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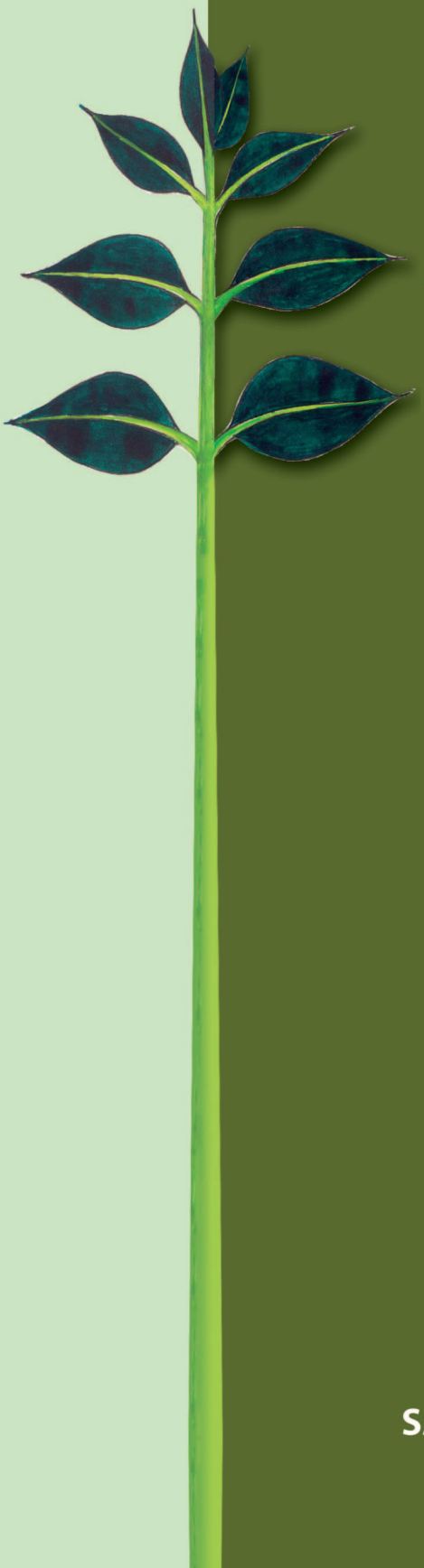

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SAARC J. Agri., 16(2): 1-12 (2018) *DOI: https://doi.org/10.3329/sja.v16i2.40254*

MUTANTS AND WEATHER PARAMETERS AFFECTING THE POPULATION DYNAMICS OF THREE MAJOR INSECT PESTS OF MUNGBEAN

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ABSTRACT

The study was conducted to know the abundance of aphid, flea beetle and pod borer on the mutants viz., MBM-07-Y-1, MBM-07-Y-2, MBM-656-51-2, MBM-527-114, MBM-07-(S)-2, MBM-347-13, MBM-390-94-Y, MBM-427-87-3, MBM-80 (Local) and a variety BARI moog-6 and the role of weather parameters on the population dynamics of insects at the Agricultural Farm of Patuakhali Science and Technology University from April to June, 2015. Results revealed that the tested mutants did not show resistance against aphid, flea beetle and pod borer. Mutant MBM-347-13 had the lowest number of flea beetle while mutant MBM-427-87-3, MBM-80(LCAL) and MBM-527-114 had the highest number of flea beetle indicating higher susceptibility to flea beetle. Mutant MBM-390-94-Y had the lowest abundance of aphid while BARI moog-6 had highest aphid abundance. Mutant MBM-347-13 had lowest number of pod borer and MBM-427-87-3 had highest abundance of pod borer followed by MBM-07(S)-2 and BARI moog-6. Flea beetle abundance gradually increased with decreasing average temperature while aphid and pod borer abundance gradually increased with increasing average temperature. In case of humidity, flea beetle abundance increased very slightly with increasing average humidity but aphid abundance increased very slightly with increasing average humidity. Pod borer abundance was low with high average humidity and then increased slightly due to decrease of humidity and finally declined with increasing humidity.

Keywords: Aphid, flea beetle, pod borer, *Vigna radiata*, temperature, relative humidity

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INTRODUCTION

Mungbean (*Vigna radiata* L.) is an excellent and easily digestible dietary source of vegetable protein. This pulse protein is rich in lysine that is deficient in rice. When it is eaten in combination with wheat, rice and other cereals, it provides a balanced diet for millions of people. According to FAO (1999) recommendation, a minimum intake of pulse by human should be 80g per day, whereas it is 14.19g in Bangladesh (BBS, 2005). This is because of the fact that national production of the pulses is not adequate to meet our national demand. Mungbean seed contains 52% carbohydrate, 26% protein, 10% moisture, 4 % minerals and 3% vitamins (Kaul, 1982). Hence, mungbean is the best of all pulses from nutritional point of view (Khan et al., 1982). Being leguminous, this crop maintains soil fertility by fixing the atmospheric nitrogen (Malik, 1994). Mungbean is originated in South East Asia (India, Burma, and Thailand region) and widely grown in India, Pakistan, Bangladesh, Burma, Thailand, Philippines, China, Indonesia and in parts of East and Central Africa, West Indies, USA and Australia (Gowda and Kaul, 1982). In Bangladesh mungbean is grown three times in a year covering 39302 ha with total yield of 31610 metric tons (BBS, 2014). It is tropical and sub-tropical crop resistant to high temperature and in many countries grown as a summer crop and can be cultivated in a wide range of soil. It is sensitive to cloudy weather and cannot tolerate frost (Gowda and Kaul, 1982). There are many constrain responsible for the low yield of mungbean. The poor yield is largely due to varietal aspect, climatic factors, management practices, insect pests and diseases (Rahman et al., 1981).

There are 64 species of insects attack mungbean (Lal, 1985) from seedling to harvest and budding is the most preferred and attractive stage to insects but a total of 16 species have been reported to attack mungbean in Bangladesh. Among them green jassid, bean fly, bean stem fly, whitefly, hairy caterpillar, galerucid beetle and aphids infesting the crops at the seedling stage, vegetative stage and continue to flowering stage while the spotted pod borer damage flower buds, flowers and pods of mungbean (Rahman, 1991). Of these insects pests, white fly, stemfly, hairy caterpillar, and pod borer are the most damaging (Gowda and Kaul, 1982; Rahman et al., 1981). The flea beetles feed on the cotyledons, making the severe innumerable round holes on leaves of young plants and ultimately dried the older damaged leaves of mungbean. Pod borer is one of the serious pests of mungbean in Bangladesh (Rahman et al., 1981), in India (Sehgal and Ujagir, 1988) and other tropical and sub-tropical countries. The larvae enter into the inflorescence and start feeding the flowers, later they cripple leaves together making nets and nets with leaves, flowers and young pods. They remain inside the nets hiding themselves and eat the young seeds after boring the pods (Rahman et al., 1981). Aphids cause damage to mungbean from flowering onwards and severe infestations most likely reduce plant vigor and yield. Honeydew produced by aphids promotes sooty mould which reduces photosynthesis (Rahman et al., 1981). In view of the above facts, the present research was undertaken to evaluate 9 mutants and a check variety of summer mungbean

against aphid, flea beetle and pod borer under natural field condition and to know the impact of these mutants and weather parameters on the population dynamics of aphid, flea beetle and pod borer of mungbean.

MATERIALS AND METHODS

The experiment was carried out at the Agricultural Farm of Patuakhali Science and Technology University during April to June, 2015. The experiment field is located at $22^0$37′ N latitude and $89^0$10′ E longitudes. The area is covered Gangetic Tidal Floodplains and falls under Agroecological Zone "AEZ- 13". The area lies at 0.9 to 2.1 metre above mean sea level (Iftekhar and Islam, 2004). The experimental area experiences sub-tropical climate with high temperature and it decreased when the season proceeded towards rabi The climate was characterized by medium rainfall, high humidity and high temperature. Nine mutants viz., MBM-07-Y-1, MBM-07-Y-2, MBM-656-51-2, MBM-527-114, MBM-07-(S)-2, MBM-347-13, MBM-390-94-Y, MBM-427-87-3, MBM-80 (Local) and a variety BARImoog-6 were used as study materials. The seeds were collected from Plant Breeding Division, Bangladesh Institute of Nuclear Agriculture, Mymensingh. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The whole field was divided into 3 unit blocks and each unit block was divided into 10 unit plots. The treatments were randomly distributed in the plots within a block. The total number of plots were 30 and unit plot size was 3.0m×2.0m. The distance between two unit plots was 0.75m and between block to block was 1.0m. The seeds were sown on the 2ndApril, 2015 at the rate of 11 kg ha^{-1}. The seeds were placed in the line continuously at a depth of 6-7cm and covered by loose soil by hand. Line to line distance was 30 cm. Urea (@ 50 kg ha^{-1}), triple superphosphate (@ 85 kg ha^{-1}) and muriate of potash (@ 35 kg ha^{-1}) were applied as the sources of N, P_2O_5 and K_2O, respectively. Whole amount of urea, TSP and MOP were applied in the field uniformly during the final land preparation. The plants were exposed to natural insect pests infestation and insecticide was not applied during the experimental. Data on different parameters were recorded at 37 and 47 days after sowing (DAS) aphid, at 14, 21 and 30 DAS for for flea beetle and at 50, 57 and 65 DAS for pod borer. Percentage of plant damaged by flea beetle was determined by eye estimation. The total number of infested and healthy plants or leaves was recorded from 15 randomly selected plants of each plot to determine the level of infestation by aphid and flea beetle.

The total number of leaves was counted and percentage of flea beetle infested leaves was calculated. The percentage of pod infestation was calculated by observing 10 randomly selected plants from each plot. During experimental period data on temperature and relative humidity (RH) were collected from the Patuakhali meteorological office.

Statistical analysis

Data were analyzed by using MSTAT software. Means were separated by using Duncan's Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

Abundance of aphid

Mean number of aphid plant^{-1} at 37, 47 DAS is presented in Table 1. At 37 DAS, significantly the highest number of aphid plant^{-1} was recorded on BARI moog-6 (7.66) followed by that of MBM-427-87-3 (5.33). The lowest number of aphid plant^{-1} was observed on mutant MBM-07-Y-1 (1.00) which statistically similar to that of MBM-390-94-Y (1.00), MBM-07-Y-2 (1.00) and MBM-527-114 (1.00).

At 47 DAS, significantly the highest number of aphid plant^{-1} was also recorded on BARI moog-6 (20.66) and the lowest number of aphid plant^{-1} was recorded on the mutant MBM-390-94-Y (2.00) (Table 1).

Table 1. Mean number of aphid plant^{-1} at 37, 47 days after sowing DAS on nine mutants and a variety of mungbean

Mutants/variety	Mean number of aphid plant^{-1}		Mean
	37 DAS	47 DAS	
MBM-07-Y-1	1.00c	5.67cd	3.34cd
MBM-07-Y-2	1.00c	3.00ef	2.00d
MBM-656-51-2	2.66c	7.34c	5.00c
MBM-527-114	1.00c	5.00de	3.00cd
MBM-07(S)-2	1.34c	6.67cd	4.00cd
MBM-347-13	1.34c	7.33c	4.34c
MBM-390-94-Y	1.00c	2.00f	1.50d
MBM-80(LCAL)	1.67c	6.00cd	3.84cd
MBM-427-87-3	5.33b	15.67b	10.50b
BARI moog-6	7.66a	20.66a	14.16a
LSD (5%)	1.830	2.141	2.321
CV (%)	5.16	11.36	8.16

Within column means followed by same letter (s) are not significantly different at 5% level by DMRT.

It was evident that the aphid abundnace plant^{-1} was the highest on BARI moog-6 which was highly susceptible to aphid followed by that of mutatants MBM-427-87-3. MBM-656-51-2, MBM-07(S)-2 and MBM-347-13. The mutant MBM-390-94-Y was the least susceptible to aphid followed by MBM-07-Y-2 and MBM-527-114. None of the tested mutants showed complete resistance against aphid while mutant MBM-390-94-Y was found comparatively tolerant to aphid among the tested mutants and variety.

Abundance of flea beetle

Mean number of flea beetle per 15 plants at different days after sowing (DAS) of tested mungbean mutants is presented in Table 2. At 14 DAS, significantly the highest number of flea beetle per 15 plants (41.67) was observed in the mutant MBM-427-87-3. The second highest number was recorded in variety BARI moog-6 (32.34) which was statistically similar to that of MBM-527-114 (31.34). However, significantly the lowest number of flea beetle was observed in the mutant MBM-07-Y-2 (14.33).

