatment genotypes followed by the same small case letter and across the treatment within the same genotype and treatment followed by the same upper-case letter for an individual parameter do not differ significantly

However, it was not enough to compensate the optimum plant stand to produce greater yield under a piece of land (Sarkar et al., 1999; Sarkar and Das, 2003). Seeing the performances of the year 2014, the experiment was changed. Only seed priming treatment, soaking followed by drying was employed (Plate 1).

Plate 1. Growth of seedlings of two rice cultivars such as IR64 and IR64-Sub1 due to water priming.

Coating of seeds with calcium peroxide is costly. Calcium peroxide coating though known to improve germination percentage for long period, the technology is still in confined to Japan due to cost and trouble in making coated seeds. Besides, the soaking and drying treatment gave similar benefit with that of calcium peroxide coating. As rice is also cultivated through transplanting mode, a new treatment i.e. transplanting was introduced to verify the water priming efficiency in improving the

yield under normal and anaerobic direct seeding and transplanting mode of rice cultivation. In general, there was no significant difference in yield under direct normal seeding and transplanting (Table 3). A compensatory mechanism was observed between panicle number per unit area and single panicle weight. Under normal direct seeding condition, panicle numbers were more whereas under transplanting weight of single panicle was greater. This is in conformity with our earlier findings (Sarkar and Das, 2003). Water seed priming had positive effect on yield. Yield was greater due to priming both under direct seeding and transplanting conditions (Farooq et al., 2009). Submergence at germination stage greatly decreased the yield. Yield attributing parameters such as panicle numbers, panicle weight and biomass production significantly decreased due to submergence at germination stage. Seed priming alleviated the stress and thus improved the yield contributing parameters as well as yield. The data showed that water seed priming produced similar yield in all the situations such as normal and anaerobic direct seeding as well as transplanting mode of cultivation (Table 3).

Table 3. Yield and yield attributes due to seed priming under different methods crop raising during the 2015 dry season

Variety	Treatment	Height (cm)	Panicle (m^{-2})	Single panicle weight (g)	Fertile spikelet (%)	Harvest Index (%)	Straw (t ha^{-1})	Grain yield (t ha^{-1})
IR64	NP-DS	81.6^{cd}	282^{bc}	1.10^{c}	83.8^{NS}	46^{NS}	3.17^{cd}	2.68^{cd}
IR64	NP-DSS	81.4^{cd}	275^{cd}	0.99^{c}	82.6^{NS}	45^{NS}	2.61^{e}	2.12^{e}
IR64	NP-TP	92.9^{b}	218^{e}	1.53^{ab}	82.5^{NS}	46^{NS}	3.33^{abc}	2.84^{b}
IR64	P-DS	80.4^{d}	347^{a}	1.01^{c}	81.7^{NS}	48^{NS}	3.54^{a}	3.02^{a}
IR64	P-DSS	84.8^{c}	347^{a}	1.03^{c}	81.9^{NS}	46^{NS}	3.43^{ab}	2.90^{ab}
IR64	P-TP	96.7^{a}	233^{e}	1.61^{a}	84.3^{NS}	46^{aNS}	3.49^{ab}	2.95^{ab}
Mean		**86.3^{A}**	**284^{A}**	**1.21^{A}**	**82.8^{A}**	**0.46^{A}**	**3.26^{A}**	**2.75^{A}**
IR64-Sub1	NP-DS	79.6^{d}	279^{cd}	0.97^{c}	81.4^{NS}	46^{NS}	3.08^{d}	2.59^{d}
IR64-Sub1	NP-DSS	78.6^{d}	247^{d}	0.96^{c}	85.4^{NS}	42^{NS}	2.75^{e}	2.02^{e}
IR64-Sub1	NP-TP	93.5^{ab}	212^{e}	1.63^{a}	84.0^{NS}	46^{NS}	3.36^{abc}	2.58^{d}
IR64-Sub1	P-DS	80.8^{d}	321^{a}	1.01^{c}	87.8^{NS}	45^{NS}	3.29^{bcd}	2.75^{bc}
IR64-Sub1	P-DSS	82.3^{cd}	315^{ab}	1.08^{c}	85.5^{NS}	46^{NS}	3.25^{bcd}	2.74^{bc}
IR64-Sub1	P-TP	95.4^{ab}	223^{e}	1.45^{b}	83.1^{NS}	44^{NS}	3.51^{a}	2.77^{bc}
Mean		**85.0^{A}**	**266^{B}**	**1.18^{A}**	**84.5^{A}**	**0.45^{A}**	**3.21^{A}**	**2.57^{B}**

NP, non-priming; NS, non-significant; DS-direct seeding without stagnation of water; DSS, direct seeding with 10 cm stagnation of water on soil surface; TP, transplanting of 25 days old seedlings; P, priming with simple tap water. In a column the same small and upper case letter do not differ significantly.

CONCLUSION

The study showed that proper management option could improve rice productivity under anaerobic direct seeding conditions. Coating with calcium peroxide though improved germination potential of rice under oxygen deficiency; the technique was not so popular outside Japan due to high cost of the chemical and tedious coating procedure (Ota, 1982). Seed treatment with KNO_3 though beneficial– the impact of it was not so big as compared to seed soaking followed by sun drying. Seed soaking with water followed by sun drying found comparable with that of calcium peroxide coating under anaerobic seeding. Water priming found to be better not only under anaerobic seeding but also under normal direct seeding and transplanting. It showed that water priming was a good contingency measure to get assured yield under different methods of rice cultivation. The technique is simple, and all the resources are available at farmers' door. So, adoption of technique is possible. Rice cultivation under direct seeding is more secured by the adoption of water priming.

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EFFECTS OF CONSERVATION AGRICULTURE ON PRODUCTIVITY AND ECONOMICS OF MAIZE-WHEAT BASED CROPPING SYSTEMS IN MID-WESTERN NEPAL

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ABSTRACT

The effects of two tillage methods (zero tillage and conventional tillage), two residue managements (residue kept and residue removed) and two levels of cropping system (maize + soybean and sole maize) were studied over 3 years (2015-2017) at Dailekh district of Nepal. Arun-2 and Puja were the varieties of maize and soybean used respectively, followed by winter wheat. The results revealed that the maize + soybean system had significantly higher plant population and ear population (34.83 thousands ha^{-1} and 34.35 thousands ha^{-1}, respectively), grains per row (37.1), ear length (16.6 cm) and 20.5% higher grain yield as compared to sole maize. The highest maize equivalent yield (7.92 t ha^{-1}) was recorded in maize + soybean as compared to the lower grain yield equivalent (7.06 t ha^{-1}) in sole maize. Zero tillage accounted relatively higher benefits (high net income and B:C ratio) as compared to conventional tillage. The residue kept plot resulted significantly higher B:C ratio (2.41) than the residue removed (2.11) and the maize + soybean recorded 82.5% greater B:C ratio compared to sole maize. Net annual income was significantly higher in zero tillage, residue kept and maize + soybean system (NRs. 223072.00, 222958.00 and 269016.00 ha^{-1} respectively). Such combinations are recommended for Dailekh district of Nepal to have profitable crop productivity.

Keywords: Intercropping, Maize, Residue, Soybean, Tillage

INTRODUCTION

Maize is one of the major food crops and main source of livelihood and income in Nepal, which contributes about 6.54% of the gross agricultural domestic product (AGDP) and 3.15% of the gross domestic product (GDP) (MoAD, 2013). Maize is extensively grown in the mid-hills of Nepal and it was usually cultivated as sole crop

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from decades. In Nepal, after rice, maize occupies the second place in terms of cultivated area (891583 ha) and production (2231517 ton) (MoAD, 2016) which plays an important role in national food security. However, area and production of maize is in declining trend annually, which might be due to the negative impact of climate change, poor soil nutrient and water availability to the plant. A novel management system needs to be promoted and adopted to address these issues. Furthermore, conservation agriculture (CA) which is characterized by minimum tillage with previous crop residue retention can be the most suitable approach to enhance prevailing agricultural system of mid-hills of Nepal.

The declining trend of crop productivity might be due to application of poor technologies and use of obsolete genotypes along with higher cost of production, which has been exacerbated by the shortage of labor in agriculture (Joshi et al., 2012). Increased numbers of plowing and furrowing have caused higher soil erosion and nutrition loss, resulting to further degradation of agricultural land (Gardener and Gerrard, 2003; Acharya et al., 2007). High rate of soil erosion is one of the major causes for low yields of maize, a major staple for poor farmers in hill region (Tiwari et al., 2004). Furthermore, Rijal (2001) reported soil erosion, poor retention of organic matter, and unbalanced fertilization as main reasons for declining soil fertility in mid-hills of Nepal. Thus, high erosion and reduced application of organic matter have caused reduction of soil fertility resulting lesser productivity and sustainability of the system. There is an insistent need to introduce better technologies to stimulate sustainable agriculture along with conservation of land resources. Katuwal et al. (2017) concluded that no-till, residue retention and incorporation, strip cropping, intercropping and systematic crop rotation along with the inclusion of legumes and introduction of improved varieties are the potential areas of CA in hills. Despite of being a potential technology to solve such problems, evaluations of CA systems have been rarely documented. Therefore, the goal of this study was to evaluate implications of CA systems on crop productivity and financial benefits of maize-based farming system in the mid-hill region of Nepal.

METHODOLOGY

The experiment was conducted at research blocks of Horticultural Research Station, Dailekh, Nepal ($28^{o}85'N$, $81^{o}72'E$, 1300 meter above sea level) during summer season of three consecutive years: 2015, 2016 and 2017. The separate research plots were allocated for the three years such that only a maize-wheat cropping pattern was followed, leaving the land to be fallow in the other seasons of a year.

The experiment was laid out in a split-split plot design with eight treatments and three replications in each year. The treatment consisted two methods of tillage (zero tillage and conventional tillage) as the whole plot, two different levels of residue management (residue kept and residue removed) as sub-plot and two different levels of intercropping namely maize + soybean and sole maize as sub-sub plot. Land was

prepared following the two different methods (zero and conventional tillage). Firstly, preceding wheat was harvested and crop stubbles were cleaned out with no any tillage operation for zero tillage plots. Secondly, tillage operations were carried out three times by a tractor driven cultivator followed by leveling of surface for the conventional tillage plots. Residue of wheat straw was applied @10 mt ha^{-1} as a crop residue of preceding cropping season in case of residue management system. Arun-2 variety of maize and Puja variety of soybean were used in the study.

Each of the plots was maintained at 15 m^2 size having the length of 5m length and 3 m width. Row to row spacing for maize crop in each plot was maintained at 100 cm with 50 cm spacing between plants maintaining two plants per hill in the individual plot. The seed of maize was sown using Zab-planter. Besides, soybean was intercropped between two maize rows with the spacing of 50 cm between the soybean rows and 10cm between the plants of the row. The harvest area used for yield measurement for maize and soybean was 15 m^2 and 12 m^2 respectively. Furthermore, total of 8 rows of soybean were established between 5 rows of maize in a plot of intercropping. Total amount of fertilizers applied for maize was @120:60:40 NPK kg ha^{-1} and 10 mt FYM ha^{-1}, wherein the 50% (60 kg ha^{-1} urea) of the recommended dose of N and full dose of P and K were applied during the land preparation and the rest 50% N was applied in two splits- 25% during knee height stage and 25% during silking stage. Similarly, the separate dose of fertilizer was applied for soybean @30:40:30 kg NPK ha^{-1} and 6 mt FYM ha^{-1}. Weeds were controlled using glyphosate during land preparation. In case of zero tillage, weeds in the standing crop were controlled using post emergence herbicide; 2, 4-D @ of 0.5-0.8 kg ha^{-1}. Similarly, manual weeding was done during the knee height stage of maize for conventional tillage.

The data on traits such as plant and ear height, plant, and ear population, grains per row, rows per ear, and ear length were recorded at the time of harvesting, taking five sample plant of each plot and averaged finally. Further, cobs were harvested, husks were removed and five sample cobs of each genotype were weighed and averaged and the final grain yield was calculated after sun-drying and moisture content measuring 12%. Also, the soybean yield was measured. The maize stover and soybean straw was weighed lastly after drying.

The total cost for different operations based on treatments was accounted. The gross income from each operation in terms of NRs. per hectare was calculated. The net income was calculated as- Net Income = Gross income – Total cost; B:C ratio = Gross income/Total cost and Harvest index (HI) = Economic yield/Biological yield. Where, the economic yield is the sum of grain yield of maize and seed yield of soybean. Biological yield includes the grain and stover yield of maize plus seed and stover yield of soybean.

The data were analyzed using GenStat Package.

RESULTS AND DISCUSSION

Biometric observations of maize plant and ear height

The effect of tillage and residue management on plant height and ear height of maize was found to be non-significant. However, the effect of intercropping on plant and ear height of maize was noticed with significant effect (Table 1). Maize and soybean intercropping showed the tallest plant (219.8 cm) and the maximum ear height (109.8 cm) whereas the shortest plant (212.2 cm) and minimum ear height (101.3 cm) was measured on sole maize. The average plant height and ear height of maize was measured to be 216.0 cm and 105.5 cm respectively. Similar findings on effect of intercropping on maize height were recorded by Hamd et al. (2014). Likewise, relatively taller plants measured due CT in comparison to ZT in our research is in accordance with the findings of Iqbal et al. (2013), who had also recorded shorter plants in ZT in comparison to CT. However, several past research findings have found that the maize plants are not always shorter in no-tillage (Zero tillage) systems (Imholte and Carter, 1987). The plant height explains the ear height and they are generally correlated.

Yield attributing characters of maize

This experiment revealed significant variation in plant population, ear population, grains per row, and rows per ear due to effect of intercropping. However, non-significant effect of tillage and residue management was recorded for this study. Similarly, this study revealed significant variation in ear length due to effect of residue management and intercropping.

Plant population and ear population

Significant variation of plant population and ear population was revealed due to the effect of intercropping (Table 1). The overall plant stand (34.83 thousands ha^{-1}) and ear population (34.35 thousands ha^{-1}) was found maximum in intercropping system as compared to the least plant stand (33.00 thousands ha^{-1}) and minimal ear population (31.39 thousands ha^{-1}) in the sole maize plots. Similarly, average plant and ear population recorded were 33.92 thousands ha^{-1} and 32.87 thousands ha^{-1} respectively.

Table 1. Effects of tillage, residue management, and intercropping on plant and ear height along with plant and ear population of maize

Treatments	Plant height (cm)	Ear height (cm)	Plant population (thousands ha^{-1})	Ear population (thousands ha^{-1})
Tillage				
ZT	213.8	102.3	33.37	31.74
CT	218.1	108.8	34.46	34.00
SEm (±)	4.06	3.67	1.077	0.909
$LSD_{(0.05)}$	Ns	Ns	Ns	Ns
Residue management				
Residue kept	216.4	106.9	32.94	32.94
Residue removed	215.5	104.1	34.89	32.80
SEm (±)	3.4	2.19	0.745	0.822
$LSD_{(0.05)}$	Ns	Ns	Ns	Ns
Cropping system				
(M+S)-W	219.8	109.8	34.83	34.35
Ms-W	212.2	101.3	33.00	31.39
SEm (±)	2.05	1.69	0.529	0.529
$LSD_{(0.05)}$	5.91*	4.87**	1.523*	0.529**
CV (%)	5.7	9.6	9.4	9.6
Grand mean	216.0	105.5	33.92	32.87

Note: ZT=Zero tillage, CT=Conventional tillage, (M+S)-W=Maize and soybean intercrop followed by wheat, Ms-W=Maize sole followed by wheat, SEm=Standard Error of Means, LSD=Least Significance Difference, CV=Coefficient of variation. Ns, * and ** indicate Non-significance, significance, and highly significance at $P<0.05$ and $P<0.01$ respectively.

Grains per row

There is significant variation in number of grains per row (GPR) from 35.3 to 37.1 in MS-W and (M+S)-W respectively due to effect of intercropping (Table 2). However, there is non-significant effect in grains per row due to tillage and residue management.

Rows per ear

There is no effect of tillage, residue management and intercropping in number of rows per ear as elucidated in the presented table. Furthermore, maximum number of rows per ear (12.6) was recorded with (M+S)-W (Table 2).

Ear length

Both the treatment factors: residue levels and intercropping had significant effect on the ear length except for the tillage (Table 2). Ear length was recorded to be maximum (16.8 cm) in residue kept plots, however, shortest ear length (15.9 cm) was found in residue removed plots. Likewise, significantly the longest ear (16.6 cm) was measured in the (M+S)-W as compared to shortest ear (16.0 cm) in Ms-W. The mean ear length measured was 16.3 cm.

Table 2. Effect of tillage, residue management, and intercropping on the grains per row, rows per ear and ear length of maize

Treatments	Grains per row	Rows per ear	Ear length (cm)
Tillage			
ZT	36.0	12.3	16.4
CT	36.4	12.6	16.3
SEm (±)	0.353	0.1242	0.231
LSD(0.05)	Ns	Ns	Ns
Residue management			
Residue kept	36.8	12.4	16.8
Residue removed	35.5	12.5	15.9
SEm (±)	0.603	0.178	0.283
LSD(0.05)	Ns	Ns	0.6**
Cropping system			
(M+S)-W	37.1	12.6	16.6
Ms-W	35.3	12.4	16.0
SEm (±)	0.499	0.1277	0.285
LSD(0.05)	1.436*	Ns	0.58*
CV (%)	8.3	6.1	7.4
Grand mean	36.2	12.481	16.3

Note: ZT=Zero tillage, CT=Conventional tillage, (M+S)-W=Maize and soybean intercrop followed by wheat, Ms-W=Maize sole followed by wheat, SEm=Standard Error of Means, LSD=Least Significance Difference, CV=Coefficient of variation, Ns, * and ** indicate Non-significance, significance, and highly significance at $P<0.05$ and $P<0.01$ respectively.

Yield parameters

There was a significant effect of tillage on the stover yield, however the tillage effect was non-significant on the yield of maize, soybean, soybean straw and harvest index. The stover and soybean yield significantly varied due to residue management.

Maize yield

The tillage system and residue levels had no significant effect on the grain yield of maize (Table 3). This is in conformity with the findings of Kapusta et al. (1996), who reported no significant difference in grain yield of maize with no tillage and conventional tillage over the time. Furthermore, this might be due to no significant difference in plant population in both systems. However, the (M+S)-W system revealed highly significant effect on the maize yield with 20.5% more yield of maize in comparison with the sole maize. Likewise, the highest grain yield of (M+S)-W as compared to Ms-W might be due to the highest values for number of ear length, number of rows/ear, and number of grains/row which was also mentioned by Hamid et al. (2014). Furthermore, the highest plant population (Abuzar et al., 2011) and maximum kernel rows per ear (Emam, 2001; Pariyar et al., 2018) might have contributed to the maximum maize yield. The mean maize yield was recorded to be 4.3 t ha^{-1}.

Stover yield

The tillage system showed insignificant effects on the stover yield (Table 3). However, the residue level and intercropping revealed statistically significant effect on stover yield with the maximum stover yield of 6.3 t ha^{-1} and 6/2 t ha^{-1} respectively. However, the minimum stover yield of 4.8 t ha^{-1} and 4.9 t ha^{-1} was recorded due to effect of residue levels and intercropping system respectively. The mean stover yield of the experiment was found to be 5.4 t ha^{-1}.

Seed and stover yield of soybean

The effects of tillage systems, residue levels and intercropping were found highly significant on soybean yield (Table 3). The soybean yield from zero tillage was significantly maximum (0.8 t ha^{-1}) as compared to that of conventional tillage (0.7 t ha^{-1}).The residue kept plots recorded the significantly highest (0.8 t ha^{-1}) soybean yield as compared to residue removed plots (0.7 t ha^{-1}). Similarly, the soybean yield was found significantly highest in the maize + soybean system which was more than 100% in comparison to mean soybean yield. Further, tillage and residue management did not show significant effect on soybean stover yield. The intercropped plot showed considerably higher soybean stover yield (3.3 t ha^{-1}).

Harvest Index (HI)

The effects of tillage system and residue levels observed non-significant effect in partitioning economic yield and biological yield, also known as Harvest Index (Table 3). However, intercropping has effect on harvest index with highly significance showing the maximum HI (0.41) in Ms-W in comparison to (M+S)-W system (0.40). Undie et al. (2012) reported similar findings with significantly high HI in sole maize than any other intercropping arrangements. Similarly, lesser HI in intercropping maize with soybean as compared to sole maize was recorded by Ahmad et al. (2016). Thus, the reduced production of maize biomass in intercropping with soybean as compared to sole maize might be due to the direct competition between them for different plant growth factors like moisture, nutrient, space, light, etc. The average HI of the experiment was recorded as 0.40.

Maize equivalent yield

The effect of tillage systems and residue management on the maize equivalent yield was found to be non-significant, though the effect of intercropping has highly significant effect. Considerably, the higher maize grain yield equivalent (7.92 t ha^{-1}) was obtained in (M+S)-W as compared to the lower grain yield equivalent (7.06 t ha^{-1}) in Ms-W. This was due to the higher grain yield and existing market price of component soybean (Rs. 80 per kg), while the existing market price of maize grain was Rs. 25 per kg. Similarly, it was recorded to be higher in all cases of intercropping with respect to pure stand yield of maize as mentioned by Kheroar and Patra (2013).The mean maize equivalent yield, however, was recorded to be 7.49 t ha^{-1}.

Table 3. Effects of tillage, residue management, and intercropping on the grains per row, rows per ear and ear length of maize

Treatments	Maize		Soybean		Harvest Index (HI)	Maize equivalent yield (tha^{-1})
	Grain yield (tha^{-1})	Stover yield (tha^{-1})	Seed yield (tha^{-1})	Stover yield (tha^{-1})		
Tillage						
ZT	4.1	5.8	0.8	1.6	0.40	7.37
CT	4.4	5.7	0.7	1.7	0.41	7.61
SEm (±)	0.096	0.133	0.038	0.1624	0.0089	0.097
LSD(0.05)	Ns	Ns	0.1238**	Ns	Ns	Ns
Residue management						
Residue kept	4.4	6.3	0.8	1.6	0.40	7.61
Residue removed	4.1	5.2	0.7	1.7	0.41	7.37
SEm (±)	0.104	0.140	0.028	0.091	0.010	0.104
LSD(0.05)	Ns	0.4**	0.1**	Ns	Ns	Ns
Intercropping						
(M+S)-W	4.7	6.2	1.5	3.3	0.40	7.92
Ms-W	3.9	5.3	0	0	0.41	7.06
SEm (±)	0.098	0.141	0.038	0.109	0.0061	0.979
LSD(0.05)	0.3**	0.4**	0.1**	0.3**	0.02**	0.28**
CV (%)	13.8	14.8	30.5	39.3	8.9	7.8
Grand mean	4.3	5.7	0.8	1.7	0.40	7.49

Note: ZT=Zero tillage, CT=Conventional tillage, (M+S)-W=Maize and soybean intercrop followed by wheat, Ms-W=Maize sole followed by wheat, SEm=Standard Error of Means, LSD=Least Significance Difference, CV=Coefficient of variation, Ns, * and ** indicate Non-significance, significance, and highly significance at P<0.05 and P<0.01 respectively.

Economics of maize

Gross Income and Net Income for Maize

The Gross Income and Net Income from tillage system was observed with non-significant effect whereas, the residue levels and intercropping practices showed highly significant effect on them respectively (Table 4). The gross income was relatively greater in ZT (NRs. 1,74,211 ha^{-1}) as compared to CT (NRs. 1,73,227 ha^{-1}). Due to residue management, the significantly highest gross income (NRs. 1,83,477 ha^{-1}) and net income (NRs. 1,17,699 ha^{-1}) was calculated on residue kept when compared with the residue removed plots (NRs. 1,63,961 and NRs. 96,949 ha^{-1} respectively). The maximum gross income and net income in the residue kept plots was due to the deduction of labor cost for removal of residue kept field. Goverdhanrao and Ramana (2017) and Sime (2015) also explained the better economic response of ZT in maize based cultivation practices.

Similarly, (M+S)-W system yields maximum gross income (NRs. 2,40,385 ha^{-1}) and net income (NRs. 1,66,971 ha^{-1}) as compared to that from Ms-W (NRs. 1,07,053 per ha and NRs. 47,677 ha^{-1} respectively). The higher gross and net return of maize from (M+S)-W system might be due to higher land, soil and resource use, higher total yield of maize and soybean and higher marketing price of soybean. This result was in agreement with the report of Verma et al. (1997) who explained the higher net income in all intercropping systems in comparison to pure or sole cropping.

B:C Ratio

The economic analysis using B:C ratio showed non-significant effect of the tillage system (Table 4). However, relatively higher B:C ratio resulted from zero tillage (2.32) as compared to conventional tillage (2.20). This inferred that ZT was more profitable than the CT and the profitability of ZT was mainly due to the less cost of production and higher gross income. Kumari and Sudheer (2016) explained the highest B:C ratio of ZT in comparison to farmers practice.

The applied residue level and intercropping system showed highly remarkable effect on the B:C ratio. Residue kept on the plots showed significantly higher ratio (2.41) as compared to residue removed operation (2.11) because of reduction of labor cost to remove the residue and the gross income was also high from the residue kept plot. (M+S)-W recorded significantly highest B:C ratio (2.92) when compared with Ms-W (1.60).

Table 4. Effect of tillage, residue management, and intercropping on the total cost, gross income, net income and B:C ratio from maize

Times	MTC (NRs. ha^{-1})	MGI (NRs. ha^{-1})	MNI (NRs. ha^{-1})	B:C Ratio
		Tillage		
ZT	71687	174211	109751	2.32
CT	76751	173227	104897	2.20
SEm (±)	273.6	3847.8	4253.4	0.0612
LSD(0.05)	892.2**	Ns	Ns	Ns
		Residue management		
Residue kept	73293	183477	117699	2.41
Residue removed	75145	163961	96949	2.11
SEm (±)	464	3588.7	3519.2	0.0547
LSD(0.05)	1391*	10759.0**	10550.6**	0.1485**
		Intercropping		
(M+S)-W	82172	240385	166971	2.92
Ms-W	66266	107053	47677	1.60
SEm (±)	164.5	4240	4156.7	0.0562
LSD(0.05)	473.7**	12213.9**	11974.0**	0.1618**
CV (%)	1.3	14.6	23.2	14.9
Grand mean	74219	173719	107324	2.26

Note: ZT=Zero tillage, CT=Conventional tillage, (M+S)-W=Maize and soybean intercrop followed by wheat, Ms-W=Maize sole followed by wheat, SEm=Standard Error of Means, LSD=Least Significance Difference, CV=Coefficient of variation, MTC= Maize Total Cost, MGI= Maize Gross Income and MNI= Maize Net Income. Ns, * and ** indicate Non-significance, significance, and highly significance at $P<0.05$ and $P<0.01$ respectively.

Economics of cropping system

System's Gross Income

Tillage has no significant effect on Gross Income. However, the residue levels affected with high significance showing maximum returns in residue kept (NRs. 3,73,011 ha^{-1}). Similarly, the cropping system showed significantly highest gross income in (M+S)-W system (NRs. 4,28,507 ha^{-1}) with mean SGI of NRs. 354917 ha^{-1}.

System's Net Income

Different tillage and residue levels and the cropping system had highly considerable influence in the net income of whole system. The Net Income of ZT was significantly highest than that of CT by 21.6%. Similarly, the residue kept recorded considerably

highest income (NRs. 2,22,958 ha^{-1}) as compared to that of residue removed (NRs. 1,83,530 ha^{-1}). Also, the (M+S)-W was more profitable with maximum income by NRs. 1,31,544 ha^{-1} as compared to that of Ms-W. The mean SNI was calculated to be NRs. 2,03,244 ha^{-1} (Table 5, Fig. 1).

Table 5. Effect of tillage, residue management, and intercropping on the total cost, gross income, and net income of the conservation agriculture system

Treatments	SGI (NRs. ha^{-1})	STC (NRs. ha^{-1})	SNI (NRs. ha^{-1})
Tillage			
ZT	363210	140138	223072
CT	346625	163209	183416
SEm (±)	7099.4	753.7	7115.2
LSD(0.05)	Ns	2458**	23204**
Residue Management			
Residue kept	373011	150053	222958
Residue Removed	336824	153294	183530
SEm (±)	4961.7	438.2	4982.6
LSD(0.05)	14875**	1314**	14938**
Cropping system			
(M+S)-W	428507	159491	269016
Ms-W	281328	143856	137472
SEm (±)	5502.4	168.9	5486
LSD(0.05)	15851**	4867**	15803**
CV (%)	9.3	0.7	16.2
Grand Mean	354917	151674	203244

Note: ZT=Zero tillage, CT=Conventional tillage, (M+S)-W=Maize and soybean intercrop followed by wheat, Ms-W=Maize sole followed by wheat, SEm=Standard Error of Means, LSD=Least Significance Difference, CV=Coefficient of variation, STC= System Total Cost, SGI= System Gross Income and SNI= System Net Income. Ns and ** indicate Non-significance and highly significance at $P>0.05$ and $P<0.01$ respectively.

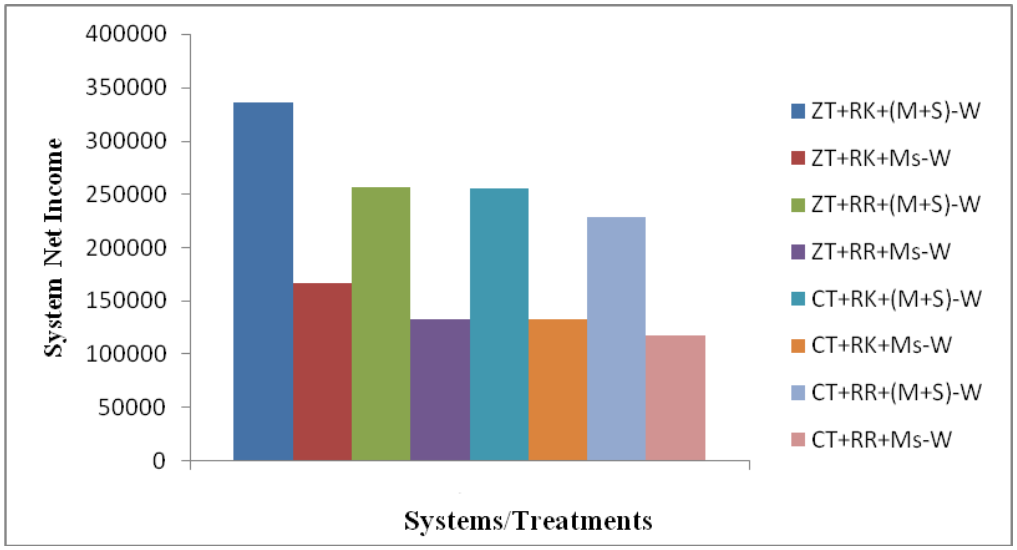

Fig. 1 Graph showing system net income in a year over different systems

Systems yield:

Table 6. Effect of tillage, residue management, and intercropping of system yield

Treatments	System yield (tha^{-1})
ZT+RK+(M+S)-W	10.8
ZT+RK+Ms-W	7.7
ZT+RR+(M+S)-W	9.3
ZT+RR+Ms-W	6.5
CT+RK+(M+S)-W	9.7
CT+RK+Ms-W	7.5
CT+RR+(M+S)-W	9.5
CT+RR+Ms-W	7.3
SEm (±)	0.2789
LSD (0.05)	0.8**
CV(%)	8.5

Note: ZT=Zero tillage, CT=Conventional tillage, RR=Residue removed, RK=Residue kept, Ms=Maize as sole crop, (M+S)-W=Maize and soybean intercrop followed by wheat, Ms-W=Maize sole followed by wheat, SEm=Standard Error of Means, LSD=Least Significance Difference, CV=Coefficient of variation and "**" signifies highly significant at P<0.01

System's yield was calculated by adding all the yield of maize, soybean and wheat obtained from the research trial and averaged over years. Analysis of variance of systems yield revealed the significant effect due to the application of several treatments. ZT+RK+(M+S)-W showed highly significant system yield (10.8 t ha^{-1}) which was considerably followed by CT+RK+(M+S)-W (9.7 tha^{-1}), CT+RK+Ms-W (9.5 t ha^{-1}) and ZT+RR+(M+S)-W (9.3 t ha^{-1}) respectively. The similar result with highest system yield in ZT+RK+(M+S)-W was found by Karki et al. (2014). The minimum system yield was found in ZT+RR+Ms-W (6.5 t ha^{-1}), (Table.6).

CONCLUSION

The total cost of tillage operation was found significantly cheaper in case of zero tillage, with higher net income and greater benefit cost ratio. Thus, zero tillage was determined to be profitable over conventional tillage for Dailekh district. The tillage and residue management has no short term effect on the yield benefits of maize and soybean. Since, the overall system showed the maximum net income in ZT, RK and (M+S)-W, the conservation agriculture technology based on maize with the combination of ZT, RK and (M+S)-W is recommended for higher crop yield and better economic return in the condition of Dailekh district.

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IMPACT OF ALUMINIUM (Al^{3+}) STRESS ON GERMINATION AND SEEDLING GROWTH OF FIVE WHEAT GENOTYPES

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ABSTRACT

A Petridish and hydroponic culture experiments were conducted at Crop Physiology Laboratory, Department of Crop Botany and Agriculture Chemistry Laboratory, Bangladesh Agricultural University, Mymensingh during the period from August to October 2011 to investigate the effect of aluminium on morphological characters and growth of wheat seedlings. The experiment comprised of two levels of aluminium concentrations viz., 0 μM (control) and 100 μM and five varieties viz; Kanchan, Shatabdi, Sourav, Bijoy (BARI-23) and Sufi (BARI-22). The experiment was laid out in two factors completely randomized design with three replications. Applications of 100 μM aluminium had a profound influence on hypocotyls and epicotyls length, germination percentages, and root-shoot length, fresh and dry mass production in wheat. Results indicated that germination percentage, hypocotyls and epicotyls length, root and shoot length, leaf length, leaf sheath length, plant height, fresh and dry mass plant were greater in control than aluminium stress conditions. It revealed that wheat seedlings are susceptible to aluminium stress. However, among the varieties, the reduction of dry mass under aluminium stress was minimum in Shatabdi followed by Kanchan showed that Shatabdi was more tolerant to aluminium stress than the other varieties namely Sourav, Bijoy (BARI-23) and Sufi (BARI-22). Sufi and Sourav were more susceptible to aluminium stress.

Keywords: Hydrophonic Culture, Hypocotyl, Epicotyl, Aluminium Ions, Germination, Growth

INTRODUCTION

In tropical climates, aluminium toxicity is a main factor for crop performance under acid soils (Barcelo and Porchenrieder, 2002). The presence of aluminium (Al) ions is the major constraints on crop production in acid soils which cover more than 30% of

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agricultural land around the world. Aluminium toxicity can be easily recognized by the inhibition of root growth by interfering with the regulation of root growth and development (Foy, 1988). Ionic Al rapidly suppresses root elongation and inhibits the uptake of nutrient and water, resulting in poor growth in plants. Although aluminium is not a heavy metal (specific gravity of 2.55-2.80), it makes up about 8% of the surface of the earth and is the third most abundant element (ATSDR ToxFAQs for Aluminium). It is readily available for human ingestion through the use of food additives, antacids, buffered aspirin, astringents, nasal sprays and antiperspirants from drinking water, automobile exhaust, tobacco smoke, aluminium foil, aluminium cookware, cans, ceramics and fireworks. Even though wheat is the second most important cereal crop in Bangladesh next to rice, the country still imports significant quantities of wheat to meet the domestic demand. Environmental stresses have adverse effects on wheat in growing stages, Al toxicity in acidic soils is one of them. Scientists reported that failure in grain set caused by Al toxicity causes yield reduction in wheat. One of the major factors leads to decrease wheat yield is aluminium toxic soil due to unavailability of aluminium tolerant cultivars. Some wheat cultivars have significant tolerance level and studies showed that wheat roots of aluminium resistant cultivars gather more Al^{3+} than those of aluminium sensitive ones (Aniol, 1983), whereas other works suggest that accumulation of Al^{3+} is alike to both resistant and sensitive wheat cultivars (Petterson and Strid, 1989; Zhang and Taylor, 1989). Therefore, the identification of wheat cultivars which are tolerant to Al toxicity is of particular significance for their immediate use in regions where Al toxicity causes limited yield. So, the present research work was undertaken to screen out the resistant variety(s) among the selected varieties with the proper investigation of aluminium tolerance variability among the different wheat varieties and to know the mineral uptake variability of cultivars under aluminium stress.

MATERIALS AND METHODS

The experiment was conducted in the green house (growth chamber),Bangladesh Agricultural University, Department of Crop Botany, Mymensingh from August 2011 to June 2012. Seeds of wheat cultivars: Shatabdi, Kanchan, Sourav, Bijoy (BARI-23) and Sufi (BARI-22). Seeds were collected from the Bangladesh Agricultural Research Institute (BARI), Gazipur, Bangladesh. The hydroponic system was constructed according to the IRRI slandered protocol (Gregorio et al., 1997).Five seeds were soaked in distilled water on filter papers (Advance Technology, Tokyo, Japan) in each Petridish for 24 hours. Plants were transferred to 4×30×35 cm rectangular plastic trays after two days of sowing. The experiments were conducted in a green house at 25ºC with 0.6 Cd m^{-2} light intensity. The volume of each tray was 8 L. On the opening of each tray, nylon net and rectangular-shaped Styrofoam having 10 × 10 holes were placed. Hogland solution (N:P:K= 21:31:23) was added to supply nutrient to plants. The solution was renewed with fresh nutrient solutions in 5 days interval. When seedlings were about 4 cm, seedlings were

pretreated with 100 μM $CaC1_2$ for six hours. The pH was maintained 5.10 by pH meter using HCl and NaOH if necessary. Than the seedlings were subjected to (Al treatment) or non-subjected (control) in 8L of solution containing 100 μM $AlCl_3$ (pH 5.5) or 0μM $AlCl_3$ (pH 5.0) for 24 hours. Parameters such as: hypocotyls length, epicotyls length, germination percentage were recorded at 4, 6 and 8 days after sowing of germinated seeds. Physical characteristics *viz.* root length, shoot length, number of roots $plant^{-1}$, leaf length, leaf sheath length, fresh weight, dry weight, total root and shoot weight, were also recorded at 10, 15 and 20 days after sowing in both Al (treatment) and control conditions.

Statistical analysis: Data were statistically analyzed for analysis of variance (ANOVA) using the MSTAT Statistical Computer package programme in accordance with the principles of Completely Randomized Design (Gomez, 1984). Least Significant Difference (LSD) was used to compare variations among the treatments.

RESULTS

1. Effect of aluminum levels on Seed related parameters of wheat grown in Petridish

1.1. Length of hypocotyl

The interactive effect of variety and aluminium level on hypocotyl length at 4, 6 and 8 DAS was significant (Table 1). The longest hypocotyl length was recorded in the treatment combination of variety Kanchan with 0 µM aluminium at all growth stages (5.6, 8.6 and 10.7 cm for 4, 6 and 8 DAS respectively) followed by varietySufi with 0 µM aluminium (5.5 and 8.3 cm for 4 and 6 DAS respectively). On the other hand, the shortest hypocotyls length was more or less observed in variety Sourav with 100 µM aluminium at all growth stages (2.7, 7.2 and 8.8 cm for 4, 6 and 8 DAS respectively).

1.2. Length of epicotyl

The interactive effect of variety and aluminium level on epicotyls length at 4, 6and 8 DAS was significant (Table 1). At 8 DAS, the longest epicotyl length was recorded in the treatment combination of Shatabdi (12 cm) with 0 µM aluminium followed by Kanchan and Sufi while the shortest was recorded in Bijoy (2cm at 4 DAS) with 100 µM aluminium.

Table 1. Combined effect of treatments and varieties on hypocotyls length and epicotyls length of wheat grown in petridish

Treatment	Variety	Hypocotyl length (cm)			Epicotyl length (cm)		
		4DAS	6DAS	8DAS	4DAS	6DAS	8DAS
T_1(0µM)	Kanchan	5.6a	8.6a	10.7a	3.3ab	9.3b	11.5ab
	Shatabdi	5.1bc	7.9bcd	9.8bc	3.4a	9.9a	12a
	Bijoy	4.5de	8.3ab	10.1b	3a-e	9b	11a-e
	Sufi	5.5ab	8.3ab	10.2b	2.8bcd	9.2b	11.2abc
	Sourav	5.2abc	8bc	10.0b	3.2abc	8.2c	10.9a-e
T_2(100µM)	Kanchan	4.4e	8bc	9.9b	2.7cd	8.4c	10.1cd
	Shatabdi	3.2g	7.5de	8f	2.1e	7.1de	9.8d
	Bijoy	4f	7.8cd	9.3d	2e	6.9e	9.8d
	Sufi	3.9cd	7.9bcd	9.4cd	2.7cd	8.1c	10.6bcd
	Sourav	2.7h	7.2e	8.8e	2.5de	7.5d	9.8d
LSD at 5%		0.19**	0.18**	0.19**	0.21**	0.18**	0.50**

LSD= Least Significant Difference; ** = Highly Significant

2. Effect of aluminum levels on germination percentage of wheat grown in Petridish

The interactive effect of variety and aluminium level on germination percentage at 4, 6 and 8 DAS was significant (Fig 1.). The highest germination percentage was recorded in the treatment combination of variety Shatabdi and variety Kanchan each with 0µM aluminium at all growth stages (98% and 100% at 8 DAS respectively). The lowest germination percentage was observed in Bijoy (84% at 8 DAS) with 100 µM aluminium.