At 21 DAS, significantly the highest population of flea beetle (45.00) was recorded in the mutant MBM-80(LCAL) followed by MBM-527-114 (41.33) and MBM-427-87-3 (36.34). The lowest number of flea beetle was found in the mutant MBM-347-13 (19.00) (Table 2).

At 30 DAS, the mutant MBM-80(LCAL) also had the highest population of flea beetle (25.00) followed by MBM-07(S)-2 (23.00). The lowest population of flea beetle was recorded in the mutant MBM-347-13 (13.34) which was statistically similar to MBM-656-51-2 (14.67). The number in mutant MBM-07-Y-2 was statistically identical to that of BARI moog-6. Likewise, the number in mutant MBM-527-114 (21.67) was statistically similar to that of mutant MBM-427-87-3 (20.66) (Table 2).

Table 2. Abundance of flea beetle on nine mutants and a variety of mungbean at different days after sowing (DAS)

Mutants/variety	Mean number of flea beetle 15 plant^{-1}			Mean
	14 DAS	21 DAS	30 DAS	
MBM-07-Y-1	21.34d	31.00e	17.00de	23.11c
MBM-07-Y-2	14.33e	23.34g	17.67d	18.45d
MBM-656-51-2	20.66d	30.33e	14.67ef	21.89c
MBM-527-114	31.34b	41.33b	21.67bc	31.44a
MBM-07(S)-2	25.66c	34.66cd	23.00ab	27.78b
MBM-347-13	21.66d	19.00h	13.34f	18.00d
MBM-390-94-Y	23.00d	26.66f	19.33cd	22.99c
MBM-80 (LCAL)	25.34cd	45.00a	25.00a	31.78a
MBM-427-87-3	41.67a	36.34c	20.66bc	32.89a
BARI Moog-6	32.34b	32.67de	17.67d	27.56b
LSD (5%)	2.599	2.341	2.452	2.610
CV (%)	12.29	9.45	10.25	13.52

Within column means followed by same letter (s) are not significantly different at 5% level by DMRT.

It was evident that the mutants MBM-427-87-3, MBM-80(LCAL) and MBM-527-114 had the highest population of flea beetle which indicated that these mutants were highly susceptible to flea beetle. On the other hand, mutant MBM-347-13 had the lowest population of flea beetle which indicated that the mutant was the least susceptible to flea beetle. Among all the tested mutants, none showed complete resistance against flea beetles however, MBM-347-13 showed tolerant against the attack of flea beetle.

Abundance of pod borer

Mean number of pod borer per 10 plants at 50, 57 and 65 days after sowing is presented in Table 3. At 50 DAS, the lowest abundance of pod borer (2.00) was recorded on the mutant MBM-347-13 while no significant differences were observed among that of mutants MBM-07-Y-2 (2.50), MBM-656-51-2 (2.56) and MBM-390-94-Y (2.60). The mutant MBM-427-87-3 had the highest number of pod borer per 10 plants (5.89).

At 57 DAS, the mutant MBM-347-13 had also the lowest number of pod borer per 10 plants (2.00) which was statistically similar to that of MBM-390-94-Y (2.33). The mutant MBM-427-87-3 had the highest number of pod borer per 10 plants (7.00) which was statistically similar to that of BARI moog-6 (6.00) (Table 3).

At 65 DAS, the lowest abundance of pod borer per 10 plants was recorded in the mutant MBM-07-Y-1 (2.61). No significant differences were observed among that of mutants MBM-656-51-2 (3.00), MBM-527-114 (4.00), MBM-347-13 (4.00) and MBM-390-94-Y (3.47). The mutant MBM-427-87-3 had the highest number of pod borer per 10 plants (7.67) which was statistically similar to that of BARI moog-6 (7.00) and MBM-80(LCAL) (7.00) (Table 3).

Table 3. Mean number of pod borer per 10 plants on nine mutants and a variety at 50, 57 and 65 days after sowing

Mutants/variety	Mean number of Pod borer 10 plants^{-1} at			Mean
	50 DAS	57 DAS	65 DAS	
MBM-07-Y-1	3.47d	4.33b	2.61d	3.47cd
MBM-07-Y-2	2.50de	3.78bcd	4.80bc	2.50de
MBM-656-51-2	2.56de	2.89de	3.00cd	2.56de
MBM-527-114	3.30cde	3.00cde	4.00cd	3.30cd
MBM-07(S)-2	5.00ab	4.75b	6.50ab	5.00ab
MBM-347-13	2.00e	2.00e	4.00cd	2.00e
MBM-390-94-Y	2.60de	2.33e	3.47cd	2.60de
MBM-80(LCAL)	3.00cde	4.00bc	7.00a	3.00cde
MBM-427-87-3	5.89a	7.00a	7.67a	5.89a

Mutants/variety	Mean number of Pod borer 10 plants^{-1} at			Mean
	50 DAS	57 DAS	65 DAS	
BARI moog-6	4.00bc	6.00a	7.00a	4.00bc
LSD (5%)	1.319	1.087	1.902	1.023
CV (%)	6.17	5.87	8.27	2.46

Within column means followed by same letter (s) are not significantly different at 5% level by DMRT.

From the mean of all mutants and a check variety the pod borer population was higher in mutant MBM-427-87-3 and was susceptible to pod borer followed by that of MBM-07(S)-2 and BARI moog-6. MBM-07-Y-1, MBM-527-114 and MBM-80(LCAL) were found moderately susceptible while MBM-347-13 was the least susceptible to pod borer followed by MBM-390-94-Y, MBM-07-Y-2 and MBM-656-51-2.

Effect of weather parameters on flea beetle

Temperature and abundance of flea beetle showed a negative correlation with each other (r = 0.509) (Fig.1). The coefficient of determination (R^2= 0.259) revealed that 25.9 % variation in the population of flea beetle accrued by the variation in mean temperature. Humidity and abundance of flea beetle showed a negative correlation (r = 0.100) (Fig.2). The coefficient of determination (R^2= 0.010) revealed that very slight i.e., 1.00 % variation in the population of flea beetle accrued by the variation in humidity.

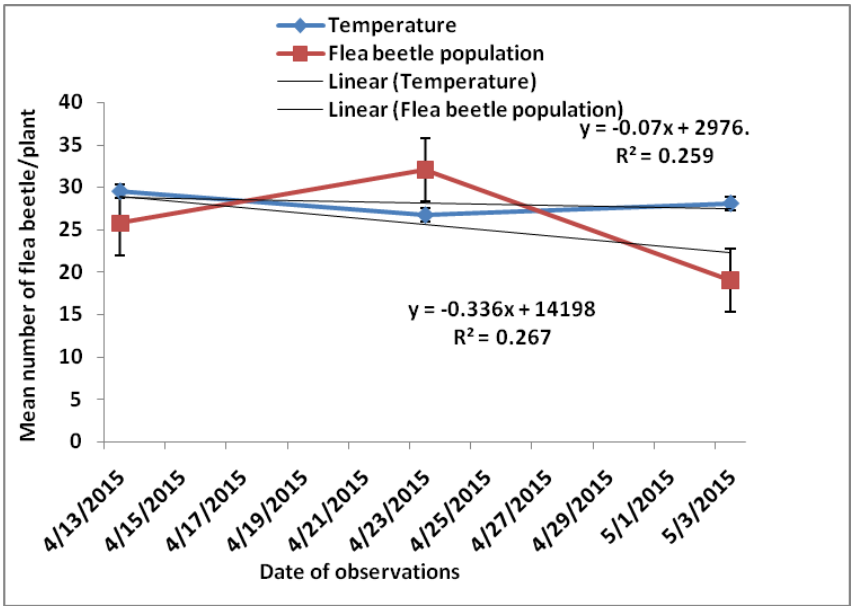

Figure 1. Relationship between mean number of flea beetle with temperature.

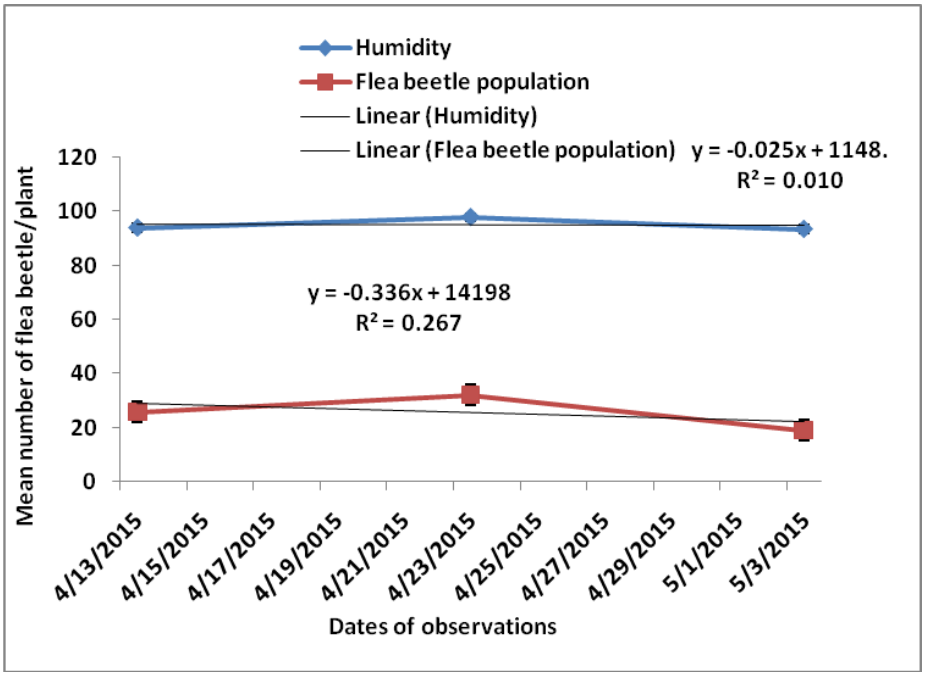

Figure 2. Relationship between mean number of flea beetle with average humidity.

Effect of weather parameters on aphid

There was a positive relationship (r = 1.00) of the abundance of aphid with temperature (Fig.3). The coefficient of determination (R^2= 1) revealed that 1.00 % variation in the abundance of aphid accrued by the variation in mean temperature. Average humidity and the abundance of aphid showed a positive correlation with each other (r = 1.00) (Fig. 4). The coefficient of determination (R^2= 1) revealed that 1.00 % variation in the population of aphid accrued by the variation in average humidity.

Effect of weather parameters on pod borer

There was a positive relationship of pod borer with temperature (Fig. 5). Average humidity and abundance of pod borer showed a negative relationship with each other (Fig. 6).

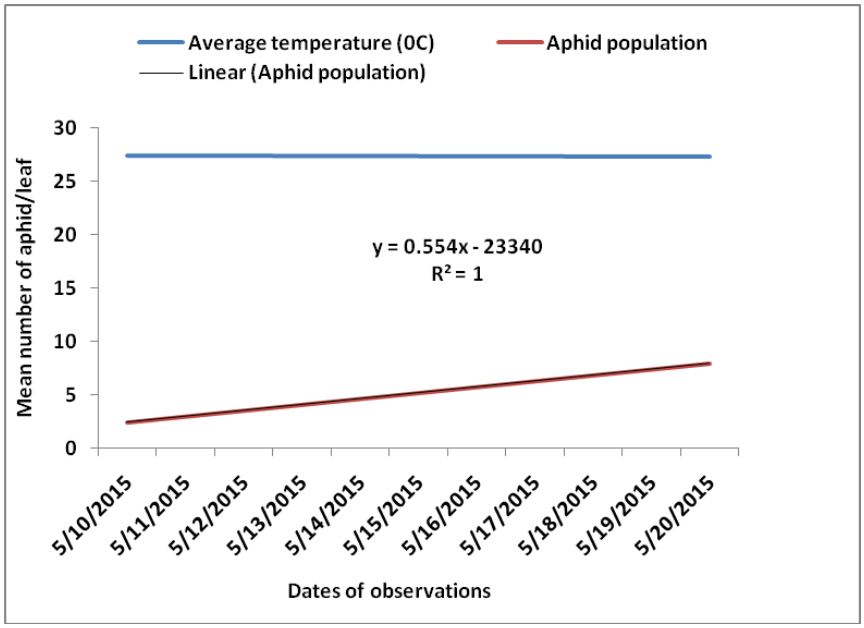

Figure 3. Relationship between mean number of aphid with average temperature.

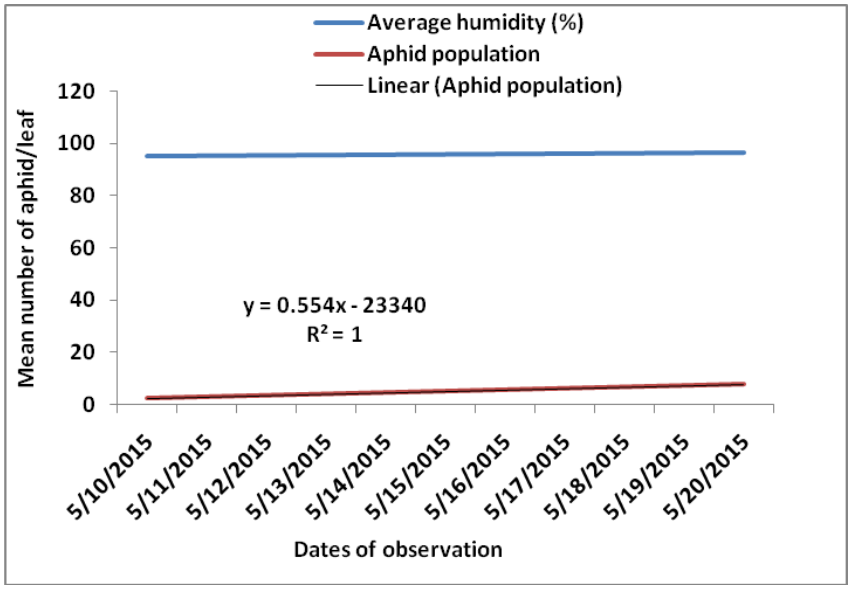

Figure 4. Relationship between mean number of aphid with average humidity.

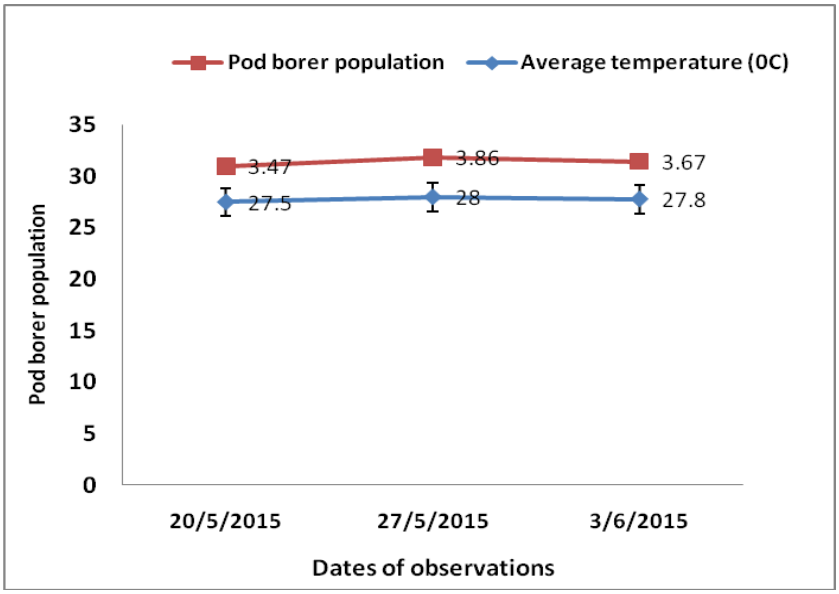

Figure 5. Relationship between mean number of pod borer with average temperature.

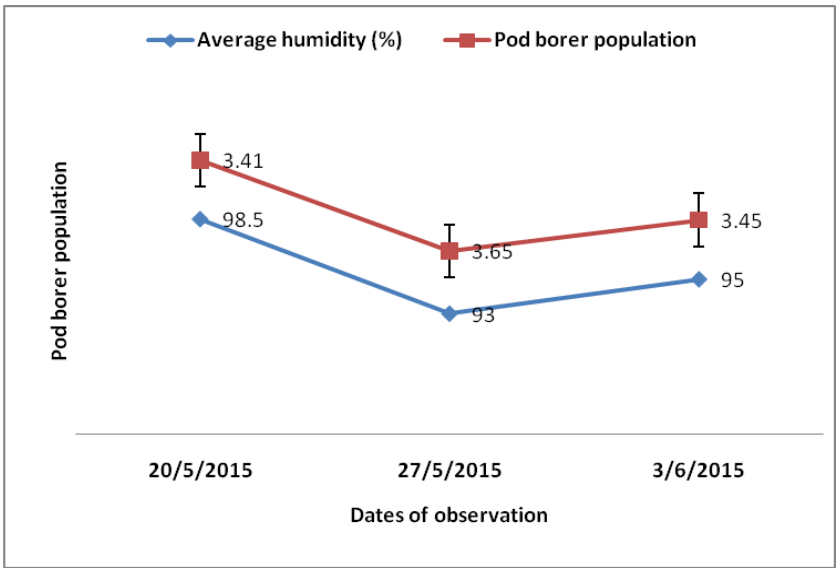

Figure 6. Relationship between mean number of pod borer with average humidity.

The incidence and development of all the insect pests are much dependent upon the prevailing weather conditions; which showed agreement with Aheer et al. (1994). Similar findings are also observed by Hossain et al. (2009) who found that the

incidence and population fluctuation of various insect pests was very much dependent on the prevailed climatic conditions of the cropping season. Sarkar et al. (2008) observed the severity of major insect pests on mungbean which might be due to variable weather conditions in the two cropping seasons. Mishra and Mukherjee (2015) reported that the three sap feeders of green gram *viz.*, white fly (*Bemisia tabaci*), thrips (*Megaleurothrips distalis*) and aphids (*Aphis craccivora*) were found to attack greengram from 2nd week of January and attainted their peak, i.e., 7, 6 and 26 (nos. plant^{-1}) at 60, 63 and 68 DAS. Qu and Kogan (1984) reported that the pod borer was wide spread in the tropics and subtropics and also found to be the most damaging pest in mungbean in Asia. Nitharwal and Kumawat (2009) found a significant negative correlation of jassid, whitefly and thrips with maximum temperature and positive correlation of thrips with minimum temperature. Yadav and Singh (2013) found a significant negative correlation of spotted pod borer with minimum relative humidity and positive correlation with sunshine and evaporation.

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SOIL ORGANIC CARBON STOCKS UNDER DIFFERENT LAND USES IN CHURE REGION OF MAKAWANPUR DISTRICT, NEPAL

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ABSTRACT

Soil C sequestration through enhanced land use is a good strategy to mitigate the increasing concentration of atmospheric CO_2. A study was conducted in Chhatiwan VDC of Makawanpur District to compare soil organic carbon (SOC) stocks of four main land use types such as forest, degraded forest, Khet and Bari land. Stratified random sampling method was used for collecting soil samples. Organic carbon content was determined by Walkley and Black method. Total SOC stock of different types of land followed the order: as Forest (110.0 t ha^{-1}) > Bari (96.5 t ha^{-1}) > Khet (86.8 t ha^{-1}) > Degraded land (72.0 t ha^{-1}). The SOC% declined with soil depths. The SOC% at 0–20 cm depth was highest (1.26 %) that recorded in the forest soils and lowest (0.37%) at 80-100cm depth in degraded forest land. Thus, the SOC stock varied with land use systems and soil depths. The study suggests a need for appropriate land use strategy and sustainable soil management practices to improve SOC stock.

Keywords: Chure, land use, soil organic carbon, soil depth

INTRODUCTION

Soil is a complex mixture of mineral nutrients, organic matter, water, air, and living organisms determined by various environmental factors such as climate, parent materials, relief, organisms, and time factors (Bajracharaya et al., 2004). Soil contains three times more carbon (C) than in atmosphere and 3.8 times more C than in biotic pool (Shrestha et al., 2012). Soils are a potentially viable sink for atmospheric carbon (Lal et al., 2012). Soil carbon sequestration is a process of transforming carbon dioxide from the atmosphere into the soil through crop residue and other organic solids, and in a form that is not immediately remitted. (Sundermeier et al., 2005). This transformation has the potential to reduce atmospheric CO_2, thereby slowing global warming and mitigating climate change.

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Soil biodiversity has a positive impact on SOC pool. All other factors being equal, ecosystems with high biodiversity sequester more C in soil and biota than those with reduced biodiversity (Lal et al., 2012). Carbon sequestration from atmosphere can be advantageous from both environmental and socio-economic perspectives. The environmental perspective includes the removal of CO_2 from the atmosphere, the improvement of soil quality, and the increase in biodiversity (Batjes, 2014); while socio-economic benefits include increased yields (Sundermeier et al., 2005). Thus, soils play a vital role in maintaining a balanced global carbon cycle. Globally, approximately 1500 Pg of C is stored in soils in the form of organic matter, approximately twice the atmospheric C pool (Sundermeier et al., 2005). Consequently, the soil organic-carbon pool and its loss through emissions have a significant influence on the CO_2 concentration in the atmosphere, and thus on global climate change driven by the greenhouse effect (Genxu et al., 2002).

Land use and soil management practices can significantly influence SOC dynamics and C flux from the soil (Post and Kwon, 2000). SOC content exhibits considerable spatial variability according to land uses and soil depths. Land use and vegetation type influence soil erosion and C dynamics through its effect on SOC contents, CO2 flux and dissolved organic carbon (DOC) leaching from soil (Bajracharaya et al., 2004). Land management that exerts the least soil disturbance contributes to increased SOC accumulation, while intensive disturbance results in lower SOC and consequent soil degradation (Post and Kwon, 2000). Soil thus, can be a source or a sink of atmospheric carbon depending upon land use and soil management. Gradual conversion of forest and grassland to cropland has resulted in significant change, depending upon various factors and processes operating in the systems, the most significant being land use, land use change, soil erosion and deforestation (IPCC, 2000). Widespread erosion and landslides along with reduction of the productive forest area and misuse of agrochemicals are the major environmental problems especially in Chure region of Nepal (Regmi, 1999), lowering the carbon sequestration. Spatially distributed estimates of SOC pools and soil C sequestration are important requirements for understanding the role of soils in the global carbon cycle and for assessing potential biosphere responses to climatic change or variation (Lal et al., 2012). In this context, there is dire need to conduct research related to C pools and C sequestration among different land uses. Few studies have been conducted in Nepal, in related to carbon sequestration in the context of climate change and the studies are focused on biomass carbon and haves largely ignored soil organic carbon. Therefore, the present study aims to provide the base line information for carbon sequestration potential of soil of different land uses in Chure region of central Nepal.

MATERIALS AND METHODS

Study Area

The study site, Chhatiwan Village Development Committee (VDC) of Makawanpur district, experiences tropical climate with characteristic monsoon rainfall and three distinct seasons: hot and dry summer (March to Mid-June), hot and moist rainy season (Mid June to September) and cold and dry winter (October to February). Average rainfall is 2274 mm in Churia hills. The majority soil in this area is sandy loam. The study area is environmentally vulnerable due to occurrence of landslide, soil erosion, and deforestation.

Broadly, the study site can be divided in-to forest, cultivable land (Khet and Bari) and degraded land. The area is mainly tropical forest mixed with *Shorea robusta* forest with other species such as *Terminalia alata, Terminalia belerica* etc. Two major types of agricultural lands are Khet (irrigated low land) and Bari (rain-fed upland). Maize and potato are the principal crops in Bari and paddy is the principal crop in Khet. Farmyard manure and compost (made from forest products used for animal bedding) are the major nutrient sources for crops in addition to some chemical fertilizers. Degraded land characterized by barren areas, with presence of trees, shrubs, or grasses is vulnerable to soil erosion. The criteria for classification of land uses are - Forest: all land with forest cover i.e. with trees whose crown covers are at least 10% not being used primarily for purpose other than forestry (DFRS, 1999) and degraded land: land with stocking class i.e. crown cover is less than 10%, or area with prominent soil erosion, deforestation and degradation etc. (DFRS, 1999). They may contain barren areas, trees, shrubs, or grasses. Khet refers to land use which is relatively alluvial flat land/ lowland/terraces having irrigation facility during drying season, primarily cultivated for rice, paddy etc. (Paudel and Thapa, 2001) and Bari refers land with higher elevation than Khet land i.e. rain fed terraces suitable primarily for maize, potato, millet etc. (Paudel and Thapa, 2001).