3. Effect of aluminum levels on seedlings characters of wheat grown inhydroponic culture

3.1. Root length

The interactive effect of variety and aluminium on root length was significant (Fig. 2). The highest root length was observed in the treatment combination of variety Shatabdi with 0 µM aluminium (16.9 cm at 20 DAS) and the lowest was recorded in the treatment combination of Sourav with 100 µM aluminium (11.6 cm at 15 DAS).

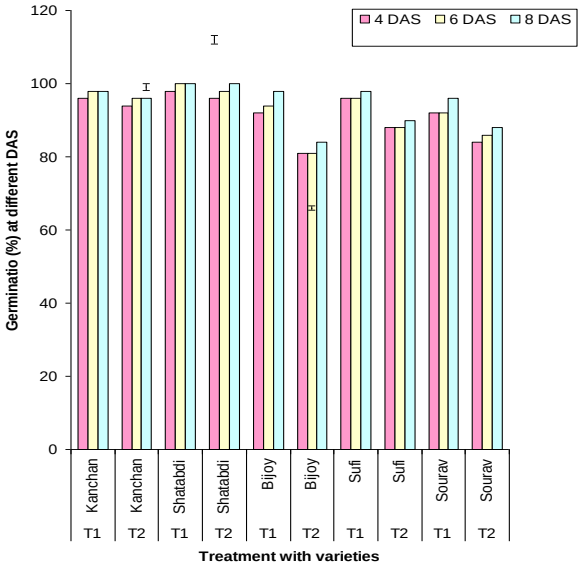

Figure 1: Combined effect of treatments and varieties ongermination percentages in wheat grown in petridish. Bar represents at LSD $_{(0.05)}$

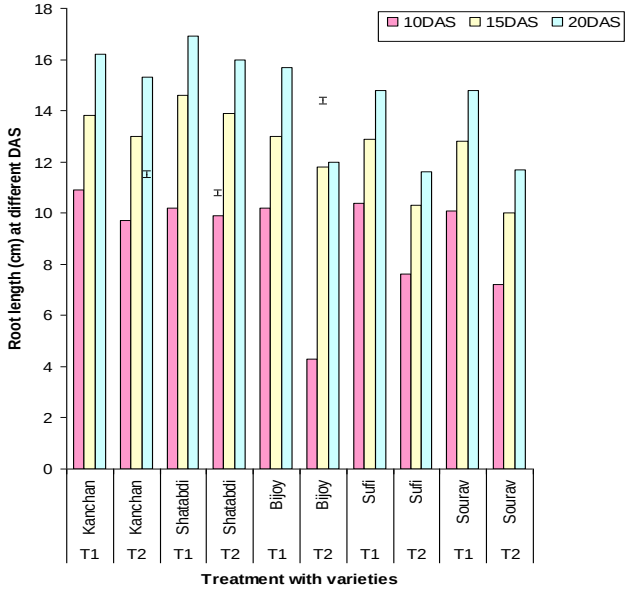

Figure 2: Combined effect of treatment**s** and varieties on root lengthin wheat grown in hydroponic culture. Bar represents at LSD $_{(0.05)}$

3.2. Shoot length

The interaction effect of variety and aluminium level on shoot length at 10, 15 and 20 DAS was significant (Table 2). At 10 DAS, variety kanchan produced significantly lengthy shoots with 0 µM aluminium (15.5 cm) as compared to all other combinations. At 15 DAS and 20 DAS, Kanchan and Shatabdi produced the lengthy shoots at both aluminium treatments which were at par with each other but significantly lengthy from all other treatment combinations.

Table 2. Combined effect of treatments and varieties on shoot length, leaf length, leaf sheath length of wheat grown inhydroponic culture

Treatment	Variety	Shoot length (cm)			Leaf length (cm)			Leaf sheath length (cm)		
		10DAS	15DAS	20DAS	10DAS	15DAS	20DAS	10DAS	15DAS	20DAS
T_1(0 µM)	Kanchan	12.5a	13.8a	15ab	14.8c	16.8a	18b	3.4a	5a	6a
	Shatabdi	11.9b	13.9a	15.1a	15.4a	17.0a	18.2a	3.5a	5a	6.2a
	Bijoy	11.2c	12.8b	14.8ab	13.9d	15.8b	17.8c	2.9bc	3.9b	6a
	Sufi	11.6bc	12.7bc	14.6b	13.5e	15.4bc	16.9e	2.6c	4b	5.7ab
	Sourav	11.4c	12.4c	14.5b	14d	15.3bcd	16.8e	2.8c	4.1b	5.3bc
T_2(100 µM)	Kanchan	9.9e	13.7a	14.8ab	14.7c	16.6a	17.8c	3.2ab	4.7a	5.7ab
	Shatabdi	9.8e	13.7a	14.9ab	15.2b	16.9a	18.1ab	3.5a	4.8a	6a
	Bijoy	9.7e	11.6d	14c	12.8f	14.9cd	17.2d	2.2d	3.2c	5.6ab
	Sufi	10.6d	11.4d	13.9c	11.7g	15.0cd	16.1f	2.0d	3.2c	5c
	Sourav	9.8e	11.0e	13.8c	13.5e	14.7d	16.2f	1.9d	3.0c	5c
LSD at 5%		0.17**	0.15**	0.47**	0.05**	0.27**	0.05**	0.14**	0.23**	0.24**

LSD= Least Significant Difference; ** = Highly Significant

3.3. Leaf length

The interactive effect of variety and aluminium levels on leaf length at all growth stages was significant (Table 2). The longest leaf length was recorded in the treatment combination of Shatabdi (15.4 cm at 10 DAS, 17.0 cm at 15 DAS and 18.2 cm at 20 DAS) with 0 µM aluminium followed by the same variety with 0 µM aluminium, which were statistically at par with each other but significantly lengthy from all other treatment combinations.

3.4. Leaf sheath length

The interactive effect of variety and aluminium concentration on leaf sheath length at 10, 15 and 20 DAS was significant (Table 2). All growth stages, Kanchan and Shatabdi with both aluminium treatments produced statistically similar leaf sheath length but significantly more than all other treatment combinations.

3.5. Root number

The interactive effect of variety and aluminium on root production was significant (Fig 3). The highest number of roots plant^{-1} was observed in the treatment

combination of shatabdi (13 plant^{-1} at 20 DAS) with 0 µM aluminium and the lowest was recorded in the treatment combination of Sourav (8 plant^{-1} at 20 DAS) with 100 µM aluminium.

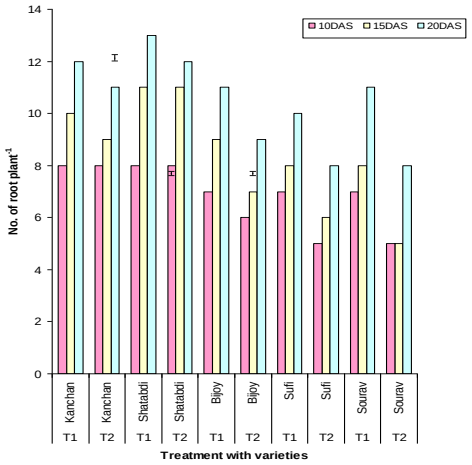

Figure 3: Combined effect of treatments and varieties on number of root plant^{-1} of wheat grown in hydroponic culture. Bar represents at LSD $_{(0.05)}$

3.6. Plant height

The interactive effect of variety and aluminium concentration on plant height at 10, 15 and 20 DAS was significant (Fig 4.). The longest plant height was recorded in the treatment combination of Shatabdi (26.3 cm at 20 DAS) with 0 µM aluminium. On the other hand, the shortest plant height was oobserved in Sourav (17.9 cm at 20 DAS) with 100 µM aluminium followed by Sufi (18.8 cm at 20 DAS).

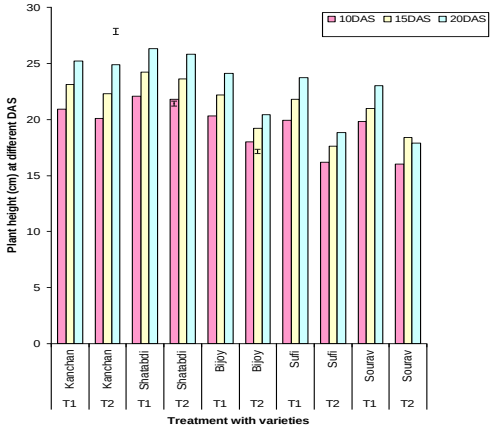

Figure 4: Combined effect of treatments and varieties on plant height of wheat grown in hydroponic culture. Bar represents at LSD $_{(0.05)}$

3.7. Fresh weight plant^{-1}

The interactive effect of variety and aluminium level on fresh weight plant^{-1} at 10, 15 and 20 DAS was significant (Table 3). The highest fresh weight plant^{-1} was recorded in the treatment combination of Shatabdi (810, 1610 and 1830 mg plant^{-1} for 10, 15 and 20 DAS respectively) with 0 µM aluminium followed by Kanchan (800, 1590and 1800 mg plant^{-1} for 10, 15 and 20DAS respectively) which were statistically at par with each other but significantly higher than all other treatment combinations at all three growth stages.

3.8. Dry weight plant^{-1}

The interactive effect of variety and aluminium level on dry weight plant^{-1} at 10, 15 and 20 DAS was significant (Table 3). The highest dry weight plant^{-1} was recorded in the treatment combination of Shatabdi (205, 480 and 550 mg plant^{-1}for 10, 15 and 20 DAS respectively) with 0 µM aluminium significantly higher than all other treatment combinations at all three growth combinations.

Table 3. Combined effect of treatments and varieties on fresh weight and dry weight plant^{-1}

Treatment	Variety	Fresh weight (mg) plant^{-1}			Dry weight (mg) plant^{-1}		
		10DAS	15DAS	20DAS	10DAS	15DAS	20DAS
T_1(0 µM)	Kanchan	800a	1590b	1800ab	200b	470b	530b
	Shatabdi	810a	1610a	1830a	205a	480a	550a
	Bijoy	550e	1380f	1760bc	100g	370e	500c
	Sufi	640d	1450e	1750bc	105f	390d	480d
	Sourav	720b	1500d	1790ab	130e	400c	430f
T_2(100 µM)	Kanchan	600b	1210c	1510ab	105d	160d	280c
	Shatabdi	650a	1285b	1560ab	115c	175c	290b
	Bijoy	300f	675g	910cd	50h	150f	200e
	Sufi	310f	705f	900d	45i	152f	180h
	Sourav	370c	710f	925cd	52h	145g	190g
LSD at 5%		11.89**	4.66**	23.32**	3.56**	2.33**	2.33**

LSD= Least Significant Difference; ** = Highly Significant

3.9. Total root fresh weight and dry weight

The interactive effect of variety and aluminium concentration on total root fresh weight was significant (Table 4). The highest total root fresh weight and dry weight were recorded in the treatment combination of Bijoy (5.98g and 5.95 g respectively) with 0 µM aluminium where the result have shown 50%-60% loss compared to the fresh weight. Almost similar was the case with total shoot weight.

Table 4. Combined effect of treatments and varieties on total root fresh weight and dry weight and total shoot fresh weight and dry weight

Treatment	Variety	Total root fresh wt (g)	Total shoot fresh wt (g)	Total root dry wt (**m**g)	Total shoot dry wt (**m**g)
T_1(0 µM)	Kanchan	5.83c	2.98a	583ab	280ab
	Shatabdi	5.67d	2.87b	561b	275abc
	Bijoy	5.98a	3.02a	595a	292a
	Sufi	5.87b	2.99a	587a	281ab
	Sourav	4.93f	2.85b	490d	271abc
T_2(100 µM)	Kanchan	4.80h	2.20cd	430d	250bc
	Shatabdi	4.89g	2.45cd	450d	260bc
	Bijoy	3.36i	1.95e	290d	195c
	Sufi	3.03e	2.00bc	300c	200abc
	Sourav	3.20g	1.85de	275d	175c
LSD at 5%		0.01**	0.03**	0.07**	0.08**

LSD= Least Significant Difference; ** = Highly Significant

DISCUSSIONS

Effect of aluminium levels on seed, germination percentage and seedlings characters of wheat grown in Petridish and hydroponic culture

Aluminium in different concentrations has influence in different parameters of seedlings characters such as length of epicotyls, length of hypocotyls and germination percentage. Foy (1996) found that the increase of aluminium concentration brings about the lowest length of epicotyls and germination percentage range (70-82%). Aluminium toxicity brings about an allelopathic effect on seed especially aluminium stress susceptible variety such as Bijoy showed significant variation in length of epicotyls and germination percentage. Fleming (1983) found that epicotyls and germination had positive co-relation so that decrease of epicotyls length brought about lower possibility of germination. It is suggested that epicotyls play a vital role in vigorous seedlings. Aluminium toxicity brings about dead seedling at an early stage. Increase of aluminium concentration inhibits epicotyls growth and development that promotes scarcity of water and nutrients in plants.The inhibitory action of aluminium plays a significant role in root elongation in Durum wheat (Foy and Fleming, 1978). On the contrary, Aluminium stress tolerance is a complex trait in plants that influence plant to uptake mineral and water by avoiding Aluminium concentration at a great extent that is shown by variety Shatabdi in the conducted

experiment. Aniol (1984) found that Al phytotoxicity was responsible for low fresh weight, dry weight as well as dwarf plant, lower leaf length and leaf sheath length. Al toxicity hampers calcium-dependent metabolism, Plasma membrane's lipid peroxidation and also quick disruption of cell elongation and division. Al^{3+} can bind to different sites of plants such as cell wall, plasma membrane and interfere with their functions. Lipid peroxidation brings about lower leaf length and lower sheath length in plants caused by aluminium toxicity (Sivaguru and Paliwal, 1993).The main symptom of oxidative stress is peroxidation of unsaturated lipids in membrane that limits the protein degradation and lowers the capacity of ion transport which ultimately brings about cell death. Limiting ion transport brings about stunted growth of plants which brings about growth parameters disruption of plants. Al toxicity brings about significant variation in seedling growth parameters and found root length has a negative correlation with relative root induction. Hydrolysis of endosperm and starch and supply of oxygen is needed for the development of seminal root caused by aluminium toxicity. In this experiment, wheat variety 'Sourov' and 'Sufi' showed susceptibility to aluminium toxicity in most cases.

CONCLUSION

Hypocotyls and epicotyls length and germination percentage decreased under 100 μM aluminium compared to control at 4,6 and 8 days after sowing indicating that 100 μM concentration is toxic to wheat seedlings growth and development. The interactive effect of variety on hypocotyls and epicotyls length and germination percentages was significant. The highest hypocotyls length was observed in Kanchan 10.7 cm) while the highest epicotyls length was recorded in Shatabdi (12 cm). In contrast, the lowest hypocotyls length was observed in Sourav (2.7 cm) and the lowest epicotyls length was observed in Bijoy (2 cm).The interactive effect of hypocotyls and epicotyls length and germination percentages was significant. The highest hypocotyls length was observed in the treatment combination of Kanchan with control at all growth stages while the highest epicotyl length was observed in the treatment combination of Shatabdi with control. However, the lowest hypocotyl length was observed in the treatment combination of Bijoy and Sourav with 100 μM aluminium while the lowest epicotyls length was observed in Sourav with 100 μM aluminium. Again the highest germination percentages were recorded in the treatment combination of Shatabdi with control. The effect of concentrated aluminium on root and shoot length, root number, leaf length fresh and dry weight was significant. The root and shoot length, fresh and dry weight were greater in control compared to 100 μM aluminium. In genotypes, the highest shoot length was observed in Shatabdi which resulted in highest dry mass $plant^{-1}$ at 15 and 20 DAS. In contrast, the lowest fresh and dry weight was recorded in Sourav and Sufi. The interaction effect of variety and aluminium on root and shoot length, fresh and dry

weight plant^{-1} was significant. For dry mass reduction due to concentrated aluminium, result showed that the lowest dry mass reduction due to aluminum was observed in Shatabdi indicating this variety more tolerant to aluminium than others. In contrast, the higher dry mass reduction was observed in Sourav and Sufi indication these two varieties were susceptible to aluminium. By measuring the minerals uptake of roots and shoots it may be concluded that at 100 μM Al treatment, based on the experimental results, it may be concluded that the aluminum concentration of 100 μ M had profound negative effect on germination percentages, growth and development of seedlings; and among the varieties, Shatabdi had highest tolerance to aluminium toxicity in respect with growth and development.

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SOCIO-ECONOMIC, FARM AND TECHNOLOGICAL CHARACTERISTICS OF THE PERI-URBAN SMALL AND MARGINAL DAIRY FARMERS OF CHITTAGONG METRO AREA, BANGLADESH

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ABSTRACT

The paper depicted the salient features of the socio-economic, farm and technological background and the existing problems of the peri-urban small and marginal dairy farmers of Chittagong Metro Area (CMA), Bangladesh. Data were collected using a pre-tested structured questionnaire. Snowball sampling method was used to gather socio-economic, farm and technological data. Both descriptive statistics and mathematical analyses were used for analyzing the data. The study finds the peri-urban small and marginal dairy farmers are not fully dependent on dairy farming for income and young people are less interested in dairy farming as well. Better education status, less profitability, unfair and unstable price, etc. might be the reasons behind this circumstance. Though the farmers get lesser price for milk, the milk price is higher in urban market. Interestingly, 62.7%, 52.9% and 51.0% of the farmer families have smartphone, facebook and internet users respectively. Based on the findings, the study recommends that technology-based market linkage could be created by any government/non-government development partner between the cluster-based farmers' group and the urban consumers for ensuring fair price for milk.

Keywords: Peri-urban, Small and Marginal Dairy Farmers, Profitability, Socio-economy, Farm and Technology

INTRODUCTION

Dairying is very common income source in rural and peri-urban areas of Bangladesh and there is prevalence of small and marginal farmers. Bangladesh Investment Development Authority (BIDA, 2010) reported that 90% of the dairy farmers have 1-3 cows, 6% dairy farmers have 3-10 cows and the rest 4% dairy farmers have more than 10 cows in the country. Though dairying is a common source of income, due to

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the wake of price-hiking of cow's feed items, medicines and other requisite inputs, dairy farming has now become expensive for those huge numbers of poor farmers. After struggling for survival many frustrated farmers are closing their business due to financial hardship. Many of them abandoned their business due to lack of marketing facilities incurring huge financial loss (UNB, 2017).

Milk production being the key income source is true for other countries as well where it plays a crucial role to generate income and employment (Pérez Urdiales et al., 2015). Moreover, small dairy farms are considered an important way to eradicate poverty in developing counties and it acts as a great social contributor in this connection (Holloway et al., 2000; Van Schaik et al., 1996; Somda et al., 2005). In Mexico, small-scale dairy farming has been regarded as an option for rural development (Espinoza-Ortega et al., 2007). Flaten (2002) showed small dairy farms produce multiple and interconnected benefits e.g. employment and rural sustainability, food security, landscape reservation, cultural heritage and biodiversity for developed countries like Norway. Kirui and Njiraini (2013) also reported the contribution of smallholder farmers in reducing food insecurity. Again, Heady and Sonka (1974) mentioned small farms can lead to greater income generation in rural communities by stimulating more activities in the community.

In particular, small-scale marginal farmers face many constraints that obstruct them from taking advantage of market opportunities (Fischer and Qaim, 2012). Such constraints would definitely impose a greater burden on the farm families and their incomes if their problems are not addressed in policy development. Proper measures can give a way to make dairy farmers' business profitable and sustainable which will lead to an improved standard of living of those farmers (UNB, 2016). Otherwise, transition to new economic sectors and activities may swap dairy farming activities (Flaten, 2002) and that is why policy for small and marginal dairy farmers needs to be fine-tuned to improve the situation. Such policy fine-tuning requires sufficient information regarding those farmers. A national dairy performance profile was developed considering the performance of the smallholder dairy production system and backward and forward supports and existing development programs and policies (Huque, 2011). Another study explored the small-scale dairy producers in Barura Upazilla of Comilla, Bangladesh to determine the role of small scale dairy cattle farming in improving their life styles also to identify the problems faced by them (Uddin et al., 2012). Quddus (2018) discussed the factors affecting dairy income and labor utilization, compared the performance of crossbred and indigenous cows, and reported the restraints of the smallholder dairy farmers of Jessore, Sherpur, Gazipur, Bogura and Mymensing. Household and farm economics of smallholding dairy farmers in Sirajganj was analyzed and cost of milk production was obtained to measure their vulnerability to international market in a report of Food and Agriculture Organization (Hemme et al., 2004). In another study, the impact of government subsidy program on small scale farm characteristics and farm financial performance was examined (Kabir and Talukder, 1999). Espinoza-Ortega et al.

(2007) found in a study in central Mexico that small-scale dairy farms are heterogeneous and the farms should not be treated as equal while developing the policy. Hence, based on the above literature review, there are still scopes for studies on small scale marginal farmers across different socio-economic and agro-ecological zonation in Bangladesh. The present study depicts the salient features regarding the socio-economic, farm and technological aspects of the peri-urban small and marginal dairy farmers, who have 1 to 10 cattle, of Chittagong Metro Area (CMA). It also aims to report the specific problems and also to pin-point the root causes of the problems faced by those farmers in the study area.

METHODOLOGY

Study area and duration

This is a cross-sectional descriptive study where the data were collected during October 2017 to December 2017 from field visits in the ten adjacent villages (peri-urban) to CMA (Gizaw et al., 2017), the second biggest metro area of Bangladesh. These ten villages mostly fit the per-urban villages of Chittagong Metro City as they are the only villages situated at the very entrance of the City namely Chikondondi, Shikarpur, Burirchor (Hathazari Upazilla); Urkirchar, Noapara (Raojan Upazilla); Gomdandi (Boalkhali Upazilla); Char Pathorghata, Shikalbaha, Kolagaon (Patiya Upazilla) and Salimpur (Sitakund Upazilla).

Sample size

Snowball sampling method was used to collect data from four to seven marginal dairy farmers from each village totaling a sample size of 51 out of 560 farmers (9.11% of the population). There was no farmers' database available and hence the population size was determined by personal observation and discussion with the local vets, Upazilla Veterinary Surgeons and Livestock Officers. In this particular study, dairy farmers having 1 to 10 cattle was considered small and marginal dairy farmers' as the classification of BIDA, 2010.

Data collection

A pre-tested structured questionnaire was used to gather farm data as well as demographic, socio-economic and technological data of the farmers. Extensive probing technique was used to collect their financial data as none of the farmers are used to keeping book of records. However, to buy the time of the farmers, they were given token gifts. Before starting the survey, they were given brief idea about the study. Data regarding problems faced by the farmers and the reasons for unfair price was collected in 5-point Likert scale where 1, 2, 3, 4 and 5 denote to Strongly Disagree, Disagree, Neutral, Agree and Strongly Agree respectively. The information provided by the farmers were put instantly on the survey sheet and later on the data were entered in the excel sheet for mean calculation. Besides, local and near-by town markets were also visited during the study time to collect market information.

Analytical Technique and Tool

Most of the variables were chosen for socio-economic and farm characterization following García, Dorward and Rehman (2012). Trending communication technology was considered while characterizing the technological background of the peri-urban marginal dairy farmers. The collected data were put in tabulation format to present the intended features of the farmers, their profitability and problems.

Regarding profitability analysis of the farms, Benefit Cost Ratio (BCR) (Meskel and Gemechu, 2017) and Return on Investment (ROI) (McDonald et al., 2013) were calculated on the basis of the simple theory of cost, revenues and investment.

$$\text{BCR} = \frac{Revenues}{Costs}$$

Here, the costs include the last year feeding, vaccination, artificial insemination (AI), labor, damage and spoilage cost. As the farmers sell the milk mostly in the locality, there is no related marketing cost. Revenues were calculated from the last year sales of milk, cow dung and calf. The farmers cannot sell the milk all the year round. Hence, yearly milk sales were calculated on the basis of average lactation amount and period of the cows.

$$\text{ROI} = \frac{Total\ Revenues - Total\ Costs}{Total\ Investment} \times 100$$

Here, total revenues minus total costs denote to the Trading Profit of the last year.

Total Investment= Cost for building housing structure + cattle value + other fixed investment

To produce the information from the collected data, the descriptive statistical analysis was performed using MS Excel 2013 and SPSS 16.0.

RESULTS AND DISCUSSION

Socio-economic characterization

Eight variables have been analyzed thana-wise to characterize the socio-economic background of the peri-urban small and marginal dairy farmers of CMA (Table 1). In general, the peri-urban small and marginal dairy farmers have other income sources rather than dairy farming and majority of them are poor. According to age group analysis, the age group ’35 years or less’ has been found dominant in Patiya (53.3%), Raojan (50.0%) and Sitakund (42.8%) and the age group ’36 to 50 years’ has been major in Boalkhali (50%). In Hathazari, 93.4% farmers are 36+ years. Adding to that majority of the farmers (62.7%) of the study area have farming experience of more than 15 years with an exception in Sitakund and Boalkhali. Quddus (2018) in his study on Bangladesh also found that around 56% of the famers were experienced from 11 to 20 years. It might indicate that young people are getting less interest in dairy farming and only the existing dairy farmers are doing the same only as their family tradition.

Table 1. Socio-economic characteristics of the peri-urban marginal dairy farmers of CMA

Socio-economic characteristics		*Thana*					
		Sitakund n=7	Hathazari n=15	Raojan n=10	Boalkhali n=4	Patiya n= 15	Total n=51
		%	*%*	*%*	*%*	*%*	*%*
Age group	35 years or less	42.80	6.60	50.00	25.00	53.30	35.30
	36 to 50 years	28.60	46.70	40.00	50.00	26.70	37.30
	51 years or more	28.60	46.70	10.00	25.00	20.00	27.40
Education status	No education	28.6	13.3	.0	50.0	33.3	21.6
	Primary to secondary education	57.1	60.0	70.0	50.0	53.3	58.8
	Higher secondary and above	14.3	26.7	30.0	.0	13.4	19.6
Years of farming experience	15 years or less	71.4	13.4	50.0	100.0	20.0	37.3
	16 to 30 years	28.6	53.3	30.0	.0	66.7	45.1
	More than 30 years	.0	33.3	20.0	.0	13.3	17.6
Main Income Source	Dairy Farming	14.3	33.3	10.0	25.0	60.0	33.4
	Agriculture	.0	6.7	50.0	.0	6.7	13.7
	Others	85.7	60.0	40.0	75.0	33.3	52.9
Economic Status	Poor (hand to mouth)	42.9	60.0	30.0	75.0	26.7	43.1
	Middle Class (moderately solvent)	57.1	13.3	10.0	.0	33.3	23.5
	Rich ((solvent)	.0	26.7	60.0	25.0	40.0	33.3
Family Members	1-5 Members	42.9	53.3	30.0	75.0	33.3	43.1
	6-10 Members	57.1	26.7	60.0	25.0	46.7	43.1
	10+ Members	.0	20.0	10.0	.0	20.0	13.8
Gender of the farmer	Male	71.4	86.7	100.0	50.0	100.0	88.2
	Female	28.6	13.3	.0	50.0	.0	11.8
House ownership	Owned	85.7	100.0	100.0	100.0	100.0	98.0
	Rented	14.3	.0	.0	.0	.0	2.0
	Others	.0	.0	.0	.0	.0	.0
Dairy contribution to total income (%)		27.1	32.0	26.4	46.9	34.3	33.5

Moreover, majority of the farm families are no more dependent on agricultural and or farming income sources. Though 60% and 33.3% of the smallholder farmers of Patiya and Hathazari are dependent on dairy farming as their main income source, only 10.0%, 14.3% and 25.0% of the farmers of Raojan, Sitakund and Boalkhali are dependent on the same source of income. The highest dairy income contributing Upazilla is Boalkhali (46.9%) and the lowest dairy income contributing Upazilla is

Raojan (26.4%). In total, 52.9% of the peri-urban dairy farmers of the selected area rely on non-farming and non-agricultural sources for their income. Better education status (Table 1), less profitability (Table 3), unfair and unstable price, lack of financing opportunities (Table 5) market need gap and lack of market linkage (Table 6) might have contributed to the less reliability on farming and agriculture and to the moves to the other income sources. The education status statistics show 58.8% and 19.6% of the marginal farmers have 'primary to secondary education' and 'higher secondary and above' education respectively whereas 21.6% farmers have no formal education. According to other socio-economic characteristics, 43.1% of the farmers are living in poor condition though 98% of the farmers have their own house. Regarding gender, 88.2% of the peri-urban marginal farmers are male and majority of the farmers (86.2%) have family members between 1 and 10.

Farm characterization

Table 2 depicts the nine farm characteristics of the peri-urban marginal farmers of Chittagong Metro Area. In general, the majority portion of the peri-urban marginal farmers are not making profit though they keep continuing their dairy farming probably for maintaining family tradition. Regarding herd size and farm structure, most of the farmers (54.9%) have 3 or fewer cattle and the same percentage of the farmers maintain mixed or semi-concrete farm structure. Semi-intensive farm management system is being used by 51% farmers. Although 64.7% of the farmers are getting the yearly production of milk below 1000 liters, the only exception is Patiya where 53.3% of the farmers are getting over 2000 liters yearly. Alam et al. (2011) also mentioned about such low productivity of the smallholder dairy farmers. A very significant percentage of the farmers (94.1%) do not get any formal credit facilities. However, 100% of them get veterinary services which are government provided and very affordable. Though 66.7% farmers of the total area have local or indigenous breeds, the farmers of Patiya (73.3%), a dairy zone of Chittagong District, have an exception of having HF Crossbred. Quite surprisingly, none of the farmers of the whole area keep any sorts of financial records. From the estimated data found from the survey, it is seen that 64.7% of the farmers are not making any profit being Sitakund in the top of the list (85.7%).

Table 2. Farm characteristics of the peri-urban marginal dairy farmers of CMA

Farm characteristics		*Thana*					
		Sitakund n=7	Hathazari n=15	Raojan n=10	Boalkhali n=4	Patiya n= 15	Total n=51
		%	*%*	*%*	*%*	*%*	*%*
Herd Size	3 cattle or fewer	28.6	66.7	60.0	50.0	53.3	54.9
	4 to 8 cattle	71.4	26.7	30.0	50.0	33.3	37.3
	9 to 10 cattle	.0	6.6	10.0	.0	13.4	7.8
Farm infrastructure	Soiled or bamboo made	14.3	33.3	20.0	50.0	20.0	25.5
	Mixed/Semi-concrete	85.7	53.3	60.0	25.0	46.7	54.9
	Concrete	.0	13.4	20.0	25.0	33.3	19.6
Farm management system	Intensive	.0	40.0	50.0	.0	93.3	49.0
	Semi Intensive	100.0	60.0	50.0	100.0	6.7	51.0
	Extensive	.0	.0	.0	.0	.0	.0
Milk production (litter/yearly)	1000 liters or less	85.7	66.7	80.0	100.0	33.3	64.7
	1001 to 2000 liters	14.3	20.0	10.0	.0	13.3	13.7
	More than 2000 liters	.0	13.3	10.0	.0	53.4	21.6
Access to credit facilities	No	100.0	100.0	100.0	100.0	80.0	94.1
	Yes	.0	.0	.0	.0	20.0	5.9
Availability of book keeping records	No	100.0	100.0	100.0	100.0	100.0	100.0
	Yes	.0	.0	.0	.0	.0	.0
Available breed	RCC	.0	.0	.0	.0	.0	.0
	Local/Indigenous	100.0	66.7	90.0	100.0	26.7	66.7
	HF Crossbred	.0	20.0	.0	.0	73.3	27.5
	Shahiwal Crossbred	.0	.0	.0	.0	.0	.0
	Other breed	.0	13.3	10.0	.0	.0	5.8
Availability of veterinary service	No	.0	.0	.0	.0	.0	.0
	Yes	100.0	100.0	100.0	100.0	100.0	100.0
Yearly Profit	No Profit	85.7	66.7	60.0	50.0	60.0	64.7
	Less than 100,000	14.3	33.3	10.0	50.0	13.3	21.6
	More than 100,000	.0	.0	30.0	.0	26.7	13.7

Profitability of the farms of the peri-urban areas have been exhibited in Table 3. It summarizes that the farmers of Sitakund, Hathazari are not profitable (ROI< 0% and BCR<1) but there exists an opposite trend in Patiya and Raojan. To be specific, the marginal farmers of Sitakund and Hathazari are getting highly negative ROI of (-59.1%) and (-48.3%) respectively. On the contrary, Patiya farmers are getting better ROI which is 31.7%. However, the farmers of Raojan and Boalkhali are making moderate ROI of 8.4% and 1% correspondingly. The BCR ratio is also denoting the non-profitability of Sitakund (0.75) and Hathazari (0.88) farmers. In total, the farmers of the whole area are earning ROI of only 2.8% and the BCR is 1.12. But in a study (Huque et al., 2002) higher figures were found where the BCR was 1.32 and 1.45 for marginal and small farmers respectively. These differences might originate from the course of time and also due to the fact that the profitability is decreasing.

Table 3. Profitability Analysis

Particulars (Yearly)	*Thana*					
	Sitakund Taka	Hathazari Taka	Raojan Taka	Boalkhali Taka	Patiya Taka	Total Taka
Investment in housing	20,571.0	46,733.0	92,700.0	21,250.0	59,800.0	54,000.0
Investment in cattle	32,857.0	56,100.0	426,950.0	6,250.0	110,400.0	137,686.0
Investment in others	2,093.0	-	500.0	1,025.0	793.0	699.0
A. Investment- Total	55,521.0	102,833.0	520,150.0	28,525.0	170,993.0	192,385.0
Milk sales	20,907.0	37,383.0	31,440.0	31,838.0	168,767.0	72,164.0
Calf sales	15,000.0	38,833.0	144,500.0	1,250.0	68,733.0	62,127.0
Cow-dung sales	26,914.0	-	-	12,000.0	800.0	4,871.0
Home consumption of milk	6,336.0	10,837.0	8,970.0	6,862.0	11,585.0	9,761.0
B. Revenue- Total	69,157.0	87,053.0	184,910.0	51,950.0	249,885.0	148,923.0
Cost of feeding	84,471.0	88,208.0	123,918.0	44,530.0	165,053.0	113,873.0
Cost of medication and vaccines	14,800.0	13,667.0	10,500.0	4,625.0	20,467.0	14,492.0
Cost of Artificial Insemination (AI)	817.0	503.0	810.0	875.0	723.0	700.0
Cost of labor	-	31,989.0	2,527.0	-	3,733.0	11,002.0
Cost of damage/wastage	1,886.0	2,400.0	3,600.0	1,500.0	5,760.0	3,482.0
C. Cost- Total	101,974.0	136,768.0	141,354.0	51,530.0	195,736.0	143,550.0
D. Profit- Total (B-C)	(32,817.00)	(49,714.00)	43,556.00	420.00	54,149.00	5,373.00
E. BCR (B/C)	0.75	0.88	1.63	1.00	1.22	1.12
F. Return on Investment % (D/A)	-59.1%	-48.3%	8.4%	1.5%	31.7%	2.8%

Poor condition of the farm family, very little credit facilities and less profitability might hinder them to increase the herd size and milk production and also to introduce high-yielding breeds. It might also indicate they are simply losing their interest in dairy farming.

Technological characterization

Table 4. Technological characteristics of the peri-urban marginal dairy farmers of CMA

Technological characteristics		*Thana*					
		Sitakund n=7	Hathazari n=15	Raojan n=10	Boalkhali n=4	Patiya n= 15	Total n=51
		%	%	%	%	%	%
Currently technology used by the farmers	No technology	.0	.0	.0	.0	.0	.0
	Mobile Phone	85.7	86.7	50.0	100.0	100.0	84.3
	Facebook	.0	.0	.0	.0	.0	.0
	Whatsapp	.0	.0	.0	.0	.0	.0
	Other	14.3	13.3	50.0	.0	.0	15.7
Internet user in the farmer family	No	42.9	53.3	20.0	100.0	53.3	49.0
	Yes	57.1	46.7	80.0	.0	46.7	51.0
Smart Phone user in the farmer family	No	57.1	40.0	10.0	50.0	40.0	37.3
	Yes	42.9	60.0	90.0	50.0	60.0	62.7
Facebook user in the farmer family	No	42.9	53.3	20.0	75.0	53.3	47.1
	Yes	57.1	46.7	80.0	25.0	46.7	52.9
Whatsapp user in the farmer family	No	85.7	93.3	100.0	100.0	100.0	96.1
	Yes	14.3	6.7	.0	.0	.0	3.9
IMO user in the farmer family	No	85.7	93.3	100.0	100.0	93.3	94.1
	Yes	14.3	6.7	.0	.0	6.7	5.9
Score on attitudes towards technology	Negative	.0	6.7	.0	.0	.0	2.0
	Neutral	.0	.0	.0	.0	.0	.0
	Positive	100.0	93.3	100.0	100.0	100.0	98.0
Likelihood of using technology by the farmers in selling milk	Strongly Disagree	.0	6.7	.0	.0	.0	2.0
	Disagree	.0	.0	.0	.0	.0	.0
	Neutral	.0	.0	.0	.0	.0	.0
	Agree	42.9	.0	.0	.0	.0	5.9
	Strongly Agree	57.1	93.3	100.0	100.0	100.0	92.2

Table 4 demonstrates the technological characteristics of the marginal dairy farmers of the study area. It shows that the farmers and their family have experienced the touch of use of communication technology. Very fascinatingly, 62.7%, 52.9% and 51.0% of the farmer families have smartphone, facebook and internet users in their families respectively. The least percentage of the farmer families are exposed to WhatsApp (3.9%) and IMO (5.9%) mobile communication application. However, 84.3% of the farmers themselves use mobile phone for communication purpose. Most importantly, the farmers (98%) have positive attitude towards use of technology. Such positive attitude towards technology and adoption of trending technology is a very good sign for future development of the community as technology is being capitalized in different sectoral development. Abdi et al. (2017) emphasized the use of different ICT platforms in publicizing agricultural market information to the farmers to enable them to access to information of markets for the products, market price, input price and weather forecast. In this connection, the peri-urban marginal dairy farmers' insight regarding the current technological ability and their positive attitude towards technology could be used as input in formulating future development program for the community.

Problems faced by the farmers

The study also attempted to pin point the problems faced by the farmers (Table 5). The data was taken in Likert scale where 1 denotes to Strongly Disagree and 5 refers to Strongly Agree. Table 5 says most of the farmers highlighted three problems: finance (mean: 4.53), unstable price (mean: 4.27) and unfair price (mean: 4.00) of the milk. The marginal farmers do not have access to formal credit facilities and they become helpless to get adequate capital supply (Quddus, 2018). Regarding unfair price, Table 7 demonstrates the highest price is 75.00 tk./liter paid by Consumer/Household customers in urban area but from the field survey, it has been found that the farmers get the lowest price (Tk. 40/liter) in Patiya and Hathazari and the mean price of the whole area is Tk. 53.65/liter (Table 8) Quddus (2018) also found that low price of the milk is a constraint for the smallholders. However, comparing Table 7 and Table 8, it is clear that there is a better opportunity for the peri-urban marginal farmers in the urban consumer market and currently they are getting lesser price of milk. Furthermore, the study attempted to know the farmers' thoughts regarding the reasons for not getting the fair price. The farmers reported the main causes: lack of value addition (mean 4.12), lack of storage facilities (mean 4.02), market need gap (mean 3.18) and lack of market linkage (mean 3.02) (Table 6). Shantana R and Proloy (2003) also reported that dairy farmers are facing marketing and storage issues in Bangladesh.

Table 5. Problems faced by the farmers

	Minimum	Maximum	Mean	Std. Deviation	Rank
Farmers lack finance	1	5	4.53	1.12	1
Farmers face unstable price of the milk	1	5	4.27	1.218	2
Farmers get unfair price of the milk	1	5	4.00	1.166	3
Farmers lack storage facilities	1	5	3.94	1.448	4
Farmers can't pack the milk	1	5	3.51	1.206	5
Farmers lack transportation	1	5	3.35	1.197	6
Farmers lack market linkage	1	5	3.02	1.086	7
Farmers feel gap with the consumer	1	5	2.59	1.023	8
Farmers lack market information	1	5	2.47	1.189	9

Table 6. Reasons for Unfair Price (Measured in Likert scale)

		N	Mean	Std. Deviation	Std. Error
Farmers not getting fair price due to lack of market info	Sitakund	7	3	1	0.378
	Hathazari	15	2.33	1.291	0.333
	Raojan	10	2.4	0.699	0.221
	Boalkhali		2	1.414	0.707
	Patiya	15	2.27	1.163	0.3
	Total	51	2.39	1.115	0.156
Farmers not getting fair price due to lack of market linkage	Sitakund	7	3.14	1.069	0.404
	Hathazari	15	2.93	1.1	0.284
	Raojan	10	2.4	0.699	0.221
	Boalkhali	4	4	0	0
	Patiya	15	3.2	1.207	0.312
	Total	51	3.02	1.068	0.149
Farmers not getting fair price due to market need gap	Sitakund	7	2.14	0.9	0.34
	Hathazari	15	3.07	0.704	0.182
	Raojan	10	3.9	0.316	0.1
	Boalkhali	4	3	0.816	0.408
	Patiya	15	3.33	1.047	0.27
	Total	51	3.18	0.932	0.13
Farmers not getting fair price due to lack of customer trust	Sitakund	7	2.14	1.345	0.508
	Hathazari	15	3.33	1.047	0.27
	Raojan	10	3	0.667	0.211

		N	Mean	Std. Deviation	Std. Error
	Boalkhali	4	1	0	0
	Patiya	15	2.33	1.952	0.504
	Total	51	2.63	1.455	0.204
Farmers not getting fair price due to lack of value addition	Sitakund	7	2.86	1.464	0.553
	Hathazari	15	3.93	1.1	0.284
	Raojan	10	4.1	0.316	0.1
	Boalkhali	4	4	0	0
	Patiya	15	4.93	0.258	0.067
	Total	51	4.12	1.032	0.145
Farmers not getting fair price due to lack of storage facilities	Sitakund	7	3.57	1.813	0.685
	Hathazari	15	4.67	1.047	0.27
	Raojan	10	4	1.633	0.516
	Boalkhali	4	4	2	1
	Patiya	15	3.6	1.404	0.363
	Total	51	4.02	1.476	0.207

Table 7. Average purchase price of the buyers

Different Buyers	Count of Buyer Category	Average of Purchase Price (Taka)
Local Market	41	
Bulk Buyer (Big)-Purchase 100 Liters+	2	52.50
Bulk Buyer (Medium)-Purchase 51-100 Liters	3	63.33
Bulk Buyer (Small)-Purchase 10-50 Liters	14	59.79
Door to Door Delivery/Consumer/Household	14	66.07
Local Village Bazaar	6	56.50
Others	2	57.50
Urban Market	16	
Bulk Buyer (Big)-Purchase 100 Liters+	1	45.00
Bulk Buyer (Small)-Purchase 10-50 Liters	4	53.75
Door to Door Delivery/Consumer/Household	10	75.00
Local Urban Bazaar	1	55

Table 8. Net price received by the farmers

	Thana					
	Sitakund Tk/Liter	Hathazari Tk/Liter	Raojan Tk/Liter	Boalkhali Tk/Liter	Patiya Tk/Liter	Total Tk/Liter
Mean	62.86	49	59	60	48.73	53.65
Maximum	70	70	60	60	60	70.00
Minimum	50	40	50	60	40	40.00

CONCLUSION

The research demonstrates the salient socio-economic, farm and technological characteristics of the peri-urban marginal dairy farmers of Chittagong Metro Area. Most of the farms are found to be in 'no profit' category. Unfair and unstable prices, poor financing opportunities, market need gap, lack of market linkage, storage facilities and value addition are found as major issues in the study area. The study output might help the future formulation of development program for the small and marginal dairy farmers' community.

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STUDY OF NITROGEN USE EFFICIENCY AND YIELD OF RICE INFLUENCED BY DEEP PLACEMENT OF NITROGEN FERTILIZERS

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ABSTRACT

Continuous increase of nitrogen fertilizer use adversely affecting the soil health as well as the environment. It necessitates the systematic study of the impact of nitrogen (N) fertilizer use-reduction on crop yield. In this article, the effects of deep placement of nitrogen fertilizers on nitrogen use efficiency (NUE) and yield of rice variety "BRRI dhan46" were investigated and compared for three N formulations: urea super granule (USG), NPK briquettes and prilled urea (PU). The experiment was conducted in randomized complete block design (RCBD) with eight N treatments replicated three times. The treatments were applied by varying doses (0, 52, 78 and 104 kg ha^{-1}) of nitrogen fertilizers in a known identical soil and weather condition. Applications of PU, USG and NPK briquettes exhibited significant differences on yield attributes of rice. Results revealed maximum grain yield of 6.391 t ha^{-1} (54% increases over control) for the dose USG 104 kg ha^{-1} which is statistically similar to the dose USG 78 kg ha^{-1} and NPK briquettes 104 kg ha^{-1}. The deep placement of USG and NPK briquettes enhanced both the recovery of applied N and N use efficiency compared to broadcast application of prilled urea. However, USG 78 kg ha^{-1} showed maximum apparent N recovery, N use efficiency, gross margin and marginal benefit-cost ratio. Thus, an application of 78 kg ha^{-1} USG can be recommended for profitable cultivation of rice variety BRRI dhan46.

Keywords: Apparent Nitrogen Recovery, Marginal Benefit-cost Ratio, Nitrogen use Efficiency, Prilled Urea, Urea Super Granule.

INTRODUCTION

Global demands for food and fiber will increase up to 70% by 2050 (Singh and Trivedi, 2017). An increase of 2% - 3% $year^{-1}$ in rice production has to be maintained to ensure the self-sufficiency in rice, within limited arable land (Haque and Haque, 2016). Further, the use of chemical fertilizer has been rapidly increasing to meet the

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continuously growing demands of increased yield from the existing land. Particularly in highly populated developing countries, the increasing rate of fertilizer use is dramatic. However, this increased rate of fertilizer has negative impact on food safety, environment and soil health. It has been reported that, the use of excess N fertilizers increases NO_3-N and NH_4-N in underground water which is a threat for human health. Chemicals like KCl, $NaNO_3$, K_2SO_4, NH_4Cl etc. added in soil due to application of fertilizers are responsible for demolishing soil structure (Savci, 2012). Thus, it is important to minimize the use of chemical fertilizers.

Rice is a dominant crop of predominantly agriculture dependent countries of the world like Bangladesh, India, China, Vietnam etc. In Bangladesh, rice farmers rely solely upon urea fertilizer (about 57%, 2.46 million MT, of total fertilizer use) and more than 50% of the total demand of urea is imported, which demands a large sums of foreign currency (BBS, 2015). Therefore, attention must be given to minimize the cost without compromising production.

Generally, the farmers of Bangladesh use urea fertilizer by broadcast method during cultivation. Most of this applied fertilizer is lost through leaching, surface runoff, NH_4^+ and NH_3 volatilization, denitrification, and other process. Consequently, N fertilizer use efficiency decreases. These losses of N result in reduced growth and yield of rice. Urea deep placement (UDP) is a proven technology that reduces N losses by up to 50% when compared with the conventional broadcast application of urea (Huda et al., 2016). Deep placement of nitrogenous fertilizers dissolves slowly in the soil providing a steady supply of nitrogen throughout the growing period of the crop. Deep placement of USG in transplanted rice cultivation can reduce nitrogen losses, which is more beneficial compared to broadcast method. Again, the deep placement of USG and NPK briquette minimizes the concentration of NH_4^+-N in floodwater compared to broadcast application of PU. The savings in applied N reached 70 and 35 kg ha^{-1} when applied USG as N fertilizer during the Boro (February-June) and Aman (August-December) seasons, respectively (Bowen et al., 2005).

Water shortage is a growing problem due to climate change and upstream water regulation. On the other hand, nitrogen loss as ammonia volatilization in the flooded soils ranged from negligible to almost 60% of the applied N (Xing and Zhu, 2000). Shallow irrigation water depth has been recommended to lower the NH_3 volatilization due to enhanced ammonium binding in the soil (Li et al., 2008). In this case AWD is very effective. In some cases it was reported that AWD decreases yield by 5.4%; however under mild AWD (i.e. when soil water potential was ≥ -20 kPa or field water level did not drop below 15 cm from the soil surface), yields were not significantly reduced in most circumstances (Carrijo et al., 2017). The AWD practice has been found to have significant positive impact on yield of rice and minimize the production cost. Though it is advantageous to the farmers to minimizes the production cost with low N losses, limited information are available for AWD system (Djaman et al., 2018).

Importantly, the efficient use of nitrogen is recognized as a production factor for rice, but it has always been a problem to improve the N utilization rate of the rice plant and to increase efficiency of absorbed nitrogen for grain production. Further, nitrogen fertilizer is costly, thus it is important to minimize the losses of nitrogen fertilizers and maximize the economic utility. Nitrogen use efficiency (NUE) of different rice cultivars such as BRRI dhan1 (Haque and Haque, 2016), BRRI dhan28, BRRI dhan36 (Alim, 2012), BRRI dhan29 (Hasan et al., 2016; Alam et al., 2010) has been studied.

Despite being a highly productive variety, NUE of BRRI dhan46 is barely reported. Considering the negative impact of inorganic fertilizers and yield of this rice variety, it is crucial to study the NUE and yield aspects for different dose of N fertilizers. This work was intended to study the NUE, grain yield, straw yield, apparent nitrogen recovery (ANR) and marginal benefit cost ratio for different doses to evaluate optimum dose.

MATERIALS AND METHODS

Experimental site, weather, soil and variety

The experimental site is located at Soil Science Field Laboratory of Bangladesh Agricultural University, Mymensingh, 24.75ºN latitude and 90.5ºE longitude, elevation 18m above the sea level and is located in the agroecological zone (AEZ) of the Old Brahmaputra Floodplain. The average temperature, rainfall and relative humidity were respectively 26.4ºC, 190.2 mm and 84.5%. Since some of the attributes such as soil pH, total nitrogen in soil, available phosphorus and exchangeable potassium reportedly affect NUE, it is important to quantify those attributes of experimental site (Chen et al., 2018). The selected field soil was a typical rice growing silt loam soil. The amount of total nitrogen in the soil was 0.136%, available phosphorus 3.16 ppm, exchangeable potassium 0.095% and the pH 6.07 (Das et al., 2016). BRRI dhan46, a high yielding variety of rice was used as the test crop in this experiment. It is a transplant rice cultivar and matures after 150-155 days of transplanting with average dry yield 5.0-7.5 Mt ha^{-1}.

Treatments

The experiment was carried out with the following treatments:

Table 1: List of treatments with different N fertilizers doses with their sources

Treatments	Name of N Fertilizers	Amount of N fertilizers (kg ha^{-1})	STBRD-N (%)
T_1	None (Control)	-	-
T_2	PU (Prilled Urea)	104	100
T_3	USG (Urea Super Granule)	104	100
T_4	USG (Urea Super Granule)	78	75
T_5	USG (Urea Super Granule)	52	50
T_6	NPK briquettes	104	100
T_7	NPK briquettes	78	75
T_8	NPK briquettes	52	50

Fertilizer applications

All treatments were controlled for N only and before application of N fertilizers, the water in the rice plots was drained. Nutrients P, K, S and Zn were provided according to soil test recommendations and typical production demands. All treatments received S (18 kg ha^{-1}) and Zn (3 kg ha^{-1}) from gypsum and zinc oxide. Treatments T_1, T_2, T_3, T_4 and T_5, received P (25 kg ha^{-1}) and K (50 kg ha^{-1}) from TSP (Ca $(H_2PO_4)_2$) and muriate of potash (KCl), respectively. Treatments T_6, T_7 and T_8, P and K were supplied from NPK briquettes. The PU was applied in three equal splits. The first dose of PU was applied 10 days after transplanting (DAT), the second dose was added as top dressing at 35 DAT (active tillering stage) and the third dose was top dressed at 55 DAT (panicle initiation stage). USG and NPK briquettes were applied after 10 DAT. The USG and NPK briquettes were placed at 8-10 cm depth between four hills at alternate rows. Irrigation, weeding and other agronomic practices were done whenever necessary.

Data collection and analysis method

Data collected for analysis of variables were: plant height, effective tillers per hill, panicle length, grains $panicle^{-1}$ and 1000-grain weight, grain and straw yield of BRRI dhan46 were recorded. For determination of yield attributes five hills were selected and number of tillers per hill, number of filled and unfilled grains per panicle and thousand grain weight was measured. The above ground plant parts were segmented into different components as leaf, stem, leaf sheath and panicle and were dried in an oven for 72 hours at 70˚C. After drying to14% moisture, the grain yield of rice was measured as metric ton ha^{-1}. The straw yield of rice was recorded as metric ton ha^{-1}

on sun dry basis. For determination of total nitrogen semi-micro Kjeldahl method of Bremner and Mulvaney was used (Bremner and Mulvaney, 1982).

The NUE (kg grain yield increase kg^{-1} N applied) was determined by the following formula: NUE = (GY_{+N}– GY_{0N}) / FN; Where, GY_{+N} = grain yield in treatment with N application, GY_{0N} = grain yield in treatment without N application and FN = amount of fertilizer N applied (kg ha^{-1}). The apparent N recovery was calculated by the following formula: ANR (kg ha^{-1}) = (UN_{+N} - UN_{0N}) /FN; where, UN_{+N} is total N uptake (kg ha^{-1}) with grain and straw; UN_{0N} is the N uptake (kg ha^{-1}) in control; FN is amount of fertilizer N applied (kg ha^{-1}) (Das et al., 2016). All the data were statistically analyzed by F-test and the mean differences were ranked by DMRT at 5% level (Gomez and Gomez, 1984). All collected data were subjected to MSTAT-C software package to perform analysis of variance (ANOVA).

RESULT AND DISCUSSION

Growth and yield contributing characters

The growth of yield contributing characters such as, plant height, panicle length, tillers per hill, grains per panicle responded significantly due to application of USG and NPK briquette in comparison with PU (Table 2). The maximum plant height of 116.8 cm was recorded for treatment T_6. The largest panicle (24.35 cm) was observed for T_4 while the smallest panicle (21.55 cm) was observed in T_1 (control). The maximum number of effective tillers $hill^{-1}$ (15.03) and grain $panicle^{-1}$ (124) both were obtained from T_3 which was similar with the result of rice cultivar BRRI dhan28 (Islam et al. 2014). The number of filled grains $panicle^{-1}$ varied from 91 to 124. However, the 1000-grain weight varied insignificantly due to application of PU, USG and NPK briquettes for BRRI dhan46.

Grain yield

Remarkable response of the grain yield of BRRI dhan46 was found due to the deep placement of N fertilizers (Table 2). The grain yield ranged from 2.92 t ha^{-1} to 6.39 t ha^{-1}. The highest grain yield was recorded in T_3 which was statistically similar to T_4 and T_6 and the lowest value was observed for control (T_1).

Table 2: Effect of deep placement of N fertilizers in the form of USG and NPK briquettes compared to PU on the yield components and yield of BRRI dhan46.

Treatments	Plant height (cm)	Panicle Length (cm)	Tillers hill^{-1} (no.)	Grains panicle^{-1} (no.)	1000-grain weight(g)	Grain yield (t ha^{-1})	Straw Yield (t ha^{-1})
T_1	97.84c	21.55d	11.67d	91.00g	21.32c	2.92d	5.63d
T_2	109.85b	22.15bcd	14.33ab	117.00bc	22.54ab	4.48c	7.26b
T_3	115.16ab	23.15abc	15.03a	124.00a	22.65a	6.39a	8.38a
T_4	115.42ab	24.35a	13.67b	115.33cd	22.55ab	6.35a	8.28a
T_5	114.43ab	23.43ab	12.0d	108.67e	22.50ab	5.17b	7.56b
T_6	116.81a	24.07a	13.67b	121.33ab	22.19b	6.22a	8.29a
T_7	114.58ab	23.41ab	13.33bc	112.00de	21.49c	5.24b	8.10a
T_8	110.89ab	21.73cd	12.33cd	100.00f	21.46c	4.42c	6.20c
*CV%	2.91	3.83	4.51	2.3	0.96	2.91	2.94
*SE (±)	2.66	0.71	0.48	2.09	0.17	121.46	179.50

Figures in a column having common letters do not differ significantly at 5% level of significance.

The percent increase of grain yield over control ranged from 34.02% to 54.34%. Fig. 1 shows the percent increase of grain yield over control for all treatments. Similar results were found for some other varieties of rice (Huda et al., 2016), (Kapoor et al., 2008). For instance, in case of BRRI dhan28 up to 97% increase over control was reported with the application of USG (Islam et al., 2014). Based on grain yield, the treatments may be ranked in the order of $T_3>T_4>T_6>T_7>T_5>T_2>T_8>T_1$. Deep placement of USG at the rate of 104 kg ha^{-1} and at the rate 78 kg ha^{-1} performed better in increasing grain yield of rice compared to PU and NPK briquette. Thus, the deep placement of N fertilizers demonstrated the most positive effect on grain yield.

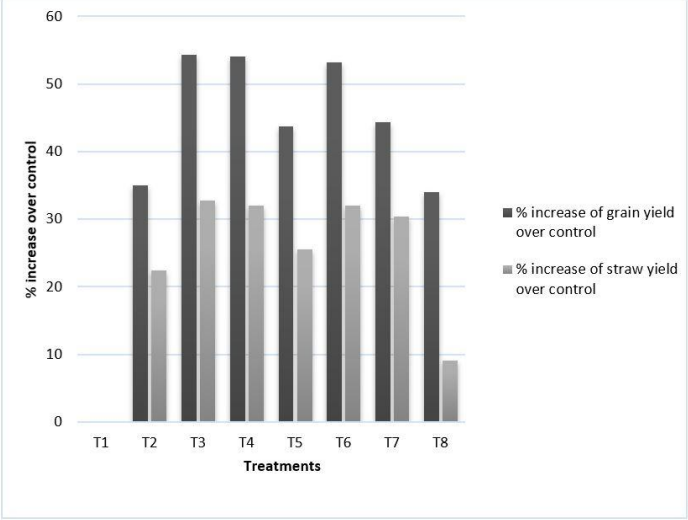

Fig.1 Bar diagram of the increase in per cent over control on the yield of BRRI dhan46 as influenced by the application of PU, USG and NPK briquettes.

Straw yield

Like grain yield, straw yield of BRRI dhan46 responded significantly to different treatments under study. The highest straw yield (8.3 t ha^{-1}) was found in case of T_3 and the lowest value (5.6 t ha^{-1}) was observed for T_1. From fig. 1, we observed that nearly 9.06% to 32.7% increase in straw yield over control due to application of N either broadcast or deep placed. Similar to grain yield, the maximum increase of straw yield over control was found in T_3. Based on straw yield the treatments may be ranked in order of $T_3>T_6>T_4>T_7>T_5>T_2>T_8>T_1$. Deep placement of USG (104 kg ha^{-1}) performed better than other treatments in increasing straw yield under controlled irrigated conditions. The findings of the present study are well corroborated with the experiment of Das et al. (2016).

Total N uptake

As shown in Table 3 total N uptake both by grain and straw of BRRI dhan46 was influenced significantly by the application of PU, USG and NPK briquettes under AWD condition. The total N uptake ranged from 50.49 kg ha^{-1} (T_1) to 139.26 kg ha^{-1} (T_3). The second highest total N uptake was recorded for T_4. In this study we observed relatively lower amount of N uptake (91 kg ha^{-1}) for broadcast application of PU. The trend of N uptake conforms with the published work (Jahan et al. 2014). The total N uptake by BRRI dhan46 due to different treatments may be ranked in the order of $T_3> T_4> T_6> T_7> T_2> T_5> T_8> T_1$. From this ranking, it is quite evident that the deep placement of N fertilizers increases the total N uptake by rice plant.

Table 3. Effect of PU, USG and NPK briquette on N content and uptake of BRRI dhan46

Treatments	N content (%)		N uptake (kg ha^{-1})		
	Grain	Straw	Grain	Straw	Total
T_1	1.03e	0.36e	30.03e	20.46f	50.49f
T_2	1.17bc	0.53c	52.72d	38.33d	91.04d
T_3	1.37a	0.62b	87.58a	51.69ab	139.26a
T_4	1.32a	0.58b	83.8b	48.34b	132.17b
T_5	1.12cd	0.36e	58.22c	27.50e	88.73d
T_6	1.21b	0.66a	75.60b	55.0a	130.60b
T_7	1.23b	0.53c	64.29c	42.96c	107.25c
T_8	1.09de	0.42d	48.12d	26.22e	74.34e
*CV (%)	2.98	4.59	4.91	5.01	4.27
*SE (±)	0.029	0.019	2.48	1.59	3.52

Figures in a column having common letters do not differ significantly at 5% level of significance.

Apparent N recovery (ANR)

The apparent N recovery (ANR) indicates the absorption efficiency of applied N. The ANR of BRRI dhan46 rice is presented in Fig. 2. Mean apparent recovery of N ranged from 38.31% to 85.35% in different treatments. The maximum value of ANR was obtained with the application of USG for treatment T_4 followed by T_3, T_6, T_7 and the minimum value was found in T_2. The data presented in fig. 2 clearly reveals that the deep placement of USG and NPK briquettes enhance the recovery of applied N compared to broadcast application of N fertilizers.

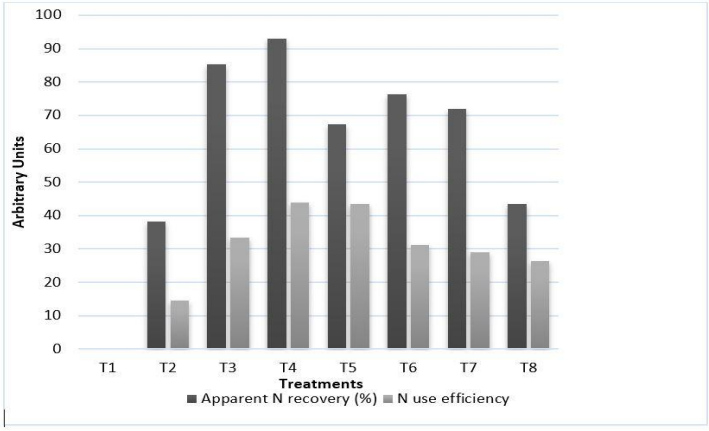

Fig. 2 Effects of PU, USG and NPK briquettes on apparent N recovery (%) and N use efficiency of BRRI dhan46.

Nitrogen use efficiency (NUE)

Agronomic NUE is used to indicate the relative balance between the amount of fertilizer N taken up and used by the crop versus the amount of fertilizer N lost. NUE represents the response of rice plant in terms of grain yield to N fertilizer. The maximum value of NUE (44.01 kg grain yield increase per kg N applied) was obtained for T_4 which is similar with the findings of (Hasan et al., 2016; Huda et al., 2016). Whereas, the minimum value was found in T_2 where, 14.46 kg grain yield increases for per kg N applied. From the data it can be concluded that the deep placement of USG and NPK briquettes enhanced the NUE as compared to broadcast application of prilled urea.

Economic analysis

The marginal-benefit cost ratio (MBCR) of BRRI dhan46 as influenced by PU, USG and NPK briquettes has been presented in Table 4. MBCR is the ratio of marginal or added benefit and cost. To compare different fertilizers treatments with control, the following equation was used (Rahah et al., 2007):

$$MBCR = \frac{\text{Gross Income of Treatment - Gross Income of Control}}{\text{Gross Cost of Production (Treatment) - Gross Cost of Production (Control)}}$$

The cost and return analysis of BRRI dhan46 shows the highest marginal benefit-cost ratio of 2.95 was obtained from T_4. The gross margin over control was maximum for T_4 (555 USD ha^{-1}). Considering the benefit-cost ratio and marginal benefit, T_4 might be ranked first.

Table 4. Economic analysis of BRRI dhan46 as influenced by the application of PU, USG and NPK briquettes (1 USD = 80 BDT)

Treatments	Yield Kg ha^{-1}		Gross return (USD/ha)	Added cost over control (USD/ha)	Added benefit over control (USD/ha)	Gross margin over control (USD/ha)	MBCR over control
	Grain	Straw					
T_1	2918	5637	808.87	-	-	-	-
T_2	4489	7267	1160.94	101.75	352.06	250.31	2.46
T_3	6391	8380	1563.61	202.00	754.73	527.73	2.73
T_4	6351	8285	1551.56	187.70	742.68	555.00	2.95
T_5	5179	7569	1343.42	180.50	534.55	354.00	1.96
T_6	6229	8290	1504.43	195.50	695.56	500.06	2.56
T_7	5241	8101	1332.66	177.30	523.78	346.48	1.95
T_8	4423	6199	1086.8	168.20	277.92	109.72	0.7

CONCLUSION

This study was conducted using a highly cultivated rice variety of Bangladesh to maximize nitrogen use efficiency (NUE) without compromising the yield by employing eight treatments of three different N fertilizers on randomly selected plots. The overall result implies that the deep placement of USG 78 kg ha^{-1} lead to the best grain yield, NUE and apparent N recovery of BRRI dhan46 with highest marginal benefit-cost ratio comparing with deep placement of NPK and broadcast application of PU. NPK briquettes, 104 kg ha^{-1} also showed statistically similar grain yield but its marginal benefit cost ratio is lower than USG. Thus, USG 78 kg ha^{-1} can be recommended as optimum dose for profitable cultivation of BRRI dhan46.

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STUDY OF CATTLE FATTENING SYSTEM IN SELECTED REGION OF BANGLADESH

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Abstract

The current study was undertaken to assess the present status of cattle mixed feeds, feed ingredients and use of growth promoters in livestock production of Bangladesh. The survey was carried out through a structured questionnaire among 80 farmers during April to June, 2017. The study revealed that agriculture is the primary occupation for 63% of respondents, whereas 27.5% of respondents are dependent over livestock. The dairy farmers are involved in both dairy and beef cattle fattening. Approximately 64% of the livestock farmers practiced fattening round the year and rest of the respondents followed fattening for period of 3 months; before Eid-ul-Adha. About 86% farmers reared uncastrated males instead of steer for fattening. It was observed that 59% of the farmers applying steroid as growth promoters in beef cattle fattening. The study indicated that middleman, feed/ medicine dealers were involved in promoting of steroids (dexavet, pednivet, oradexon, decason, paractin, gludex etc) usages in livestock. Owing to the lack of knowledge on steroids use in livestock over public health, the farmers are influenced by the vendors for quick profit. They sell their animals prior to withdrawal periods of drugs. Training and knowledge about the health hazards of steroids had inverse significant relationship with use of steroid as growth promoter ($p<0.01$). Improvement of education, training and financial status of the farmers significantly affected the use of steroids in beef fattening. Present problems could be addressed by intervention measures by the policy makers of the livestock sector.

Keywords: Growth Promoters, Fattening Cattle, Steroids

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INTRODUCTION

In Bangladesh, livestock is one of the most important sub-sectors of agriculture which plays a vital role in promoting national economy of the country (Sarma et al., 2014). About 80 to 85% of the households keep livestock in the rural areas and most of them are landless, marginal and small farmers (Hossain et al., 2004). Livestock may be considered as "Cash income" to rural farmers that is instantly available for sale or barter (Hossen et al., 2008). Cattle fattening for beef production have become an important business of the small farmers in Bangladesh. Now it is necessary to find out the limitations of existing beef production system to make it more sustainable at farmer's level. It was suspected that stimulating substances like, steroids, feed additives etc. were using n Bangladesh. (Islam et al., 2012). Experts believe that cattle feed shortages have been a major limitation to improve cattle productivity in Bangladesh. Besides, there is a festival demand of beef cattle during Eid-ul- Adha. To fulfill the animal protein requirement and poverty alleviation for rural people, cattle fattening can play a significant role. In Bangladesh, feed additives and growth promoters imported by pharmaceutical industries and overseas marketing agencies and attract farmers to use them in fattening animals. Most of the cattle brought for sale as sacrificial animals in the northern districts ahead of Eid-ul-Adha are fattened allegedly by unscrupulous cattle traders ignoring the scientific formula prescribed by Livestock Department for rapid live weight gain and quick profits (Islam et al., 2012). Apparently, the animals look very attractive, muscular and high live weight but the consumers are very disappointed by deception and cheating. Some of them may have harmful residual effects on human health or some may not respond cost effectively. For over 25 years, the use of hormonal substances has been banned in animal production in Europe (Council Directive 88/146/EEC). Recently, there has been plenty of attention paid to the occurrence of veterinary drug residues in animal-food products.

METHODOLOGY

Selection of the study area and preparation of interview schedule

The data was collected through an interview schedule from the farmers of 4 districts (Gazipur, Mymensingh, Sirajgonj and Rajshahi) of Bangladesh, for having high cattle population in those areas. The respondents were selected who rear cattle or bought cattle for fattening or rearing. Respondents those are involved in cattle fattening purpose were randomly chosen from each upazila.

Collection of data

Data were collected following direct interviews and making personal visits from beef cattle farmers. Key informant interview (KII) was done with government livestock officers and feed dealers.

Parameters studied

The interview schedule contained general information (occupation, education, family member etc.) of the cattle owners, livestock population, management of the fattening cattle, feeds and feeding cattle, indigenous knowledge on rearing and marketing of cattle, and the application of steroid and feed additives, feed ingredients, feeding and animal management.

Computing and statistical analysis of data

Descriptive analysis was done, like average and percentages as well as spearman correlation coefficient (r_s), level of significance through SPSS Statistics 17.0. Spearman correlation coefficient is measured by following formula,

$$r_s = 1 - \frac{6 \sum d_i^2}{n(n^2 - 1)}.$$

Where ,

- $d_i = \mathrm{rg}(X_i) - \mathrm{rg}(Y_i)$, is the difference between the two ranks of each observation.
- *n* is the number of observations

RESULTS AND DISCUSSION

Socio-economic background of the farmers

There are many interrelated and constituent attributes that characterize an individual and form an integral part in the development of one's behavior and personality. Farmer's educational level, income and sources of money influence the cattle production system because uneducated and poor farmers intend to get more profit by investing less money in the illegal way such as, use of harmful growth promoter.

Table 1. Socio-economic background of the farmers

Parameters	Categories	% of farmers
Main occupation	Agriculture	63.8
	Livestock. Business	27.5
	Services	2.5
	Others	6.3
Level of education	Illiterate	33.8
	Primary	32.5
	Secondary	13.8
	Higher secondary	7.5
	Above	12.5
Family member	2-4	3.8
	5-7	53.8
	8-10	40
	>10	2.5
Annual income (BDTK)	20000-30000	5
	31000-40000	26.3
	41000-50000	40
	>50000	28.8
Sources of money	Own	51.3
	Bank loan	23.8
	NGO loan	20
	From Mohajon	5
	Others	
Training on cattle fattening	Have	23.8
	Have not	76.3

Table 1 revealed that the majority (63.8%) of the respondents had main occupation as agriculture, 27.5% were related in the livestock business. About 51.3% of the farmers run their cattle fattening business by own money, 20% from NGO loan, 23.8% bank loan, 5% taken loan from mohajon. In case of training, only 23.8% respondents had cattle fattening training and 76.3% farmers whom had not any training on cattle rearing and corroborated with the earlier findings (Ahmed et al., 2010; Rahman et al., 2012; Islam et al., 2012). Currently, higher educated (graduation) people are attracting towards the livestock business then before (Hossen et al., 2008; Sharma et al., 2014 and Rahman et al., 2012). The result of this study contradicted the earlier

findings of Begum et al. (2007), where the authors reported that 86.7% farmers used own capital. From these above statements it was revealed that now farmers get more loans from bank, NGOs and other financial institution. Reports on similar studies were also available from different authors (Ahmed et al., 2010 and Rahman et al., 2012).

Factors associated with cattle rearing

It was revealed that 32% of farmers selected beef type cattle for fattening purpose and the rest of them selected dairy and beef for rearing (Table 2). The result of this study was not similar to Islam et al. (2012) where they showed that majority (92%) of farmers selected beef type cattle for fattening purpose. We surveyed all types of farmers where only large farmers reared beef type cattle only for beef fattening. Among the farmers, 26.3% selected indigenous and 32.5% farmer's selected crossbreeds and 41.3% select both crossbreeds and local for their farm (Table 2). Rahman et al (2012) reported that about 60% farmers used both deshi and crossbreeds cattle for fattening, 28% deshi and 12% used crossbreeds. Hossain et al (2016) stated that about 12% cattle were indigenous and 88% crossbred in origin.

Table 2. Factors associated with cattle fattening

Parameters	Categories	% of farmers
Farm type	Beef type	42.5
	Dairy type	
	Beef + Dairy	57.5
No. of cattle for fattening	2-5	27.5
	6-9	33.8
	10-12	22.5
	>12	16.3
Breed of cattle	Indigenous	26.3
	Crossbreeds	32.5
	Both	41.3
Pattern of the program	Just before Eid Ul Adha	30
	Round the year	63.8
	Seasonal	6.3
Fattening period	3 months or less	16.3
	3-6 months	35
	6 months-1 year	31.3
	>1 year	17.5
Sex of animal	Castrated male	13.8
	Uncastrated male	86.3

The pattern of cattle fattening from the present study indicated that 30% farmer practiced fattening only before Eid-ul-Azha, 63.8% farmer practiced fattening round the year and the rest of the farmers perform seasonal fattening (Table 2). Islam et al. (2012) showed that majority (53.3%) of the respondents start fattening before Eid-ul-Azha and the rest practiced round the year. Fattening period was the most important factor because it measured profit percentage of the respondents. Among the farmers 16.3% farmers practiced fattening for 3 months or less and maximum number farmers (35%) farmers fattening period was 3 to 6 months and 31.3% farmers fattened their cattle for 6 months to 1 year and the rest above 1 year (Table 2). Ahmed et al. (2010) stated that 79.1% respondents found that the fattening period of cattle was 3-6 months. Rahman et al. (2012) stated that most of the respondents fattened cattle for 3 months (44.7%) and rest fattened for 6 months or one year. Sex is the crucial point for fattening, because customer chooses the meat of male beef cattle more than female cattle. Majority (86.3%) of them selected uncastrated male and rest of them fattened castrated male (Table 2). Starting age of cattle fattening also varied famer to farmer. Islam et al. (2012) reported that majority (80.7%) of them selected uncastrated male and rest of them fattened castrated male.

Information about steroids and feed additives

Among the respondents 58.8% farmers practiced using steroid as a growth promoter and rest of them did not practiced any kinds of growth promoter at the period of fattening (Table 2). Rahman et al. (2012) observed that about 34.7% farmers used beef fattening tablets. Islam et al. (2012) reported that among the respondents 70.6% used anabolic steroid as a growth promoter and rest of them did not use any kinds of growth promoter. Use of growth promoter was decreasing day by day due to training of farmers. Only 30% farmers had the knowledge about health hazard effect of steroid (Table 3).

It was found that 28.8% farmer got information of steroids from mohajon, 15% from feed dealer, 8.85 from neighbor, 2.5% from NGO worker and 3.8% from medical representative. About 58% farmer use steroid (drugs) in cattle fattening (Fig. 1). 55.3% farmer had withdrawn steroid immediately before marketing, 27.7% withdraw immediately before slaughtering and 17% before one month of marketing which was alarming (Fig. 2).

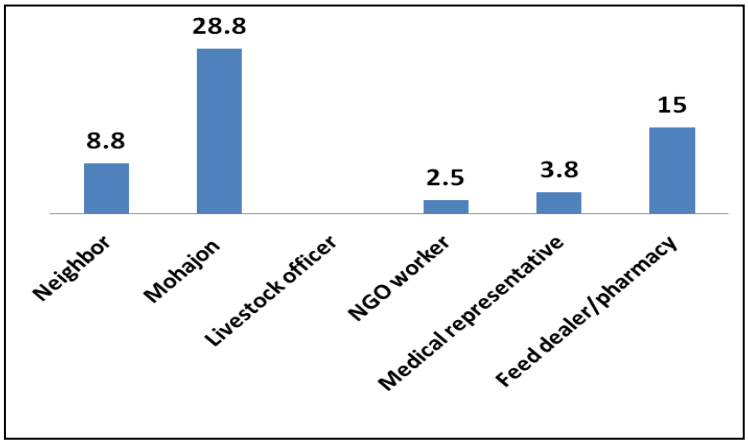

Fig. 1 Source of information to use steroids

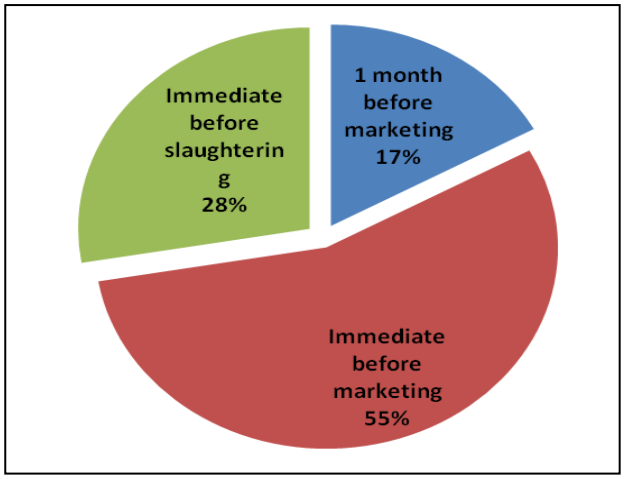

Fig. 2 Withdrawal period of steriod

Table 3. Information about steroids and feed additives

Parameters	Categories	% of farmers
Use of steroid	Yes	58.8
	No	41.3
Impact of steroid on growth rate (farmers opinion)	Yes	97.9
	No	2.1
Knowledge about health hazard effect of steroid	Have	30
	Have not	70
Knowledge about feed act	Have	12.5
	Have not	87.5

98% farmers thought that steroid had positive impact on growth rate or production (Table 3). Nichols et al. (2002) reported that in an intensive beef cattle production system use of steroid implants increased average daily gain by 15 to 25% and feed efficiency by 10 to 15% but decreased in marbling was observed due to longer use of steroid implants. Platter et al. (2003) found that use of growth implants increased ($P<0.05$) average daily gain by 11.8 to 20.5% of steers. Haque and Sarker, (2014) reported that different types of steroids were used rampantly for poultry and bovine in Bangladesh. Asem-Hiablie et al. (2017) stated that in an average 30% of northwest and southwest ranches of United States used growth implants for beef cattle production.

Information about feed and cattle management

Table 4. Information about feed and cattle management

Parameters	Categories	% of farmers
Type of feed given	Roughage	-
	Concentrate	3.8
	Both roughage and concentrate	96.3
	TMR	-
Roughage	Straw	8.8
	Roadside grass	61.3
	Cultivated fodder	30
Concentrate	Compound feed/ Pellet	18.8
	Hand mixed feed	33.8
	Both	47.5
Preservation/Treatment	Hay	1.3
	Silage	-
	Urea molasses block	-
	Urea treatment	30
	None	68
Parameters	Categories	% of farmers
Rearing system	Intensive	30
	Semi-intensive	51.3
	Extensive	18.8
Sources of water	Safe	48.8
	Unsafe	51.3
Ration formulation	By own	72.5
	Consultant/Technical people	27.5

Presented result (Table 4) showing that, 96.3% farmers gave both roughage and concentrate and 3.8% farmer gave only concentrate. They did not use any total mixed ration (TMR) which was not similar with Buza and Holden, (2016) where they reported that in Pennsylvania, 97.6% survey respondents fed a total mixed ration. 61.3% farmer gave roadside grass as the source of roughage, 8.8% gave straw and 30% gave cultivated fodder as the source of roughage (Table 4). Hossain et al. (2016) reported that most of the farmers (83%) used cultivated fodder and only 17% farmers used cultivated fodder and roadside grass during rainy season.

As a source of concentrate, 18.8% used commercial pellet feed, 33.8% used hand mixed feed which was made by different raw materials found locally and 47.5% gave both pellet and hand mix feed (Table 4). Among the farmers only 30% farmer treated straw with urea and rest of the farmers didn't follow any treatment (Table 4). In case of rearing system 30% followed intensive management, 51.3% followed semi-intensive management, and 18.8% followed extensive management system (Table 4). García-Torres et al. (2016) found that consumer chose beef produced from intensive organic farming at sensory level and grass-fed or extensive organic farming at the point of purchase. Most of the farmers (72.5%) did their ration formulation by own and the rest from the technical person (Table 4). For this reason, maximum animal doesn't get proper nutrition for maintenance and production.