Soil Sampling

The stratified random sampling method was adopted for the study. The starting point was selected randomly. Samples were taken from each land uses with W-type shape sample. Soil samples were collected from five replicated sites of each land uses types within the study area. In each sampling site, a pit of 30cm by 100 cm pit was dug and undisturbed soil core samples were taken by a cylindrical core sampler (5.5cm diameter and 10cm height) from the 0-20cm, 20-40cm, 40-60cm, 60-80cm and 80-100cm soil depths for the determination of bulk density. The bulk soil samples were oven dried, sieved through a 2mm sieve and carefully stored before basic considerations.

Soil Analysis

Soil bulk density was determined using core sampling method (Blake and Hartge, 1986). Oven dry (at 105 ^{0}C) soil samples were used for moisture correction. Bulk density was calculated by the following formula;

Bulk density (gm cm^{-3}) = (Oven dry weight of soil in gm)/ (Volume of the soil in cm^3)

Where,

Volume of the soil= Volume of core – Volume of the stone

Soil Organic carbon (SOC) percent was analyzed using the Walkley-Black wet oxidation method as described by Walkley and Black (1934). This method is based on the oxidation of organic matter by potassium dichromate ($K_2Cr_2O_7$) and sulfuric acid mixture, followed by titration of the excessive dichromate by a ferrous ammonium sulfate ($Fe(NH_4)2(SO_4)2*6H_2O$). Total SOC was estimated using following formula by (Chhabra et al., 2003).

SOC= Organic carbon content % x soil bulk density (gm cm^{-3}) x thickness of horizon (cm)

RESULTS

Bulk Density

The BD increased with soil depths for all land uses. The minimum BD, 1.04 gm cm^{-3}, was found at the top soil i.e. 0-20 cm depth in the forest land and the maximum BD, 1.45 gm cm^{-3}, was found at 80-100 cm depth in Khet land (Table 1).

Table 1. Bulk density (gm cm^{-3}) of soil at different depths in different land uses

Soil Depth (cm)	Land uses							
	Forest		Degraded land		Khet		Bari	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
0-20	1.04	0.12	1.31	0.04	1.24	0.4	1.15	0.05
20-40	1.13	0.08	1.36	0.05	1.35	0.06	1.29	0.06
40-60	1.19	0.04	1.39	0.06	1.37	0.10	1.33	0.05
60-80	1.21	0.07	1.40	0.06	1.39	0.10	1.41	0.07
80-100	1.32	0.11	1.43	0.08	1.45	0.08	1.44	0.09
Average	1.18		1.38		1.36		1.32	

Higher BD was found in cultivable land which was probably due to continuous cultivation and a lower turnover of organic matter in soil as cultivation often leads to soil compaction which increases BD and decreases pore volume. On the contrary, Bhandari and Bam (2013) reported higher BD in forest land.

Bulk density of a soil is a dynamic property depending on the soil structural conditions. The increasing soil BD with increasing soil depths could be due to lower organic matter contents, less aggregation, fewer roots and other soil dwelling organisms and soil compaction (Liefeld et al., 2005). Chaudhari et al (2013) reported that with increasing soil depth the organic matter content of soil decreases and which leads to decrease in porosity of soil and also to the compaction of soil.

Soil Organic Carbon

SOC was found ranging from 0.45% to 1.26% in the study area (Table 2).

Table 2. SOC percentage of different land uses at different soil depths

Soil Depth (cm)	Average SOC percentage (%)							
	Forest		Degraded land		Khet		Bari	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
0-20	1.26	0.0	0.71	0.05	0.91	0.10	1.01	0.10
20-40	1.02	0.10	0.58	0.05	0.73	0.09	0.86	0.11
40-60	0.93	0.10	0.52	0.02	0.61	0.06	0.71	0.08
60-80	0.81	0.09	0.45	0.05	0.53	0.07	0.62	0.03
80-100	0.72	0.07	0.37	0.03	0.45	0.06	0.51	0.05

The SOC content percent was found higher in the upper layers which could be related to higher soil organic matter content, and less influence of parent materials. As reported by Lal (2005), most of the soils contained between 0.3 and 11.5% Soil Organic Matter (SOM) in the surface 20 cm of mineral soil. The forest soil had the highest SOC percentage (0.95%), followed by Bari (0.74%), Khet (0.65%) and degraded land (0.52%). This result agrees well with that of Islam and Weil (2000), who reported that the SOC content percent in the soil of cultivated land was lower than that of forest and grassland. The lower SOC content in Khet and Bari soil probably reflects continuous cultivation with minimum addition of SOM and sandy textured soil (Poudel and Thapa, 2001).

Table 3. Total SOC of different land uses at different soil depths

Soil Depth (cm)	SOC(t ha^{-1})							
	Forest		Degraded land		Khet		Bari	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
0-20	26.2	3.96	18.60	1.69	22.6	2.20	23.2	3.36
20-40	23.1	1.75	15.77	1.71	19.7	2.61	22.2	3.93
40-60	22.1	2.97	14.45	0.57	16.7	1.23	18.9	2.92
60-80	19.6	1.09	12.60	1.09	14.7	3.02	17.5	1.77
80-100	19.0	3.88	10.58	0.74	13.1	2.69	14.7	2.43
Total	110.0		72.0		86.8		96.5	

Comparison of SOC in natural and cultivated land gives some insight into the management effect on SOC content. It indicates that land use practices have made significant impact on total SOC stock. A decreasing trend in soil organic carbon was seen for all the land uses with increase in soil depths, which ranged from 26.2 t ha^{-1}to 19.0 t ha^{-1}for Forest soil for the depths 0-20 cm to 80- 100 cm respectively. The trend was the same for cultivated land (both Bari and Khet) and degraded forest land, where SOC values decreased with increasing depths, ranging from 23.2 t ha^{-1} to 14.7 t ha^{-1}, 22.6 t ha^{-1} to 13.1 t ha^{-1} and 18.6 to 10.6 t ha^{-1} respectively for Bari, Khet and degraded forest land.

The total SOC stock followed the order as Forest > Bari > Khet > Degraded land with the total SOC stock in each land use being 110.0 t ha^{-1}, 96.5 t ha^{-1}, 86.8 t ha^{-1} and 72.0 t ha^{-1} respectively.

Relation between BD, SOC percentage and Total SOC

Relationship between BD and carbon content of soil is non-linear or polynomial based on the type of soil and amount of parent materials available in soil (Chaudhari et al., 2013). The study concluded that three is a linear relationship (adjusted R^2 value 0.74, 0.94, 0.92 and 0.87 for forest, degraded forest, Khet and Bari, respectively) between SOC stock and organic carbon percentage for all types of land use (Figures 3, 4, 5 and 6).

However, there was no linear relationship (adjusted R^2 value 0.30, 0.19, 0.08 and 0.07 for forest, degraded forest, Khet and Bari, respectively) between bulk density and total SOC content. This implies that the quantity of organic carbon stored in the soil is governed by SOC percentage and BD. Thus, improvement of SOC percentage and soil quality maintenance is an important intervention to increase SOC storage capacity.

DISCUSSION

The soil organic carbon in forest soil depends upon forest types, climate, moisture, temperature and types of soil (Chaudhari et al., 2013). The variables investigated for the study were soil BD, SOC content percent and SOC stock. Significant variations in all tested variables were found among all the land uses. There was a distinct variation in the BD with respect to soil depths among all the land uses. Indeed there was a gradual increase of BD with the increase in soil depth for all four land uses. The top soil layer had lower BD indicating that the soil was better for plant growth compared to other soil depths which could be attributed to the higher SOC content percent in the top layer of soil. The BD depends on various factors such as compaction, consolidation and amount of SOC present in the soil but is negatively correlated to the organic carbon content (Morisada et al., 2004). Ali et al (2017) also reported SOC stock had negative correlation with BD as lower soil layer contains lower SOC content. Lower organic contents, less aggregation, fewer roots and other soil dwelling organisms and compaction caused by the weight of the overlying layers increases the bulk density of soil (Brady 1999).

The study shows that soil under forest land had higher SOC than cultivated land and degraded land. As we could see cultivated land was highly disturbed with tillage farming and heavy uses of chemical fertilizers whereas the forest land was less disturbed with adequate vegetation cover. Conventional agricultural system can decrease soil organic carbon (Liefeld et al., 2005). Higher SOC stock in the forest soil can be attributed to higher organic input from litter fall and lower soil disturbance compared to cultivated land (Dhakal et al., 2010). Shrestha and Singh (2008) reported that leaf litter, and root litter inputs play a major role in forest soil carbon dynamics. Comparatively lower SOC stock in degraded forest land might be due to lower amount of organic matter which could be attributed to lower inputs of leaf litter, low decomposition of fine roots, greater soil disturbance, lower root biomass and loss of vegetation cover (Lal et al., 2012). Depth wise average SOC results are mentioned in Figure 2. A significantly higher SOC stock was observed in the top soil than in other depths within the profile of the same land use. As we can see SOC decreases with the increase in soil profile depth. It may be due to less leaching of dissolved organic content (DOC) and hence less accumulation at lower depths. The ease and speed with which SOC becomes available is related to the soil organic matter fraction in which it resides. SOM contains approximately 58% of organic carbon (Sakin et al., 2011). Leaf litter inputs, root biomass, vegetative residues and available nutrients of the soil played an important role and influenced the amount of organic matter in soils (Shrestha and Singh, 2008). Ali et al (2017) also reported that higher SOC stock in forest land compared to arable land and pasture land. Comparatively higher SOC stock in top layer could be due to high organic matter content, low soil disturbance, greater root biomass and returns of vegetative residue. The results seem to be justified as Bajracharya (2004) who concluded that land use had a significant effect on the SOC content in the soil profile and soils under natural vegetation had a higher SOC content in soil compared to cultivated soil.

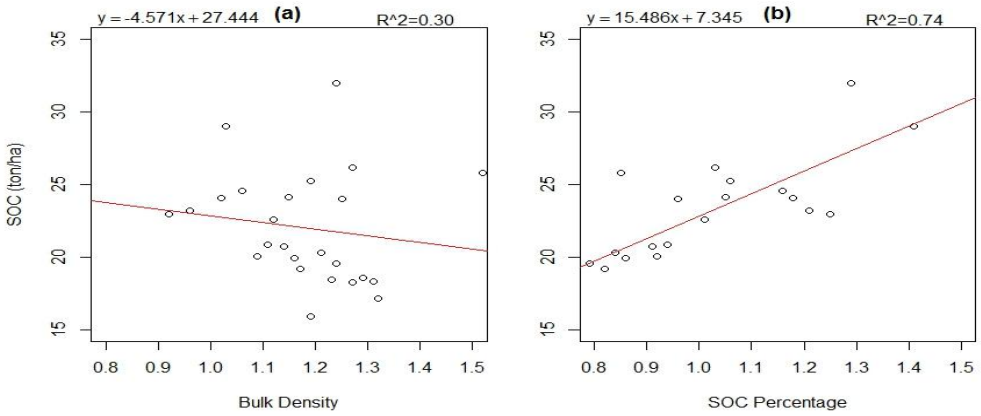

Figure 3. (a) SOC content (t ha^{-1}) and BD (g cm^{-3}), (b) SOC Content (t ha^{-1}) with organic carbon content percentage of forest

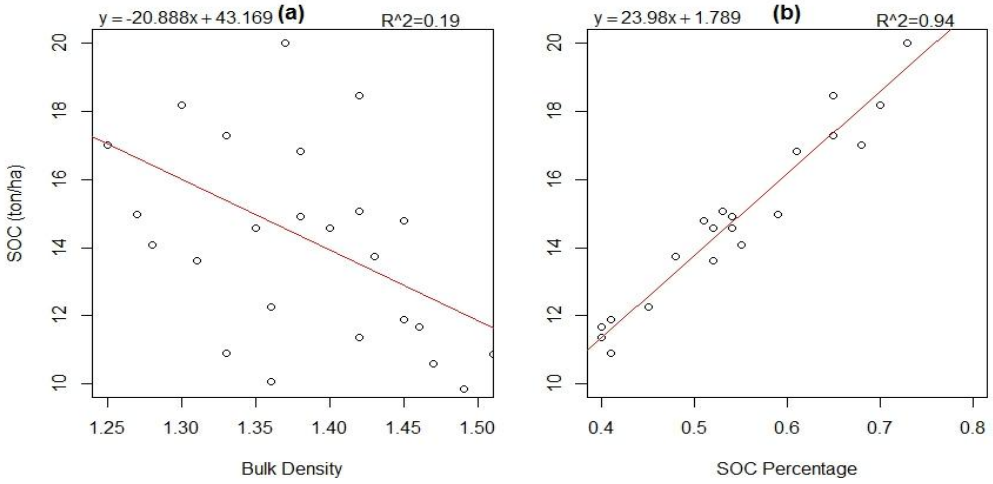

Figure 4. (a) SOC content (t ha^{-1}) and BD (g cm^{-3}), (b) SOC Content (t ha^{-1}) with organic carbon content percentage of Degraded land