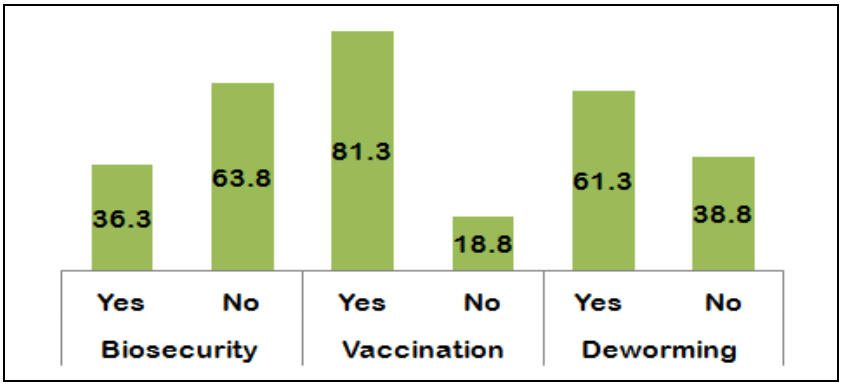

Fig. 3 Biosecurity measures

Only 36% farmer maintained biosecurity measure in their farm which is not satisfactory (Fig. 3). The term 'biosecurity' includes various types of measures that farmers can perform to lessen the risk of spread out of pathogen (Cardwell et al., 2016). 72% farmers thought that biosecurity measures was important for their farm and 53% farmer thought that they had lack of knowledge of biosecurity, reported by Sayersa et al. (2013). 81.3% farmers gave vaccine to their animal and 61.3% performed deworming (Fig. 3) which was similar with Begum et al. (2007) and Ahmed et al. (2010). About 48.8% animals get safe water (Table 4). It was vital that cattle should be provided drinking water by the farmers to ensure safety and it was

considered as good practice. According to the survey, only 28.8% farmers cultivated fodder for their animal (Fig. 4).

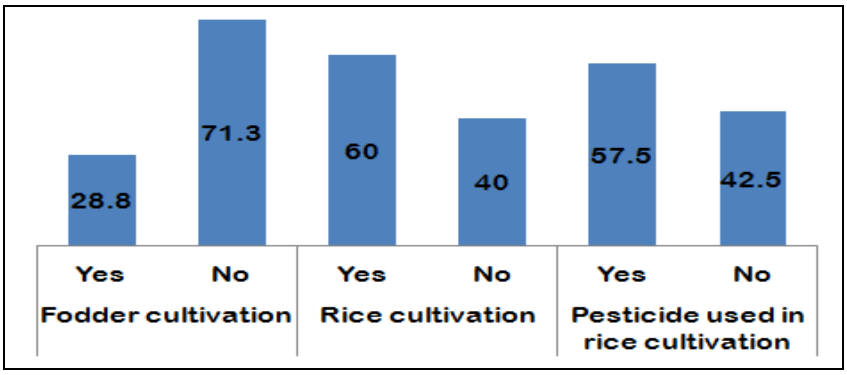

Fig. 4 Fodder cultivation

Hossain et al. (2016) reported that most of the farmers (83%) used cultivated fodder and only 17% farmers used cultivated fodder and roadside grass during rainy season. About 60% farmers cultivate rice and among them near about 57% farmer apply pesticide (Fig. 4). Straw, rice polish, broken rice are the main by product of rice which may contain those pesticides. It is hypothesized that pesticides residues will be found in rice by-products which will be used as livestock feed.

Relationship of use of steroids with other factors

Table 5 revealed that the different parameters such as sex, occupation, annual income, source of money, farm type, breed type, and no. of cattle fattened, fattening period, training, health hazard of steroid etc. were considered as influencing practice of steroid use in the small scale cattle rearing. Significant ($p<0.05$) association was observed (Table 5) on the use of steroids with different sex, occupation, education level, annual income, breed of cattle, training of farmer and knowledge about health hazards of steroid. The chi square value of education was 12.367 indicating (Table 5) that with the increase of level of education of farmer was associated with decrease of steroids which was significant ($p<0.05$). The x^2-value of annual income was 8.396 indicating that with the increase of annual income was associated with the decrease of steroids was significant ($p<0.05$).

Table 5. Relationship of use of steroids with other factors

Parameter	Categories	Spearman correlation coefficient (r_s)	Level of sig.
Sex	Male Female	0.274	0.026 (*)
Main occupation	Agriculture Liv. Business Services Others	0.370	0.007 (**)
Education	Illiterate Primary Secondary Higher secondary Above	0.319	0.015 (*)
Annual income	20000-30000 31000-40000 41000-50000 Above 50000	0.212	0.039 (*)
Sources of money	Own Bank Loan NGO Loan Loan Mohajn	0.080	0.096 (NS)
Farm type	Beef Dairy Beef & Dairy	-0.050	0.413 (NS)
Breed of cattle	Indigenous Cross Both	-0.313	0.002 (**)
Pattern of program	Eid-ul-Adha Round the year Seasonal	0.042	0.897 (NS)
Fattening period	3m or less 3 to 6 m 6m to 1 year Above 1 year	0.251	0.082 (NS)
Training	Have Have not	-0.368	0.001 (**)
Health hazard of steroid	Know Don't know	-0.560	0.000 (**)

r_s=Spearman correlation coefficient; NS, Non-significant ($p>0.05$); *= $p<0.05$, **= $p<0.01$

The r_s value of sex, occupation, education, annual income was positively correlated with steroid practiced and had a significant ($p<0.05$) positive relationship with steroid use. The r_s value of source of money, pattern of program, fattening period had a positive correlation but weakly ($r_s<0.3$) correlated (Table 5) which was not significant ($p>0.05$). Here we can say that poor and uneducated people are more suspected to use different steroid in illegal way to get more profit. The r_s value of training was -0.368, it indicates the use of steroids was increased with the decreased farmer training which was significant ($p<0.01$). Again r_s value of knowledge about health hazard of steroid is -0.560, it indicates that the use of steroid increased with the lack of knowledge about health hazard of steroid which was significant ($p<0.01$).

Available steroids in Bangladesh

During the study we have found that injection for veterinary purpose used as growth promoter. Again tablet for human medication (Paractin, Gludex) used in beef fattening frequently in different areas of Bangladesh. All these are drugs; depending on their dosages they impact kidney functions, sometime lessen urination, make body tissue edematous; excessive dose causes death of animals sometimes.

Table 6. Common drugs / steroids found during the study

Injection	Tablet
Dexavet (Synthetic steroid)	Paractin (for human medication but used for fattening)
Pednivet (Steroid)	Gludex (Dexamethasone for human)
Oradexon (Glucocorticoid steroid)	Pednivet (Steroid)
Decason (Glucocorticoid steroid)	
Tredexanol (Synthetic steroid)	

CONCLUSION

In the majority of villages in Bangladesh, farmers rear beef cattle for fattening without having any scientific knowledge. Some drugs/steroids are being used for fattening purposes which are prohibited as per feed act rule of Bangladesh. Farmers are not getting proper training on production and management practices of beef cattle fattening. Details studies on different contaminants in cattle feed are needed to produce quality and safe beef.

Conflict of interests

The authors declare that there is no conflict of interest.

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CHICKEN GERMPLASMS AND THEIR CONSERVATION IN BANGLADESH: A REVIEW

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Gazipur-1705, Bangladesh

ABSTRACT

The present article addresses the scenario of chicken genetic resources, their production and reproduction performances and their conservation in Bangladesh. The chickens, among other poultry species available in the country, are the most versatile component for meat and egg production. The chicken germplasms available in the country are indigenous, exotic, crossbred, and commercial hybrid. The indigenous chicken population is comprised of Non-descript Desi (ND), Naked Neck (NN), Aseel (AS), Hilly (H), Native Dwarf and Jungle Fowl etc. The exotic chicken such as, White Leghorn (WL), White Rock (WR), White Cornish (WC), Rhode Island Red (RIR), Australorp, Fayoumi, Barred Plymouth Rock (BPR) etc. are imported mostly to upgrade the indigenous stock. The crossbred of different chickens are used in the country in intensive, semi-intensive and scavenging management system. The commercial hybrid such as grandparent stock (GP), parent stock (PS), commercial broiler, commercial layer etc. has got most popularity for meat and egg production in the country. Conservation and improvement program of endangered native chicken such as Aseel and Native Dwarf chicken should be taken both *in-situ* or *ex-situ in vivo* by public sector/research institutes/universities.

Keywords: Bangladesh, Chicken, Germplasm, Conservation

INTRODUCTION

Bangladesh has a long history of chicken rearing under traditional backyard farming. Since 1990, commercial chicken farming started on small scales. Presently the industry is being accomplished the capacity to fulfill almost the domestic demand for broiler meat and layer eggs. Bangladesh is rich in respect of chicken germplasms. Different types of chicken such as indigenous chicken, exotic and crossbred chicken, and commercial hybrid are available in the country.

This sub-sector is an important avenue in fostering agricultural growth and reduces malnutrition for the people in Bangladesh. Development of chicken has generated

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considerable employment through the production and marketing of chicken and chicken products in Bangladesh. It is an integral part of farming system in Bangladesh and has created direct, indirect employment opportunity including support services for about 6 million people (Ansarey, 2012; Da Silva and Rankin, 2014). It has proved as an attractive economic activity, thereby, indicating its` importance for the entire economy. It accounts for 14% of the total value of livestock output and is growing rapidly (Raihan and Mahmud, 2008). Chicken meat alone contributes 37% of the total meat production in Bangladesh. Chicken contributes about 22 to 27% of the total animal protein supply in the country (Prabakaran, 2003). In Asia, chicken manure is used as feed for fish where chicken are raised on top of the ponds as part of an integrated system, for example, fish-cum- chicken farming (FAO, 2014).

In the public sector, the present number of chicken farms and hatcheries are 31 and 6, respectively (DLS, 2015). The objective for establishing of those farms was to produce, conserve and develop chicken genetic resources. There are 9 grandparent stock farms in Bangladesh and supplies about 80% of the total demand of parent stock; the rest 20% is imported (BPD, 2019). In October 2011, there were 82 parent stock farms and hatcheries in operation in Bangladesh and producing 55-60 lac day old broiler and 5 lac day old layer chicks per week.

In the recent year, attention has been given to improvement and conservation of native chickens due to higher preference of consumers for native chicken and higher price of native chicken than the exotic, crossbred and commercial hybrids. Among the native chicken, Non-descript Deshi, Nacked Neck and Hilly are not endangered and they don't need to be conserved. The Aseel and the Native Dwarf are endangered breed and variety of native chicken and need to be conserved.

The present article addresses the available chicken genetic resources with their distributions, productive and reproductive performances along with conservation status of endangered breed/variety so the chicken producers and researchers can get all the information for future improvement and conservation program of chicken.

Geographic distribution of different genotypes of chicken

The distribution pattern of chicken is very interesting in the country. The Non-descript Deshi chickens are distributed throughout the country except in some hilly areas of the country. Normal neck and Naked Neck indigenous birds are found in different regions of the country though the distribution of Naked Neck bird is comparatively very thin. The Aseel is a rare variety found only in some areas of Brahmanbria district. The Hilly birds are found in the hilly areas of Chittagong region. Jungle fowl as the name implies is found in the forest of Hill Tracts, Sundarbans and also found in the Madhupur and Rajendrapur forest areas. The breed/types of chicken, their geographic distribution and utility are presented in Table 1.

Table 1. Geographic distribution and utility of chicken in Bangladesh

Breed /Type	Geographic distribution	Agro-ecological Zone	Utility
Non-descript Deshi	Throughout the country except Chittagong Hill districts	All agro- ecological zones except Chittagong Hill districts	Egg and meat production
Naked Neck	Throughout the country	All agro- ecological zones	Egg and meat production
Aseel	Brahmanbaria district	Middle Meghna flood plain	Game and recreation
Hilly	Chittagong Hill districts	Chittagong Hill tracts	Egg and meat production
Native Dwarf	Sporadically available in the country	-	Egg and meat production
Jungle Fowl	In forest of Chittagong, Chittagong Hill Tracts, Sundarbans, Madhupur, Sylhet	Chittagong coastal plain, Old Brahmaputra flood plain areas	Meat
Fayoumi	All over the country	All agro- ecological zones	Egg production
RIR	In Govt. farms	-	For crossbreeding
WL	In Govt. farms	-	Egg production and crossbreeding
WR	In Govt. farms	-	For crossbreeding
BPR	In Govt. farms	-	For crossbreeding
Sonali (RIR Fayoumi)	All over the country	All agro- ecological zones	Meat production
Rupali (WL Fayoumi)	All over the country	All agro- ecological zones	Egg production
Broiler GPS and PS	Mainly Chittagong, Kishoregonj, Thakurgaon, Panchogor, Chuadanga, Gazipur district	All agro- ecological zones	Commercial broiler chick production
Layer GPS and PS	Mainly Chittagong, Kishoregonj, Thakurgaon, Panchogor, Chuadanga district	All agro- ecological zones	Commercial layer chick production
Commercial broiler hybrids	All over the country	All agro- ecological zones	Commercial meat production
Commercial layer hybrids	All over the country	All agro- ecological zones	Commercial egg production

Source: FAnGRBD, BLRI, 2015; BPD, 2019

[RIR = Rhode Island Red, WL = White Leghorn, WR = White Rock, BPR = Barred Plymouth Rock; GPS = Grand Parent Stock, PS = Parent Stock]

Available chicken germplasms in Bangladesh

The chicken germplasms of Bangladesh is composed of indigenous or native type, exotic type, crossbred type and commercial hybrid which have been described as below -

A) Indigenous chicken

The indigenous chicken population is comprised of a number of breeds/types such as Non-descript Desi (ND), Naked Neck (NN), Aseel (AS), Hilly (H), Native Dwarf, Jungle Fowl and Frizzled Plumage (Bhuiyan et al., 2005; Das et al., 2008) in respect of the morphological variations as well as production performances. Non-descript native colored chicken as an important source of meat and eggs are more acceptable to all classes of people (Barua and Howlider, 1990). Blood protein variants study revealed that Non-descript Deshi, Naked Neck, Hilly and Native Dwarf they may be regarded as one breed or population because of having small distances among them (Okada et al., 1988). The indigenous chickens of Bangladesh do not fall into any recognized breed. It is assumed that the present Deshi (indigenous) chicken was originated from *Gallus gallus* (Faruque et al., 1987). The body measurements of different types of indigenous chicken are presented in Table 2.

Table 2. Body measurements of different adult native chicken

Parameter	Non-descript Deshi	Naked Neck	Aseel	Hilly	Jungle fowl
Mature body weight (g)	1114 ± 266	969±150 969± 132	3166±457 3166± 457	1585±422 1585.71± 422	961± 150
Body depth (cm)	12.88±1.81[1, 2]	12.64±0.39[1, 2]	20.90±2.19[1, 2]	7.44±0.16[1, 2]	11.84± 0.41[1]
Shank length (cm)	7.6± 0.94[1] 7.60±0.40[2]	7.18±0.75[1, 2]	14.60±1.14[1, 2]	9.95±1.15[1, 2]	6.67± 0.82[1]
Trunk length (cm)	22.25± 2.88[1] 22.30±2.88[2]	20.09± 0.83[1] 10.09±0.83[2]	33.80±1.92[1, 2]	21.5± 2.41[1] 21.50±2.40[2]	21.67± 0.82[1]
Wing length (cm)	17.70±2.13[1, 2]	16.09± 1.04[1] 16.69±1.04[2]	34.80±4.21[1, 2]	33.39±3.73[1, 2]	15.0± 1.55[1]

Source: Uddin et al., 2011[1]; Bhuiyan et al., 2005[2]

i. Non-descript Deshi

The Non-descript Deshi chicken is more acceptable to rural people as an important source of meat and eggs due to lower nutritional demand and higher resistance to diseases and heat stress (Barua and Howlider, 1990). They are long adapted to local climate, reared under low inputs system, and have low productivity, but produce tasty meat and egg. The morphological characteristics of indigenous Deshi chicken are presented in Table 3.

Table 3. Morphological characteristics of Indigenous chicken *ex situ*

Trait	Description
Plumage colour	Reddish black (33.13%), Blackish red (13.5%), Red (13.7%), Black (12.67%), White with black spot (11.04%), Reddish white (0.61%), Brown (4.9), Blackish white (4.9%), Mixed (5.55%)
Shank colour	Yellow (37.22%), White (39.87%), Black (20.04%)
Eye colour	Black (99%)
Ear lobe colour	Red (25.97%), Reddish white (44.79%)
Comb colour	Bright red (59%) and pale ((41%)
Skin colour	White (92.22%), Red (7.78%)
Egg shell colour	Light brown (67%) and white (27%)
Feather pattern	No definite (61%) and lacing (17%)
Body size	Medium (70%) large (19%) small (11%)
Comb type	Single (96.12%), Single (cape headed) (3.84%), Rose (0.02%), Butter (0.02%)
Spur	Rudimentary (98%)
Egg size	Medium (80%)

Source: Sarker et al., 2014; Bhuiyan et al., 2005

ii. Naked Neck

The Naked Neck chickens are special type within Non-descriptive Deshi chicken adapted to scavenging system and are available all over the country. The mixed colour of feathers is common and red, black or reddish yellow are predominant all over the body. Featherless red skin on neck and yellow skin on legs are the most typical characteristics of these chickens. They are more resistant to diseases than the exotic chickens. They are used for meat and egg production and also efficient producer of high quality and high priced meat. The morphological characteristics of Naked Neck chicken are presented in Table 4.

Table 4. Morphological characteristics of Naked Neck and Hilly chicken

Trait	Naked neck	Hilly
Plumage colour	Black or reddish	Grey or reddish
Skin colour	Yellow	Yellow
Shanks	Featherless	Featherless
Egg shell colour	Brownish	Brownish

Source: Bhuiyan et al., 2005

iii. Aseel

Aseel is found in Brahmanbaria district and some cities like Dhaka, Chittagong and Sylhet. They are known as game bird used for fighting and recreation. The morphological characteristics of Aseel chicken are presented in Table 5.

Table 5. Morphological characteristics of Aseel chicken

Trait	Description
Shank colour	Yellowish (100%)
Shank feathering	No feathering (100%)
Wattles	Medium size (22.81%), Rudimentary (77.19%)
Beak color	Yellow (100%)
Eye colour	Yellowish (100%)
Ear lobe colour	Red (100%)
Ear lobe shape	Small (75.40%), Medium (24.60%)
Comb type	Pea comb (75.95%), Strawberry comb (24.05%)
Skin colour	Whitish (100%)
Egg shell colour	Light brown (77.78%), White (22.22%)
Spur	Large spurs (98%)

Source: Sarker et al., 2012

iv. Hilly

The Native chickens of Chittagong Hill districts are called Hilly chicken. The Hilly chickens are also adapted to scavenging system and are available in the southeastern hilly districts of the country. They are bigger in size than the native chicken and round in shape covered with feathers of different colours. The legs are featherless with yellow skin. They are more resistant to diseases than the exotic chicken. The shell colour of egg is light brown and they have the brooding habit. They are used for meat and egg production. The morphological characteristics of Hilly chicken are presented in Table 4.

v. Native Dwarf

Native Dwarf is usually found sporadically in the country. They are long adapted with special genetic merit of low input requirement. They are used for meat and egg production. The morphological characteristics of Native Dwarf chicken are presented in Table 6.

Table 6. Morphological characteristics of indigenous dwarf chicken

Trait	Description
Plumage colour	Black (41.11%), Blackish red (12.22%), Reddish black (12.22%), Golden (11.11%), Blackish golden (17.78%) and Black with white spot (5.56%)
Shank colour	Black (27.78%), Slate (23.33%), Yellow (22.22%), Yellowish (16.67%) and White (10.00%)
Eye colour	Black (100%)
Ear lobe colour	Red (40.00%), White (15.56%) and Reddish white (44.44%)
Beak color	Black (33.33%), White (22.22%) and Yellow (44.44%)
Comb colour	Bright red (66.67%) and Reddish (33.33%)
Skin colour	White (90.00%) and Yellow (10.00%)
Egg shell colour	Light brown (76.56%) and white (23.44%)
Comb type	Mainly single (97%)

Source: Ferdaus et al., 2016

vi. Jungle Fowl

Jungle Fowl usually found in the forest of Chittagong, Chittagong Hill Tracts, Sundarbans, Madhupur and Sylhet.

B) Exotic chicken and their crosses

The exotic chicken such as, White Leghorn (WL), White Rock (WR), White Cornish (WC), Rhode Island Red (RIR), Australorp, Fayoumi, Barred Plymouth Rock (BPR) are imported mostly to upgrade the indigenous stock. Fayoumi is extensively used in rural areas and well adapted under farm condition in Bangladesh (Anisuzzaman, 1988). This breed is originated from Egypt and possesses the characteristics of early sexual maturity, more egg production and low mortality (Barua et al. 1998). Some research reports supported that crossing of Fayoumi with exotic breed increased egg production, egg size and body weight. Ali (1989) also found that crossing of Fayoumi with other standard exotic breed improved egg size, growth rate and adaptability of crossbreds under farm condition of Bangladesh.

The crossbred of different chicken such as Deshi × WL, Deshi × WC, Deshi × RIR, Deshi × Fayoumi, WL × Fayoumi, RIR × Fayoumi, Aseel × Australorp, RIR × Naked Neck, WL × Naked Neck are used in the country in intensive, semi-intensive and scavenging management system. The Department of Livestock Services (DLS) of Bangladesh has introduced Sonali crossbred chicken (by crossing RIR males with Fayoumi females) to improve rural poultry production. They are very much suited to the semi intensive rearing system in rural areas. They have better production records and higher disease resistance (Miah et al., 2002). The Sonali have

the highest egg production, lowest mortality and highest profit per hen among eight crossbred chickens tested under rural condition of Bangladesh (Rahman et al., 1997).

C) Commercial hybrid

There are many commercial hybrid such as grandparent stock (GP), parent stock (PS), commercial broiler, commercial layer etc. are available in the country. The grandparent stock is imported and the country relies on importation of this stock. Currently there are 9 grandparent stock farms such as Aftab G.P. Farms Limited, C.P. (Bangladesh) Co. Ltd., Kasila (Bangladesh) Limited, Kazi Grand Parents Limited, M.M. Agha G.P. Farms Limited, Nourish Grand Parents Limited, Paragon G.P. Limited and Rashik G.P. Hatchery Limited are in the country (BPD, 2019, Hamid et al., 2017). The available GP chicks are Cobb 500, Hubbard Classic, Lohman Meat, Novogen Brown etc (BPD, 2019).

The Parent Stock chicken such as Lohmann Brown Classic, Lohmann White, Lohmann Indian River, Isa Brown, Isa White, Shaver Star Cross 579 Brown, Shaver White, Shaver Black, Hisex Brown, Hisex White, Bovan's Brown, Bovan's White, Bovan's Goldline, Bovan's Nera, Dekalb Gold, Dekalb White, Dekalb Black, Sasso Coloured, Hubbard Classic, Novogen Brown, Novogen White, Hubbard HI-Y Flex, Colored Broiler, Arbor Acres Plus S, Arbor Acres Plus, Lohman Meat, Nick chick, Brown Nick, Super Nick etc. are reared and marketed by 14 Parents Farms in the country (Hamid et al., 2017; BPD, 2019).

The commercial broiler, such as Cobb, Hubbard Classic, Starbro, Ross, Arbor Acres, Vancobb etc. are reared by different large, medium and small commercial broiler farms in the country (BPD, 2019).

The commercial layer, such as B.V. 300, Isha Brown, Isha White, Lohmann Brown, Lohmann White, Hisex Brown, Hisex White, Starcross-579, Hy-line etc. are reared by different large, medium and small commercial layer farms in the country (BPD, 2019).

Production and reproduction performances of chicken in Bangladesh

A) Performances of indigenous chicken

The production and reproduction performances of Non-descript Deshi, Naked Neck, Aseel, Hilly, Native Dwarf and Jungle Fowl chicken are summarized in Table 7, 8, 9, 10, 11 and 12 respectively.

Table 7. Production and reproduction performances of Non-descript Deshi chicken

Trait	Average
Day old chicks weight (g)	26-32[1], 30.39±0.44[2]
Adult female live weight (g)	1600-1700[1], 1500[3], 1000-1300[4]
Adult male live weight (g)	2000-2500[1]
Egg production/hen/year	150-155[1], 35 - 45[5], 50-60[3], 45-50[4]
Egg weight @ onset of lay (g)	29-33[1]
Egg weight (g)	43-45[1], 35-40[3] 35-39[5]
Fertility (%)	94.86±1.38[1], 88.60±2.03[2], 85.7±1.0[6]
Hatchability (%)	84.29±2.10[1], 83.04±1.82[2], 84-87[5], 89.0±1.0[6], 73.28±1.29[7]
Mature live weight (g)	1141.48[5], 1100[3], 1212.2±6.6[6], 805.46±8.60[7]
Age at point of lay (d)	190-200[5]
Length of laying (d)	10-16[5, 3]
No. of eggs/clutch	10-16[5, 3]
No. of clutch/ year	3-4[5, 3]
No. of eggs/set/clutch	10-15[5, 3]
Brooding age (d)	49[5, 3]
Age at sexual maturity (d)	145[5, 3]
Feed intake (g/d)	83[5, 3]

Source: BLRI, 2017[1]; Faruque et al., 2017[2]; BLRI, 2004[3]; Rahman and Salah Uddin, 2017[4]; Bhuiyan et al., 2005[5]; Faruque et al., 2015[6]; Jahan et al., 2017[7]

Table 8. Production and reproduction performances of Naked Neck chicken

Trait	Average
Day old chicks weight (g)	27-34[1], 29.61±0.53[2]
Adult female live weight (g)	1300-1500[1], 1170[3], 1171[4]
Adult male live weight (g)	1500-2000[1]
Egg production/hen/year	170-180[1], 50-55[3], 90-120[5]
Egg weight @ onset of lay (g)	27-30[1]
Egg weight (g)	42-44[1], 37-40[5], 42[3]
Fertility (%)	88.09±2.11[1], 81.93±2.69[2], 85.4±1.4[6]
Hatchability (%)	68.99±1.49[1], 80.47±2.38[2], 77.5±1.4[6], 76.67±4.22[7]
Age at sexual maturity (m)	6.5±1.46[3], 6.5±1.5[5]
Weight at sexual maturity (g)	969±132[3], 1149[5], 1180.7±9.3[6], 782.85±31.56[7]

Source: BLRI, 2017[1]; Faruque et al., 2017[2]; Bhuiyan et al., 2005[3]; Rahman and Salah Uddin, 2017[4]; BLRI, 2004[5]; Faruque et al., 2015[6]; Jahan et al., 2017[7]

Table 9. Production and reproduction performances of Aseel chicken

Trait	Average
Adult live weight male (g)	3,749.12 ± 83.44
Adult live weight female (g)	2,062.50 ± 105.26
Age at first lay (w)	28.86 ± 1.40
Number of clutch per year	3.36 ± 0.17
Number of eggs per clutch	10.71 ± 0.26
Total number of eggs per year	35.71 ± 1.68
Egg weight (g)	40.69 ± 0.82
Hatchability (%)	71.68 ± 9.59

Source: Sarker et al., 2012

Table 10. Production and reproduction performances of Hilly chicken

Trait	Average
Day old chicks weight (g)	26-30[1], 32.73±0.60[2]
Adult female live weight (g)	1800-2000[1], 1900[3]
Adult male live weight (g)	2500-3000[1]
Egg production/hen/year	130-140[1], 80-100[3]
Egg weight @ onset of lay (g)	28-30[1]
Egg weight (g)	43-45[1], 40-42[3]
Fertility (%)	88.40±2.31[1], 84.73±2.72[2], 85.2±1.4[5]
Hatchability (%)	80.26±2.50[1], 75.55±2.43[2] 85.6±1.4[5]
Age at sexual maturity (d)	150[3]
Weight at sexual maturity (g)	1326[3], 1499.0a±9.5[5]

Source: BLRI, 2017[1]; Faruque et al., 2017[2]; BLRI, 2004[3]; Faruque et al., 2017[4]; Faruque et al., 2015[5]

Table 11. Production and reproduction performances of Native Dwarf

Trait	Average
Age at sexual maturity (m)	195 [1], 166.53±0.93[2]
Egg weight (g)	39[1], 38.25±0.12[2]
Adult body weight (kg)	1.2-1.6[1]
Egg number per year	121[1]
Feed intake (g/d)	80[1]

Source: BLRI, 2004[1]; Ferdaus et al., 2016[2]

Table 12. Production and reproduction performances of Jungle Fowl

Trait	Average
Age at sexual maturity (m)	5.9±0.42
Weight at sexual maturity (g)	961±150
Adult body weight (kg)	3.20
Egg production (%)	14.07

Source: BLRI, 2004

B) Performances of exotic and crossbred chicken

The production and reproduction performances of exotic and crossbred chicken are summarized in Table 13.

Table 13. Production and reproduction performances of exotic and crossbred chicken

Economic Trait	Name of chicken				
	RIR	WL	WC	Fayoumi	Sonali
DOC weight (g)	33.8±1.34[1]	-	-	32.6±1.06[1]	33.8±1.86[1]
Growth rate (g/d)	13.8±0.10[1]	-	-	11.7±0.04[1]	13.7±0.10[1]
Death rate (%)	2.82±0.15[1]	-	-	1.68±0.20[1]	3.82±0.15[1]
Fertility (%)	89.5±2.65[1] 87.88[2]	79.86[2]	69.0[2]	91.2±0.64[1] 79.17[2]	91.2±0.30[1]
Hatchability (%)	83.1±1.66[1] 66.12[2]	76.41[2]	71.0[2]	82.9±0.40[1] 68.34[2]	83.3±1.41[1]
Age at first laying (wk)	19.1±0.33[1]	-	-	22.4±0.20[1]	21.1±0.61[1]
Egg weight (g)	47.58[2]	54.44[2]	59.0[2]	43.29[2]	-

Source: Dutta et al., 2012[1]; Khan and Bhuiyan, 2001[2]

C) Performances of commercial chicken

The production and reproduction performances of some commercial layer of Aftab Hatchery Limited, Bhagalpur, Bajitpur, Kishoregonj, Bangladesh are summarized in Table 14. The production and reproduction performances of Novogen Brown and Bovan's Brown layer of Dimond Chicks Limited, Baridhara DOHS, Dhaka, Bangladesh are summarized in Table 15. The production and reproduction performances of Shaver Brown of Nahar Agro Limited, South Khulshi, Chattagram, Bangladesh are summarized in Table 16. The production and reproduction performances of Isa Brown of Bay Agro Industries Limited, Kawran Bazar, Dhaka, Bangladesh are summarized in Table 17.

Table 14. Production and reproduction performances of commercial layer chicken

Trait	Average		
	Novogen Brown	Isa Brown	Novogen White
Live ability (%)	94-96	94-96	93-95
Feed intake @ 1-18 wks (kg)	6.84-7.02	6.17-6.32	6.07-6.23
Highest egg production (%)	95	95.	95
Egg weight (g)	66.6	64.8	66.4
Daily feed intake @ production period (kg)	115-120	115-120	106-110
Body weight @ end of egg production (kg)	2.1	2.1	1.7

Source: Based on Aftab Hatchery Limited Farm Report

Table 15. Production and reproduction performances of Novogen Brown and Bovan's Brown layer

Trait	Average	
	Novogen Brown	Bovan's Brown
Live ability (%)	97-98	98
Highest egg production (%)	98	98
Egg weight (g)	63-64	63-64
Feed intake @ 1-17 wks (kg)	6	6
Daily feed intake @ production period (kg)	113-115	113
Body weight @ 90 wks of age (g)	1920	1975
Production period (wks)	18-90	18-110
Hen housed egg production (no.)	406-415	500

Source: Based on Dimond Chicks Limited Farm Report

Table 16. Production and reproduction performances of Shaver Brown layer

Trait	Average
Live ability (%)	94.2
Highest egg production (%)	95
Egg weight (g)	63.2
FCR	2.22
Daily feed intake @ production period (kg)	114
Body weight @ 80 wks of age (kg)	2
Production period (wks)	18-80

Source: Based on Nahar Agro Limited Farm Report

Table 17. Production and reproduction performances of Isa Brown layer

Trait	Average
Live ability @ 18-90 wks (%)	93.2
Highest egg production (%)	96
Egg weight (g)	62
Daily feed intake @ production period (kg)	110
Body weight @ 90 wks of age (g)	2015
Hen housed egg production (no.)	409

Source: Based on Bay Agro Industries Limited Farm Report

Conservation of Chicken Genetic Resources

According to the number of bird available in the country, some varieties of the native chicken such as, Non-descript Deshi, Nacked Neck and Hilly are not endangered and they don't need to be conserved. The number of Aseel Aseel and the Native Dwarf are low and so endangered. These two type of chickens need to be conserved. It is important for economic, social and cultural reasons. There are two means of conservation i.e. *in situ* and *ex situ*. Conserving the live animals that exist in nature is *in situ* conservation. The animals are maintained in their original habitats under native conditions with no interference in their mode of management, feeding and other conditions. The main problem of *in situ* conservation is inbreeding and genetic drift typical of small populations. The *ex situ* conservation is to be used when the endangered population is dismally low in numbers, as this process has its own innate problems. It may suffer from spread of disease, or neglect during periods of institutional weakness, besides being costly in long term preservations and losing the relatedness of current genotype with environment when one of these is preserved for long time.

The importance of conservation between and within breed genetic diversity is widely recognized. Irreversible loss of breeds, or genetic variation within breeds, is undesirable. The FAOs Global Plan of Action on AnGR (FAO, 2007), as well as the Convention on Biological Diversity and national policies all addresses the importance of conservation and sustainable use of animal genetic resources. These international agreements formed the basis for national policies related to the conservation and management of FAnGR through *in situ* or *ex situ* conservation strategies. Presently the project research for the conservation of Aseel chicken is ongoing in Bangladesh Agricultural University and Hazi Danesh Science and Technology University with the joint research of Japan. On the other hand, the project research for the conservation of Native Dwarf is ongoing in Department of Livestock Services and Bangladesh Livestock Research Institute.

CONCLUSION

From the above discussion, it may be concluded that Bangladesh is rich in chicken genetic resources. These serve well in fulfill nutritional requirement of the country and income generation for millions of people. There is scope to improve the productivity of Indigenous chicken through appropriate breeding and husbandry practice. Aseel and Native Dwarf need immediate attention for conservation and improvement.

This study represents useful resources for future study that may be threatened to the existence of local varieties, especially Aseel and Native Dwarf. This two endangered varieties, Aseel and Native Dwarf need immediate attention for conservation

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PRODUCTION PROCESS AND MARKETING SYSTEM OF CUCUMBER: A SOCIOECONOMIC STUDY IN MYMENSINGH DISTRICT OF BANGLADESH

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ABSTRACT

The study was undertaken to evaluate the production process and marketing system of cucumber in Mymesingh district of Bangladesh. Primary data were collected from 50 stakeholders (30 farmers, 7 wholesaler, 7 retailers and 6 local traders) of Phulpur upazila and Mymensingh city. Purposive sampling technique was used to select the producers and convenience sampling was used for selecting the traders. The study revealed that production of cucumber was profitable in the study areas (with benefit cost ratio 1.59). Total marketing cost of cucumber was the highest for local traders (Tk. 2.73 per acre**)** and lowest for retailers (Tk.1.57per acre).In the study area, six market participants were identified which were producer, local trader, wholesaler, retailer, street seller and consumer. Gross and net marketing margin were the highest for retailers (4.25 Tk./kg and 2.65 Tk./kg, respectively). The study identified two cucumber marketing channels in Phulpur upazila and five in Mymensingh city. The seasonal price index of cucumber was the highest in the month of October (135.67) which indicated that price of cucumber in this month was 35.67 percent higher than average price and the lowest was in May (60.62). The result implied that price in this month was 39.38 per cent less than average price. The findings of this study about production, marketing function and seasonal price will help farmers and intermediaries involved with cucumber production and marketing to improve cucumber business.

Keywords: Production; Marketing; Cucumber; Bangladesh.

INTRODUCTION

Cucumber is a popular cultivated plant in the gourd family Cucurbitaceae that managed to captivate our attention from the moment it appeared in ancient India. Since that pivotal moment over 4000 years ago, cucumber was spread beyond Indian borders, moved through Ancient Greece, Rome, Europe, New World, China, and

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eventually becoming fourth most widely cultivate vegetable in the world. This journey was filed with golden periods when they were viewed as integral parts of many culture's cuisines, and sometimes they were treated as bringers of disease. Agricultural is the dominant sector of the Bangladesh economy and growth and stability of Bangladesh depends largely on the growth of agriculture. About 60-75% people of Bangladesh fully and partially depend on Agricultural sector. In Bangladesh about 22286 acres of land is under cucumber cultivation and total production is approximately 54854 metric tons (BBS, 2014). Thus, the average yield of cucumber is about 55 quintal per hectare which is very low compared to those of other countries of the world. It has scope to decrease this quantity of import but the fact is the absence of high yielding cultivars of cucumber and the improved method of cultivation. Since the soil and climatic condition of Bangladesh are suitable to cultivate cucumber, it is expected the selection of high yielding varieties will augment the yield considerably. Indeed there is a vast scope to increase cucumber production with the introduction of selected high yielding varieties (Siful, 2008).

Cucumber plays an important role to meet the vegetable shortage during the scarce period, which ultimately helps to improve the malnutrition problem in Bangladesh. It was found useful against human constipation and improvement in digestion. It is used as a cooling food in summer (Maurya et al., 2015). A fresh Cucumber provides vitamin C, niacin, iron, calcium, thiamine, fibers and phosphorus (Khan et al., 2015). Besides, it is one of the very low-calorie vegetables; provide just 15 calories per 100 g. It is an excellent source of potassium, an important intracellular electrolyte. 100 g of cucumber provides 147 mg of potassium but only 2 mg of sodium. Cucumbers contain unique antioxidants in moderate ratios such as ß-carotene and α -carotene, vitamin-C, vitamin-K vitamin-A, *zeaxanthin*, and *lutein*. It helps in checking weight gain and high blood pressure. More than 50% production of Cucumber comes from Asia. Turkey, Iran, Uzbekistan, Japan and Iraq, were considered as leading Cucumber producing countries in Asia (Khan et al., 2015). In Bangladesh it is grown as a cash crop but the farmers of Comilla, Bogra, Rangpur, Noakhali, Faridpur, Chittagong and Mymensingh districts grow cucumber commercially. There is a scope for cultivation of cucumber in the cultivable land during summer season. It is profitable and its net return per hectare is relatively higher (Siful, 2008).

Modalities of such impact have been described in a good number of literatures. A modest attempt has been made here to review the previous research studies which are: Nahar, (2009) conducted a study in Jessore district and the major findings of the present study were that the year round vegetables production was profitable from the viewpoints of marginal, small, medium and large farmers. Bean, cabbage, cucumber and snake gourd were mainly produced in the study areas and per ha net returns of producing these crops were Tk. 89383, 90040, 90737.6 and 65473, respectively and undiscounted BCR came out to be 1.81, 1.87, 1.82 and 1.76 respectively which showed that vegetables production was profitable in the study area. The farmers

tamed the highest profit from cucumber vegetables. Suraiya, (2008) made an economic analysis of some selected summer vegetables production in Purbadhala Upazila of Netrakona District. Per ha net returns of producing cucumber, okra, white gourd and snake gourd were Tk. 93452.0, 70380.0, 96896.0 and 58843.0 respectively. In other words, all the selected summer vegetables were highly profitable to their farmers. However, the farmers earned the highest profit from white gourd. Siful, (2008) found that cucumber is a profitable business in Mymensingh district. Gross returns per hectare for the corresponding categories of farmers were tk. 2525200, 24500 ,240000 and 245833.33 respectively. Per hectare yield of cucumber for small, medium, large and all farmers were 25250, 24500,2400 and 24583.33kg respectively. Parvin, (2008) conducted an economic study of alternative rice and vegetables production in selected area of Mymensingh District. Boro rice, Aman rice, lady's finger, cabbage and white gourd were mainly produced in the study areas and per ha net returns of producing these crops were Tk. 23581, 3896, 86898, 89640 and 99000, respectively. The farmers earned the highest profit from white gourd vegetables.

In the past, there was no exclusive study on the production and marketing of cucumber in Mymensingh. As such, it was felt that the study on the production of cucumber in some selected area of Mymensingh district would be of much importance. The findings of the study are likely to be helpful to the researchers and policy makers in the formulation of policies regarding efficient production and marketing system of cucumber in Bangladesh. The study may induce researchers to conduct further research in cucumber production. The current study aimed to assess the cost and return of cucumber production in addition to its marketing system in Mymensingh district of Bangladesh.

MATERIALS AND METHODS

The study was conducted in Phulpur upazilla and Mymensingh city from Mymesingh district where cucumber farmers were available. A total of 50 stakeholders where farmers were 30, wholesalers were 7, retailers were 7 and local traders were 6 in number who were interviewed using structured questionnaire for collection of data and information. Face-to-face interview method was conducted by the researcher.

Analytical Technique

Profitability analysis

Profitability of crop farming from the view point of individual farmer was measured in terms of gross return, gross margin, net return and benefit cost ratio (undiscounted). The formula need for the calculation of profitability is discussed below:

Gross return (GR)

Gross return was calculated by multiplying the total volume of output of an enterprise

by the average price in the harvesting period (Dillon and Hardaker, 1993). The following equation was used to estimate GR:

$GR = Y_m P_m + Y_b P_b$

Where,

Y_m = Yield of main product per unit area;

P_m = Price of main product;

Y_b = Yield of by-product per unit area; and

P_b = Price of by-product.