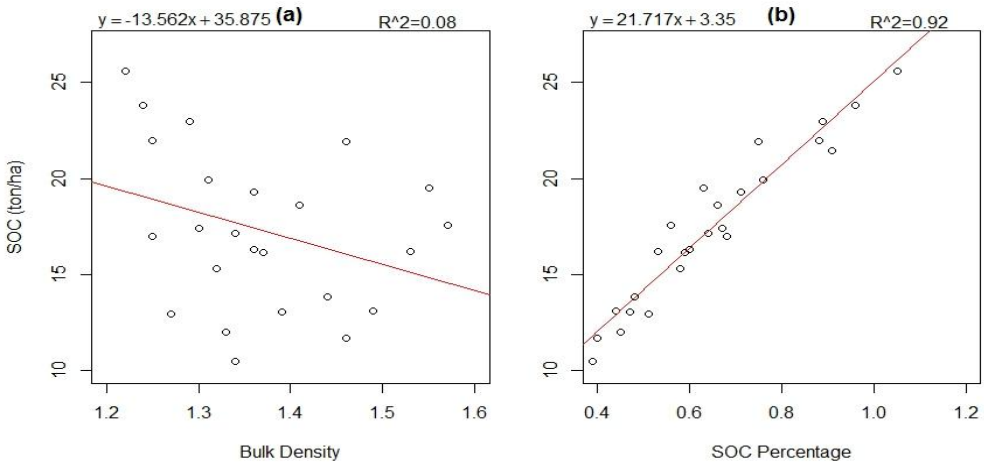

Figure 5. (a) SOC content (t ha^{-1}) and BD (g cm^{-3}), (b) SOC Content (t ha^{-1}) with organic carbon content percentage of Khet

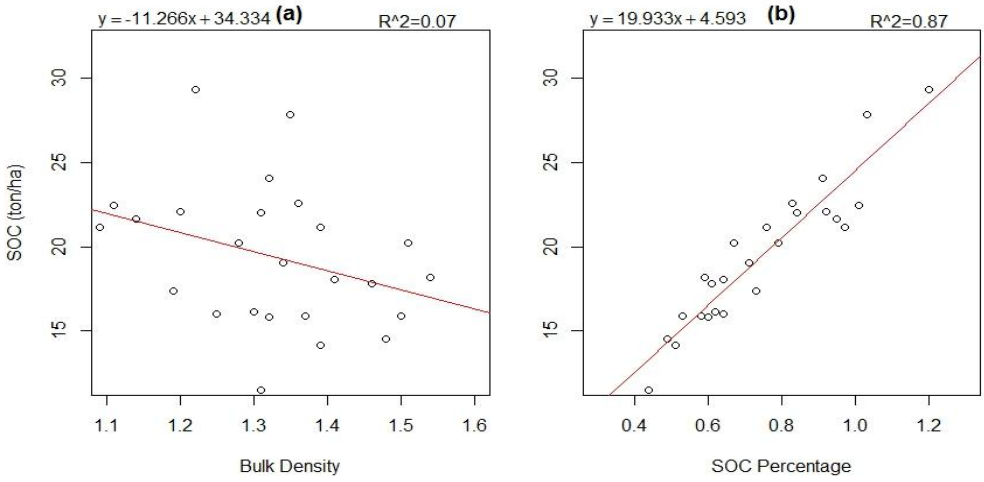

Figure 6. (a) SOC content (t ha^{-1}) and BD (g cm^{-3}), (b) SOC Content (t ha^{-1}) with organic carbon content percentage of Bari

CONCLUSION

Land use and soil depth both affected SOC stock significantly. The total SOC followed the order as Forest > Bari > Khet > Degraded forest land with the total SOC stocks of each land uses as 110.0 t ha^{-1}, 96.5 t ha^{-1}, 86.8 t ha^{-1} and 72.0 t ha^{-1} respectively. Bulk density (BD) was found to be increasing with increases in the depth of soil profile for all the land uses which shows negative co-relation with SOC whereas soil organic carbon percentage was decreasing with increase in depth of the soil profile. This implies that the quantity of organic carbon stored in the soil and land use is governed by SOC percentage and BD. Hence, appropriate land use strategy and sustainable soil management practices are most important interventions to increase SOC storage capacity of different land use systems.

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NUTRIENT PROFILE OF FIVE FRESHWATER FISH SPECIES

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ABSTRACT

The nutrient profile of five freshwater fish species viz., *Mystus vittatus, Ompok bimaculatus, Channa striata, Wallago attu* and *Pangasianodon hypophthalmus* were studied. The proximate composition data shows that the moisture and fat content differed significantly (P<0.01) among the fish species. The fat content was significantly higher in *P. hypophthalmus* and *M. vittatus*. The moisture was significantly higher in *C. striata*. The potassium content was significantly (p<0.01) higher in *C.striata*. *M.vittatus* shows higher content of calcium. The other trace minerals like iron, copper and zinc contents of fish did not differ significantly among the species. The vitamin A content is maximum in *O.bimaculatus* whereas vitamin D content is higher in *Mystus vittatus*. The palmitic acid was significantly (p<0.01) higher in *M. vittatus*. The oleic acid was significantly (p<0.01) higher in *C. striata* and *W. attu.* The linoleic acid content was significantly (p<0.05) higher in *P. hypophthalmus*. One of the important PUFA i.e. DHA was significantly higher in *O. bimaculatus* and *C.striata*. The PUFA content was significantly (p<0.05) higher in *O.bimaculatus* and *P.hypophthalmus*. Among the amino acids, arginine, histidine, threonine and isoleucine were higher in *P.hypophthalmus*. *C.striata* and *W. attu* contain high amount of Tryptophan. Glutamic acid was high in *O.bimaculatus* and Aspartic acid was high in *C. striata*. The energy content was maximum in *P. hypophthalmus*. The nutrient profile of these fish species revealed that they were rich in all the essential nutrients required by human being. The information on nutrient profile of fish will give a guideline to dieticians, nutritionists, medical practitioners, researchers to advice consumers to take fish in their daily diet as a health food.

Keywords: Amino acid, Fatty acid, Freshwater fish, Mineral and vitamin, Proximate composition.

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INTRODUCTION

Fish is a healthy food and is a major player in human nutrition, ensuring about 20% of protein intake to a third of the world's population which is more evident in developing countries (Bene et al., 2007). India is a global biodiversity hotspot and harbours more than 10% of the global fish diversity and thereby has the potential to meet the daily requirement of the essential nutrients for human health and can also provide food and nutritional security (Mohanty et al., 2019). On a fresh weight basis, fish contains a good quantity of protein about 13-20% and contains all the essential amino acids. The fat content of fish ranges from 0.2 to 15% and it varies depending on the species as well as the season in general and fish has less fat than red meats. Fat from fish species contain the poly unsaturated fatty acids (PUFA) viz., EPA (eicosapentaenoic acid) and DHA (docosahexaenoic acid) are ω-3 fatty acids which are essential for growth of children and prevents the occurrence of cardiovascular diseases such as coronary heart diseases (Calder, 2004). In pregnant women, the presence of PUFA in their diet helps in proper brain development among unborn babies and prevents preterm delivery and low birth weight (Mohanty et al., 2016 and Giri et al., 2010). Fish plays an important role in human nutrition as an efficient vehicle to deliver health promoting long chain ω-3 polyunsaturated fatty acid (PUFA) in the diet (Sargent, 1997).

Micronutrients like vitamins and minerals are also present in the fish muscle. The micronutrients fulfil the hidden hunger of human population and prevent many disorders due to deficiency of such micronutrients (Mohanty et al., 2016a). Fish is soft, easy to cook, easily digestible than meat so young children can be fed fish as balanced diet with some cereals. The high nutritional value of fish is mainly related to their digestible protein which is an excellent source of EAA (Sanchez-Alonso, 2007). Fish protein occupies an important position in human nutrition (Nargis, 2006). FAO (2014) reported that a protein of 150g of fish flesh can provide 50-60% of an adult's daily protein requirements.

Some information are available on nutrient composition of Indian major carp (Paul et al., 2015a, and 2016), catfish (Paul et al., 2015), air breathing fish (Paul et al., 2017), minor carps (Paul et al., 2018) and Freshwater fish (Paul et al., 2019). Keeping in view of importance of eating fish, the nutrient profile of four freshwater fish (*M. vittatus*, *C. striata*, *W. attu* and *P. hypophthalmus*) and one freshwater catfish (*O. bimaculatus*) were studied to document on protein, fat, minerals, vitamins, amino acids and fatty acids which will be helpful to dieticians, nutritionists, researchers, fish farmers and related stakeholders to promote fish as health food in human nutrition.

MATERIALS AND METHOD:

Collection of Samples: The samples were collected from various places of different states of India viz, West Bengal and Odisha. The weight and length ranges for the five different freshwater fish species were i.e. 5-25g and 7-14 cm for *Mystus vittatus*,

20-200g and 15-30cm for *Ompok bimaculatus*, 150-850g and 25-55cm for *Channa striata*, 250-2000g and 35-65cm for *Wallago attu* and 400-2000g and 30-60cm for *Pangasianodon hypophthalmus*. The number of fish samples collected were viz., *M. vittatus* (n=59), *O. bimaculatus*, n=52, *C. Striata*, n=52, *W. Attu*, n=48 and *P. hypophthalmus*, n=56. The sampling procedure and the sample preparation for analysis were done as per Sankar et al. (2010) and Paul et al. (2018)

Proximate and mineral composition analysis:

Proximate composition of fish tissue samples were done as per AOAC (1995). The mineral assay was done as per AOAC (2005) and Paul et al. (2014) using atomic absorption spectrophotometer (AAS) (Thermo Fisher, M Series). The energy content of fish samples were analysed by Bomb Caloric Method as per the AOAC (2005).

Fatty acid analysis

Pooled samples were extracted for fatty acid analysis following the method of Folch et al. (1957) using chloroform: methanol (2:1, v/v) solvent system that contained 0.01% butylated hydroxyl anisole as an antioxidant. Fatty acid methyl esters (FAMEs) were prepared by the transmethylation with boron trifluoride in methanol from lipids fraction according to Metcalfe et al., (1996). The fatty acid methyl esters were quantified by injecting 1µL (50:1 split ratio) into a Gas Chromatograph (GC) (Perkin Elmer; CLARUS 480). The oven temperature was programmed from an initial temperature at 30^{o}C rising to 140^{o}C (hold time 4 min.) and up to 200^{o}C. Nitrogen gas was used as a carrier gas. The injection port and the flame ionization detector were maintained at 260^{o}C and 300^{o}C. GC operating software "Total Chrome" was followed. Identification of individual FA was identified by comparing with retention times to those of standards (SUPELCO, Cat.No. 47885-U) and quantified by comparing with respective areas.

Amino Acid Analysis

The amino acid analysis was done as per the method of Ishida et al. (1981). The amino acid samples were analysed from Edward Food Research and Analysis Centre Limited, Nilgunge, Kolkata- 700121(www.efrac.org) as per Paul et al. (2018).

Vitamin analysis

The fat soluble vitamins Retinol (Vitamin A), Cholecalciferol (Vitamin D) are assayed in High Performances Liquid Chromatography. Fish tissue (30g) was grinded with anhydrous sodium sulfate and extracted the oil using 2:1 chloroform: methanol after adding BHA as antioxidants (Folch et al., 1957).The sample preparation was done as per Sankar et al. (2010) and vitamin analysis was done in High Performance Liquid Chromatography from Edward Food Research and Analysis Centre Limited, Nilgunge, Kolkata- 700121 (www.efrac.org) as per Paul et al. (2018).

Statistical Analysis:

The data were statistically analysed as per Snedecor and Cochran (1968) by one way ANOVA and the least significance difference (LSD) was used for comparison of the mean values. The data are presented as Mean± S.E.

Results and Discussion

The proximate compositions of the five freshwater fish are presented in table 1. The moisture content was significantly (P<0.01) higher in *C.striata* vis-à-vis other fish species. The fat content was significantly (P<0.01) higher in *P. hypophthalmus* and *M.vittatus* compared to other fish species. Both protein and ash content of freshwater fish did not differ significantly among these fish.

Table 1. Proximate composition (% as such basis) of five freshwater fish species

Particulars	*M. vittatus*	*O. bimaculatus*	*C. striata*	*W. attu*	*P. hypophthalmus*
Moisture**	72.67^{a}±0.30	75.17^{a}±0.34	76.11^{b}±0.17	74.25^{a}±0.42	70.82^{a}±0.53
Protein	14.94±0.20	13.93±0.19	14.46±0.21	14.13±0.19	15.41±0.29
Fat**	6.91^{bc}±0.18	3.92^{a}±0.15	2.09^{a}±0.09	3.58^{a}±0.15	7.17^{c}±0.39
Ash	2.57±0.08	2.12±0.05	2.28±0.04	1.97±0.05	1.88±0.07

[a, b, c] Means bearing different superscripts in a row differ significantly**(P<0.01)

The moisture content of *C.striata* (76.11%), *O.bimaculatus* (75.17%) and *W. attu* (74.25%) were similar to the moisture content of magur and singhi as reported by Paul et al. (2015); eel (*M. armatus*) reported by Pal and Ghosh (2013) and in *A. mola*, *G. chapra* and *P. chola* as reported by Mazumder et al. (2008). The moisture content of *M.vittatus* (72.67%) and *P.hypophthalmus* (70.82%) were lower than the earlier report. Paul et al. (2017) reported that the moisture content of *Anabas testudineus* (68.00%) was lower than our findings. The protein content of these fish species in the present study was lower than the protein content of *Anabas testudineus* (16.91%) as reported by Paul et al. (2017). The fat content of freshwater fish studies ranged from 2.09 to 7.17%. There is an inverse relationship between moisture and lipid content of fish tissue (Wheeler and Morrissey, 2003 and Jankowska et al., 2007) also observed in fat and moisture content of *M. vittatus* and *P. hypophthalmus*. Our finding on fat contents were similar to magur and singhi (Paul et al., 2015), small indigenous fish species of Bangladesh (Mazumder, 2008), freshwater eel (Pal and Ghosh, 2013) and *Anabas testudineus* (Paul et al., 2017).

The ash content of five freshwater fish as studied ranged from 1.88 to 2.57%. Our results were in agreement with earlier reports (Mazumder et al., 2008, Paul et al., 2015, Bogard et al., 2015 and Chrisolite et al., 2015). The protein and ash content of *P. hypophthalmus* was similar to Thai pangas whereas fat content was lower and moisture content was higher than Thai pangas in the present work as reported

elsewhere (Bogard et al., 2015). The fat (9.5%) and protein content was higher in modhu pabda compared to our data protein and fat; but ash content (2.12%) was higher (16.20%) than the modhu pabda (0.90%) as reported by Bogard et al. (2015). The fat and ash content of *C. striata* was higher than shoal but protein content (14.46%) was lower than shoal (18.70%) as reported earlier (Bogard et al., 2015). However the protein content of *C. striata* of our finding was similar to protein content of *C.stiata* (Chrisolite et al., 2015). The protein and ash content of *M. vittatus* was similar to tengra whereas fat and moisture content was higher in tengra in comparison to our findings in *M. vittatus* (Bogard et al., 2015).

The total crude protein content of five freshwater fish species ranged from 13.93 to 15.41 (% as fresh basis); which seems to be of high dietary quality, being an animal sourced protein (WHO, 2007). Fat varies to a great extent compared to other proximate component of fish and it reflects the differences in the way fat is stored in particular species. It may also vary due to seasonal/lifecycle variations and the diet/food availability of the species at the time of sampling (Ababouch, 2005).

The mineral content of these five species is presented in table 2. Perusal of data showed Potassium content was significantly ($P<0.01$) higher in *C.striata* and *P.hypophthalmus*. The manganese content was significantly ($P<0.01$) higher in *P. hypophthalmus*. The sodium, iron, copper and zinc content did not differ significantly among the fish species. The Calcium content is presented in figure 2. The Calcium content was maximum in *M.vittatus* and followed by *O.bimaculatus*, *W. attu* and *P. hypophthalmus*. The sodium, potassium, iron, copper, zinc and manganese content of all species are shown in (Table 2). Sodium content varied considerably with a range from 36.66 to 51.65 (ppm). The sodium content of five fresh water fish was lower than the value as reported in magur and singhi (Paul et al., 2015). The sodium content of *P. Sutchi* (99.40ppm) was higher than the value reported in *P. hypophthalmus* (Chrisolite et al., 2015); whereas sodium content of *M. vittatus* in our study was higher than the value of *M. oar* as reported elsewhere (Chrisolite et al., 2015). The potassium content of the five freshwater fish was lower than the value in *M. oar* and *P. sutchi* (Chrisolite et al., 2015) and also in singhi and magur (Paul et al., 2015). The iron content of five freshwater fish ranged from 0.46 to 0.67 (ppm). The iron content of *O. bimaculatus* (0.46ppm) was higher than the iron value of *O. bimaculatus* (0.16) as reported by Ghosh et al. (2004). The iron content of *M. vittatus* and *P. hypophthalmus* were higher than the iron content of *M. oar* and *P. Sutchi* respectively as reported earlier (Chrisolite et al., 2015). The copper content ranged from 0.24 to 0.68 (ppm) in the fish species (table 2). Our results were in agreement with the copper content of *O. bimaculatus* with the modhu pabda. The copper content of *C. striata* was higher than the copper content of Shoal and the copper content of *P. hypophthalmus* was lower than Majhari Thai pangas are reported by Bogard et al. (2015). The zinc content of *O. bimaculatus* was higher than the earlier report of zinc content of *O. bimaculatus* (Ghosh et al., 2004) and modhu pabda (Bogard et al., 2015). However, the zinc content of *M. vittatus* and *W. attu* were lower than the zinc

content of *Mystus spp*. and *W. attu* as reported earlier (Chari et al., 2000). Our results on zinc content of freshwater fish were lower than the zinc content of singhi and magur (Paul et al., 2015). The manganese contents of fish in the present study were lower than the earlier reports (Paul et al., 2015 and Chari et al., 2000). The calcium content of five freshwater fish ranged from 150 to 255 (mg 100^{-1}). Our results were higher than the value of modhu pabda shoal and Thai pangas (Bogard et al., 2015); *W. attu* and *Mystus spp*. as reported by Chari et al. (2000). However, our results were in agreement with the calcium content of singhi and magur (Paul et al., 2016).

Table 2. Mineral content (ppm) of five freshwater fish species

Particulars	*M. vittatus*	*O. bimaculatus*	*C. striata*	*W. attu*	*P. hypophthalmus*
Sodium	36.92±5.24	47.70±2.74	39.66±5.30	51.58±6.25	51.65±3.88
Potassium**	70.48^{a}±16.14	126.55^{b}±6.13	170.60^{c}±4.95	112.10^{b}±5.10	129.33^{bc}±7.33
Iron	0.67±0.06	0.46±0.05	0.54±0.06	0.50±0.04	0.47±0.03
Copper	0.38±0.07	0.24±0.06	0.56±0.07	0.68±0.11	0.43±0.06
Zinc	0.54±0.03	0.68±0.07	0.49±0.06	0.38±0.02	0.49±0.06
Manganese**	0.08^{a}±0.01	0.17^{ab}±0.02	0.19^{ab}±0.02	0.11^{ab}±0.02	0.21^{b}±0.04

[a, b, c] Means bearing different superscripts in a row differ significantly**(P<0.01)

The fatty acid profile of five freshwater species are presented in table 3.The total saturated fatty acid (SFA) was significantly (P<0.01) higher in *Mystus vittatus* and followed by *W. attu*, *C. striata* and *O. bimaculatus*. The predominant SFA was palmitic acid which was significantly higher in *M. vittatus* and followed by *C. striata*. Another SFA stearic acid was significantly higher in *W. attu* and *P. hypophthalmus*. The total mono unsaturated fatty acid (MUFA) was significantly higher in *P. hypopthalmus* and followed by *C. striata* and *W. attu*. Oleic acid, a predominant MUFA was significantly (P<0.01) higher in *P. hypophthalmus*, *W. attu* and *C. striata*. Other MUFAs like myristoleic acid, pentadecenoic acid, palmitoleic acid and erucic acid also differed significantly (P<0.01) among the five fish groups.

The polyunsaturated fatty acids (PUFA) are one of the key fatty acids which are important from human health point of view. The linolenic acid was significantly (P<0.01) higher in *P. hypophthalmus* and *O. bimaculatus*. The γ-Linolenic acid was significantly (P<0.05) higher in *W. attu*. Another important as well as predominant PUFA, docosahexaenoic acid was significantly (P<0.05) higher in *C. striata* and *O. bimaculatus*. The total ω3 fatty acid was significantly (P<0.05) higher in *O. bimaculatus*, *P. hypophthalmus* and *C.striata*. The other fatty acids viz., EPA, arachidonic acid, eicosatrienoic acid, eicosadienoic acid, α Linolenic acid and Linolelaidic acid did not differ significantly among the fish species.

Table 3. Fatty acid profile (% of total fatty acid) of five freshwater fish species

Fatty acid	*M. vittatus*	*O. bimaculatus*	*C. striata*	*W. attu*	*P. hypophthalmus*
Butyric acid (C4:0)	ND	0.06±0.05	0.17±0.07	0.11±0.08	0.13±0.02
Caproic acid (C6:0)	ND	0.08±0.03	0.07±0.02	0.15±0.09	0.12±0.03
Caprylic acid (C8:0)	0.05±0.01	0.08±0.03	0.03±0.02	ND	ND
Capric acid (C10:0)	ND	ND	0.04±0.02	0.02±0.01	ND
Undecanoic acid (C11:0)	0.21±0.04	0.05±0.02	0.05±0.02	0.05±0.03	0.07±0.03
Lauric acid (C12:0)	0.01±0.02	0.47±0.07	0.25±0.23	0.43±0.07	0.32±0.20
Tridecanoic acid (C13:0)	0.15±0.10	0.53±0.22	0.95±0.09	0.66±0.40	0.16±0.06
Myristic acid** (C14:0)	1.83^{a}±1.04	7.03^{b}±0.35	0.45^{a}±0.14	5.54^{b}±0.36	5.98^{b}±2.13
Pentadecanoic acid (C15:0)	0.53±0.23	3.64±1.51	0.30±0.20	2.87±0.77	1.41±0.38
Palmitic acid** (C16:0)	68.53^{d}±1.88	27.60^{ab}±9.09	47.03^{c}±5.31	33.50^{b}±0.49	17.74^{a}±4.86
Heptadecanoic acid (C17:0)	1.16±0.03	1.97±0.61	0.43±0.40	1.80±0.70	0.10±0.01
Stearic acid** (C18:0)	3.29^{b}±0.10	5.79^{c}±0.63	1.62^{a}±0.02	10.60^{d}±2.82	12.00^{d}±1.25
Arachidic acid** (C20:0)	0.14^{b}±0.01	0.18^{b}±0.03	0.12^{b}±0.02	0.39^{c}±0.05	0.05^{a}±0.01
Heneicosanoic acid (C21:0)	1.33±0.16	2.16±1.37	0.09±0.01	0.94±0.29	0.65±0.05
Behenic acid (C22:0)	0.08±0.00	ND	0.14±0.01	0.88±0.34	0.13±0.04
Tricosanoic acid (C23:0)	0.45±0.11	1.03±0.34	0.62±0.46	0.92±0.12	0.39±0.27
∑SFA**	77.74^{c}±0.80	49.53^{b}±6.13	52.84^{b}±3.18	57.76^{b}±0.19	39.26^{a}±1.29
Myristoleic acid** (C14:1)	0.04^{ab}±0.01	0.07^{b}±0.01	0.16^{c}±0.02	0.14^{c}±0.06	0.02^{a}±0.01
Pentadecenoic acid** (C15:1)	0.46^{a}±0.44	0.24^{a}±0.12	1.15^{b}±0.03	0.12^{a}±0.09	0.22^{a}±0.11
Palmitoleic acid** (C16:1)	5.12^{c}±0.94	0.84^{a}±0.78	0.91^{a}±0.11	0.90^{a}±0.21	2.84^{b}±1.22
Heptadecenoic acid (C17:1)	0.32±0.12	0.18±0.11	0.06±0.02	ND	0.28±0.23