Gross margin (GM)

Gross margin was calculated by the difference between gross return and total variable costs.

That is,

$GM = GR - TVC$

Where,

GR = Gross return; and

TVC = Total variable cost.

Net return (NR)

Net return was calculated by deducting all costs (variable and fixed) from the gross return. To estimate the relative profitability of crops produced, profit equation of the following algebraic form was used:

$NR = GR - GC$

Where,

GR = Gross return;

GC = Gross cost (i.e., TFC + TVC);

TFC = Total fixed cost per unit area; and

TVC = Total variable cost per unit area.

Benefit cost ratio (BCR)

A benefit cost ratio (BCR) is a relative measure which is used to compare the return per unit of cost. BCR was estimated as a ratio of gross return and gross cost. The formula of calculating BCR (undiscounted) is shown as below:

$BCR = GR \div GC$

Where,

GR = Gross return; and

GC = Gross cost (i.e., TFC + TVC).

Marketing Margin

Marketing margin has been calculated by using the following formulas (Ahmed, 2015):

Gross marketing margin =Sale price -Purchase price

Net marketing margin =Gross marketing margin -Marketing cost

Return on investment (%) = (Net marketing margin/ Total investment) ×100

Where, Total investment = Purchase price + Marketing cost

Ratio to moving average method

Ratio to moving average method was applied in this study to measure the seasonal price variation of cucumber. Here, the original prices are expressed as percentage of the moving average. The 12-months moving average is a fairly good estimate of the trend and cyclical components combined. Therefore ratio to moving average provides an index of seasonal and irregular components combined because averaging this over years and adjustment through correction factor provides a better estimate of seasonal index (Acharya and Agarwal, 2001).

RESULT AND DISCUSSION

Cost and Return of Cucumber Production

For calculating total production cost, variable and fixed costs were taken into consideration. The components of variable cost were the cost of seed, fertilizers, irrigation, pesticides and human labour. Fixed cost items for crop production was land use cost (lease value of land) and interest on operating capital. Table 1 shows the cost of employing inputs in cucumber production. It is evident that total variable cost of cucumber production was tk.67129.72 per acre which was 92.18% of total cost. Total fixed cost was tk.5694.44 which was 7.81% of total cost. Total cost of cucumber production was tk.72824.16 per acre in the study area. In the study area, leasing cost of land is tk.1500 per *katha* (8 decimal) per year. Here land used cost of cucumber production was calculated for 3 months per acre and it was tk.4687.5 which accounted 6.43 per cent of the total cost. So we can see that the per acre cost of cucumber cultivation was about tk.72824.16 (Table 1). Analysis shows that the highest cost was for T.S.P (38.06%) purpose. Other costs of farmer in descending manner were pesticides cost, urea cost, and human labour cost. Besides production cost, farmers had to spend for marketing purpose. Total cost of marketing of cucumber per kg was tk. 1.73. Of the total marketing cost, the highest share went to transportation (57.80%). The obtained gross return, gross margin, net margin of cucumber production was tk. 115986.87, tk.48857.15 and tk. 43162.71per acre in the study area. Calculated BCR (Benefit cost ratio) was 1.59 which is greater than one; means cucumber cultivation was profitable (Table 1). Siful, (2008), in his economic analysis of cucumber production also found the same result.

Table 1: Production cost, marketing cost and return of cucumber producing farmer

Production cost		
Particular	Amount (Tk./acre)	Percentage of total cost
Labour Sowing/planting	7048.39	9.67
Seed	2152.96	2.95
Urea	10023.08	13.76
TSP	27720.36	38.06
MP	3006.94	4.12
Cow-dung	1966.85	2.70
Irrigation	2711.11	3.72
Pesticides	12500.00	17.16
Total variable cost	67129.72	92.18
Fixed cost		
Interest on operating capital	1006.94	1.38
Land use cost (lease value of land)	4687.5	6.43
Total fixed cost	5694.44	7.81
Total cost	72824.16	100
Marketing cost		
Cost item	Amount (Tk./kg)	Percentage
Transportation	1.00	57.80
Market toll	0.50	28.90
Telephone cost	0.05	2.89
Personal expenses	0.18	10.40
Total marketing cost	1.73	100
Return of cucumber production		
Particular	Amount	
Production (kg/acre)	8338.38	
Price (Tk./kg)	13.91	
Gross return (Tk./acre)	115986.87	
Gross margin (Tk./acre)	48857.15	
Net margin (Tk./acre)	43162.71	
BCR(undiscounted)	1.59	

Source: Field survey, 2017.

Marketing System of Cucumber

Marketing channels

Two marketing channels of cucumber in Phulpur upazila and five channels from Mymensingh city were identified (Table 2).

Table 2: Marketing channels of cucumber in Phulpur and Mymensingh city

A: Marketing channel of cucumber in Phulpur	
Channel-I	Producer→Local traders→ Wholesaler→Retailer→Consumer
Channel- II	Producer→Consumer
B: Marketing channel of cucumber in Mymensingh city	
Channel-I	Producer→ Local trader → Wholesaler →Retailer → Consumer
Channel-II	Producer→ Local trader →Retailer →Consumer
Channel-III	Producer→ Retailer → Consumer
Channel-IV	Producer→Local trader→ Consumer
Channel-V	Producer→Local trader→Retailer→Street seller→Consumer

Source: Field survey, 2017.

Market Participants

There were six market participants i.e. producer, local trader, wholesaler, retailer, street seller and consumer. The producers usually sold their cucumber to the local traders at the local market (*Sosar bazar*). Local traders were professional traders who purchased cucumber from producers at the local market. Purchased cucumber were packed those were consigned by truck to the wholesalers and retailers; who were located at the Mymensingh city. Wholesaler purchased cucumber from local traders and sold to the retailer. The retailers bought cucumber from local traders at farm level through wholesaler and sold those to the consumer and street seller. Sometimes they had no permanent shop, usually use open market place for selling cucumber. Most of the retailers had been doing business for more than ten years. The Street sellers were mainly school going boys and girls. They usually collected cucumber from retailer through wholesaler and sold them to the direct user in the busy roads of Mymensingh city. The consumers were the final buyers of cucumber. They purchased cucumber from the market place but sometimes they also purchased these from wholesale market and production area.

Marketing functions

Buying, selling and handled volume of cucumber

From producers to final users, price found to be changed many times and each time a new price was determined by the interaction of demand and supply. Pricing of cucumber was fixed by individual traders. The sellers reported that they did not

follow any fixed price. The local traders at farm level purchased cucumber per kg at Tk. 12.11 and sold them at tk.16.17. On the other hand, wholesaler and retailer purchased cucumber at tk.15.50 and tk.17.93 respectively and sold them at tk.16.98 and tk.20.23 respectively. On an average a local trader, wholesaler and retailer handled respectively 200, 500-800 and 50-100 kg cucumber per day. The highest amount of cucumber was handled by the wholesalers followed by local trader and retailer (Table 3).

Table 3: Purchase, Sales and handled volume Price of Different Intermediaries

Type of intermediaries	Purchase price (Tk./kg)	Sales price (Tk./kg)	Handled volume (kg)
Local trader	12.11	16.17	200/day
Wholesaler	15.50	17.93	500-800/day
Retailer	16.98	20.23	50-100/day

Source: Field survey, 2017.

Transportation, Financing and Market Information

Farmers transported most of their product by van in the local market of Phulpur upazila, due to short distance (3 km) from the production site. The retailers of Mymensingh city used auto, van etc. for transportation.. The distance between Phulpur to Mymensingh city was 21 km. Table 4, represents that 50% farmers were self-financed and 50% operated their business with own capital and borrowed from different NGOs. In case of local traders, 66.66% of them were self-financed and bank provided funds 33.33 % to local traders. Almost all of the wholesaler were self-financed (71.42%) and others (28.57%) were own sources and bank loan. Most of the retailers (71.42%) were self-financed and other sources were bank loan (28.57%). The main source of financing of cucumber trading was own capital. Most of the producer (40%) received their market information from fellow traders. Local traders collected information through observation (50%) and rest (50%) from fellow traders. In case of wholesaler (71.42%) information obtained over telephone or mobile. Most of the retailers (71.42%) received their market information through visit to market and personal observation and information got from fellow traders (28.57%) (Table 4).

Table 4: Mode of Transportation, Sources of Financing and Market Information Collection by Producers and Intermediaries

Producers and Intermediaries	Modes of transport				Source of financing				Source of information			
	Shoulder-load	Auto	Van	Truck	Own	Own + Bank loan	Own + NGO	Total	Visit to market and personal observation	Fellow traders	Neighbour /friends	Telephone /mobile
Producer	12 (40.0%)	0 (0.0%)	18 (60.0%)	0 (0.0%)	15 (50%)	0 (0.0%)	15 (50%)	30 (100%)	12 (40%)	12 (40%)	6 (20%)	0 (0.0%)
Local trader	2 (33.3%)	4 (66.6%)	-	0 (0.0%)	4 (66.66%)	2 (33.33%)	0 (0.0%)	6 (100%)	3 (50%)	3 (50%)	0 (0.0%)	0 (0.0%)
Wholesaler	-	1 (14.28%)	1 (14.28%)	5 (71.42%)	5 (71.42%)	2 (28.57%)	0 (0.0%)	7 (100%)	2 (28.57%)	0 (0.0%)	0 (0.0%)	5 (71.42%)
Retailer	3 (42.85%)	4 (57.14%)	0 (0.0%)	0 (0.0%)	5 (71.42%)	2 (28.57%)	0 (0.0%)	7 (100%)	5 (71.42%)	2 (28.57%)	0 (0.0%)	0 (0.0%)
Total	17 (34%)	9 (18%)	19 (38%)	5 (10%)	29 (58%)	6 (12%)	15 (30%)	50 (100%)	22 (44%)	17 (34%)	6 (12%)	5 (10%)

Source: Field survey, 2017.

Marketing Cost and Marketing margin by the Intermediaries

Table 5 indicates that total marketing cost was tk. 6.16 per kg cucumber. Here total retailer cost was 25.59% of total marketing cost, wholesaler spent money 30.07% of total marketing cost and local traders share money 44.31% of total marketing cost. Shop rental cost was the highest cost (19.25%). Next main costs in descending order were transport cost (16.24%), electricity, market toll, assembling cost, and personal expenses. The table 6 also shows that average gross marketing margin was the highest for retailer (4.23Tk./kg) and lowest for wholesaler (2.43Tk./kg). Net marketing margin was highest for retailer (2.65tk./kg) and lowest for wholesaler (0.58tk./kg). While return on investment was highest for retailer (14.27%) and lowest for wholesaler (3.34%) (Table 5).

Table 5. Marketing Cost and Marketing Margin of Cucumber by Various Intermediaries

Marketing Cost (Tk./ kg)					
Cost items	Local traders	Wholesaler	Retailer	Cost	Percentage
Assembling	0.60	-	-	0.60	9.74
Transportation	0.50	0.50	-	1.00	16.24
Shop rent	0.44	-	0.75	1.19	19.25
Electricity	0.28	0.45	0.37	1.10	17.88
Market toll	0.25	0.25	0.25	0.75	12.18
Personal expenses	0.47	0.45	-	0.92	14.97
Telephone	0.20	0.20	0.20	0.60	9.74
Total	2.73	1.85	1.57	6.16	100
Percentage (%)	44.31	30.07	25.59	100	
Marketing Margin (Tk./kg)					
Particular	Local traders		Wholesaler		Retailer
Purchase price	12.11		15.50		16.98
Sale price	16.17		17.93		21.21
Gross marketing margin	4.06		2.43		4.23
Marketing cost	2.73		1.85		1.58
Net marketing margin	1.33		0.58		2.65
Return on investment (%)	8.96		3.34		14.27

Source: Field survey, 2017.

Seasonal Price Behavior of Cucumber

As cucumber is perishable and cannot be stored for a long time, so cucumber producers and intermediaries want to sell their products as soon as possible. For this condition, when the production of cucumber increased then the price of cucumber decreased. The highest growers price index for cucumber was 135.67 found in the month of October, i.e., growers price of cucumber was 35.67% higher than the average growers price in this month and the lowest price index of growers was 60.62 in the month of May i.e., growers price was 39.38% lower than the average growers price in this month. After reaching the highest price in the month of October, then price declines till Month and then price rises. Since, seasonal growers price indices of cucumber was bigger in the month of September, October and November, so cucumber producers have to plan to cultivate in such a way so that they can harvest their cucumber in these months, then they will receive higher price. There is a big difference between highest and lowest price indices (135.67-60.62=75.05) (Table 6).

Table 6: Seasonal Price Index of Cucumber in Bangladesh

Month	Seasonal price index	Highest value	Lowest value
January	100.70		
February	102.59		
March	85.05		
April	71.72		
May	60.62	135.67 in the month of October	60.62 in the month of May
June	67.87		
July	91.68		
August	117.23		
September	135.42		
October	135.67		
November	117.43		
December	114.02		

Source: Author's estimation, 2017.

Noonari, (2015) analyzed simple average seasonal index for onion and tomato in his study. The findings of the result was that for onion seasonal index was highest in November (221.75) and was lowest in January (65.95). On the other hand, for tomato it was highest in October (287.10) and was lowest in May (144.70).

CONCLUSION

The findings of the study shows that in cucumber business gross and net marketing margin were higher for retailers than other intermediaries and they were local traders and wholesaler. For movement of cucumber from farmers to the consumers, a number of marketing channels were identified. The most common marketing function performed was buying and selling, transportation, packing, grading, financing and market information. The seasonal price indices of cucumber were the highest in the month of October and the lowest in the month of May. Production of cucumber was profitable with high gross returns. Some recommendations were suggested to improve the situation for cucumber production and marketing with a view to increase the income and employment opportunities of the cucumber farmers like lower price and good quality plant, low price of fertilizers and insecticides, access to scientific knowledge and training, reducing attack by pests and diseases, high market price, good environment, contact with extension work etc. If the modern production, harvesting and post-harvest technology can be made available to farmers and traders and performance of marketing system is to be improved, cucumber farming could be more viable and attractive to commercial enterprise which can improve their socioeconomic status and help in alleviating rural poverty in many areas of Bangladesh.

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EFFECT OF GAMMA IRRADIATION ON SHELF LIFE AND QUALITY OF BROILER MEAT

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ABSTRACT

The experiment was conducted on fresh broiler meat treated with ^{60}Co gamma irradiation having dose of 0 (T_0), 1 (T_1), 2 (T_2) and 3.5 kGy (T_3)) and stored 0, 30 and 60 days at -20ºC to estimate the effect on proximate, sensory, physicochemical, biochemical and microbial changes in broiler meat. Factorial experiment (4x3) in completely randomized design (CRD) replicated three times per cell was applied to study the variation among treatment combination. Color was changed significantly ($p<0.05$) with higher irradiation doses. DM, EE, CP was increased, and Ash and pH was decreased significantly ($p<0.05$) with higher irradiation doses. Thiobarbituric acid reactive substances (TBARS), Peroxide value (PV), Free fatty acid (FFA), cooking loss was increased significantly ($p<0.05$) with irradiation level and storage period. Total viable count (TVC), Total coliform count (TCC), Total yeast and mold count (TYMC) was significantly ($p<0.05$) reduced with irradiation level. Considering all traits it can be concluded that irradiation significantly decreased microbial population and maintain nutritional quality of broiler meat. The irradiation dose 2.0 kGy showed most acceptable for microbial population reduction, maintains overall acceptability and for shelf life extension of broiler meat comparison to non-irradiated meat sample.

Keywords: Gamma Irradiation, Broiler Meat, Physicochemical and Microbiological Traits

INTRODUCTION

Poultry meat has a high biological value and it is the most important source of protein. Commercial broiler strains and few indigenous chicken breeds are fulfilling the global demand for broiler meat over the years (Jaturasitha et al., 2008). Broiler meat is also a good source of phosphorus, other minerals, B-complex vitamins and rich in proteins. Radiation processing of fresh meat extends shelf life and protects the consumer against pathogenic bacteria (Al-bachir and Zeinou, 2009). Fresh meat has a

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shelf life of 1 day or less at ambient storage temperatures (20-30°C) (Olaoye, 2010). Irradiation is recognized as an effective, widely applicable food processing technique. Irradiation, as a method of meat preservation, is the most effective technology in the elimination of pathogenic microorganisms without compromising the nutritional properties and sensory quality of food (WHO, 1999). The wholesomeness of irradiated food has been permitted by the World Health Organization (WHO), the Food and Agriculture Organization (FAO), the International Atomic Energy Agency (IAEA), and the US Food and Drug Administration (FDA) (Sohn et al., 2009). In Korea, 20 food items are approved to be treated by irradiation up to 10 kGy for the purpose of inhibition of sprouting, destruction of food borne insects and parasites, delay of physiological ripening, an extension of shelf life, or improvement of food qualities.

Lately Bangladesh is producing 72.60 Lakh MT meat vis-à-vis demand of 72.14 Lakh MT (DLS, 2018) where broiler is contributing more share (around 50%). It indicates we are in surplus 0.46 Lakh MT meats production. It`s a prime time for Bangladesh to seek exporting opportunities of meat. To overcome the international trade barrier irradiation can be an effective way to increase the shelf life and safety of meats. At present in Bangladesh, no research has yet been carried out on irradiation of broiler meats. Hence, the study was carried out to determine the effect of gamma irradiation on sensory, proximate, biochemical and microbial qualities of broiler meat and to find out the safe level of irradiation dosage on broiler meats to increase the shelf life.

MATERIALS AND METHODS

Sample collection and processing

The study was conducted during December, 2017 to November, 2018 in the Department of Animal Science, Bangladesh Agricultural University, Mymensingh. Sample was collected from local market of Mymensingh. Samples were divided into four groups. Each group was exposed to the irradiation dose having of 0 (T_0), 1 (T_1), 2 (T_2) and 3.5 kGy (T_3)) at Bangladesh Institute of Nuclear Agriculture. Meat sample was irradiated at $Cobalt^{60}$ GC-5000 (BRIT, India) machine, whose central dose rate was 4.29 kGy/hr. Each group was treated with 4.29 kGy for 14 min, 28 min and 35 min 55 sec for giving 1.00, 2.00 and 3.50 kGy, respectively.

Proximate Ccomponents

Proximate components such as Dry Matter (DM), Ether Extract (EE), Crude Protein (CP) and Ash were carried out according to the methods (AOAC, 1995). All determinations were done in triplicate and the mean values were reported.

Physicochemical and bio-chemical assessment

pH value of raw meat and cooking loss was measured using pH meter (Hanna HI99163) from raw meat homogenate. The homogenate was prepared by blending 5

g of meat with 10 ml distilled water. FFA value, POV value and TBARS value were determined by (Sharma et al., 2012). All determination was done in triplicate and mean value was reported.

Sensory evaluation

Sensory evaluation was executed by a trained 6-member panel (color, flavor, tenderness, juiciness and overall acceptability). Prior to sample evaluation, all panelists participated in orientation sessions to familiarize with the scale attributes (color, smell, juiciness, tenderness, overall acceptability) of indigenous chicken meat using an intensity scale. Each sample was evaluated by using a 9-point hedonic scale (9 = like extremely, 8 = like very much, 7 = like moderately, 6 = like slightly, 5 = neither like nor dislike, 4 = dislike slightly, 3 = dislike moderately, 2 = dislike very much and 1 = dislike extremely) (Pena et al. 2016). Sensory evaluation was accomplished at 0 days and repeated at 30 and 60 days, respectively.

Microbial Assessment

Ten grams of sample were aseptically homogenized after adding 90 mL of sterile solution in a sterile Stomacher bag for 2 min (BagMixer® 400, Interscience, France). Consequently the diluents were planted onto aerobic plated count agar (Difco Laboratories), incubated at 37^0c for 45 h. The total number of colonies observed on plate of each sample after incubation was counted and expressed as log of colony forming units per gram (Log CFU/g).

Statistical Model and Analysis

The proposed model for the planned experiment was a factorial experiment with two factors A (Treatments) and B (Days of Intervals) is:

$yijk = \mu + Ai + Bj + (AB)ij + \varepsilon ijk$ i = 1,…,A; j = 1,…,B; k = 1,…,n

Where: yijk = observation k in level i of factor A and level j of factor B

μ = the overall mean

Ai = the effect of level i of factor A

Bj = the effect of level j of factor B

Data were analyzed using SAS Statistical Discovery software, NC, USA. DMRT test was used to determine the significance of differences among treatments means.

RESULTS AND DISCUSSION

Proximate analysis

Table 1 shows DM, CP, EE and Ash content at different treatments was 25.68 to 27.22, 23.17 to 24.03, 1.94 to 2.93 and 1.61 to 1.41 %, respectively. The range of different days of interval DM, CP, EE and Ash content was 25.51 to 27.51, 23.82 to 23.57, 2.23 to 2.72 and 1.72 to 1.33, respectively. The result showed that increasing irradiation dose increased DM content significantly ($p<0.05$) and also increased with

shelf life. A similar result was found by Fallah et al. (2010). Crude protein (CP) was significantly ($p<0.05$) increased with increasing irradiation doses but significantly ($p<0.05$) decreased with storage period. Irradiated treated samples had significantly ($p<0.05$) higher amounts of EE compared to control group and significantly increased with storage period. Haque et al. (2017) found similar trend in beef irradiation. Ash was significantly ($p<0.05$) decreased with higher irradiation doses and also significantly decreased with increased storage period. Similar results were found by Al-Bachir and Zeinou, (2014) where they showed that Ash content of meat was decreased with the increasing level of irradiation dose. There was positive and significant interaction between treatments and days of interval for DM and EE (Table 1).

Physicochemical and bio-chemical properties

Table 2 shows the range of different treatments of pH and cooking loss score was 6.15 to 5.99 and, 23.46 to 25.30%. The rage value of different days of interval for pH and cooking loss was 6.18 to 5.98 and 23.01 to 25.83%, respectively. The pH value was significantly ($p<0.05$) decreased with increasing irradiation doses and also decreased with storage period. Similar result was found by Aftab et al. (2015) in irradiated broiler meat where pH was slightly decreased as the irradiation doses increased. Cooking loss was significantly ($p<0.05$) increased with higher irradiation doses and with storage period. Decrease in cooking loss of irradiated meat samples could be due to the degradation of myofibrillar and structural proteins were found by Sweetie et al. (2015) in irradiated meat samples which are not similar with the present study.

Biochemical properties

The range of different treatments for FFA, POV and TBARS were 0.36 to 1.22, 0.64 to 0.96 and 0.29 to 0.54%, respectively. The range values of different days of intervals for FFA, POV and TBARS were 0.50 to 0.86, 0.73 to 0.95 and 0.31 to 0.48% (Table 2). FFA value was significantly ($p<0.05$) increased with irradiation level as well as with storage period. Similarly Quattara et al. (2002) showed that gamma irradiation increased lipid oxidation in ground beef samples. In general terms, irradiation accelerates the lipid oxidation process, which is highly significant in foods with a high content of fats and much unsaturated fatty acids, in which numerous free radicals are formed due to this oxidation (O'Bryan et al., 2008). Haque et al. (2017) found same trend in beef irradiation. POV values were increased significantly ($p<0.05$) with higher irradiation doses as well as storage time. Similarly Chengliang et al. (2017) found that lipid oxidation was promoted due to irradiation. TBARS was significantly ($p<0.05$) increased with irradiation doses of broiler meat samples and with storage period. Irradiated samples at 3.5 kGy had higher TBARS value than those irradiated at 2 and 1 kGy. Gomes and Silva, (2006) suggested that gamma radiation (3 and 4 kGy) increased TBARS values of mechanically deboned broiler meat in first days of frozen storage (−18°C) which is in agreement with our results. FFA had significantly interaction between treatment and days of interval.

Table 1: Proximate composition (mean ± SE) of irradiated broiler meat

Parameters	DI	Treatments				Mean ± SE	Level of significance		
		T_0	T_1	T_2	T_3		Treat	DI	Treat*DI
DM (%)	0	23.73 ± 0.024	25.21 ± 0.176	26.30 ± 0.017	26.80 ± 0.023	**25.51^{c} ± 0.06**	<.0001	<.0001	<.0001
	30	25.21 ± 0.017	26.51 ± 0.017	26.76 ± 0.023	27.14 ± 0.034	**26.65^{b}± 0.023**			
	60	27.09 ± 0.029	27.58 ± 0.020	27.65 ± 0.020	27.74 ± 0.029	**27.51^{a} ± 0.025**			
	Mean	**25.68^{d}± 0.023**	**26.43^{c} ± 0.071**	**26.90^{b} ± 0.02**	**27.22^{a} ± 0.029**				
CP (%)	0	23.25 ± 0.017	23.82 ± 0.038	24.05 ± 0.007	24.15 ± 0.026	**23.82^{a} ± 0.060**	<.0001	<.0001	0.5863
	30	23.15 ± 0.017	23.69 ± 0.029	23.82 ± 0.038	23.98 ± 0.011	**23.66^{b}± 0.023**			
	60	23.10 ± 0.012	23.53 ± 0.029	23.70 ± 0.014	23.96 ± 0.029	**23.57^{c} ± 0.021**			
	Mean	**23.17^{d}± 0.015**	**23.68^{c} ± 0.032**	**23.86^{b} ± 0.019**	**24.03^{a} ± 0.022**				
EE (%)	0	1.77 ± 0.290	2.09 ± 0.017	2.42 ± 0.023	2.64 ± 0.029	**2.23^{c} ± 0.089**	<.0001	<.0001	<.0002
	30	2.09 ± 0.017	2.21 ± 0.029	2.67 ± 0.052	2.92 ± 0.029	**2.44^{b} ± 0.031**			
	60	2.10 ± 0.030	2.48 ± 0.023	3.09 ± 0.017	3.23 ± 0.023	**2.72^{a} ± 0.023**			
	Mean	**1.94^{d} ± 0.11**	**2.26^{c} ± 0.023**	**2.72^{b} ± 0.031**	**2.93^{a} ± 0.027**				
Ash (%)	0	1.83 ±0.026	1.78 ± 0.017	1.68 ± 0.023	1.61 ± 0.017	**1.72^{a} ± 0.021**	<.0001	<.0001	0.2972
	30	1.79 ± 0.017	1.48 ± 0.023	1.40 ± 0.017	1.37 ± 0.023	**1.45^{b} ± 0.02**			
	60	1.41 ± 0.017	1.35 ± 0.023	1.32 ± 0.023	1.25 ± 0.017	**1.33^{c} ± 0.021**			
	Mean	**1.61^{a} ± 0.02**	**1.54^{b} ± 0.021**	**1.47^{c} ± 0.021**	**1.41^{d} ± 0.02**				

Mean in each row having different superscript varies significantly at values $p < 0.05$. Again, mean values having same superscript in each row did not differ significantly at $p > 0.05$ T_0=Control group, T_1= 1 kGy irradiated group, T_2= 2 kGy irradiated group T_3= 3.5 kGy irradiated group, DI=Days of Intervals, Treat= Treatment, T*DI=Interaction of Treatment and Days of Intervals.

Table 2: Physicochemical and bio-chemical properties (mean ± SE) of irradiated broiler meat

Parameters	DI	Treatments				Mean ± SE	Level of significance		
		T_0	T_1	T_2	T_3		Treat.	DI	T*DI
Raw pH	0	6.25 ±0.017	6.21 ± 0.017	6.15 ± 0.022	6.10 ± 0.038	**6.18^{a} ± 0.024**	<.0001	<.0001	0.1384
	30	6.21 ± 0.017	6.09 ± 0.020	6.02 ± 0.026	6.00 ± 0.027	**6.07^{b} ±0.023**			
	60	6.15 ± 0.017	5.98 ± 0.023	5.94 ± 0.015	5.89 ± 0.015	**5.98^{c} ±0.018**			
	Mean	**6.19^{a} ± 0.017**	**6.09^{b} ±0.020**	**6.03^{c} ± 0.021**	**5.99^{d} ± 0.027**				
FFA (%)	0	0.24 ± 0.017	0.38 ± 0.014	0.48 ± 0.017	0.89 ± 0.017	**0.50^{c} ±0.016**	<.0001	<.0001	<.0001
	30	0.38 ± 0.017	0.49 ± 0.011	0.68 ± 0.017	0.49 ± 0.017	**0.69^{b} ± 0.016**			
	60	0.45 ± 0.014	0.61 ± 0.015	0.84 ± 0.011	1.55 ± 0.017	**0.86^{a} ± 0.014**			
	Mean	**0.36^{d} ± 0.016**	**0.49^{c} ± 0.013**	**0.67^{b} ± 0.015**	**1.22^{a} ±0.017**				
PV (meq/kg)	0	0.55 ± 0.020	0.72 ±0.008	0.78 ±0.017	0.87 ± 0.011	**0.73^{c} ± 0.014**	<.0001	<.0001	0.4753
	30	0.72 ± 0.008	0.82 ± 0.008	0.93 ± 0.014	0.97 ± 0.012	**0.83^{b} ±0.011**			
	60	0.77 ± 0.020	0.95 ± 0.020	1.02 ± 0.017	1.06 ± 0.046	**0.95^{a} ±0.026**			
	Mean	**0.64^{d} ± 0.016**	**0.83^{c} ± 0.012**	**0.91^{b} ± 0.016**	**0.96^{a} ± 0.023**				
TBARS (mg-MDA/kg)	0	0.18 ± 0.015	0.25 ±0.023	0.35 ± 0.023	0.48 ± 0.026	**0.31^{c} ± 0.031**	<.0001	<.0001	0.0822
	30	0.27 ± 0.029	0.37 ± 0.032	0.47 ± 0.015	0.56 ± 0.048	**0.42^{b} ± 0.039**			
	60	0.43 ± 0.016	0.42 ± 0.02	0.48 ± 0.020	0.59 ± 0.008	**0.48^{a} ± 0.039**			
	Mean	**0.29^{d} ± 0.02**	**0.35^{c} ± 0.025**	**0.43^{b} ± 0.028**	**0.54^{a} ± 0.027**				
Cooking Loss (%)	0	21.39 ± 0.243	23.09 ± 0.793	23.67 ± 0.103	23.90 ± 0.074	**23.01^{c} ± 0.30**	<.0001	<.0001	<.0001
	30	23.09 ± 0.079	23.88 ± 0.092	24.22 ± 0.120	25.48 ± 0.233	**24.27^{b} ± 0.13**			
	60	25.45 ± 0.241	23.68 ± 0.170	25.69 ± 0.142	26.53 ± 0.162	**25.83^{a} ± 0.17**			
	Mean	**23.46^{d} ± 0.19**	**24.21^{c} ± 0.35**	**24.52^{b} ± 0.12**	**25.30^{a} ± 0.16**				

*Mean in each row having different superscript varies significantly at values p<0.05. Again, mean values having same superscript in each row did not differ significantly at p > 0.05 T_0=Control group, T_1= 1 kGy irradiated group, T_2=, 2 kGy irradiated group T_3= 3.5 kGy irradiated group, DI=Days of Intervals, Treat= Treatment, T*DI=Interaction of Treatment and Days of Intervals.*

Sensory evaluation

Color, flavor, tenderness, juiciness and overall acceptability score at different treatment was 3.72 to 4.05, 4.33 to 4.44, 3.44 to 3.88, 3.88 to 3.88 and 3.88 to 3.33, respectively (Table 3). The range values of different days of intervals for color, flavor, tenderness, juiciness and overall acceptability score was 4.75 to 3.33, 4.33 to 3.58, 4.58 to 3.00, 4.66 to 3.16 and 4.58 to 3.16, respectively. Color, tenderness, juiciness and overall acceptability had significantly ($p<0.05$) reduced with different storage time. Similar results were found by Souza et al. (2007). Sweetie et al. (2015) found that chicken, lamb and buffalo meat tenderization is increased with irradiation doses. Flavor was decreased with higher irradiation doses and also decreased with storage period. Juiciness was almost same with all irradiation doses and significantly ($p<0.05$) decreased with storage time. Overall acceptability was almost same with irradiation doses but decreased significantly ($p<0.05$) with storage period. Among all treatment groups higher dose 3.5 kGy showed lower value due to higher lipid oxidation of broiler meat. There was no interaction between treatment and days of internal among all parameters.

Microbiological assessment

Table 4 shows the range of total viable count, coliform count and yeast and mold among different treatments was 4.17 to 1.50, 2.17 to 0.75 and1.73 to 0.85, respectively. The range value of overall total viable count, coliform count and yeast and mold count among different days of interval was 2.16 to 2.99, 1.10 to 1.51 and 1.02 to 1.42, respectively. TVC, TCC and TYMC were significantly ($p<0.05$) decreased with higher irradiation doses but increased with storage period. Similar results were found by Henriques et al. (2013) and Fallah et al. (2008). There was positive and significant interaction between treatments and days of interval for TVC, TCC and TYMC values (Table 4).

Table 3: Sensory-attributes (mean ± SE) of irradiated broiler meat

Parameters	DI	Treatments				Mean ± SE	Level of significance		
		T_0	T_1	T_2	T_3		Treat.	DI	T*DI
Color	0	4.67 ±0.333	4.67 ±0.333	4.83 ± 0.166	4.83 ± 0.166	**4.75^a ± 0.249**	0.0908	<.0001	0.2293
	30	4.67 ±0.333	4.67 ±0.333	4.50 ±0.288	3.67 ±0.333	**4.16^b ± 0.321**			
	60	2.67 ± 0.333	3.33 ± 0.333	3.67 ± 0.303	3.67 ± 0.333	**3.33^c ± 0.325**			
	Mean	**3.72 ± 0.33**	**4.22±0.33**	**4.33± 0.252**	**4.05± 0.277**				
Flavor	0	4.67 ± 0.333	4.33 ± 0.333	4.33 ±0.666	4.00 ± 0.577	**4.33 ± 0.48**	0.1836	0.1272	0.9948
	30	4.33 ±0.333	4.00 ± 0.577	3.67 ±0.666	3.33 ± 0.333	**3.83 ± 0.48**			
	60	4.00 ±0.577	4.00 ±0.577	3.33 ± 0.333	3.00 ± 0.577	**3.58 ± 0.52**			
	Mean	**4.33 ± 0.41**	**4.11 ± 0.49**	**3.77 ± 0.56**	**3.44 ± 0.49**				
Tenderness	0	4.67 ±0.333	4.67 ±0.333	4.67 ±0.333	4.33 ± 0.333	**4.58^a ± 0.33**	0.4887	<.0001	0.6594
	30	4.67 ±0.333	3.67 ±0.333	3.67 ±0.333	3.33 ± 0.333	**3.50^b ± 0.33**			
	60	2.33 ± 0.333	3.33 ±0.333	3.00 ± 0.577	3.33 ± 0.333	**3.00^b ± 0.39**			
	Mean	**3.44 ± 0.33**	**3.66 ± 0.33**	**3.77 ± 0.41**	**3.88 ± 0.33**				
Juiciness	0	4.33 ± 0.333	4.67 ±0.333	4.67 ±0.333	5.00 ± 0	**4.66^a ± 0.25**	0.3519	<.0001	0.3685
	30	4.67 ±0.333	3.33 ± 0.333	3.67 ±0.333	3.33 ± 0.333	**3.50^b ± 0.33**			
	60	3.67 ±0.333	2.33 ± 0.333	3.33 ± 0.333	3.33 ± 0.333	**3.16^b ± 0.33**			
	Mean	**3.88 ± 0.33**	**3.44 ± 0.33**	**3.88 ± 0.33**	**3.88 ± 0.22**				
Overall Acceptability	0	4.67 ±0.333	4.67 ±0.333	4.67 ±0.333	4.33 ± 0.333	**4.58^a ± 0.33**	0.1290	<.0001	0.6154
	30	3.33 ± 0.333	3.67 ±0.333	3.67 ±0.333	4.67 ±0.333	**3.50^b ± 0.33**			
	60	3.67 ±0.333	3.33 ± 0.333	3.33 ± 0.333	2.33 ± 0.333	**3.16^b ± 0.33**			
	Mean	**3.88 ± 0.33**	**3.88 ± 0.33**	**3.88 ± 0.33**	**3.33 ± 0.33**				

*Mean in each row having different superscript varies significantly at values $p < 0.05$. Again, mean values having same superscript in each row did not differ significantly at $p > 0.05$.T_0 = Control group, T_1= 1 kGy irradiated group, T_2= 2 kGy irradiated group T_3= 3.5 kGy irradiated group, DI=Days of Intervals, Treat= Treatment, T*DI=Interaction of Treatment and Days of Intervals.*

Table 4: Microbial population (mean ± SE) of irradiated broiler meat

Parameters	DI	Treatments				Mean ± SE	Level of significance		
		T_0	T_1	T_2	T_3		Treat.	DI	T*DI
	0	3.69 ± 0.095	2.35 ±0.054	1.65 ± 0.048	0.97 ± 0.049	**2.16^{c} ±0.062**	<.0001	<.0001	0.0158
TVC	30	4.18 ± 0.074	2.80 ± 0.061	1.68 ± 0.061	1.59 ± 0.026	**2.61^{b} ±0.051**			
(log CFU/g)	60	4.62 ± 0.120	3.23 ± 0.037	2.18 ± 0.061	1.96 ± 0.052	**2.99^{a} ±0.068**			
	Mean	**4.17^{a} ± 0.089**	**2.79^{b} ± 0.050**	**1.89^{c} ± 0.056**	**1.50^{d} ±0.042**				
	0	1.92 ±0.070	1.11 ± 0.040	0.80 ± 0.043	0.60 ± 0.030	**1.10^{c}± 0.046**	<.0001	<.0001	<.0001
TCC	30	2.14 ± 0.029	1.52 ± 0.037	0.87 ± 0.029	0.78 ± 0.008	**1.32^{b} ±0.028**			
(log CFU/g)	60	2.48 ± 0.026	1.74 ± 0.026	0.97 ± 0.052	0.88 ± 0.034	**1.51^{a} ±0.035**			
	Mean	**2.17^{a} ±0.045**	**1.45^{b} ± 0.034**	**0.88^{c} ±0.041**	**0.75^{d} ± 0.024**				
	0	1.55 ± 0.048	1.05 ± 0.040	0.92 ± 0.023	0.58 ± 0.020	**1.02^{c} ±0.033**	<.0001	<.0001	0.0103
TYMC	30	1.65 ± 0.055	1.36 ± 0.043	1.05 ± 0.057	0.84 ± 0.014	**1.26^{b} ±0.038**			
(log CFU/g)	60	1.82 ± 0.078	1.49 ± 0.049	1.25 ± 0.023	1.15 ± 0.045	**1.42^{a} ±0.049**			
	Mean	**1.73^{a} ±0.055**	**1.30^{b} ± 0.044**	**1.07^{c} ± 0.034**	**0.85^{d} ± 0.026**				

*Mean in each row having different superscript varies significantly at values p< 0.05. Again, mean values having same superscript in each row did not differ significantly at p > 0.05.T_0=Control group, T_1= 1 kGy irradiated group, T_2= 2 kGy irradiated group T_3= 3.5 kGy irradiated group, DI=Day Intervals, Treat= Treatment, T*DI=Interaction of Treatment and Day Intervals*

CONCLUSIONS

The study revealed that gamma irradiation had significant effect on nutritional quality of broiler meat. Among the treatments, irradiation dose 2.0 kGy showed best results in terms of overall acceptability, microorganisms load and the shelf life extension of broiler meat. It may be concluded that gamma irradiation will enable to deliver the larger amount of high quality broiler meat with extended shelf life.

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FARMERS' ADAPTATION STRATEGIES TO DROUGHT AND THEIR DETERMINANTS IN BARIND TRACT, BANGLADESH

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ABSTRACT

Farmers' choice of drought adaptation measures depends on several determinants that include their socioeconomic, demographic, and agricultural characteristics. This study aimed to investigate the presence of dependency or association between the adaptation strategies implemented by farmers' own initiative and their determinants in the Barind Tract of Bangladesh. The study was mainly based on primary data collected through a household level survey using a structured questionnaire covering 400 farming households from an extended area comprising 10 Unions from 03 Districts, *viz.* Rajshahi, Chapai Nawabganj, and Naogaon in northwest Bangladesh. The chi-square test and Cramer's V test has been applied to measure the association between variables and the strength of the association respectively. The study found that the nature of adaptation strategies implemented by farmers is mainly related to crop production and income generation. Their capability noticeably lacks to facilitate artificial irrigation that made them dependent on government's initiatives. The association between the implemented adaptation measures and selected variables suggests that the farm size, irrigation accessibility, monthly household income, land ownership status, literacy level, and poverty status played significant role in the implementation of adaptation measures. Finally, limitations of currently practiced adaptation strategies and future way forwardhave been discussed for better drought risk management.