Fatty acid	*M. vittatus*	*O. bimaculatus*	*C. striata*	*W. attu*	*P. hypophthalmus*
Oleic acid** (C18:1n9c)	6.03^{a}±1.55	18.95^{b}±0.92	28.81^{c}±1.11	26.30^{c}±3.77	34.12^{d}±1.05
Elaidic acid (C18:ln9t)	ND	2.98±0.00	ND	ND	ND
Eicosanoic acid (C20:ln9c)	0.32±0.03	1.42±0.31	0.13±0.005	1.28±0.07	0.88±0.59
Erucic acid** (C22:1n9)	0.20^{a}±0.00	1.04^{d}±0.07	0.48^{b}±08	ND	0.87^{cd}±0.15
∑MUFA**	12.09^{a}±1.19	22.97^{b}±2.05	31.69^{c}±1.14	28.64^{c}±3.98	39.21^{d}±0.94
Linolelaidic acid (C18:2n6t)	0.07±0.02	0.10±0.03	0.11±0.04	0.13±0.03	0.03±0.02
Linoleic acid* (C18:2n6c)	2.75^{a}±0.18	8.24^{bc}±2.11	1.39^{a}±0.15	5.77^{b}±1.34	10.30^{c}±3.11
γ-Linolenic acid* (C18:3n6)	0.29^{bc}±0.12	0.35^{cd}±0.05	0.07^{a}±0.03	0.55^{d}±0.05	0.12^{a}±0.04
α Linolenic acid (C18:3n3)	3.52±1.71	8.67±2.40	1.40±0.98	1.32±0.32	4.95±2.85
Eicosadienoic acid (C20:2)	0.29±0.06	1.72±1.20	0.24±0.15	0.19±0.04	0.47±0.24
Eicosatrienoic acid (C20:3n6)	0.28±0.07	0.69±0.04	1.24±0.15	0.54±0.26	1.40±0.19
Eicosatrienoic acid (C20:3n3)	ND	1.08±0.45	0.40±0.09	0.85±0.50	0.31±0.02
Arachidonic acid (C20:4n6)	0.24±0.02	3.52±0.23	1.6±0.55	1.08±0.93	1.49±0.44
Eicosapentaenoic acid or EPA (C20:5n3)	1.61±0.51	0.13±0.03	4.81±0.46	2.80±2.51	1.54±0.56
Docosahexaenoic acid or DHA* (C22:6n3)	2.30^{b}±0.18	4.80^{c}±1.87	4.78^{c}±1.15	0.31^{a}±0.15	1.31^{a}±0.33
∑PUFA*	9.98^{a}±1.30	27.49^{c}±4.34	15.51^{ab}±4.32	13.61^{a}±3.98	21.59^{bc}±0.31
ω3: ω6	1.72±0.48	1.70±0.58	2.41±0.32	0.46±0.13	0.59±0.46
∑ω3*	6.26^{a}±1.45	15.76^{c}±0.88	11.33^{bc}±3.78	4.31^{a}±2.22	14.80^{c}±4.09
∑ω6	3.72±0.15	11.73±3.74	4.61±1.16	8.65±2.42	6.79±4.39

$^{a, b, c, d}$ Means bearing different superscripts in a row differ significantly* (P< 0.05); **(P<0.01), ND: Not detected, SFA- Saturated Fatty Acid, MUFA- Mono Unsaturated Fatty Acid, PUFA- Poly Unsaturated Fatty Acid

The fatty acid content of fish varies due to species, sex, size and other external factors like feed, temperature, salinity, geographical locations and general rearing condition (Sener et al., 2005). Kamler et al. (2001) reported that fatty acid in fish is derived from diet and its biosynthesis. The oleic acid was predominant MUFA and it was maximum in *P. hypophthalmus*. The oleic acid content of *W. attu* was similar to the oleic acid content of mrigal of size 501-2000g as reported by Paul et al. (2015). The PUFA content Mystus, Ompok, Channa, Wallago and Pangas were less than the SFA content. This result was in agreement with the earlier report in Indian Major Carp (Paul *et al*., 2015) and Koi (Paul et al., 2017). The hypothesis that the freshwater fish contains low PUFA as their feed is largely based on plant materials (Vlieg and Body, 1988). The PUFA content was maximum in *O. bimaculatus* (27.49%) which was in agreement with PUFA content of Catla of size 51-500g as reported earlier (Paul et al., 2015). Fish oils are rich in ω-3 fatty acids. The docosahexaenoic acid (DHA) content ranged from 0.31 to 4.78% and maximum in Channa; which was in agreement with DHA content of catla of size 501-2000g and rohu of size >2000g as reported by Paul et al. (2015). The Eicosapentaenoic acid was also maximum in *C. striata* (4.81%). The ω-3 fatty acids viz., DHA and EPA are essential and important fatty acids that enhance quality of life and lower the risk of premature death (Mohanty et al., 2016). DHA is proven to be essential to pre and post natal brain development whereas EPA influences mood and behaviour (Kidd, 2007). Consumption of fish and fish oils containing ω-3 fatty acids prevents cardio vascular diseases, arthritis, psoriasis etc (Kris-Etherton and Haris, 2002 and Giri et al., 2010). Freshwater fish species are also known to contain high amount of EPA and DHA (Wang et al., 1990).

The chain length varies from C14 to C20 of varying degree of unsaturation from saturated to poly unsaturated (Swapna et al., 2010). The different classes of fatty acids are saturated fatty acids (SFA), mono unsaturated fatty acids (MUFA) and poly unsaturated fatty acids (PUFA). Among the saturated fatty acids the palmitic acid was predominant which was in agreement with earlier reports (Paul et al., 2015, 2017 and Jakhar et al., 2012). The total SFA content of *M. vittatus* (77.74%) was maximum among other fish species and this content was similar to that of Rohu (Paul et al., 2015). The palmitic acid is considered to be as key to many metabolic processes in fish and other aquatic animals (Ackman and Eaton, 1966). The myristic acid was high in *O. bimaculatus* (7.03%). The myristic acid is used as flavouring agents in food items (Burdock et al., 2007). The tasty flavour of *O. bimaculatus* could be due to high content of myristic acid present in it. The MUFA content of *P. hypophthalmus* was similar to rohu, catla and magur as reported earlier (Paul et al., 2015, 2016).

The energy content of five freshwater fish species are presented in figure 5. The gross energy content was maximum in *P. hypophthalmus, W. Attu* and *O. bimaculatus*. The total energy content varied with a range of 504-591 Kcal $100g^{-1}$ which is related to the variation in fat content of freshwater fish and our result was higher than the

earlier reports (Schreckenbach et al., 2001, Chrisolite et al., 2015 and Bogard et al., 2015).

The vitamin A and D content (I.U. $100g^{-1}$) are presented in figure 1. Vitamin A content was maximum in *O. bimaculatus* and followed by *M. vittatus* whereas the vitamin D content was higher in *M. Vittatus* and *C. Striata* vis-à-vis other freshwater fish. Vitamin A content of these five fish ranged from 5.0-1058.0 (I.U $100g^{-1}$). The vitamin A content was maximum in *O. bimaculatus* and was higher than the vitamin A content of *A. testudineus* (Paul et al., 2017). Our data on vitamin A content of five freshwater fish was higher than the vitamin A content of some important fish of Bangladesh (Bogard et al., 2015). Liu (2003) reported that vitamin content from fish is readily available to the body compared to plant sources. Vitamin A plays a vital role for normal vision and bone growth; its derivative retinoic acid regulates gene expression in the development of epithelial tissue (Roos et al., 2003). The vitamin D content ranged from 5.0 to 384.0 (IU $100g^{-1}$). The vitamin D activate the innate immune system whereas dampen the adaptive immune system (Hewison, 2011); in addition to its role in bone development. Vitamin D content of *M. vittatus* was higher than the vitamin D content of *A. testudineus* (Paul et al., 2017). The vitamin D is also higher than the freshwater fish as reported by Bogard et al. (2015). Our data on vitamin A content of fish was higher than the vitamin A content of some important fish of Bangladesh (Bogard et al., 2015).

The essential amino acid content is presented in figure 3, where the Arginine, Threonine and Isoleucine were more in *P. hypophthalmus*. The histidine content was high in *P. hypophthalmus* and followed by *M. vittatus* and *O. bimaculatus*. The tryptophan was higher in *C. striata* and *W. attu* as depicted in figure 3.The Non Essential Amino Acid is presented in table 4. The Glutamic acid was more in *O. bimaculatus* and *M. vittatus*.

Figure 3 and 4 show the amino acid composition of the fish muscle of five freshwater fish species. Fish muscle is known to contain balanced amino acid composition (Venugopal et al., 1996 and Mohanty et al., 2014). Among the fish species Arginine, Histidine and Isoleucine were in higher amount in *P. hypophthalmus* vis-à-vis other fish species. Arginine plays an important role in wound healing, immune function, cell division, ammonia removal and hormone release. It is also the precursor for the biological synthesis of nitric oxide which plays an important role in neurotransmission, blood clotting and maintenance of blood pressure (Mohanty et al., 2014). The arginine content in *P. hypophthalmus* was similar to *A. testudineus* as reported by Mohanty et al., (2014). The histidine content in *P. hypophthalmus* was similar to *C. mrigala*, *S. weitei*, *S. commersonii* as reported earlier (Mohanty et al., 2014). Histidine is needed for growth and repair of tissue, for maintenance of myelin sheaths (Heimann, 1992). Histidine content was also rich in *M. vittatus* and *O. bimaculatus*. Isoleucine content of *P. hypophthalmus* was lower than the isoleucine content of other food fishes reported earlier (Mohanty et al., 2014).

Tryptophan is a precursor for serotonin, a neurotransmitter. Free tryptophan enters the brain cells to form serotonin. The tryptophan content of *C. reba* and *W. Attu* were similar to *S. waitei* and *S. Commersonii* as reported elsewhere (Mohanty et al., 2014). The glutamic acid content of *M. vittatus* and *O. bimaculatus* was lower than *H. fossilis* and *C. batrachus* as reported by Mohanty et al. (2014). Glutamic acid plays an important role in transmission reactions and required for key molecules viz., glutathione, required for removal of toxic peroxide and the poly glutamate folate cofactors. The Aspartic acid was maximum in *C. striata* and followed by *W. attu* and *M. vittatus*. Another NEAA glutamine was higher in *M. vittatus* and *O. bimaculatus*. The Asparagine was more in *W. attu* and *C. striata*.

The amino acid contents vary from fish species to species. Therefore, in general, arginine, histidine and isoleucine were rich in *P. hypophthalmus*. Tryptophan, asparagine and glutamine content were higher in *C. Striata* and *W. attu*. Aspartic acid was rich in *C. striata* and glutamic acid was rich in *O. bimaculatus*.