Keywords: Adaptation, Drought, Barind Tract, Determinants

INTRODUCTION

The nature of drought occurring in Bangladesh is mainly agricultural drought. It refers to the scarcity of water required for the plant's growth resulted from a soil moisture deficiency due to precipitation shortage and the difference between actual

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and potential evapotranspiration (Wilhite, 2000). Almost 15% households in Bangladesh were affected by drought between the year of 2009 and 2014, while one household in every four is affected by drought in Rajshahi Division (BBS, 2015). Farmers are the most direct sufferer from drought as they face difficulties to irrigate their cropland due to scarcity of water resulted from drought (Shahid, 2010). The direct consequence of drought is the loss of crop production that affects the life and livelihood of the concerned people as well as indirectly it affects GDP, local labor market, and economic growth as a whole. For example, Aman[1] Rice accounts about two-third of total annual rice production of 34 million tons (BBS, 2015), from which one-fifth portion is damaged due to inadequate irrigation in a typical year. In 2006, the last severe drought occurred in the country, caused a reduction of Aman Crop production of about 25–30% in the northwest region (Rahman et al., 2008). Overall, in all of the three cropping seasons, namely Kharif-1, Kharif-2, and Rabi of Bangladesh, about 0.40, 0.34, and 0.45 M ha agricultural lands respectively are severely affected by drought in every year (Habiba et al., 2011).

Barind Tract, the largest Pleistocene physiographic unit of the Bengal Basin covering the northwest region of the country, is considered as most drought prone area (Ahmed, 2012; Shahid and Behrawan, 2008; Hasan and Islam, 2013; Shahid, 2008). This region receives less amount of rainfall than that of other parts of the country. Due to complex geologic formation, groundwater is also not available in many parts of the region. As a result, water scarcity creates a soil moisture deficiency that affects crop production. It is not possible to alter climatic or geologic phenomena to control the adversity caused by drought; however, it is possible to lessen the damage of a disaster by undertaking adaptation measures. The farmers in northwest Bangladesh, the most drought affected region of the country, are implementing different types of adaptation measures to reduce the adverse consequences of drought (Habiba et al., 2012; Karim et al., 2017, Hossain et al., 2016; Paul, 1998; Alam, 2015). Adaptation helps farmers to achieve their goals of food, income, and livelihood security in the face of changing climatic and socioeconomic conditions, including climate variability, extreme weather conditions, i.e. drought (Kandlinkar and Risbey, 2000).

The capability of decision making regarding the implementation of adaptation measures by farmers' own initiatives depends on several influential factors called the determinants. The determinants mainly play their role in influencing farmers' decision making regarding the types of adaptation measures they intend to undertake. The previous studies found that the factors that determine the nature of adaptation measures undertaken by farmers vary within social, economic, demographic, and agricultural characteristics of farmers and their households (Hassan and Nhemachena, 2008; Deressa et al., 2009; Ishaya and Abaje, 2008). Knowledge of the

[1]Bangladesh has three cropping seasons locally known as Kharif–1 (mid-March – June), Kharif–2 (July – mid-October), and Rabi (mid-October – mid-March). Among them, Rabi season completely depends on irrigation, whereas other two are mainly rain-fed agriculture.

adaptation methods and factors affecting farmers' choices can enhance the policies directed toward tackling the challenges that drought is imposing on agriculture (Deressa et al., 2009). However, there is a lack of studies addressing the determinants of adaptive policy implementation in the case of drought in Barind Tract. Therefore, this study intends to investigate the currently practicing adaptation measures by farmers as well as to examine the influence of different explanatory variables on farmers' decision making regarding the nature of adaptation methods considering various socioeconomic, demographic, and agricultural characteristics.

The findings from this study will help the policy implementers in understanding the types of determinants having more or less influence regarding the capacity building of implementing the adaptation measures. Government and other non-government organizations (NGOs) would be able to improve the farmers' capacity of implementing different types of measures through developing these factors in order to reduce the adverse impacts of drought.

MATERIALS AND METHODS

This study has carried out mainly based on primary data collected through a household-level survey of an extended area. The target group of the survey was farmers who are affected by drought and cultivating different types of crops on their own or rental land as well as undertaken at least one adaptation measure by their own initiative. A structured questionnaire was prepared to collect the data through face-to-face interview of respondents across the study area. The survey was held during February-March, 2017. The data covered socioeconomic and other possible factors that influenced the farmers' decision making regarding the implementation of adaptation strategies.

Sample Size Estimation

Cluster sampling methodology was adopted to select the units of observations (farmers) where the Unions (lowest unit of administrative hierarchy) were considered as clusters. The following recognized formula was applied to determine the sample size:

$$n = \frac{p(1-p)Z^2}{(d)^2} \times Deff \qquad (1)$$

Here,

p = Indicator percentage = 50% (proportion of households adopted any sort of measures to cope with drought)

Z = Value of normal variate with 95% confidence interval = 1.96

d = Relative error margin = 0.06

$Deff$ = Design effect = 1.5

The above-mentioned formula yields that at least 400 targeted households are required to cover for the study.

Sampling Technique

The study areas and households for questionnaire survey were selected following several steps. Firstly, according to drought severity ranking prepared by MoDMR (2013), seven Upazilas were selected, which are ranked as 'very severely' drought-affected areas. Secondly, total ten Unions were picked up using the Systematic Probability Proportional to Size sampling procedure from those Upazilas (Table 1). Then, two villages were chosen randomly from each of the selected Unions. Finally, twenty farming households were interviewed from each of the villages following UNICEF pencil-spin method (WHO, 2015). Fig 1 shows the map of the study area.

Table 1: Details of study area

District	Upazila	Union
Rajshahi	Godagari	Matikata
		Rishikul
ChapaiNawabganj	Tanore	Talanda
	Nachole	Kasba
	Gomastapur	Radhanagar
Naogaon	Niamatpur	Parail
		Niamatpur
	Porsha	Chhaor
		Tentulia
	Sapahar	Tilna

Analytical Techniques

At first, Pearson's Chi–Square Testwas performed to assess the association between implementation of adaptation measures and their determinants. This test determines the association between categorical variables, *viz.* whether the variables are independent or correlated. It is a non-parametric test consisting of two hypotheses. The null hypothesis states that there is no association between the variables, whereas the alternative hypothesis is in favour of the association. If the calculated p-value of the test is greater than α (=0.05), the null hypothesis will be accepted, while thep-value less than/equal to α allows the acceptance of alternative hypothesis.Secondly, Cramer's V (Cramer, 1946) was calculated to determine the strength of correlations between the variables. The value of the V varies from 0 to 1. The V values closer to zero shows a weak association between the variables, whereas the value closer to 1 indicates a strong association. In addition, frequency distribution was used to

describe the background characteristics of respondents. All of the statistical operations were carried out using SPSS Software.

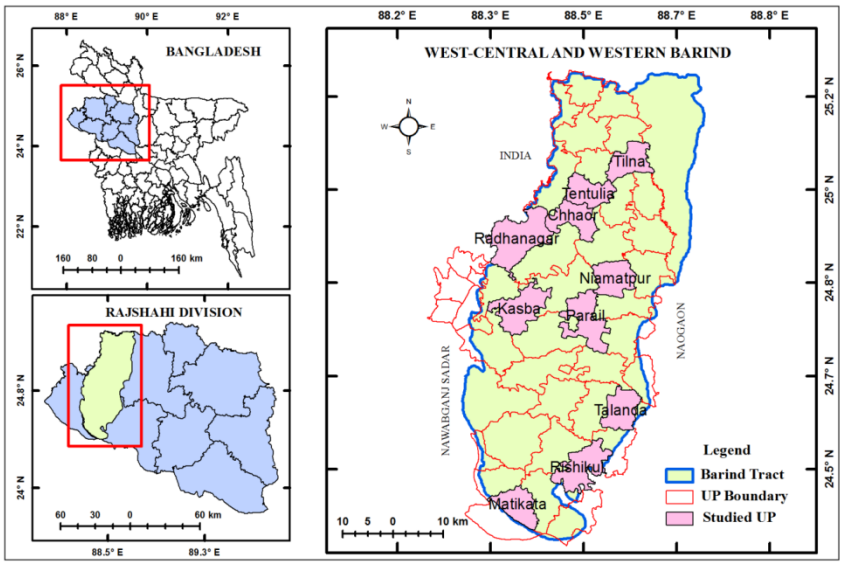

Figure 1. Map of the study area showing selected Unions

RESULTS AND DISCUSSION

Background Characteristics of Farmers

Farmers' background characteristics include demographic, socioeconomic, landholdings, irrigation, and agricultural related variables. This section intends to describe some key figures of background characteristics, whereas details are shown in Appendix Table A. There is a dominance of middle-aged farmers (about 66%) in the study area followed by older aged farmers (about 30%). About two-fifth of farmers had not received any formal education, while almost two-third have received a primary level education. Almost half of the farmers cultivate their crops as tenant farmers followed by quarter of them with own agricultural land. The number of nuclear family accounts almost four times higher than its counterpart—the joint family. Nearly half of the farming households belong to the lower medium income group earning Tk.5000.00 to Tk.10,000.00 on a monthly basis. The poverty status shows that about 36% and 50% households remain below poverty line considering the lower and upper poverty line, respectively, which is higher than previous national level estimations [21.1% and 35.2% based on lower and upper poverty line respectively (BBS, 2010)]. About 80% farmlands have accessibility to irrigation facilitated by the Barind Multipurpose Development Authority (BMDA). Most of the agricultural farms are small in size (1 – 2 acre) followed by very small and moderately large categories that cover ≤1 and 3 – 7.5 acre respectively. The study has also found that almost two-third portion of households is partially capable of

purchasing food, whereas a very small portion (about 3.5%) is incapable. Overall, the background characteristics suggest that the surveyed respondents came from a heterogeneous group of farmers representing all classes of society.

Adaptation Measures Undertaken by Farmers

Table 1 shows the adaptation measures undertaken by drought-affected farmers in Barind Tract alongside the percentage of their implementers. Most of the measures are mainly related to agriculture, as this sector is the most vulnerable due to drought. However, some economic related adaptive measures have also been found. More than half of the farmers are using organic fertilizer, which helps soil to retain water and reduces the water loss that ultimately helps crop growing during drought period. Many farmers are preparing 'early seedbed' that allows them to plant seeds immediately after onset of monsoon. This approach saves time and ensures the best use of rainwater during monsoon season. Some farmers have re-excavated the ponds to store rainwater in order to use them for irrigation purpose during dry season, while some are withdrawing groundwater through shallow and deep water-pump. Crop Diversification is another dynamic approach undertaken by farmers that allowed them to cultivate various types of crops instead of rice. They are cultivating potato, wheat, maize, etc. instead of rice as rice consumes more water, which become s inadequate during drought. The tendency of using limited resources in the most profitable way has been observed among the drought affected farmers as many of them are cultivating more than one crop at a time in the same land by irrigating same amount of water. This 'intercropping/mixed cultivation' approach is highly innovative for ensuring the best use of the water, which becomes a valuable and scarce resource during drought. The popular combinations of intercropping in the Barind region are 'rice + mango', 'wheat + mango', 'rice + papaya', etc. A large number of farmers are adopting a different strategy called 'alternative crop cultivation' in order to cope with water scarcity as well as to draw the maximum profit from farming. In this case, they are cultivating mango in large scale instead of rice. Many of the farmlands in Barind region, especially in Naogaon District, are gradually turning into the mango garden from rice field, because mango cultivation returns more profit than rice consuming less water and labour. The impacts of drought have combined consequences on local and the national level economy. One of the vital consequences is seasonal unemployment that significantly reduces farmers' food security. To mitigate this hardship, many farmers adopted 'alternative economic activities' in parallel with agriculture for earning extra money that enables them to survive during the disaster period. The most common alternative economic activities are petty business, driving, day laborer, etc. Since the precipitation is not adequate, a few well-off farmers are irrigating their farms by withdrawing water from nearby ponds.

Determinants of Adaptation Measures

Implementation of different adaptive measures depends on several factors covering demographic, social, and economic characteristics, which are responsible for farmers' capacity building to cope with drought by undertaking an adaptive strategy. Table 2 shows the factors/determinants, which have been tested to estimate their

correlation with the implementation of different adaptation measures. The significance of the relationship between the variables has been determined based on their corresponding p-values. The findings show that the size of agricultural land has a significant correlation with a highest number of adaptation measures followed by income and irrigation accessibility that influenced the second highest number of adaptation measures. The larger farm size facilitates farmers to implement adaptation measures in easiest way as some adaptation strategies, i.e. crop diversification, alternative crop cultivation, intercropping, etc. requires enough space for implementation. Moreover, farmers with larger land parcel can take the challenge of implementing a new strategy as well as can cope with immediate stress if any strategy does not return expected outcome. As for income, which significantly influences seven measures out of ten, plays the fundamental role to develop the farmers' capability of strategy implementation. They require to purchase and/or rent water pump, seeds, fertilizer, etc. that completely depend on the availability of capital. Without capital, farmers cannot implement adaptive measures independently even though they have satisfied other influencing factors. Most of the adaptation measures are related to agricultural activities that makes farmers dependent on irrigation accessibility. Therefore, according to the findings, availability of irrigation facility strongly determines the farmers' capability of implementing adaptation measures. Another two important determinants are education and ownership status of agricultural land as both of them have significant correlations with exactly six numbers of measures. It is understandable that farmers with formal education can easily access to updated information and can understand training, circulation, instructions, etc. provided by government and NGOs regarding disaster management. Similarly, farmers with own agricultural land can implement adaptive strategies more independently than those of tenant farmers as their decision making ability is not absolute rather controlled by landlords. The other determinants in Table 2, including family type, poverty status, and food affordability have moderate influence over the measures as they significantly correlate with the implementation of four or five measures. It is interesting that farmers' age has a significant association with only two adaptation measures, although it is widely believed that with age comes experience and wisdom; however, in case of drought risk management, the findings imply that the availability of other determinants can overcome the lacking of age-oriented advantages.

Table 3 shows the values of V test that reports the strength of the calculated correlations between the determinants and adaptation measures. The results revealed that most of the correlations are moderately strong as the V values are less than 0.5. However, it is not the function of V test to approve or reject any correlation rather than providing a quantitative concept regarding the degree of the relations. Despite the correlations between the decision-making about the implementation of adaptation measures and their determinants, the overall findings suggest that there are still some scopes for farmers to make the decision independently.

Table 2. Chi-square test statistics between adaptation measures and determinants

Adaptation Measures	% of implementer farmers	*P* values of Chi-square test								
		Age	Education	Farm Ownership	Family Type	Income	Farm Size	Food Affordability	Irrigation Accessibility	Poverty Status
Organic Fertilizer	55.2	.34	.10	.08	.001*	.68	.002*	.01*	<.001*	.92
Early Seedbed	26.2	.17	.10	.02*	.07	.02*	.07	.01*	.005*	.42
Re-excavation of Pond	5.8	.61	<.001*	<.001*	.03*	<.001*	<.001*	<.001*	<.001*	<.001*
Water Withdrawal using Shallow Pump	4.3	.005*	.33	.36	.31	.12	.29	.11	.02*	.42
Water Withdrawal using Deep Pump	6.8	.60	.003*	.60	.37	.001*	.02*	.41	.40	.44
Crop Diversification	13.6	.01*	.003*	.01*	.001*	<.001*	<.001*	<.001*	.20	<.001*
Mixed Cultivation/Intercropping	32.2	.12	.003*	.01*	.16	.05*	.005*	.10	.009*	.06
Alternative Crop Cultivation	41.6	.12	.05*	<.001*	.57	<.001*	<.001*	<.001*	.006*	<.001*
Alternative Economic Activities	61.7	.13	.62	.48	.08	.12	.002*	.06	.96	.09
Irrigation by Pond Water	7.1	.43	.01*	<.001*	.005*	.001*	<.001*	.06	<.001*	.004*

Note: *Statistically significant considering $\alpha = 0.05$

Table 3. Cramer's V statistics between adaptation measures and determinants

Adaptation Measures	V values of Cramer's V test								
	Age	Education	Farm Ownership	Family Type	Income	Farm Size	Food Affordability	Irrigation Accessibility	Poverty Status
Organic Fertilizer	.073	.164	.110	.167*	.076	.205*	.149*	.182*	.020
Early Seedbed	.094	.163	.134*	.090	.168*	.146	.152*	.140*	.066
Re-excavation of Pond	.050	.349*	.259*	.105*	.305*	.318*	.276*	.215*	.231*
Water Withdrawal through Shallow Pump	.163*	.131	.072	.051	.136	.112	.105	.110*	.066
Water Withdrawal through Deep Pump	.051	.223*	.050	.045	.216*	.167*	.066	.042	.064
Crop Diversification	.150*	.226*	.142*	.166*	.360*	.407*	.224*	.064	.197*
Mixed Cultivation/Intercropping	.103	.225*	.148*	.069	.154*	.194*	.107	.131*	.117*
Alternative Crop Cultivation	.103	.177*	.233*	.028	.279*	.334*	.214*	.139*	.250*
Alternative Economic Activities	.100	.106	.060	.087	.135	.207*	.117	.002	.108*
Irrigation by Pond Water	.065	.204*	.211*	.142*	.222*	.335*	.117	.411*	.165*

Note: *Statistically significant according to their corresponding *P* values (≤ .05)

CONCLUSION

The main goal of this study was to investigate the correlations between different types of determinants and farmers' choice of drought adaptation measures. The determinants that has been analyzed here are mainly farmers' social, economic, demographic, and agricultural characteristics. The statistical analyses suggest that each adaptation measure is influenced by at least one or more determinants; similarly, every single determinant showed its influence on at least one or more adaptation methods. In short, the types and nature of adaptation measures implemented by farmers were determined by their demographic, socioeconomic, and agricultural characteristics. Apart from this summary outcome, the study presents some other key findings that need to be considered during future policy formulation. It is also few findings that all of the households have undertaken at least one or more adaptive measure, but the majority of households did not implement the most needed adaptive measures, *viz.* water harvesting. Only a small number of households have implemented surface water harvesting and/or ground water exploitation measure, which is the most effective approach to mitigate irrigation scarcity. This scenario has exposed farmers' limitations to undertake an effective adaptation strategy. According to the findings of V test, it can be interpreted that the determinants definitely have some influence over the decision-making process of the implementation of adaptation strategies, but farmers still hold partial ability to choose an adaptation option independently.

The drought management policy should include the capacity building strategy so that farmers can afford the implementation of appropriate measure by their own initiative without depending on government or NGOs. It is also required to develop and implement an inclusive policy that will guide farmers to select the type of adaptation measure based on their socioeconomic and agricultural characteristics. Since this study has identified the determinants of farmers' capability regarding implementation of adaptation measures, government and other developing partners now can easily categorize the types of measures that can be implemented by any particular household through analyzing their demographic, socioeconomic, and agricultural characteristics, as mentioned in Table 2. This approach might increase the performance of disaster-risk reduction activities significantly.

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Appendix Table A: Background characteristics of farmers

Category	N	%	Category	N	%
Age category			**Education**		
Young (≤ 25 Years)	13	3.3	No formal education	167	42.1
Middle-age (26 – 50 Years)	264	66.5	Primary (class 01 to 05)	118	29.7
Old (≥ 51 Years)	120	30.2	Incomplete secondary (class 06 to 09)	67	16.9
Household Size			Secondary	21	5.3
Small (≤3)	95	23.9	Higher secondary	17	4.3
Medium (4-6)	293	73.8	Bachelor and/or above	7	1.8
Large (≥7)	9	2.3	**Farm ownership**		
Family type			Owner	101	25.4
Nuclear family	311	78.3	Tenant	190	48.0
Joint family	86	21.7	Owner + Tenant	106	26.7
Housing type			**Monthly income**		
Thatch and mud-wall	16	4.0	Low (≤ Tk. 5215.92)	143	36.0
Tin roof and mud-wall	359	90.4	Lower medium (Tk. 5215.92 – 10,000)	178	44.8
Tin roof and wall	8	2.0	Medium (Tk. 10,000 – 15,000)	45	11.3
Semi-pucca and pucca	14	3.6	Upper medium (Tk. 15,000 – 20,000)	13	3.3
Land holdings			High (≥ Tk. 20,000)	18	4.5
Absolute landless (≤15 decimal)	13	3.3	**Poverty status based on lower poverty line**		
Functionally landless (15-50 decimal)	105	26.4	Below poverty line	143	36.0
Small (marginal) (50-249 decimal)	149	37.5	Above poverty line	254	64.0
Medium (250-749 decimal)	112	28.2	**Poverty status based on upper poverty line**		
Large (>749 decimal)	18	4.5	Below poverty line	201	50.6
Source of drinking water			Above poverty line	196	49.4
Tube well (hand operated)	218	54.9	**Farm size**		
Tube well (motorized)	45	11.3	Very small (≤ 1 acre)	118	29.7
Dug well	45	11.3	Small (1 – 2 acre)	136	34.3

Category	N	%	Category	N	%
Deep tube well installed by BMDA	89	22.3	Medium (2 – 3 acre)	44	11.1
Food affordability			Moderately large (3 – 7.5 acre)	81	20.4
Fully capable	101	25.4	Large (>7.5 acre)	18	4.5
Partially capable	283	71.3	**Availability of BMDA irrigation**		
Incapable	13	3.3	All year round	259	82.1
Access to BMDA irrigation			Rabi + Kharif-1	35	11.2
Yes	313	78.8	Kharif-1	16	5.1
No	84	21.2	Rabi	3	1.0
			Total (n)	313	100

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LINE×TESTER ANALYSIS IN *LILIUM*×*FORMOLONGI:* IDENTIFICATION OF SUPERIOR PARENTS FOR GROWTH AND FLOWERING TRAITS

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ABSTRACT

An experiment was carried out using eight double cross F_1s (DCF_1s) as lines and two testers to obtain sixteen Line ×Tester hybrids for the evaluation of major growth and flowering traits thereby to understand the breeding potentiality of the parental lines. The performance of growth and flowering traits of all twenty six genotypes were evaluated in a randomized complete block design (RCBD) with three replications. The analysis of variance (ANOVA) showed all the genotypes were significantly different for all agro-morphological traits under study. The estimated general combining ability (GCA) effects showed that parent 5(P5), were superior for plant height, stem diameter, number of leaves, leaf length, days to flowering and attitude of floral axis followed by parent 2(P2) for leaf length, leaf width, days to flowering and attitude of floral axis and parent7 (P7) for number of flower, flower diameter, bud length and attitude for floral axis. Likewise; tester 1 found to be best combiner with significant GCA effect for almost all growth and flowering traits (except number of leaves). The plant height, leaf width, number of flower and attitude of floral axis showed prevailing additive gene action while stem diameter, number of leaves, leaf length, days to flowering, flower diameter and bud length indicated predominance of dominance gene action. We can conclude that parent P5, parent P2 and parent P7 can be used as good mother lines and the tester 1, as good donor for the seed production.

Keywords: General Combining Ability (GCA), Line×Tester Analysis, Line ×Tester Hybrids, *Lilium*×*formolongi,* Specific Combining Ability (SCA)

INTRODUCTION

Lily (Lilium L., 2n = 2x = 24), comprising members of the Liliaceae family, is one of the most popular groups of ornamental bulbous monocot outcrossing perennial herbs worldwide due to their incomparable beauty and commercial importance (Shahin et

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al., 2012). Many commercial cultivars have been produced by interspecific hybridization (van Tuyl and Arens, 2011). The *Lilium* × *formolongi* hort; an interspecific hybrid of *L. formosanum* and *L. longiflorum*, is a popular commercial cut flower in Korea, Japan and China (Ho et al., 2006). The production of hybrid lilies was done by hybridization of two single cross hybrids. Double cross (DC) hybrids can be produced by crossing two unrelated single cross (SC) hybrids. Firstly, two pairs of inbred lines crossed to produce SC hybrids and secondly, those SC hybrids need to cross to produce DC hybrids are the usual two steps needed for the development of DC hybrids. The DC hybrids with comparison to the SC hybrids, have wider genetic diversity thereby possess ecologically wider spans and are more adaptable to environmental conditions as a mixture of genotypes have better chances of success to cope up with varied environmental conditions (Ekinci et al., 2016). The double cross was revealing high potentiality it could be an indication of differences in the dominant favorable alleles distributed among the two single cross parents is different (El-hashash, 2013). DC hybrid F_1s are stable and intermediate in terms of performance for different growth and flowering traits. The genotypic performance of DC hybrid F_1s of *L.*×*formolongi* demonstrated early flowering and middle plant height and moderate performance for some important growth and flowering traits. The attitude of the floral axis as considered one of the most important cut flower traits. As most growth and flowering traits of the DCF_1s are more stable than $SCF_{1;}$ some important cut flower traits need to improve to fulfill consumer's need. In this context, some clonal lines of donor cultivar and breeding lines using as tester(whose pedigree are not related to lines) an attempt has been made to produce the special cross F_1s using double cross F_1s as mother lines with the application of lines × Tester mating design.

Line × Tester mating design was first proposed by Kempthorne (Sharma, 2006). Among the different breeding tools, the line × tester analysis is used in both self as well as cross-pollinated crops to estimate general and specific combing abilities of specific traits and to determine favorable parents and cross. This design emphasizes hybridization between lines (f) and wide based testers in one to one fashion of mating generating f × m = fm hybrids (Sharma, 2006). In this way, on the basis of GCA we can select favorable parents (both male and female), as well as on the basis of the estimated SCA, we can determine the appropriate hybrids (cross combination).The objectives of the present study were therefore to examine the combining abilities patterns of selected Lilium × formolongi in a line × tester analysis, to assess genetic parameters of some agronomic traits, to determine superior candidates for promising hybrid cross combinations.

MATERIALS AND METHODS

Preparation of plant material, generation of crosses and field experiment:

The plant material preparation, generation of crosses and field experiment has been

carried out in KNU, experimental farm in Chuncheon, Kangwon-do, South Korea during 2015-17. The experiment area is located at 37°52´N latitude and 127°44´E longitudes. The area located in a basin formed by the Soyang River and Han River. The area lies at 99 m from msl and annual precipitation appears 1347.3 mm. The experiment area demonstrates high temperature and humidity during the summer and coldness and dryness during the winter (Kwon et al., 2016). The F_1s (single cross F_1s) seeds were obtained from KNU, department of Horticulture, Floricultural breeding laboratory in 2015, double cross hybridization, selection of double cross F_1s lines and L×T mating has been carried out in the succeeding year continuously. In this way, in 2017 we have prepared the seeds of 26 genotypes including the 8 lines, 2 testers and 16 L×T hybrids for the execution of the experiment. The details of parental materials used for this experiment are given in Table 1.

The seedling has been prepared inside the plastic house during January to April (Goo, 2008). Since the temperature of chuncheon in winter becomes very cold (Kwon et al., 2016), inside the plastic house night and day temperature has been maintained 15±3°C and 25±3°C as described by Rai et al. (2018). In the third weeks of April prepared seedling has been transplanted in main field laying out in RCBD (Randomized complete block design) with 3 replication to evaluate the growth and flowering traits. The seedlings of all genotypes has been grown randomly in multiple bed plots as block consisting 3 cm long and 1m in width. The seedlings has been transplanted maintaining row to row and plant to plant equal distance of 12.5 cm using the mulching plastic (black color) available in the market. In each replication for all treatments 1 m^2 area has been provided to maintain the seedling population 64. The distance between the beds has been maintained 80 cm to ease for intercultural operation. Since chuncheon represents very hot and humid weather during summer so well provision of irrigation has been provided fixing the 4 drip irrigation hose as length wise of bed at the equal distance of 25 cm before covering the bed with mulching plastic. Before making beds, the land has been well prepared ploughing the 2-3 times and recommended N, P, K containing fertilizer has been provided as per the recommended doses. The weeding and application of insecticide and fungicide has been provided with the interval of 2-3 weeks from the transplanting of seedling (3^{rd} week of April) until harvesting of bulbs (usually first week of November).

Morphological observation of studied growth and flowering traits has been taken during main season of flowering i.e. July-August; sampling12 plants from each replication. At the last, crossing procedure for preparing plant material, seedling preparation and morphological observation of studied traits has been carried out following Rai et al. (2018).

Statistical analysis

The ANOVA for L×T analysis was carried out on the basis of method as suggested by Kempthorne (1957). The estimation of components of genetic variances, the estimation of combining ability effects, specific combining ability effects, the

standard errors for testing the significance of GCA and SCA effects and the proportional contribution of lines, testers and line × tester interactions to the total variance. All these calculations were performed with the help of the software package TNAUSTAT statistical packages (Manivannan, 2014). On the basis of overall GCA status of their parents involved, the ranking of the best specific combiner has been arranged for the particular growth and flowering traits adopting the method as outlined by Arunachalam and Bandyopadhyay (1979).

RESULTS

The mean performance of parents and L×T hybrids

he mean performance of lines, testers and L×T hybrids showed genetic variability among those genotypes for studied growth and flowering traits (Fig. 1). Among the lines, testers and L×T hybrids; testers demonstrated the outstanding performance for all most all traits besides intermediate performance in flower diameter. Likewise lines possessed outstanding result for flower diameter and stem diameter, number of leaves, leaves width and number of flower with lowest performance for days to flowering and attitude of floral axis. L×T hybrids showed intermediate performance i.e. in between the testers and lines for almost traits.

ANOVA for L×T analysis

The ANOVA for L×T analysis (table 2) demonstrated that there were significant differences among the L×T hybrids (crosses) for all studied growth and flowering traits. Likewise, there were significantly different among the both lines and testers for all studied traits. The interaction effect between line and tester was significant for almost studied traits (except attitude of floral axis).

Gene action and contribution of line, tester and line x tester interaction

The plant height, leaf width, number of flower and attitude of floral axis demonstrated additive gene action while remaining traits viz.stem diameter, number of leaves, leaf length, days to flowering, flower diameter and bud length demonstrated dominance gene action (Table 4). As shown in table 3, contribution of lines were recorded highest for number of leaves (81.69%) while lowest contribution of lines were 13.78% for days to flowering. Likewise, contribution of testers was found highest 76.20% for days to flowering and lowest 3.73% for number of leaves. Lastly, contribution of L×T interaction was found highest 27.95% for leaf length and lowest 1.07% for attitude of floral axis.

Table 1. List of lines (DCF_1s) and testers (CV/breeding line), pedigree and traits remarks

S.N	Genotypes	Pedigree	Remarks
(A)Lines			
1.	(Stu× W)-9 × (AugE×BT)-6 (P1)	DCF_1 of L.Fl.SCF_1s(Stu × W)-9 &(AugE×BT)-6	M-T,upward facing ,middle fl. time
2.	(Stu × W)-9 ×57-6 (Aug×AugE) (P2)	$DCF_1$of L.Fl.SCF_1s(Stu ×W)-9&(57-6 (Aug×AugE)	Taller ,upward ,strong but late
3	(Stu × W)-9 × (AugE×IS)-1(P3)	DCF_1 of L.Fl.SCF_1s(Stu × W)-9 &(AugE×IS)-1	Middle side -up dir, very early
4	(Stu × W)-9 × (AugE×Gelria)-16(P4)	DCF_1 of L.Fl.SCF_1s(Stu ×W)-9 &(AugE×Gelria)-16	M-T,up dir.& strong
5	(Stu × W)-9 × 58.15(AugE×J) (P5)	DCF_1 of L.Fl.SCF_1s(Stu × W)-9 &58.15(AugE×J)	Middle, early ,strong and up dir.
6	(Stu × W)-9 × (WT×AugE)-9(P6)	DCF_1 of L.Fl.SCF_1s(Stu × W)-9 &(WT×AugE)-9	Middle PHT,early &upward
7	(Stu × WT)-4 × (J×G)-1(P7)	DCF_1 of L.Fl.SCF_1s(Stu × W)-9 &(J×G)-1	Mid PHT& fl. Time and Upward
8	(AF× 12-1)-8 × 57-6 (Aug×AugE) (P8)	DCF_1ofL.Fl.SCF_1s(AF ×12-1)-8 &57-6 (Aug×AugE)	Taller,upward,M-L fl. time
(B) Testers			
1.	R.H.-4(P9)	Selected clone of L.fl. CV Raizan Herald(RH)	Middle PHT,v early & up-near up
2	HU-2(P10)	Selected clone of L.L breeding line Hinomoto Up	M-T,early& near up

Abbr. P1=Parent 1,……., P10=Parent 10, SCF1s=Single cross F_1s, DCF1s=Double cross F_1s,L.fl=Lilium ×formolongi,LL=Lilium longiflorum,CV=Cultivar,M-T=Middle-Tall,PHT=Plant height

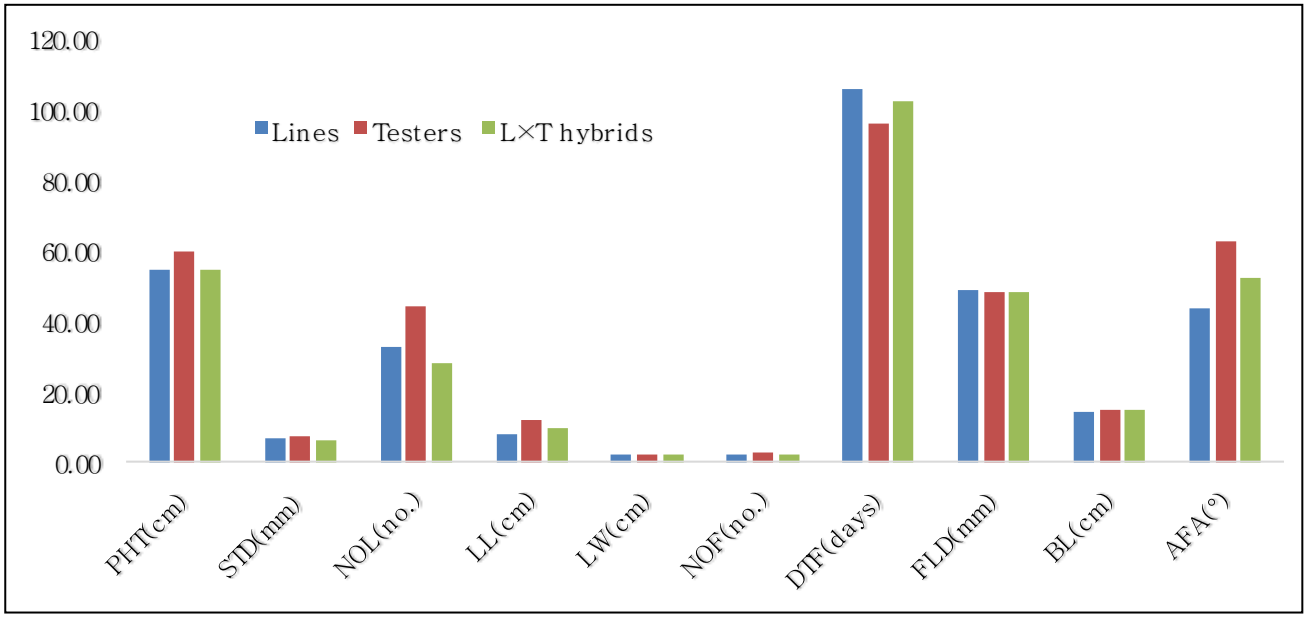

Figure 1. Comparative mean performances of Line, Testers and L×T hybrids for growth and flowering traits

Table 2. ANOVA for L×T analysis

Sources of variation	d.f.	Mean Sum Square of ……..									
		PHT	STD	NOL	LL	LW	NOF	DTF	FLD	BL	AFA
Replications	2	0.2425ns	0.0099ns	2.1102ns	0.0419ns	0.0008ns	0.0019ns	1.1502ns	0.1143ns	0.0058ns	45.70ns
Cross	15	99.91**	0.3552**	37.62**	2.70*	0.1049**	0.0979**	124.16**	2.0558**	3.80**	320.13**
Lines(c)	7	71.84**	0.4781**	65.85**	3.18**	0.0631*	0.1347*	36.67**	1.1415**	5.57**	430.53**
Tester(c)	1	978.31**	1.39**	21.06**	6.90**	1.050**	0.4219**	1419.18**	15.6751**	8.16**	1737.01**
L×T (C)	7	2.4893**	0.834**	11.74**	1.61**	0.0116**	0.0147**	26.66**	0.7645**	1.41**	7.32ns
Error	30	0.2878	0.0230	1.2073	0.1157	0.0008	0.0019	0.8347	0.1389	0.1532	19.14

ANOVA=Analysis of Variance, d.f. =degree of freedom ,PHT-Plant height,STD-Stem diameter,NOL-Number of leaves,LL-Leaf length,LW-Leaf width,NOF-Number of flowers,DTF-days to flowering,FLD-Diameter of flower,BL-length of bud and AFA-attitude of floral axis, L×T (C)=Line×Tester(Cross)

**and *Significant at 1%and 5% level of significance respectively

Table 3. Proportional contribution of Lines, Testers and their interaction for studied growth and flowering traits

Parameters	PHT	STD	NOL	LL	LW	NOF	DTF	FLD	BL	AFA
Contribution of Lines (L)	33.56	62.81	81.69	55.02	28.06	64.24	13.78	31.81	68.32	62.76
Contribution of Testers (T)	65.28	26.23	3.73	17.03	66.76	28.74	76.20	50.83	14.30	36.17
Contribution of LXT	1.16	10.96	14.57	27.95	5.18	7.02	10.02	17.35	17.38	1.07

General combining ability effects

The estimation of GCA effects of lines (table 5.1) and testers (table 5.2) indicated that, line 5, (Stu× W)-9 × 58.15 (AugE×J) has significant GCA effect for 6 traits viz. Plant height, stem diameter, number of leaves, leaf length, days to flowering and attitude of floral axis. While line 2, (Stu× W)-9 × 57.6 (Aug×AugE) has significant GCA effect for 5 traits viz. leaf length, leaf width, days to flowering, bud length and attitude for floral axis and line7, (Stu× WT)-4 × (J×G)-1 has demonstrated significant GCA effect for 4 traits viz. Number of flower, flower diameter, bud length and attitude for floral axis etc. In case of testers, tester 1, (Stu× WT)-4 × (J×G)-1 (RH-4) found to be best combiner with significant GCA effect for almost all quantitative traits (except no of leaves)

Specific combining ability effects

The specific combining ability effects included both dominance and epistemic gene effects. It is very important indicator for the selection of particular cross combination i.e. cross hybrids. In this experiment we have observed that none of the cross combination have found superior performance for all the traits under study. It is the evidence that high specific combination were also obtained from High×Low and Low×Low general combiners not only directly resulted from the combination of High×High general combiners (Table 6). The cross combination having significant SCA effects in positive direction has been listed in the table 8 and ranked on the basis of the significant GCA effects of their parents on the basis of overall performance (Arunachalam and Bandyopadhyay, 1979).

DISCUSSION

L.× *formolongi* is an interspecific hybrid of *L. formosanum* and *L .longiflorum*. In *L.* × *formolongi* F_1 hybrids .The homogenous performance of the growth and flowering traits is essential to get the good price from cut flower market. For the selection of genotypically diverse parental line and to understand the gene action among the quantitative traits an experiment has been conducted including 8 double cross F_1s(DCF_1s) as lines and 2 testers as donor to obtain 16 special (L×T) hybrids . The mean performance of special Line×Tester hybrids demonstrated superior performance for important growth and flowering traits viz. days to flowering, bud length and attitude of floral axis. It is the proof of improvement of these growth and flowering traits with the application of testers. While other remaining traits remain more or less near to the performance of double cross F_1s (DCF_1s). Moreover mean performance of testers were higher for the traits of plant height, stem diameter, number of leaves, leaf length, leaf width, number of flowers, days to flowering and attitude of the floral axis, thereby proving the rationality of selecting those testers for the improvement of those traits to increase the value of cut flower in *L.* ×*formolongi* .All the genotypes used; demonstrated highly significant mean sum square value for all studied growth and flowering traits. Furthermore, Line×Tester hybrids also demonstrated significant mean sum square for almost studied traits indicated the significance of Line×Testers model for combining ability and gene action.

Table 4.Estimation of genetic component for studied growth and flowering traits

Parameters	PHT	STD	NOL	LL	LW	NOF	DTF	FLD	BL	AFA
Var of GCA	2.7677	0.0077	0.7350	0.0308	0.0026	0.0024	2.7701	0.0367	0.0679	8.8867
Var of SCA	0.7338	0.0201	3.5140	0.5008	0.0036	0.0043	8.6086	0.2085	0.4216	-3.9388
GCA:SCA ratio	3.7717	0.3830	0.2091	0.0615	0.7222	0.5581	0.3217	0.1760	0.1610	2.2581
σ^2A(VA=4σ^2GCA)F=1	5.5353	0.0154	1.4700	0.0616	0.0053	0.0047	5.5403	0.0734	0.1358	17.7734
σ^2D(VD=4σ^2SCA)F=1	0.7338	0.0201	3.5140	0.5008	0.0036	0.0043	8.6086	0.2085	0.4216	-3.9388

GCA=General combining ability,SCA=Specific combining ability,A=Additive,D=Dominance,L×T (C)=Line×Tester(Cross),F=breeding coefficient of crop

**and *Significant at 1%and 5% level of significance respectively

Table. 5.1. GCA effect of lines for 10 quantitative traits in special breeding

Parents	PHT	STD	NOL	LL	LW	NOF	DTF	FLD	BL	AFA
Lines1	-2.57**	-0.42**	-0.21ns	-0.32*	-0.14**	-0.24**	1.53**	-0.45**	-1.32**	-5.86**
Lines2	-0.41ns	-0.04ns	-3.75**	0.70**	0.21**	0.01ns	-1.80**	0.10ns	0.68**	9.77**
Lines3	-2.44**	-0.36**	-0.50ns	-1.20**	-0.04**	-0.14**	-3.12**	-0.68**	-1.55**	-11.48**
Lines4	-0.14ns	0.21**	-3.50**	0.11ns	-0.09**	-0.01ns	-1.22**	-0.47**	0.10ns	-8.98**
Lines5	8.26**	0.32**	3.99**	1.20**	-0.00ns	-0.11**	-1.24**	0.27ns	0.07ns	7.89**
Lines6	-0.42ns	0.25**	0.27ns	-0.09ns	0.01ns	-0.01ns	0.43ns	0.38*	0.82**	-3.98*
Lines7	-1.31**	-0.13*	-1.86**	0.08ns	0.01ns	0.26**	4.90**	0.71**	1.10**	5.39**
Lines8	-0.97**	0.16*	5.55**	-0.47**	0.01ns	0.01ns	0.53ns	0.13ns	0.10ns	7.27**
SE	0.2190	0.0619	0.4486	0.1388	0.0118	0.0177	0.3730	0.1521	0.1598	1.7861

Table 5.2.GCA effect of testers for 10 quantitative traits in special breeding

Parents	PHT	STD	NOL	LL	LW	NOF	DTF	FLD	BL	AFA
Testers 1	4.51**	0.17**	-0.66**	0.38**	0.15**	0.09**	-5.44**	0.57**	0.41**	6.02**
Tester2	-4.51**	-0.17**	0.66**	-0.38**	-0.15**	-0.09**	5.44**	-0.57**	-0.41**	-6.02**
SE	0.1095	0.0310	0.2243	0.0694	0.0059	0.0088	0.1865	0.0761	0.0799	0.8930

Line 1=(Stu× W)-9 × (AugE×BT)-6**, Line 2=**(Stu× W)-9 × 57.6(Aug×AugE)**, Line3=**, (Stu× W)-9 ×(AugE×IS)-1,**Line 4=**(Stu× W)-9 × (AugE×G)-16,**Line 5=**(Stu× W)-9× 58.15(AugE×J), **Line 6=**(Stu× W)-9 × (WT×AugE)-9,**Line 7=**(Stu× WT)-4 × (J×G)-1,**Line 8=**(AF× 12-1)-8 ×57.6(Aug×AugE), Tester 1=R.H-4 and Tester 2=HU-2

Table 6. Overall performance of L×T hybrids for major quantitative traits

Traits	Cross	SCA effect	GCA effect		Per se Performance	Combination
			Female	Male		
1.PHT	(1×2)	0.85*	-2.57**	-4.51**	48.77	H×L
	(3×2)	1.15**	-2.44**	-4.51**	49.20	H×L
	(7×1)	0.65*	-1.31**	4.51**	58.57	H×H
2. NOL	(2×1)	1.46*	-3.75**	-0.66**	25.10	H×H
	(3×2)	2.55**	-0.50ns	0.66**	30.77	H×L
	(6×1)	1.45*	0.27ns	-0.66**	29.10	L×H
3.LL	(5×1)	1.20**	1.20**	0.38**	12.37	H×H
4.LW	(2×2)	0.05*	0.21**	-0.15**	2.20	H×L
	(4×2)	0.05*	-0.09**	-0.15**	1.90	L×L
	(6×1)	0.05*	0.01ns	0.15**	2.30	L×H
	(7×2)	0.05*	0.01ns	-0.15**	2.00	H×L
	(8×1)	0.05*	0.01ns	0.15**	2.30	L×H
5.NOF	(1×1)	0.06*	-0.24**	0.09**	2.30	H×H
	(5×2)	0.09**	0.11**	-0.09**	2.50	H×L
	(7×1)	0.06*	0.26**	0.09**	2.80	H×H
6.DTF	(3×1)	-4.48**	-3.12**	-5.44**	89.53	H×H
	(4×2)	-1.75**	-1.22**	5.44**	105.03	L×L
	(5×2)	-2.07**	-1.24**	5.44**	104.70	H×L
	(7×2)	-1.27*	4.90**	5.44**	111.63	H×L
8.FLD	(2×1)	0.54*	0.10ns	0.57**	49.68	H×H
	(4×1)	0.53*	-0.47**	0.57**	49.10	L×H
9.BL	(4×1)	0.77**	0.10ns	0.41**	16.00	L×H
	(5×1)	0.60*	0.07ns	0.41**	15.80	H×H
	(6×2)	0.55*	0.82**	-0.41**	15.67	L×L

GCA=General combining ability,SCA=Specific combining ability, H×L=High×Low,……, L×L= Low×Low

On the basis of GCA effects out of 8 lines (DCF_1s) we can use line 5(P5), (Stu× W)-9 × 58.15 (AugE×J), line 2 (P2) (Stu× W)-9 ×57-6 (Aug×AugE) and line7 (P7), (Stu× WT)-4 × (J×G)-1 as mother line for seed production inside the plastic house. Likewise for homogenous seed production, among the tester, we can use tester1 (RH-4) as donor for those selected mother lines. Besides SCA effects indicated that none single crosses possessed all the traits under study. But some crosses demonstrated

significant SCA effects in positive direction for some traits. It is obvious that SCA effects indicated, it would not be possible to isolate crosses all traits are in the desirable combination. High specific combiner not only resulted from the combination of High×High general combiners but also obtained from the combination of High×Low and Low×Low general combiners. Narasimhamurthy and Gowda (2013) demonstrated same types of results in their research experiment.

Xuan et al. (2005) reported prevailing of additive type of gene action for the inheritance of quantitative traits viz. stem length, stem diameter, number of leaves, days to flowering, number of flowers, outer tepal length and attitude of the floral axis in *L.*× *formolongi*. But in this experiment, it is demonstrated that out of 10 growth and flowering traits so far we had studied some of them possessed dominance gene action. Stem diameter, number of leaves, leaf length, days to flowering, flower diameter and bud length indicated predominance of dominance gene action for the inheritance of these traits. While remaining traits like plant height, number of flowers, attitude of the floral axis (Xuan et al., 2005) and leaf length (Song et al., 2004) demonstrated additive type of gene action for the inheritance of these traits. Song et al. (2004) had also reported additive type of gene action for the inheritance of growth and flowering traits like plant height, length of leaves, the width of leaves, internode length, days to flowering and flower height etc.

CONCLUSIONS

The mean performance of all 26 genotypes indicated that improvement in some quantitative traits like days to flowering (DTF), bud length (BL) and attitude of the floral axis (AFA) can achieve as special L×T hybrids demonstrated superior performance for these traits as comparisons with lines (DCF_1s) and testers. We can exploit parent-5, (Stu× W)-9 × 58.15 (AugE×J) and Parent-2 (Stu× W)-9 ×57-6 (Aug×AugE) as mother lines and tester1 (RH-4) as donor line for commercial seed production system inside plastic house. In another hand, gene action clearly indicated that both types of gene action are important for the inheritance of studied growth and flowering traits. The additive type of gene action is found for acting for the inheritance of plant height, leaf length, the number of flower and attitude of the floral axis. While stem diameter, number of leaves, leaf length, days to flowering, flower diameter and bud length indicated prevailing of dominance gene action.

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RESOURCE USE EFFICIENCY ANALYSIS IN STRAWBERRY PRODUCTION IN SELECTED AREAS OF BANGLADESH

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ABSTRACT

Inefficient use of existing scarce resources has adverse effect on food production and production cost hence, low income among the farmers across the nation. Strawberry farming is profitable but costly. So the study was designed to explore resource use efficiency of strawberry cultivation in Rajshahi and Joypurhat district of Bangladesh. Primary data were collected from 100 strawberry growing farmers. Data were analyzed by using descriptive statistics, Cobb-Douglass production function and marginal productivity analysis. The results showed that 41% farmers were 18 to 30 years old. Highest 26% farmers had primary level of education, 61% farmers had small farm, and 69% farmers had 1 to 3 years' experience of strawberry cultivation. The double log function showed the best fit with adjusted R^2 of 61%. Production inputs such as sapling and fertilizer had positive and labour and chemicals had negative and significant effect on outputs. Sapling, land and water were under-utilized and labour, cowdung, fertilizer and chemicals were over used. About 37% farmers reported that strawberry plants were attacked by many more diseases. Approximately, 48% farmers reported that transportation facilities of the study areas were poor. Efficiency ratio of the inputs indicates, farmers of the study area were not efficient in using inputs and it is needed to adjust resource use in order to improve farm profit at this level of technology used. The study also recommends that the farmers need training to be efficient.

Keywords: Cob-Douglas Production Function, Efficiency, MFC, MVP, Resource use, Strawberry

INTRODUCTION

Strawberry is a tasty and nutritious fruit which is popular for its attractive colour, aroma and sweetness. It is a significant cold loving fruit, grown throughout the world. USA, Spain, Japan, Poland, Korea and Russian Federation are the key strawberry producing countries of the world. A cup of strawberries provides 55

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calories and vitamin C content is more than the recommended human daily requirement (Salami et al., 2010). For producing sufficient berries for an average-sized family, 25-50 strawberry plants are enough (Dickerson, 2004). Strawberry (*Fragaria× ananassa* Duchesne) fruits are commonly consumed in fresh forms, as processed food products, and as botanical extracts for dietary supplements. Strawberry juice extracts be full of high levels of antioxidant which works against superoxide radicals, hydrogen peroxide, hydroxyl radicals, and singlet oxygen free radicals. It also has the total antioxidant capacity for low-density lipoproteins of the fruit extracts (Salami et al., 2010).

In Bangladesh, it is new crop grown commercially in few district such as Tangail, Rajshahi, Joypurhat, Bogra, Kumilla, Sathkhira, Khagrachari and Coxbazar. It has a great significance as it is grown in winter season when our native fruits are rare. In this time, strawberry can play an important role by meeting nutrition of mass people. Strawberry cultivation is also considered as a profitable crop grown to the farmers but it is not enough accepted to Bangladeshi farmers due to its huge cost association. Besides, strawberry is a highly perishable fruit and the farmers do not have any training on its production and handling technique. Consequently, they take intensive care of it and to do so sometimes they over used their resources. Agricultural economists always offer the direction of efficient utilization of inputs to the farmers. Efficient utilization of inputs has significant impacts on food security (Chiedozie et al., 2010). Resource use efficiency investigates the efficiency of each input and indicates the overutilization or underutilization of inputs (Ali et al., 2017). So it is essential to evaluate efficiency level of the farmers in case of input use as the aim of any profitable farm is to maximize profit by minimizing cost. Therefore, the study was designed with the following objectives: 1) to examine the socioeconomic characteristics of strawberry farmers; 2) to estimate input-output relationship of strawberry production; 3) to assess the resource use efficiency of strawberry growers and 4) to identify the production problems, and marketing constraints of strawberry cultivation.

Several literatures are accessible about the estimation of resource use efficiency for different agricultural crops except strawberry (Majumder et al., 2009; Islam et al., 2011; Rahman, 2011; Ahmed et al., 2015; Bapari, 2016; Sujan et al., 2017a; Sujan et al., 2017b; Sarker et al., 2018). Goni et al. (2013) investigated the efficiency of resource use in the production of dry season vegetables in Nigeria. They stated farmers were inefficient in the utilization of all resources because of under-utilization (seed, pesticide and land) and over-utilization (fertilizer, herbicide and labour). They mentioned if farmers increase the use of seed, pesticide and land, vegetable output will be increased by 114.58, 322.64 and 568.72 kg ha^{-1}, respectively. Similarly, Shrestha et al. (2015) estimated the efficiency of resource use in the production of vegetables in Nepal. The value of technical efficiency (0.79) pointed out toward the possibility of increase in the production of vegetable by efficient utilization of resources (land, seeds, labour, fertilizers, compost, farm capital and pesticides) while

technology remains constant. They suggested for improvement in land, labour, training, and easy capital access. Miah et al. (2006) explored the resource use efficiency of credit users and non-credit users in modern variety of boro rice production. They showed that both types of farmers did not use inputs efficiently. Non-borrowers under-utilized human labour, tillage, manure, fertilizer and pesticides and over used seeds and irrigation. Borrowers paid out less money on the use of seed or seedling, manure, fertilizer, pesticide and human labour and more money on tillage and irrigation. Khandoker et al. (2014) studied resource use efficiency of commercial floriculture in Bangladesh. They found positive and significant effect of power tiller, seedling and chemical fertilizer on floriculture. They also mentioned flower cultivator allocated their resources in the first stage of production where increasing returns to scale prevail.

But, resource use efficiency in strawberry production was still not studied in Bangladesh. For this reason this study was conducted.

MATERIALS AND METHODS

The study was mainly based on primary data that were collected through face to face interview using a pre-tested interview schedule which was conducted through field survey during the month of December, 2016 to March, 2017. Rajshahi and Joypurhat district was the pioneer of strawberry cultivation. At present strawberry is being cultivated by the farmers of Tangail, Kumilla, Sathkhira, Khagrachari and Coxbazar in scattered way but in Rajshahi and Joypurhat a good number of farmers are cultivating strawberry. So, Rajshahi and Joypurhat were selected for this study.

Sampling technique and sample size

Multistage sampling technique was followed to collect sample farmers for this study. At first, two districts namely Joypurhat and Rajshahi were selected on the basis of availability of strawberry farmer. In the second stage, concentrate strawberry growing upazila from each district were selected on the basis of area and production of strawberry. Sadreupazila from Joypurhat and Charghatupazila from Rajshahi were selected. Thirdly, 2-3 agricultural Blocks were selected in consultation with DAE personnel for selecting sample farmers. Finally, the samples were randomly selected from the complete list of strawberry farmers for interview. Mari (2009) and Ali et al, (2017) stated that 60 sample was appropriate for decision making in case of large population. However, a total of 100 strawberry growers taking 50 farmers from each district were selected for the study. Open source software R, Microsoft Excel and STATA-10 were used for analyzing results.

Production function and its stages

Production function is a functional relationship between output and inputs (Jhingan, 2007). There are three stages of production. MPP is negative in stage III and it is not rational to produce with negative MPP (Akighir and Shabu, 2011).

Model Specification

The Cobb-Douglas production model was useful for the estimation of resource use efficiency due to econometric and statistical advantages like sign and size of coefficients, t-test, f-test and R^2 (Ashfaq et al., 2012).It was also used in many studies (Abid et al., 2011; Ali et al., 2017; Khatun et al., 2017; Ibitoye et al., 2015; Umar and Abdulkadir, 2015). The double-log function (Cobb-Douglas) provided the best fit and was therefore chosen for the study (Olomla, 1991; Mbata et al., 1993).

Using the ordinary least square (OLS) estimator, the production response function model was expressed implicitly as:

$Y = f (X_1, X_2, X_3, X_4, X_5, X_6, X_7, Ui)$ ..... (1)

Where

Y = quantity of output in kilograms,

X_1= labour(man-days),

X_2 = no. of sapling,

X_3 = quantity of cowdung in kilograms,

X_4 = quantity of fertilizer in kilograms,

X_5=land (farm size),

X_6= quantity of water in liter and

X_7= quantity of chemicals in kilograms.

The functional form of the double-log function was ex-pressed as follows:

$\ln Y = b_0 + b_1 \ln X_1 + b_2 \ln X_2 + \ldots + b_7 \ln X_7 + e$ .... (2)

Resource use Efficiency

It is a ratio between Marginal Value Product (MVP) for a specific input and Marginal Factor Cost (MFC) of that particular input (Abid et al. 2011; Ashfaq et al. 2012; Mohammed et al. 2014; Umar and Abdulkadir, 2015; Ali et al. 2017) as:

$r_i = MVP_i / MFC_i$……..(3)

where:

r_i = Resource use efficiency ratio

MVP_i = Value of additional output by using an additional unit of a particular input resource

$MVP_i = MPP_i \times Py$ ..... (4)

$MFC_i = PX_i$ = It is price of one unit of input resource.

Where, Py and MFC_i, are the unit prices of output and factor input respectively.

The marginal physical product (MPP) was given by: $MPP_i = b_i \times APP_i$.....(5)

Where b_i = elasticity's of the various inputs

$$APP_i = \frac{\bar{Y}}{\bar{X}_i} \quad \text{..... (6)}$$

Where

$\bar{Y}$ is the mean of output and $\bar{X}_i$ is the mean of factor inputs and bi are the regression coefficients.

The decision of whether a resource is used efficiently or not, thus efficiency, is based on the value of r_i, Ifr_i is equal to one (r_i = 1), then the factor input is efficiently utilized. The factor input is over-utilized if r_i is less than 1 (r_i<1) and under-utilized if r_i is greater than unity (r_i>1). The relative percentage change in MVP of each resource required so as to obtain optimal resource allocation, which is r = 1 or MVP = MFC, was estimated using equation 7 below:

D = (1 – MFC/MVP) X 100 = (1 – r-1) x 100

=(1 -1/r)x 100 ……(7)

Where:

D = absolute value of percentage change in MVP of each resource (Mijindadi 1980; Gani and Omonona 2009; Chandra et al. 2017). The significance of each explanatory variable was determined using the t-test. The overall significance was determined by the F-ration.

RESULTS AND DISCUSSION

Farmers' profile

Age: Age is an important factor that influences farmer's production decision, efficiency and managing the capital used in farming. Strawberry is a new crop in Bangladesh and comparatively young farmers (minimum age 18 years) were cultivating it. Majority of the strawberry farmers (41%) were 18 to 30 years old (Table 1). Mean age of the strawberry farmers was 36.52 years. Other farmers were belonging to the age group of 31 to 43 years (32%), 44 to 56 years (17%), 57 to 69 years (8%) and 70 to 82 years (2%). Maximum age of the farmers was 74 years and standard deviation was 13.30.

Literacy status: The sample farmers were classified into six categories based on their education level. Table 1 indicates that literacy status of the strawberry farmers were better in position. Only 4% farmers were illiterate. Highest 26% farmers had primary level of education. Number of farmers having higher secondary level of education was 11%and degree and above level education was 21%. About 19% farmers had secondary level of education and another 19% farmers can sign only.

Table 1. Profile of the respondent farmers in the study areas

Particulars	Freq.	%	Min.	Max.	Mean	Std. dev
1. Age			18	74	36.52	13.30
18-30 years	41	41				
31-43 years	32	32				
44-56 years	17	17				
57-69 years	8	8				
70-82 years	2	2				
2. Literacy status						
Illiterate	4	4				
Can sign	19	19				
Primary (Class I-V)	26	26				
Secondary (Class VI-X)	19	19				
Higher secondary (HSC)	11	11				
Degree and above	21	21				
3. Occupation						
Main occupation						
Agriculture	70	70				
Student	20	20				
Business	6	6				
Service	2	2				
Other	2	2				
Subsidiary occupation						
No profession	54	54				
Agriculture	31	31				
Business	15	15				
4. Farm size (ha)			0.07	4.90	0.71	0.67
Marginal (below 0.19 ha)	16	16				
Small (0.19-0.99 ha)	61	61				
Medium (1.00-3.03 ha)	22	22				
Large (above 3.03 ha)	1	1				
5. Experience			1	8	2.94	1.14
1-3	69	69				
4-6	30	30				
7-9	1	1				

Occupational status: A good number of respondent farmers have both main and subsidiary occupation. Main occupation of a farmer generally reflects his commitment in that particular field and demonstrates his economic standing in the society. Majority of the farmers (70%) main occupation was agriculture (Table 1). In the study areas main occupation of few farmers were business (6%), service (2%) and others (2%). More than half of the farmers (54%) had no subsidiary occupation. About 31% farmers had agriculture and 15% farmer had business as their subsidiary occupation.

Farm size: Farm size of most of the farmers (61%) was small. In the study areas lowest farm size was found 0.07 ha. Average land holdings of the farmers were estimated 0.71 ha. Farm size was medium and marginal reported by 22% and 16% farmers respectively. Only 1% farmers had large farm size which is 4.90 ha and standard deviation was 0.67.

Farmers' experiences: Highest strawberry cultivation experience of the farmers was found 8 years. Mean experience of strawberry farming was 2.94 years. About 69% of the farmers had 1 to 3 years' experience. A good percentage of farmers (30%) had also experiences with in the year ranged from 4 to 6 years (Table 1). Minimum experience was only 1 year and standard deviation was 1.14.

Estimated production function and resource use efficiency

Results of the production function indicate output was positively related to sapling, Cow dung, fertilizer, land (farm size) and water. This implies that output increased with the increase of the quantities of those inputs. On the other hand output was negatively related to labour and chemicals (insecticides, pesticides and fungicides). This implies that output increased with the increase of the quantities of those inputs. The value of the coefficient of determination (R^2) was 0.611 which indicated that around 61% of the variation in output was explained by the independent variables included in the model (Table 2). The value of F was 1.931 which was significant at 5% level indicates the good fit of the model. The total elasticity (sum of the partial elasticity 0.456) showed decreasing returns to scale implies that when all other variables are held constant, a unit increase in one of them results in less than proportionate increase in output.

Table 2. Estimated value of coefficients and related statistics of Cobb-Douglas production function

Dependent Variable: LNOUTPUT			
Included observations: 100			
Variable	Coefficient	Std.Error	t-statistic
Labour	-0.0094*	0.004	-1.92
Sapling	0.3187***	0.170	3.20
Cowdung	0.0068	0.0072	0.94
Fertilizer	0.0715*	0.038	1.86
Land	0.067	0.110	0.609
Water	0.0057	0.0037	1.53
Chemicals	-0.0043***	0.0016	-2.620
Constant	6.128***	1.073	5.71
R-squared		0.611	
F-ratio		1.931**	
Returns to scale (b_{1+} b_{2+} b_{3+} b_{4+} b_5+b_6+$b_{7)}$		0.456	

Note: ***, ** and * indicate significant at 1% and 5% and 10% level respectively

Table 3 shows that the ratios of MVP and MFC are greater than unity for sapling, land, and water indicating that such inputs were underutilized. Farmers in the study area used too little of these inputs to cultivate strawberry that means the cost of using these inputs is less than the value of marginal product. This suggests that farmers can incur more cost for these inputs to be efficient. For key variable, labour, cow dung, fertilizer and chemicals comparison of the ratio of MVP to MFC revealed a resulting ratio to be less than unity implying that such inputs were over utilized. This suggests that farmers can deduct the use of the amount of these inputs to be efficient. In both cases all the inputs were not optimally utilized.

Table 3. Estimated resource use efficiency in strawberry production

Variable	Coefficients	MPP	Py	MVP	MFC	MVP/MFC	Adjustment required (%)
Labour	-0.0094	-0.1487	104.56	-15.5498	300	-0.0518	2031
Sapling	0.3187	0.1945	104.56	20.341	8	2.5426	61
Cowdung	0.0068	0.0117	104.56	1.2192	1.55	0.7865	27
Fertilizer	0.0715	0.0437	104.56	4.5655	35.95	0.1270	687
Land	0.067	1962.82	104.56	205232.1	31486	6.5182	85
Water	0.0057	0.00029	104.56	0.0307	0.022	1.3941	28
Chemicals	-0.0043	-15.55	104.56	-1626.41	400	-4.0660	125

The adjustment in the MVPs for optimal resource use indicated that for optimal allocation of inputs their level of use should be increased or decreased. Human labor was needed to decrease by 20-31% to obtain the optimum profit. Similarly, the level of use of cowdung, fertilizer and chemical should be decreased by 27%, 687% and 125% respectively. On the other hand, for optimal allocation of sapling, land, and water, their level of use should be increased by 61%, 85% and 28% respectively (Table 3).

Production problems faced by the farmers

Though strawberry has a good potentialities, farmers in the study areas faced some problems to produce strawberry because they had no training on strawberry cultivation. Highest 37% farmers reported that strawberry plants were attacked by many more diseases. About 30.5% farmers reported that they faced the problem of quality sapling in time. 28% farmers reported that their plant was dying (Table 4). Since more capital was required in strawberry production, 13% farmers in the study areas faced the problem of capital. 12% farmers reported that they had no adequate knowledge about strawberry cultivation practices. They also faced the problem of fruit damage (9%), attack of birds (7%) and insect pest (4%), plant damage (4%) and scarcity of labour (2%).

Table 4. Problems faced by the farmer in producing strawberry in the study areas

Problems	% farmers responded		
	Joypurhat	Rajshahi	All areas
More disease presence in strawberry plant	38	36	37
Lack of quality sapling in proper time	18	34	30.5
Plant is dying	36	20	28
Lack of capital	16	10	13
Lack of knowledge about strawberry cultivation	20	4	12
Fruits damage due to raining	8	10	9
High price of sapling	4	12	8
Attack of birds	-	14	7
Attack of insect	-	8	4
Production of sapling is so difficult	6	2	4
Requirement of insecticide is high	4	4	4
Damage of plant due to fog	4	4	4
Lack of labour	2	-	1

Marketing constraints faced by the farmers

In the study areas there was no marketing system of strawberry, so they faced problems to market their product. 48% farmers reported that transportation facilities of the study areas were poor. Farmers (24%) could not sell their product without Arath, commission of the Arathder was high (23%). Therefore, they did not get fair price (16%) (Table 5). On an average 9% farmers reported that in local market there was no demand for strawberry. As a result, when unrest situation prevail in the country, farmers lost their whole amount of strawberry. They also mentioned there was no cold storage facility (6%) and transportation cost was high (2%).

Table5. Marketing Problems faced by the farmer in the study areas

Problems	Joypurhat (%)	Rajshahi (%)	All areas (%)
Poor transportation facilities	50	46	48
Do not sell without Arath	30	18	24
Commission of Arathdar is high	16	30	23
Do not get fair price	8	24	16
There is no specific strawberry market	-	12	12
There is no demand in local market	12	6	9
There is no cold storage facility	10	2	6
High transportation cost	2	2	2

CONCLUSION

A large number of people, mostly unemployed youths, were engaged on strawberry farming. It was observed that labour, sapling, fertilizer and chemicals had significant effect on strawberry production. As strawberry cultivation is new in Bangladesh, farmers have no scientific knowledge about its production technology. They were not efficient in using inputs, they used excessive amount of several resources like labour, cow dung, fertilizer and chemicals and under used sapling, land and water to produce strawberry. Farmers in the study area faced some problems to produce strawberry because they have no training on strawberry cultivation.

To ensure efficient use of resources training on production technology should be given to the farmers. To control disease presence in strawberry, plant pathologist should undertake research on it. To reduce the use of chemicals, Entomologist should undertake research to control insect. To make sapling of BARI variety available in the farmers' field, Pomology division, HRC, BARI should produce and disseminate it to the farmers. If done so, production of strawberry will be increased, import will be decreased and foreign currency will be saved.

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EFFECTS OF UREA AND POULTRY MANURE COMBINATION ON YIELD AND QUALITY OF DIFFERENT LETTUCE (*Lactucasativa* L.) VARIETIES IN CHITWAN, NEPAL

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ABSTRACT

A study was conducted to evaluate the effect of combined application of urea and poultry manure(viz., 100% N-urea, 75% N-urea + 25% N-PM, 50% N-urea + 50% N-PM, 25% N-urea + 75% N-PM and 100% N-PM) on yield and quality of two varieties of lettuce viz., Green Span and NAI RE KUI DA F1at the Horticulture Farm of Agriculture and Forestry University, Rampur, Chitwan, Nepal from October 30, 2015 to January 30, 2016. Results revealed that the integration of 50% or more N-PM had significantly higher values in growth, yield and quality parameters while the use of 100% N-urea had the lowest one. Similarly, the two varieties significantly differed in all characters and the variety Green Span performed better at all levels of integration of N-urea with N-poultry manure than NAI RE KUI DA F1. Based on interaction effect, Green Span performed better with 100% N-poultry manure while NAI RE KUI DA F1 did better with the combination of 50% N-urea and 50% N-PM.

INTRODUCTION

Lettuce (*Lactuca sativa)* is globally important cool season leafy vegetables. It is taken as synonym of "salads" and contains about 6-19% mineral elements on the dry weight basis. It is the richest source of calcium among other vegetables and is the second richest source of minerals after spinach. The milky liquid substance, latex, present in lettuce contains "Lactucin" and 'Lactucopicrin' which helps to regulate nervous system, improves sleepiness, appetite and digestion and reduces high blood pressure, lowers high cholesterol levels, lowers inflammation and provides a supply of antioxidants (Sharma, 2005).It is minor crop in case of Nepal and its cultivation and consumption is mainly confined to Kathmandu and Pokhara valley where tourism industry has been flourished. However, with the growing increment in living standard of people, increasing awareness among people about health benefits of

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lettuce and also with the improvement of tourism in Nepal, its market demand has been increasing. Limited research and extension work has been conducted on it.

Lettuceis short duration high value crop with higher productivity which can be obtained through optimum nutrient use provided through organic, inorganic or bio-fertilizer sources. Chemical fertilizers are expensive and along with increment in production results in poor health condition of soil and water when used repeatedly. Public concern has been increased about the health and environmental hazardous brought by excessive use of inorganic fertilizers. Use of higher dose of inorganic source of nitrogen as urea in leafy vegetables has come up with the problem of accumulation of nitrate which is highly toxic substance to human being. Organic manure is arising as alternative practice to inorganic fertilizer and its use reduces the amount of nitrates together with increase in quality and yield of lettuce (Naeem, Iqbal and Bakhsh, 2006). However, for the use of organic manure, no clear recommendation is available. Farmers tend to apply either too much or too low organic fertilizers due to which soil condition is influenced and amount of nutrients provided by them is either insufficient or over dose for plants (Mbatha, 2008). Precise calculation of rate of use of organic manure is very important as their nutrient sources; composition as well as mineralization rate differs. Also, it is essential to improve and maintain soil fertility for higher productivity of vegetable crops, for which the advantages and disadvantages of organic and inorganic fertilizers need to be integrated in order to make optimum use of each type and achieve balanced nutrient management for crop growth (Chen, 2006). This research study is aimed at generating information on the optimum sole organic manure, inorganic fertilizer or combinations for optimum yields and quality along with appropriate varietal selection of lettuce that can be utilized by those interested in commercializing it.

MATERIALS AND METHODS

The experiment was carried out at the Vegetable Farm of Agriculture and Forestry University, Rampur, Chitwan from the month of October, 30, 2015 to January 30, 2016. It is situated at $27^{o}40'$ North latitude and $84^{o}19'$ East longitude with elevation of 228 masl. The location is inner Terai with humid sub-tropical climate. The average temperature during the field research was 20.4^{0}C. The experimental site had acidic soil with pH 5.5, soil texture was sandy loam with 1.4% organic matter, low nitrogen level (0.08%), high phosphorous (360 kg ha^{-1}) and medium potash (146 kg ha^{-1}). Similarly, poultry manure analysis data showed that N, P_2O_5, and K_2O content were 1.06%, 0.79% and 0.52% respectively. The two factor experiment was laid out in RCBD, where nutrient management with combined use of nitrogen from urea (N-urea) and poultry manure (N-PM) was one factor and variety was the next. Green Span is a released open pollinated variety of leafy type while NAI RE KUI DA F1 is a hybrid romaine leaf type variety.

There were altogether 10 treatment combinations and 4 replications. Total experimental area was 218.5m^2 (23m x 9.5m). Space between replication or main plot was 1m and space between sub-plots was 0.5m. The individual plot size was 3.375 m^2 (2.25m X 1.5m). The row to row distance was 45cm and plant to plant distance was 30cm apart. There were 5 rows of in each plot and 5 plants comprised a single row thus compromising 25 plants in each plot. Out of five rows, 2 rows were taken as boarder plants and remaining 3 rows were used for observation. Five randomly selected plants from these three rows were taken for observation.

Nursery was prepared at 3rd October and transplanted in main field 30 days after sowing.While fertilizing the land, total amount of urea and poultry manure applied depended on respective nutrient combination. Poultry manure was applied at double dose of calculated amount and half dose of nitrogen, full dose of phosphorus and potassium was applied after calculating the required amount as per nutrient combination with references to the recommended dose of 120:60:40 @NPK kg ha^{-1}. Remaining a lf dose of nitrogen (25 kg ha^{-1}) was applied at 25 DAT.

Data regarding the growth parameters like leaf length and breadth of leaves, number of leaves per plant, economic yield and quality parameters as vitamin C were taken and analyzed using RSTAT and Microsoft excel and interpretations were made based on results and findings. The purpose of analysis of variance was to determine the significant effect of nutrient combination and varieties on yield and quality of lettuce.

RESULTS AND DISCUSSION

Effect of varieties and different combination of N-urea and N-poultry manure

The data in table show the statistically significant variation for all the growth parameters, yield and quality of lettuce at the time of harvest. The highest records of number of leaves (21.11), leaf length (17.75 cm), plant height (19.41 cm),economic yield (15.05 t ha^{-1}) was found in the nutrient combination of 50% N-urea + 50% N-PM and above ground mass (20.16 t ha^{-1}), leaf breadth (18.32 cm), rosette diameter (32.05 cm), dry weight (14.17%) and Vitamin C (16.50 mg $100g^{-1}$) was found highest in 100% N-poultry manure. However, it was found that the nutrient combination of 50% N-urea + 50% N-PM, 25% N-urea + 75% N-PM and 100% N-PM were statistically at par for all growth parameters. The lowest record in all the parameters was observed in 100% N-urea followed by 75% N-urea + 25% poultry manure. Among the two varieties, NAI RE KUIDA F1 and Green Span, all growth parameters, above ground mass and economic yield was found significantly higher in Green Span than NAI RE KUI DA F1 but in Vitamin C, no significant difference was found between two varieties.

Table 1. Effect of varieties and different combination of N-urea and N-poultry manure on number of leaves, leaf length, leaf breadth, economic yield and Vitamin C of lettuce at Rampur, Chitwan, Nepal (2015/16)

Treatments	Plant height(cm)	No. of Leaves	Leaf Length (cm)	Leaf Breadth (cm)	Rosette diameter (cm)
Combination of N-urea with N-poultry manure					
100 % N-urea	14.35^{b}	17.25^{b}	13.39^{b}	14.18^{c}	24.44^{b}
75 % N-urea + 25 % N-PM	15.25^{b}	18.58^{b}	14.70^{b}	16.05^{bc}	26.63^{b}
50 % N-urea + 50 % N-PM	19.41^{a}	22.11^{a}	17.75^{a}	17.48^{ab}	31.4^{a}
25 % N-urea + 75 % N-PM	18.95^{a}	21.26^{a}	16.89^{a}	17.15^{ab}	30.84^{a}
100 % N-PM	19.28^{a}	23.33^{a}	17.52^{a}	18.32^{a}	32.05^{a}
SEM(±)	3.56	4.58	2.16	2.49	7.71
$LSD_{(0.05)}$	2.24	2.54	1.74	1.87	2.08
P value	0.000	0.000	0.000	0.001	0.000
Varieties					
NAI RE KUI DA F1	15.296^{b}	19.02^{b}	13.94^{b}	14.34^{b}	25.81^{b}
Green Span	19.608^{a}	21.98^{a}	18.16^{a}	18.93^{a}	32.33^{a}
SEM(±)	3.56	4.58	2.16	2.49	7.71
$LSD_{(0.05)}$	1.41	1.61	1.10	1.18	2.08
P value	0.000	0.000	0.000	0.000	0.000
Mean	17.45	20.50	16.05	16.63	29.07
CV (%)	10.81	10.44	9.15	9.49	9.55

Means within the column followed by same letter are not significant at 5% level by DMRT. DAT=Days after transplanting, SEM (±) = Standard error of mean, LSD=least significant difference and CV=coefficient of variance

Table 2. Effect of varieties and different combination of N-urea and N-poultry manure on above ground mass, economic yield, dry weight and Vitamin C of lettuce at Rampur, Chitwan, Nepal (2015/16)

Treatments	Above ground mass (tha^{-1})	Economic Yield (tha^{-1})	Dry weight (%)	Vitamin C ($mg\ 100g^{-1}$)
Combination of N-urea with N-poultry manure				
100 % N-urea	17.67^{c}	12.67^{b}	7.67^{b}	13.17^{b}
75 % N-urea + 25 % N-PM	18.79^{b}	14.3^{a}	9.33^{b}	14.23^{b}
50 % N-urea + 50 % N-PM	19.37^{ab}	15.05^{a}	13.50^{a}	16.40^{a}
25 % N-urea + 75 % N-PM	19.02^{b}	14.96^{a}	12.67^{a}	16.41^{a}
100 % N-PM	20.16^{a}	14.97^{a}	14.17^{a}	16.50^{a}
SEM(±)	0.44	0.58	1.11	0.922
$LSD_{(0.05)}$	0.79	0.91	2.33	1.142
P value	0.000	0.000	0.000	0.000
Varieties				
NAI RE KUI DA F1	17.57^{b}	13.4^{b}	10.20^{b}	15.41
Green Span	20.44^{a}	15.29^{a}	12.73^{a}	15.27
SEM(±)	0.44	0.58	0.702	0.92
$LSD_{(0.05)}$	0.5	0.57	1.48	NS
P value	0.000	0.000	0.001	
Mean	18.76	14.39	11.47	15.34
CV (%)	15.08	5.32	16.75	6.25

Means within the column followed by same letter are not significant at 5% level by DMRT. DAT=Days after transplanting, SEM (±) = Standard error of mean, LSD=least significant difference and CV=coefficient of variance.

The reason behind significant effect of the varieties on growth, yield and quality parameters might be the highly heritable characters of plant receiving the equivalent dose of fertilizer. The integration of 50% or more nitrogen through poultry manure with urea had significant effect on measured parameters which might be due to synergetic effect of both the sources or the nutrient efficiency of combining urea and poultry manure. The positive influence of poultry manure on the growth and yield of lettuce crop might be due to the release of the balanced nutrients contained in the organic nutrient especially nitrogen which ensures favorable condition for the elongation of lettuce plant as well as availability of other macro and trace elements and improvement in soil physical structure as water holding capacity. Similar result was obtained by Madisa, Mathowa, Mpofu, Stephen, and Machacha (2013) in *Corchorus olitorius* and Xu et al. (2005) in a study on leafy vegetables. The leaf proliferation and expansion in leaf vegetables attributed to organic soil amendments,

had been demonstrated in field experiments by Sanchez and Miller, (1986); Obatolu, (1995) and Richert and Salomon, (1998). Also the urea when used in combination act as catalyst for decomposition of poultry manure and helps in the release of nutrients essential for crop during whole crop period. Dutta, Chakeraborty, and Chakrabarti (2003) reported that the use of organic fertilizers together with chemical fertilizers, compared to the addition of organic fertilizers alone, had a higher positive effect on microbial biomass and hence soil health. Ullah, Islam, Islam and Haque (2008) reported that application of organic and inorganic fertilizers solely or combined had a great influence on the vegetative growth of the crop. Similarly, the higher ascorbic acid grown organically compared to those grown conventionally was found by Schuphan (1974). But Lairon, Spitz, Termine, Ribaud, Lafont and Hauton (1984) observed no difference in vitamin C content of lettuce grown organically and conventionally. This study also established that the sole use of N-urea is found inferior to rest of the treatment. The reason behind this might be that inorganic fertilizer do not possess good characteristics in aggregating soil particles and have low ability of moisture retention as reported by Masarirambi et al. (2012). Okokoh and Bisong (2011) also reported that applying N-urea without organic manure produced scanty foliage whereas poultry manure alone had superior effect over any rate of N-urea-N on development of foliage.

Interaction effect of varieties and different combination of N-urea and N-poultry manure

Interaction effect of different nutrient combinations and varieties showed statistically significant variation in leaf length, above ground mass and dry weight of lettuce.

The leaf length and dry weight of both varieties was statistically at par only at 50% N-urea + 50% N-PM nutrient combination and they differ in other. The highest leaf length and dry weight of Green Span was found with 100% N-PM (21.43 cm and 16% respectively) which was statistically at par with the nutrient combination of 25% N-urea + 75% N-PM and 50% N-urea + 50% N-PM while the lowest was found with 100% N-urea (15.54 cm and 8.67% respectively) which was statistically at par with 75% N-urea + 25 % N-PM. The highest above ground mass was found in Green Span with 100% N-PM (22.5 t ha^{-1}) while the lowest was found with 100% Urea (18.91 t ha^{-1}) while other nutrient combination had intermediate effect on it. Similarly, NAI RE KUI DA F1 had longest leaf length, highest above ground mass and dry weight with 50% N-urea + 50% N-PM (16.70 cm,18.55 t ha^{-1} and 14.33% respectively) which followed by with 25% N-urea + 75% N-PM and the lowest was found with 100 % N-urea which was statistically similar with 75% N-urea + 25% N-PM and 100% N-PM.

Table 3. Effect of varieties and different combination of N-urea and N-poultry manure on number of leaves, rosette diameter, above ground and economic yield, and Vitamin C of lettuce at Rampur, Chitwan, Nepal (2015/16)

Treatments	No. of leaves	Rosette diameter (cm)	Above ground yield (tha^{-1})	Economic yield (tha^{-1})	Vitamin 'C' ($mg100g^{-1}$)
NAI RE KUI DA F1 X 100 % U	15.26	21.13	16.44	11.18	13.61
Green Span X 100 % U	19.23	27.76	18.91	14.16	12.7
NAI RE KUI DA F1 X (75 % U + 25 % PM)	17.36	22.75	17.42	13.67	14.10
Green Span X (75 % U + 25 % PM)	19.80	30.51	20.17	14.93	14.36
NAI RE KUI DA F1 X (50 % U + 50 % PM)	22.63	30.13	18.55	14.55	16.86
Green Span X (50 % U + 50 % PM)	21.60	32.66	20.20	15.55	16.14
NAI RE KUI DA F1 X (25 % U + 75 % PM)	20.0[b]	28.46	17.37	14.15	16.46
Green Span X (25 % U + 75 % PM)	22.53	33.21	20.68	15.76	16.36
NAI RE KUI DA F1 X (100 % PM)	19	26.61	18.08	13.9	16
Green Span X (100 % PM)	26.73	37.50	22.25	16.03	16.76
Mean	20.5	29.07	19.01	14.39	15.34
SEM(±)	4.58	7.71	0.44	0.58	0.92
$LSD_{(0.05)}$	NS	NS	NS	NS	NS
CV (%)	10.44	9.55	3.51	5.32	6.25

Means within the column followed by same letter are not significant at 5% level by DMRT. DAT=Days after transplanting, SEM (±) = Standard error of mean, LSD=least significant difference and CV=coefficient of variance

Table 4. Interaction effect of varieties and different combination of N-urea and N-poultry manure on leaf length of lettuce at Rampur, Chitwan, Nepal (2015/16)

Nutrient combinations	Varieties					
	Leaf length (cm)		Above ground mass (tha^{-1})		Dry weight (tha^{-1})	
	Green Span	NAI RE KUI DA F1	Green Span	NAI RE KUI DA F1	Green Span	NAI RE KUI DA F1
100 % N-urea	15.54^{de}	11.24^{f}	18.91^{c}	16.44^{e}	8.67^{ef}	6.67^{f}
75 % N-urea + 25 % N-PM	15.74^{de}	13.67^{f}	20.17^{b}	17.42^{de}	10.67^{de}	8.00^{ef}
50 % N-urea + 50 % N-PM	18.81^{bc}	16.70^{cd}	20.20^{b}	18.55^{c}	12.67^{abc}	14.33^{abc}
25 % N-urea + 75 % N-PM	19.28^{ab}	14.50^{de}	20.68^{b}	17.37^{de}	15.67^{ab}	9.67^{def}
100 % N-PM	21.43^{a}	13.61^{f}	22.25^{a}	18.08^{cd}	16.00^{a}	12.33^{cd}
SEM(±)	2.47		0.44		3.70	
$LSD_{(0.05)}$	2.16		1.12		3.30	
P	0.01		0.01		0.01	

Means within the column followed by same letter are not significant at 5% level by DMRT. DAT=Days after transplanting, SEM (±) = Standard error of mean, LSD=least significant difference and CV=coefficient of variance.

It was revealed that Green Span along with poultry manure only and NAI RE KUI DA F1 with 50% N-urea + 50% N- poultry manure ensured the highest records in all parameters studied. The reason behind this might be that variety being hybrid found more adoptive to inorganic fertilizer while the Green Span response was more preferable to organic source, poultry manure. Similarly when observing the interaction effect of each variety with each treatment, Green Span performed better than NAI RE KUI DA NAI RE KUI DA F1. Radovich (2000) studied the response of basil (*Ocimum basilicum* L.) to chicken manure, compost and urea applications and reported that response to manure applications was cultivar dependent.

CONCLUSION

Result of the study indicated that Green Span variety of lettuce performs better in Chitwan and has better adaptation capacity. Study suggests that poultry manure alone can produce better result than inorganic fertilizer alone. Besides, for sustainable and better yield of lettuce varieties, especially hybrid, integration of 50% or more poultry

manure with urea based on precise calculation of recommended dose of nutrition is suggested.

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WAY OF COMPOST APPLICATION FOR ORGANIC FARMING

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ABSTRACT

Application of composts is an alternative of synthetic agrochemicals for eco-friendly farming. Work is limited on the effective and economic way of compost application in Bangladesh. A study was done at the Field Science Center, Saga University, Japan with green tea waste – rice bran compost (GRC) application. Radish (*Raphanus sativus* L.), spinach (*Spinacia oleracea* L.) and komatsuna (*Brassica rapa* var. *pervidis*) were used as test plants. GRC was applied at 1.0 kg m^{-2} by mulching on soil after seeding. It enhanced seed germination, seedling growth and improved crop yield of spinach and radish grown in a controlled condition. Among the two application methods, post-sowing mulching (PSM) reduced water loss from upper soil surface, thus enhanced seed germination and better growth compared to pre-sowing incorporation (PSI) system. This study also suggests that improper compost incorporation to soil may impair seed germination, seedling growth and likely crop yield.

INTRODUCTION

Organic amendments in agriculture have contributed immensely to converting much of the fragile land of the world into stable productive zones (Svotwa et al., 2009). Composting is a viable means of transforming various organic wastes into products that can be used safely and beneficially as bio fertilizers and soil conditioners in organic farming systems. Over time, yearly additions of compost create a desirable soil structure, making the soil much easier to work, lowering bulk density, reducing soil erosion and improving soil fertility (FAO, 1987).

In a previous study, 30:70 ratio of green tea waste and rice bran (v/v) produced the best compost quality that enhanced spinach growth and controlled weeds (Khan et al.,

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2009). But research on the effective and economic way of application of this compost for maximizing yield and quality not yet has done. Hence, research is needed to determine it and to replace or supplement chemical fertilizers for vegetables production. Considering the above facts, this study was designed to determine the effective way of compost application in an organic farming system for vegetables production.

MATERIALS AND METHODS

The experiments were conducted consecutively for two seasons (autumn and spring) under greenhouse and laboratory conditions at the Field Science Center, Saga University, Japan (33º 18′ 20″ N and 130º 20′ 12″ E).

Compost application

Pre-sowing incorporation (PSI) and post-sowing mulching (PSM) of compost at 0.5, 1.0 and 2.0 kg m^{-2} were used and compared with control (0 kg m^{-2}). In PSI, compost was incorporated with the soil at 6 cm depth before seeding and for PSM, compost was applied on the upper soil surface after sowing of seeds.

Effect of compost water extract on seed germination

The effects of compost water extracts on seed germination were evaluated through seed germination test. A crude aqueous extract was prepared by stirring 100 g of oven dried (60ºC for 24 hr with forced air circulation) ground sample with 1000 ml of distilled water for 12 hrs and kept overnight. Then the suspension was centrifuged at 3000 rpm for 30 min and the supernatant was used for bioassay. The concentrated water soluble fractions of compost was diluted with distilled water from 10^{-10} to 10^{-1}. Twenty-five seeds of komatsuna (*Brassica rapa* var. *pervidis*) were used germination test in which seeds were imbibed in 5 ml of either solution of compost water soluble fraction or distilled water (control) in a covered 9 cm petridish on a double sheet of sterile filter paper (Advantec No. 2) and incubated at 25ºC for 72 hrs under completely dark conditions.. Electrical conductivity (EC) of the respective concentrations of compost extract was measured and calculated the correlation coefficient between seed germination percentages after 12 hours incubation period and EC of the respective concentrations. The experimental design was a completely randomized design (CRD) with the treatment replicated five times.

Evaluation of plant growth and quality

Ninety-six seeds of spinach (*Spinacia oleracea* L.) var. Jiromaru (Takii seeds, Japan) and radish (*Raphanus sativus* L.) var. Hatsuka daikon, JA, Japan were sown in a 45 L pot (84.5 cm x 28.0 cm) at early October for autumn and early March for spring. The treatments were consisted of control (only soil), 0.5, 1.0 and 2.0 kg m^{-2} of compost as PSI or PSM. Pots were watered to approximately field capacity. After seed germination, 32 plants pot^{-1} were kept maintaining 15 cm line to line and 5 cm plant to plant distances. Plant height, leaf area and dry weight and root length, root

diameter and root dry weight were measured at 30 days after seeding. Additionally, nitrate and iron concentrations in fresh spinach leaves were also determined spectroscopically (Tagliavini et al. 2000) using the Merck RQflex (E. Merck D 64271 Darmstadt, Germany) with specific tests (nitrate test n. 1.16971 and iron test n. 1.16982).

Statistical analyses

Statistical analyses were performed using SAS package version 6.12 (SAS Institute, 1996). Differences among the treatments were determined by LSD.

RESULTS

Effect of compost extract on seed germination

In vitro seed germination of komatsuna using different concentrations of GRC water extracts (10^{-10} to 10^{-1}) showed that there was no significant differences among the treatments including control after 24 hours of incubation. Negative effect on seed germination was found at 10^{-1} concentration compared to control up to 12 hrs of incubation (data not shown).

Effects of compost on seedling emergence

Germinations radish and spinach seeds under different treatments are illustrated in Fig. 1. Speed of germination was faster in radish than in spinach. In case of application method, PSM was better than PSI to enhance seed germination. Application of compost at 1.0 kg m^{-2} as PSM was the best among the treatments. Increased PSI application rate reduced germination percentages for both the tested crops. Application of GRC at 2.0 kg m^{-2} as mulching also reduced seed germination compared with control.

Effect of compost on plant growth and quality

Increased GRC application rate favored plant growth and PSM system showed significantly better performance than PSI system (Table 1).

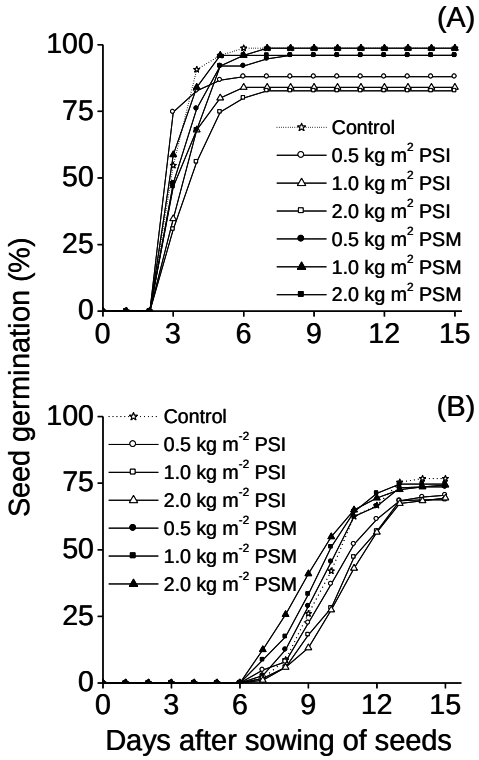

Fig. 1. Effects of GRC application methods and rates on seed emergence of radish (A) and spinach (B) under greenhouse condition

Table 1. Effect of compost application methods and rates of GRC[a] on growth of spinach and radish under greenhouse condition, averaged over two consecutive seasons (autumn and spring)

Treatments ($kg\ m^{-2}$)	Spinach			Radish		
	Plant height (cm)	Leaf area ($cm^2\ plant^{-1}$)	Dry weight ($g\ pant^{-1}$)	Root length (mm)	Root diameter (mm)	Dry weight ($g\ root^{-1}$)
PSI						
0	8.26	23.51	0.02	23.47	21.10	0.47
0.5	14.47	90.68	0.06	30.05	28.33	0.88
1.0	15.05	100.10	0.09	31.81	30.72	0.93
2.0	18.01	166.72	0.10	34.28	37.20	1.36
PSM						

Treatments (kg m^{-2})	Spinach			Radish		
	Plant height (cm)	Leaf area (cm^2 $plant^{-1}$)	Dry weight (g $pant^{-1}$)	Root length (mm)	Root diameter (mm)	Dry weight (g $root^{-1}$)
0	8.26	23.51	0.02	23.47	21.10	0.47
0.5	15.33	118.54	0.07	27.17	32.17	0.85
1.0	20.74	219.52	0.12	32.72	37.26	1.25
2.0	22.59	256.55	0.19	38.60	37.80	1.39
LSD (p=0.05)	1.52	22.38	0.04	5.36	4.30	0.04
Appli. method x rate						

[a]GRC: Green tea waste – rice bran compost originated from 30% green tea waste and 70% rice bran (v/v and dry basis) PSI = Pre-sowing incorporation; PSM = Post-sowing mulching.

Only spinach quality in terms of nitrate and iron contents was determined in this study and data are shown in Table 2. Nitrate content was increased significantly with higher rate of compost application for both the systems. But, PSM system provided significantly lower nitrate contents in spinach than PSI system. Rate of iron accumulation was inconsistent with both the systems.

Table 2. Nitrate and iron contents in spinach leaves as influenced by GRC[a] application methods at variable rates; averaged over two consecutive seasons (autumn and spring)

Treatments (kg m^{-2})	Nitrate (mg 100 g^{-1} fresh weight)	Iron (mg 100 g^{-1} fresh weight)
PSI		
0	44.0	3.3
0.5	70.0	3.3
1.0	290.0	2.5
2.0	471.0	2.2
PSM		
0	44.0	3.3
0.5	31.0	2.4
1.0	275.0	2.6
2.0	370.0	2.5
LSD (p=0.05) Appli. method x rate	21.38	0.62

[a]GRC: Green tea waste – rice bran compost originated from 30% green tea waste and 70% rice bran (v/v and dry basis) PSI = Pre-sowing incorporation; PSM = Post-sowing mulching.

DISCUSSION

The quality and acceptability of agro-industrial wastes as soil amendment can be greatly improved through composting. Details studies on the physico-chemical and microbial properties of GRC have already done (Khan et al., 2007, 2009). But substantial studies are lacking for economic and efficient ways of GRC application.

PSM method provided better performance in enhancing seed germination and seedling growth might be due to conservation of soil moisture that favored plant growth and development. Optimum soil moisture is one of the essential elements for seed germination under field condition; both high and low moisture content affects the seed germination and seedling growth (Agami, 2008; Foshee et al., 1996). In the present investigation, up to 1.0 kg m^{-2} in PSM method maintained the optimum soil moisture for seed germination and seedling growth compared with other treatments. Excessive moisture and physical pressure at 2.0 kg m^{-2} under PSM system reduced seed germination percentages. High concentrations of GRC water extract inhibited seed germination might be due to greater concentration of allelochemicals or high EC (Woodell, 1985; Zia and Khan, 2004).

Plant growth and quality of test crops were also affected by GRC application rates. The increase in soil available nutrients because of higher amounts of GRC favored plant growth up to a certain level and then reduced plant growth due to increase in EC levels, especially in PSI method. Nitrate content in spinach was also affected by the GRC treatments. Besides, soil available nitrogen is one of the major factors that influence plant nitrate content especially in spinach (Khan et al., 2007).

CONCLUSIONS

This study demonstrated the effective way of compost application at 1.0 kg m^{-2} by mulching on soil after sowing of seeds that enhanced seed germination and seedling growth, improved crop productivity and quality of spinach and radish under controlled conditions.

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DOES GENDER INFLUENCE FARM HOUSEHOLDS' DECISION TO ADOPT TECHNOLOGY AND COMMERCIAL AGRICULTURE: IMPLICATION FOR HOUSEHOLD FOOD SECURITY IN RURAL BANGLADESH

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ABSTRACT

This paper investigates whether gender of household head is associated with the household's decision to adopt technology and commercial agriculture in rural Bangladesh. It further investigates if household food security of the adopters differs significantly on the basis of gender of the household head. By using χ^2 test and Cramer's V statistic this paper finds evidence to suggest that adoption of both technology and of commercialisation of agriculture in rural Bangladesh significantly differs between male-headed and female-headed households. The incidence of adoption among the female-led households is low possibly because they are constrained by lack of access to input, credit, and extension services. It is also found that household food security of the adopters improves irrespective of gender of the household head. Thus the policy implication of the study is that technology adoption and commercial farming may have good prospect for improving household food security of rural farm households.

INTRODUCTION

This research is concerned about gender difference in Bangladeshi agricultural households' adoption of technology and commercial agriculture and about implication of such adoption on household food security. Bangladesh is an agricultural country, in which reducing poverty along with ensuring food security are the foremost development priorities (HKI and JPGSPH, 2014). Unfortunately these priorities are further challenged by the country's declining agricultural resource base and vulnerability to climate change. Intensifying agriculture through adoption of technology and commercial farming may play a vital role in ensuring food security in the country. For example, the yield of *Boro* rice – the principal source of staple food grain in Bangladesh – is about 1.8 t ha^{-1} for local varieties, 3.8 t ha^{-1} for modern

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varieties; whereas it is 4.7 t ha^{-1} for hybrid *Boro* (BBS, 2016). This implies that *Boro* production may be increased approximately by a tonne per hectare by cultivating hybrid varieties. Yet hybrid rice is being grown in only about 6% of the country's total rice cultivated area (BBS, 2016). Nonetheless about 9.5% of total domestic rice production comes from hybrid rice (BBS, 2016). These figures clearly underscore the enormous potential of technology-intensive hybrid crops for increasing domestic food production in Bangladesh.

Hybrid crop cultivation is technology-intensive as well as capital intensive. Thus its adoption depends on farmers' solvency; however, farming communities in Bangladesh are disproportionately represented by marginal and small farmers (84.4% of all farm households) (BBS, 2010) who are generally resource poor. Accordingly they have low endowment for adopting technology and capital intensive crops or commercial oriented farming practices. Studies that have documented factors which underlie farm households' decision to adopt modern agricultural practices highlight two broad factors: household head's socioeconomic characteristics and institutional facilities. A study in Nepal has revealed that education, extension services, and seed access play significant role in households' technology adoption decisions. Another study has documented that adoption of modern rice varieties can be explained by age and education of household head along with access to extension services (Ghimire and Huang, 2016). A study in Ghana showed that farm households' technology adoption decisions depend on farmers' socioeconomic circumstances and institutional effectiveness (Akudugu et al., 2012).

The concern over adoption of technology or commercialisation in Bangladesh has been stemming from the fact that the incidence of female-headed households is rising in the country. In 1996 the share of female-headed households were about 3.5% which rose to 4.3% in 2008 and it further increased to 7.2% in 2013 (BBS, 2015, 2016). It implies that more women are becoming directly engaged in food production compared to the past. Nonetheless women in Bangladesh are often constrained by lack of credit, lack of information, and inaccessibility to institutional services. Moreover preference for growing a particular crop or a variety may differ on the basis of gender (Mehar et al., 2017). In such a context, it may be worth investigating whether gender of household head has any influence on adoption of technology and commercial agriculture in farm households of rural Bangladesh. Eliciting such evidence and investigating whether adoption of technology and commercialisation improve household food security of the farm households are the key interest of this study.

DISCUSSIONS

For empirical analysis this study uses data from the Bangladesh Integrated Household Survey 2012, which contains information on types of crops grown by the households and on household food consumption diversity. A total of 3,409 agricultural

households of the BIHS constitute the sample for this study, of which 199 households are female headed.

'Technology adoption' is defined as whether or not a household cultivates hybrid variety of any crops. If the household cultivates hybrid variety of any crop then the value 1 is assigned to indicate that the household is an adopter of technology.

Commercial farming is meant to indicate whether the households grow any cash crops. In Bangladesh context cash crops generally include maize, fibre crops, pulses, oilseeds, potatoes, sugarcane and tobacco. Thus the variable 'cash crop' is defined as whether or not a household grows any of the above cash crops: the value 1 is assigned if the household grows and otherwise 0.

In order to measure the variable 'food security' household dietary diversity score (HDDS) is used in this study. The HDDS better tells about both the quantitative and the qualitative aspects of a household's diet (Swindale and Bilinsky, 2006). The BIHS has collected information on what food groups a household had consumed over the past week. The food groups considered are (i) cereals, (ii) roots and tubers, (iii) vegetables, (iv) meat, (v) eggs, (vi) fish, (vii) dairy, (viii) pulses, (ix) oils, (x) fruits, (xi) sugar, and (xii) miscellaneous. For consuming a particular type of food the value 1 is assigned and otherwise 0. The values are then summed over the 12 food groups, which ultimately generates the household dietary diversity score. It follows that HDDS ranges between 0 and 12 and a higher HDDS reflects greater variation in the household's diets. Based on the variability of the HDDS the sample is split into terciles. Then the mean HDDS of top-tercile is taken as a threshold: a HDDS below the threshold will imply a lack of variation in the household's diet and thus regarded as food insecure. On the other hand, a HDDS which is equal to or higher than the threshold value will mean the household's diet is sufficiently diverse and hence the household is food secure. The variable 'food security' takes the value 1 to denote a household is food secure and otherwise 0. In the sample, among the 460 hybrid crop growing households 207 households are categorised as food secure on the basis of the of the HDDS. Of the food secure households, only 7 households are headed by a woman.

At first this paper presents bi-variate distribution of the sample in respect of technology adoption, cash crop cultivation, and food security across gender of household head. Afterwards in order to test whether or not the observed variation in the distribution of the households with respect to technology adoption and commercialisation across gender is statistically significant, the χ^2 test is performed. The χ^2 test statistic is computed as $\chi^2 = \frac{\sum (f_o - f_t)^2}{f_t}$ with (r-1)(c-1) degree of freedom. The term f_o means observed frequency, f_t means expected frequency, r means the number of rows, and c means the number of columns. Expected frequency

f_t is computed as $f_t = \frac{(\text{Row total})(\text{Column total})}{\text{Total sample size, N}}$. The first hypothesis here is that the incidences of technology adoption are not statistically different between male-headed and female-headed households. The next hypothesis is that among the technology adopters food security is not significantly different between male-headed households and female-headed households. The third hypothesis is set out as the incidences of cash crop cultivation are not significantly different between male-headed and female-headed households. The last hypothesis is set out as no significant difference in the incidences of food security among the cash crop growing households on the basis of gender of household head.

If the calculated value of χ^2 is greater than the tabulated value at a low level of significance then the null hypothesis will be rejected. It is important to note here that the χ^2 value does not tell anything about the extent of association between the variables of interest. With a view to finding a comprehensive measure of the degree of association of the adoption indicators with the gender of household head, this research additionally reports Cramer's V statistic. Notably this statistic is capable of quantifying strength of a relationship between two nominal variables. Cramer's V is computed as $V = \sqrt{\chi^2 / N(k-1)}$ where N is the sample size, and k is the smaller of the number of rows and columns. Since in all instances in this paper, the bi-variate distribution table is of 2×2 dimension, the term k-1 is equal to 1. The rule of thumb in interpreting the Cramer's V is that if it ranges between -1 to -0.7 then there is a very strong negative association, -0.7 to -0.3 would mean weak negative association, 0.3 to 0.7 means weak positive association, and finally 0.7 to 1 represents a very strong positive association (Babu and Sanyal, 2009). Any value between -0.3 to 0.3 means no association.

Table 1 shows the comparison of technology adoption and food security status across the gender of the household heads. As can be seen from panel A in Table 1, overall 460 households out of 3,409 households grow hybrid crops. About 14% male-headed households are technology adopters compared with 8.5% female-headed households. This result is suggestive of the fact that male-headed households are more likely to adopt modern technology relative to female-headed households. This is so possibly because female-headed households may not have access to critical inputs required for adopting hybrid varieties or because female household heads are generally risk averse in the case of adopting a new technology. In the sample overall 13.50% households are technology adopters.

Table 1. Distribution of technology adopters and food secured households across gender of household head

Gender	Technology adoption			Food security		
	No	Yes	Total	No	Yes	Total
Female	182	17	199	10	7	17
Male	2,767	443	3,210	243	200	443
Total	2,949	460	3,409	253	207	460

Source: author's calculation

Panel B in Table 1 shows the distribution of the technology adopters in respect of food security across gender of household head. It is evident that among the technology adopters about 45% male-headed households are food secure compared with about 41% female-headed households. Panel A and B clearly signifies that fewer female headed households adopt technology and among the adopters the proportion of food insure household is high for female-led households.

Panel A of Table 2 also shows a similar gender difference in the incidence of cash crop cultivation. About 38% of the male-headed households are found to have grown cash crops compared with about 18% female-headed households. It is generally very difficult to explain why this is the case from the cross-tabulation results; however, one possibility may be is that female-headed households are disadvantaged in respect of access to markets, agricultural extension service, market information and so on in contrast to male-dominated households.

Table 2. Distribution of cash crop growers and food secured households across gender of household head

Gender	Cash crop			Food security		
	No	Yes	Total	No	Yes	Total
Female	136	63	3,210	40	23	63
Male	1,980	1,230	199	689	541	1,230
Total	2,116	1,293	3,409	729	564	1,293

Source: author's calculation

Turning to panel B of Table 2 it can be observed that among the cash crop growing households, about 44% male-headed households are food secure compared to 36.51% of the female-headed households. This again indicates that fewer female-headed households are food secured in comparison with male-headed cash crop growing households.

Now it is evident from Table 3 that in the case of technology adoption the p-value is smaller than 0.05 which implies that the null hypothesis of no relationship between gender of household head and adoption of hybrid varieties can be rejected. It implies that incidences of technology adoption are significantly different between male-headed and female-headed households. However the extent of the relationship is very weak as Cramer's V is very low but the negative sign suggests that there is an inverse relationship between them.

Table 3. Results of hypothesis test

	Null hypothesis	χ^2 statistic	p-value	Cramer's V
1.	Technology adoption does not vary between male-led and female-led households	4.438	0.035	-0.036
2.	Among the technology adopters food security status does not vary between male-led and female-led households	0.104	0.747	-0.015
3.	Incidences of cash crop cultivation do not vary between male- and female headed households	3.530	0.060	-0.032
4.	Among the cash crop growers food security status does not vary between male-led and female-led households	1.362	0.243	-0.033

Source: author's calculation

In the case of food security status of the technology adopters the null hypothesis cannot be rejected because the associated p-value is larger than 0.05 which means that among the adopters of technology there is no significant difference in the food security status across gender of household head. This may also mean that technology adoption does not create any gender differentiated effect on household food security, which is a very good sign as far as food security is concerned. Furthermore the absence of any strong relationship between gender and household food security of the technology adopters is confirmed by the very low Cramer's V.

Moving on to the hypothesis concerning cash crop cultivation, it can be seen that the p-value of the χ^2 test barely exceeds 0.05, which means that the null hypothesis can be rejected at 5 per cent level of significance. However as the p-value is just over 0.05 but less than 0.10 the null hypothesis cannot be rejected at 10 per cent level of significance. Thus by considering a slightly broad level of significance it may be said that there is perhaps some association between cultivation of cash crops and gender of household head with male-led households are more prone to grow cash crops. Nevertheless the small negative Cramer's V indicates that the association is not very strong but there exists an opposite relationship.

Among the cash crop growers, there is no significant difference as regards food security across gender of household head as the p-value of χ^2 is greater than 0.05. This means that commercialisation of agriculture does not create any gender differentiated effect on household food security. As revealed by the Cramer's V, there is no strong association between food security and gender of household head in the case of cash crop growing households.

CONCLUSION

The understanding of the linkage between female-headed households and adoption of technology or commercial agriculture is inherently complex. Female-headed households usually have less access to crucial inputs such as land, labour, credit, and extension services. In such a perspective and taking Bangladesh into account, this paper has found evidence to suggest that gender matters for technology adoption and commercialisation of agriculture in the country. For the sake of ensuring food security, which is a top priority of the country, there are practically few other options left other than pursuing cultivation of high-tech hybrid crops. However, on the basis of the findings of this paper it becomes apparent that gender of household head has a strong influence on hybrid crop cultivation in Bangladesh. Male-led farm households are more prone to grow hybrid crops compared to female-led households, which has a policy concern because the share of female-headed households in farming community in Bangladesh has gone up over the past years. In the case of cash crops cultivation, a very similar result of strong influence of gender has been found. The policymakers need to seriously take into account such gender difference and should trigger research as to understand the underlying causes. If the barriers encountered by the female- headed households can be eliminated then food security of those households would considerably improve because this study suggests that once a household adopts technology-intensive or commercial crop cultivation, its food security gets better irrespective of the gender of household head.

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font size 12. The manuscript must be double-spaced. The double-spacing requirement applies to all written material, including footnotes, references, tables, and figure captions. Authors are requested for limited use of italics, bold, and superscripts and subscripts, however, scientific names should be typed in italics. Word processing features such as automatic footnoting and outlining must be avoided and if numbered list is required to place in the manuscript enter the numbers and use appropriate tabs and indents by hand instead of using automatic outlining.

Manuscripts should be organized in the order:

1. Title (Should be clear and not long);
2. Present Address (es) of authors;
3. Abstract;
4. Key words (arrange alphabetically);
5. Running title;
6. Introduction;
7. Materials and Methods;
8. Results (sometimes combined with the discussion);
9. Discussion;
10. Conclusion;
11. Acknowledgments;
12. References;
13. Figure captions;
14. Tables;
15. Figures;

Essential Title page information:

- **Title:** The title should represent the content of the article. The terms in the title should be limited to those words that give significant information about the content of the article. It is discouraged to start title with 'Study on', 'Effect of', and 'Influence of.' An ideal title briefly identifies the subject, indicates the purpose of the study, and introduces key concept. Scientific names may be given where necessary.
- **Author names and affiliation:** There should be a cover page which includes title and all the names of authors. It is encouraged to use full names of authors in bylines. An asterisk (*) follows the name of an author denotes the corresponding author and is matched to the words "*Corresponding author" at the footnote of the cover page. In this place email address and phone number for the corresponding author is included.

Peer Review Policy

Manuscripts will be sent to reviewers via e-mail for review the manuscripts electronically using track change mode. All manuscripts are subject to peer review and are expected to meet standards of academic excellence. All articles are initially screened by the managing editor/ associate editor solely or with the help of members of editorial board. If the article is found to be in order as per the 'Guidelines' and there is adequate original information, it is sent to an expert for peer review. On the contrary, the articles that contain inadequate information or are not conform to 'Guidelines' are rejected as such or returned to the author for revision. After the article has been examined by the reviewer or followed by over viewer, it is also suitably edited by a relevant member of Editorial Board. Both reviewer/ over viewer and editorial board comments along with the manuscript are passed on to an author, who resubmits it after incorporating suggestions and comments. The thoroughly revised article will be checked by the editorial board and managing editor in the light of review/ over viewer comments whether it would be worth for publishing or not. The articles accepted for publication by editorial team are checked by a professional editor for english language, uniformity and any other ambiguity before sending to the press for composing. Proofs are mailed to the corresponding authors if needed and are also gone through by the managing editor/ associate editor/ member of editorial board.

Article Processing Charges

Articles are published in the SAARC Journal of Agriculture (SJA) free of charge.

Title and Authorship Information

The following information should be included

- Paper title
- Full author names
- Full mailing addresses
- Email addresses

Abstract

The manuscript should contain an abstract. The abstract should be self-contained and citation-free, single paragraph and should not exceed 200/250 words. An ideal abstract may contain objectives, materials & methods, results and conclusions of the experiment. Abbreviations that appear in the abstract must be defined before they are first used.

Keywords

List up to 5 key words in alphabetical order and separated by comma at the end of the abstract. The first letter of each of the key word can be in upper/ lower case.

Introduction

This section should be concise, with no subheadings, following the key words. It should justify the research problem and specify the hypothesis to be tested.

Materials and Methods

This part should contain sufficient details so that all procedures can be reflected. It can be divided into subsections if several methods are described. It should include year and place of study.

Results (may be combined with results)

The content of this section should permit full comprehension of the data reported in figures and tables without repeating the number extensively within the text.

Discussion (may be combined with results)

A comprehensive discussion section is required to justify the results. Normally a comparison between your results and results from previous works should be given in the Discussion

Conclusions

This should clearly explain the main findings of the work highlighting its implications and relevance.

Acknowledgments

Acknowledgments of people, grants, funds, etc. should be placed in a separate section before the reference list. The names of funding organizations should be written in full. Please check this section carefully before publication, as amendments or corrections are not allowed after publication.

SHORT COMMUNICATIONS

Short Communications typically describe research techniques, apparatus, and observations which were not confirmed normally by repetition (preliminary findings based on a single experiment). These articles are usually shorter than research papers and there are no individual abstract, introduction, materials and methods, results and discussion. Instead, they are written in continuous form without any sub headings.

References

1. In general, not more than 10-15 references would be required. Recent and relevant not more than 20 years old references are encouraged.
2. All references quoted in the text must appear at the end of the article and vice-versa. The spellings author's names and dates or years at the two places should be carefully checked.
3. The references should include names of all authors, years (within brackets), full title of the article, full name of the journal (in italics) (no abbreviations),

volume number, issue number, and pages. For book or monograph, the name of the publisher should also be given as well as its volume, edition and relevant pages.

4. The references cited together in the text should be arranged chronologically. The list of references should be arranged alphabetically on author's names, and chronologically per author.
5. References from standard scientific journals should be preferred, while those concerning unpublished data are generally to be avoided or mentioned as 'Personal communications' in the text. These need not be given in the reference list. A few examples for correct citation of references in the list are given below:

The references in the bibliography should be listed alphabetically adopting the following style:

Journal Article

Buhler, D.D., and Mester, T.C.(1991). Effect of tillage systems on the emergence depth of giant and green foxtail. *Weed Science*, 39, 200-203.

Mowla, G.M., Mondal, M.K., Islam, M.N., and Islam, M.T. (1992). Farm level water utilization in an irrigation project. *Bangladesh Rice Journal*, 3 (1&2), 51-56.

Rahman, M.M. (1990). Infestation and yield loss in chickpea due to pod borer in Bangladesh. *Bangladesh Journal of Agricultural Research*, 15(2), 16-23.

Book/Bulletin/Reports/Series

Bhuiyan, S.I. (1982). Irrigation system management research and selected methodological issues. *IRRI research paper series no 81*. Los Banos, Manila.

De Datta, S.K. (1981). Principles and practices of rice production. Los Banos, Manila.

International Rice Research Institute. (2000). International rice trade: a review of 1999 and prospects for 2000. *International Rice Commission Newsletter*, IRRI, Manila.

Steel, R.G.D., and Torrie, J.H. (1980). Principles and procedures of statistics: A biometrical approach. 2nd ed. McGraw-Hill, New York.

Siddiky, N.A., ed. (2017). Sustainable goat farming for livelihood improvement in South Asia. SAARC Agriculture Centre, Dhaka, Bangladesh, p.190

Chapter in a Book

David, H., and Easwaramoorthy. (1988). Physical resistance mechanisms in insect plant interactions. p. 45-70. In Ananthakrishnan, T.N., and Rahman, A, ed., *Dynamics of insect plant interactions: Recent advances and future trends*. Oxford and IBH Publication, New Delhi.

Johnson, D.W., and Todd, D.E. (1998). Effects of harvesting intensity on forest productivity and soil carbon storage. p. 351–363. In R. Lal et al. ed., *Management of carbon sequestration in soils*. Advances in Soil Science. CRC Press, Boca Raton, FL.

Conference/Symposium/ Proceedings

Joshi, B.K. (2004). Crossing frequency and ancestors used in developing Nepalese mid and high hill rice cultivars: Possible criteria for yield improvement and rice genes conservation. p. 502-523. In Proc. *National Conference on Science and Technology*, 4th, Vol. 1. 23-26 March, 2004. NAST, Kathmandu, Nepal.

Ramanujam, S., ed. (1979).*Proceedings of International Wheat Genet Symposia*, 5th, New Delhi, India. 23–28 February 1978. Indian Soc. Genet. Plant Breeding, Indian Agric. Res. Inst., New Delhi.

Dissertation

Singh, A.A. (2005). Weed management approaches and modeling crop weed interaction in soybean. M. Sc. (Ag.) thesis. Tamil Nadu Agricultural Univ., Coimbatore.

Online publication

Venugopal, D. (2000). Nilgiri tea in crisis: Causes consequences and possible solutions. Retrieved October 11, 2000 from http://www.badaga.org.

Online journal article

Doerge, T.A. (2002). Variable-rate nitrogen management creates opportunities and challenges for corn producers. *Crop Manage*. doi:10.1094/cm-2002-0905-01-RS.

Tables

1. Each table must be typed on a separate sheet (not to be included in the text) and numbered consecutively in the same order as they mentioned in text.
2. The title should fully describe the contents of the table and explain any symbol or abbreviation used in it as a footnote, using asterisks or small letters viz. a, b, etc.
3. Tables should be self-explanatory, not very large (< 10 columns in portrait and <14 columns in landscape formats respectively) and may cover space up to 20-25% of the text.
4. Maximum size of table acceptable is that can be conveniently composed within one full printed page of the journal. The large sized tables should be suitably split into two or more small tables.
5. Standard abbreviations of units of different parameters should be added between parentheses.
6. The data in the tables should be corrected to minimum place of decimal so as to make it more meaningful.

7. Vertical lines should not be used to separate columns. Similarly, horizontal lines should be used only where these are necessary, not in the body of the article.
8. The tables should be typed double spaced and placed immediately after reference. All the tables should be cited in the text.

Figures

1. Figures may be given in place of tables where a large number of values are presented that can be interpreted through figures. In no case the same data should be presented in both tables and figures. All the figures must be referred in the text.
2. Originals of the figures should be no larger than twice the final size, of good quality and printed clearly in black on plain white paper or in color. The figures may be sized to fit within the columns of the journal (8 cm width for single column or 17 cm for columns i.e. full page).
3. Lines should be bold enough to allow the figure to be reduced to either single or double column width in the journal.
4. Black and white photographs are also accepted if these are necessary to improve the presentation and quality of the article.
5. Imported figure from any other published manuscript is not accepted

Some useful hints

1. All scientific or technical names as well as all data and facts must be rechecked carefully before submitting the manuscript.
2. Dates and years may be mentioned as 28 May 2007, 28 May to 7 June, and 28-30 May instead of May 28, 2007, 28 May-7 June, and 28 to 30 May, respectively.
3. Avoid numerals and abbreviations at the beginning of a sentence; spell out or change the word order if necessary.
4. A comma may be used for data in thousands or more such as 10,000 or 2,30,000 etc. Alternatively, these data can also be presented as 10.0 or 230.0 if a common expression such as ' $x10^3$' is used in tables or figures. Avoid expressing data in 'lakhs', instead use 'thousand' or 'million'.
5. Only standard abbreviations should be used and these should invariably be explained at first mention. Avoid use of self-made abbreviations such as Rhizo., Azo., buta, isop. etc. for *Rhizobium*, *Azotobacter*, butachlor, isoproturon, respectively.
6. For names of plant protection chemicals, the first letter of the name need not be capitalized for scientific names but should be capitalized for trade names. All the names should be checked very carefully.
7. Use of unnecessary abbreviations and treatment symbols such as T1, T2 etc.

under Materials and Methods or tables without actually using these under Results and Discussion should be avoided.

8. All weights and measurements must be in SI or metric units. Use kg ha^{-1}, or t ha^{-1} but not q ha^{-1}. Do not follow the style g/ha, mg/kg, mg/l, mg/g, ml/l or g per ha, etc
9. Use % after numbers, not per-cent, e.g. 7%. In a series or range of measurements, mention the units only at end, e.g. use 30, 100, 170 and 300 C.10. Numeral should be used whenever it is followed by a unit measure or its abbreviations e.g. 1 g, 3m, 5h, 6 months etc. Otherwise, words should be used for numbers one to nine and numerals for larger ones except in a series of numbers when numerals should be used for all in the series.
10. For the composition of fertilizers, manures, crops or soil, the elemental forms (K, P, Mg etc.) should be used and not the oxides.
11. Statistical analysis of data in the standard experimental design should be sound and complete in itself with both ±SE (Standard Error of means) and CD (Critical Difference) or LSD (Least Significant Difference) (P=0.05) values given for comparison of treatment means in tables and figures.
12. Use multiplication sign (×) not a alphabet x for indicating multiplication, crossing, etc

Submission checklist:

Before final submitting the manuscript the authors must check the followings in the list:

Please check the relevant section in this Guide for Authors for more details.

Ensure that the following items are present:

One author has been designated as the corresponding author with contact details:

• E-mail address

• Full postal address

Manuscript:

- Keywords are included
- All figures are included with relevant captions
- All tables (including titles, description, footnotes)
- All figures and table citations in the text match the files provided
- Manuscript has been 'spell checked' and 'grammar checked'
- All references mentioned in the Reference List are cited in the text, and vice versa
- Permission has been obtained for use of copyrighted material from other sources (including the Internet)
- Journal policies detailed in this guide have been reviewed
- Referee suggestions and contact details provided

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