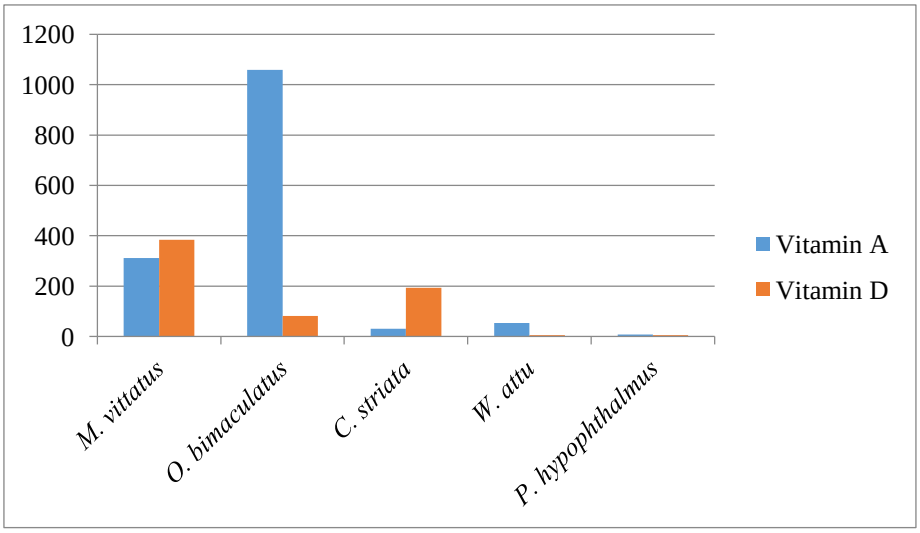

Figure 1. Vitamin A and D content (IU $100g^{-1}$) of five freshwater fish species

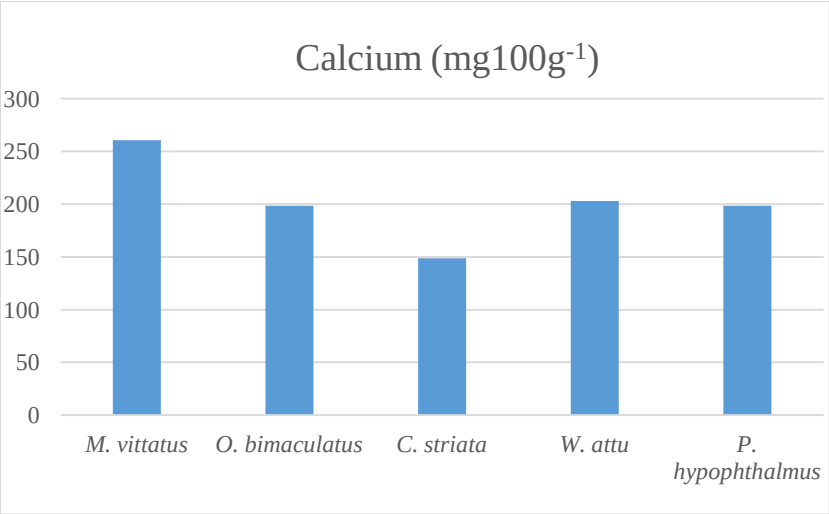

Figure 2: Calcium content (mg100g^{-1}) of five freshwater fish species

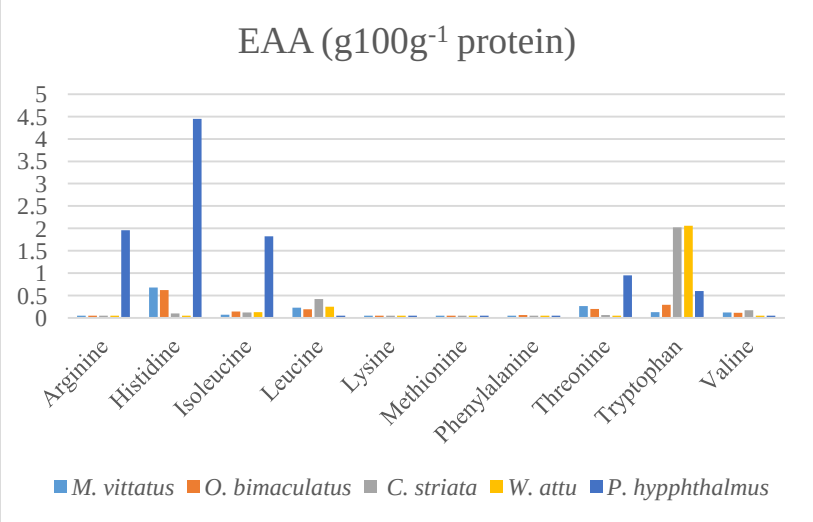

Figure 3. Essential Amino Acid composition (g 100g^{-1} protein) of five freshwater fish species

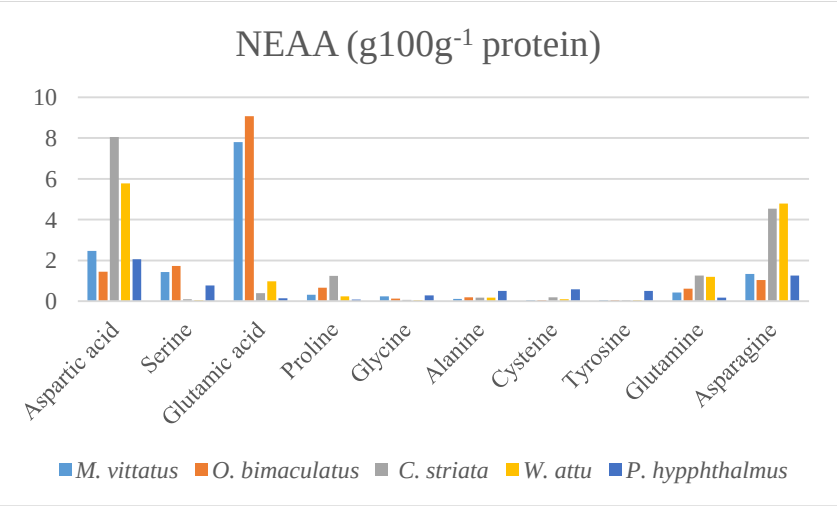

Figure 4. Non-Essential Amino Acid composition (g $100g^{-1}$ protein) of five freshwater fish species

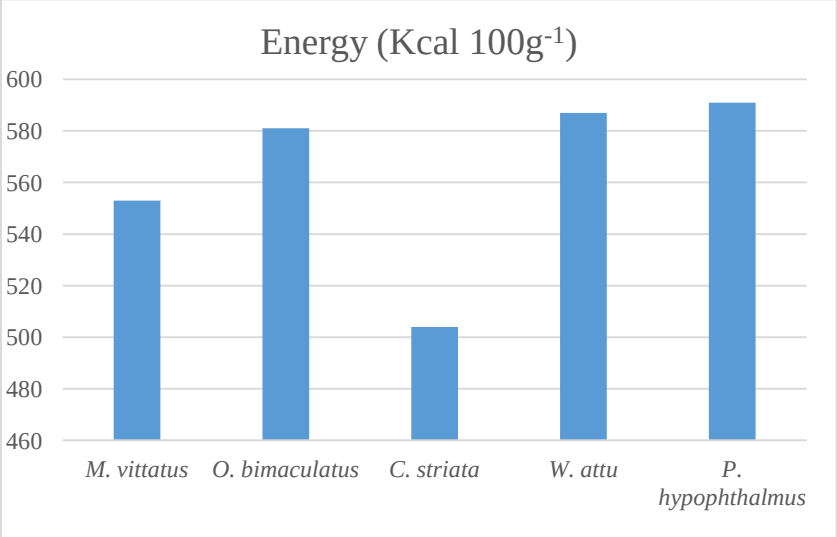

Figure 5. Energy content (Kcal $100g^{-1}$) of five freshwater fish

CONCLUSION

The nutrient profile of five freshwater fish species viz., *Mystus vittatus*, *Ompok bimaculatus*, *Channa striata*, *Wallago attu* and *Pangasianodon hypophthalmus* revealed that they are rich in protein, fat, ash, energy, minerals, vitamins, amino acid and fatty acid contents which are required for human health. The important fatty acids eicosapentaenoic acid and docosahexaenoic acid are present in these fish species. Arginine, threonine, isoleucine, histidine contents are rich in *P. hypophthalmus*. The vitamin A and D content are higher in *O. bimaculatus* and *M. vittatus* respectively. The obtained data on the nutrient profile of fish will help the nutritionists, researchers, medical practitioners, dieticians and other related stakeholders to advise consumers to take fish as health food.

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DAIRY BUFFALO PRODUCTION SYSTEM UNDER SEMI-INTENSIVE MANAGEMENT IN THE COASTAL AREA OF BANGLADESH

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ABSTRACT

This study was conducted to evaluate the present status of production system of dairy buffalo under semi-intensive management in coastal area of Bangladesh. The data were collected during farm visit and recorded in prepared questionnaire and check list. The findings of the study revealed that very minimum housing facilities were provided to the buffaloes. Both the grazing and confinement time were found similar (around 6 hrs in a day) and they spent almost 3 hrs in a day for wallowing. The majority of the lactating buffaloes were not being adequately fed. Farmers usually supplied local grass (4.98±2.89 kg DM/day) and rice straw (10.90 ±2.85 kg DM/day) with one or two concentrate feed separately as supplement (1.51±0.80 kg DM/day). The daily average DCP and TDN supply were 0.365 and 6.417 kg/d respectively which were undersupplied as compared to standard requirement. The productive and reproductive performance of indigenous dairy buffalo was not similar to high producing dairy buffaloes. The average lactation yields (litre/lactation) were found as 469.52±163.71. The EC value (2.73±3.53) of milk indicated as healthy milk production. Milk consumption pattern (8%) was not satisfactory. Milk market was volatile. Natural breeding (95.7%) was more prominent practice than artificial insemination (AI) (4.3%). The most of the buffalo cows showed heat from early night to early morning (22.2-54.2%). Technology adaptation for buffalo rearing was very much poor. Technology adaptation index for the use of concentrate feed, artificial insemination, de-worming and vitamin-mineral premix were 16.34, 13.46, 23.07 and 6.25 respectively. It therefore be concluded that technological transformation could be boost up to national milk production by developing of the management practise of dairy buffalo under semi-intensive system in Bangladesh.

Keywords: Dairy buffalo, semi-intensive, management practice, coastal area, technology

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INTRODUCTION

The dynamics of buffalo production systems in South Asia Region is transforming day by day due to increasing the population more rapidly specially in Asia for its emerging role in economic development (Dhanda, 2013). Buffalo production system varies widely in accordance with climate, soil and socio economic opportunities in Bangladesh (Saadullah, 2012). Buffalos graze in natural pasture in coastal areas. A total of 11, 5 and 84% farmers reared buffalo for milk purpose, meat purpose and milk and meat purpose, respectively in coastal areas (Nahar et al., 2014). According to Saadullah (2012) buffaloes are kept mainly for specific purposes, i.e. either for milk or for meat production in Bangladesh under semi intensive system. It is an important livestock resource in several countries of South Asia and the Mediterranean regions. Buffalo is playing a leading role in the national economy by producing milk, meat and draught power in India and Pakistan. Buffalo contributes about 57% and 68% of total milk production of India and Pakistan, respectively (FAO, 2010). Due to high fat content of buffalo milk, it is the most preferred species and called Black gold of Pakistan (Bilal et al., 2006). Climatic condition of Bangladesh is nearly similar to India and has many rivers and marshy lands that favour for raising buffaloes. Recently Government of Bangladesh, private sector and research organization has given emphasis on Buffalo production. The availability of milk in Bangladesh is only about 158.19 ml h^{-1} d^{-1} of about 63.27% (DLS, 2018) whereas, the availability of milk in India and Pakistan is about 290 ml, 525 ml, h^{-1} d^{-1}, respectively (Hamid et al.,2016). This figure indicates that Bangladesh need to give more emphasis on the milk production to fulfil the national demand. The indigenous dairy cows are low producers and the crossbred cow has the limitation regarding disease resistance, repeat breeding etc. Use of other mammalian livestock species for milk production could help to improve the scenario (Siddiki, 2017) and the success of India and Pakistan dairy industry based on buffalo might be a good example for Bangladesh. However, buffaloes are low producers in Bangladesh, because of poor genetic potentialities, poor nutrition, longer puberty age, seasonality of breeding, longer calving interval, high calf mortality and poor management practices (Nahar, 2015;Amin et al.,2015; Sarker et al., 2013; Faruque and Amin, 1995; Shamsuddin et al., 2001). Faruque and Amin (1995), Uddin et al., (2016) and Amin et al., (2017) reported the management and production performances of buffaloes of Noakhali district of Bangladesh. However, there is no report on the management and production performances of buffaloes of Bhola district in Bangladesh which possesses the highest number of buffaloes of the country. Moreover different management system e.g. extensive and semi-intensive systems were followed in this area. Semi-intensive system introduces very recently for emphasised lactating buffaloes. Therefore, the present study was designed to investigate the existing management system along with reproduction and production characteristics of dairy buffalo in Bhola district of Bangladesh under semi-intensive system.

MATERIALS AND METHODS

Location of study areas

The study area was Vhalu Miar Char, Sub-district: Bhola sadar, District: Bhola (AEZ-18, coastal area), Bangladesh. This is a coastal area of Bangladesh having high buffalo concentration (10.1-32.3 buffaloes/1000 people (Huque and Khan, 2017).Under the Köppen Climate Classification, Bhola is under Tropical Monsoon Climate (Wikipedia, 2017). General information of study area demonstrated in Table 1.

Table 1. General information and satellite image of study area

The Köppen Climate Classification	Tropical wet climate (Aw)
Location Vhalu Miar Char, Bhola sadar in Bangladesh	22.6903°N& 90.6525°E
Temperature (Min-Max)	19-29°C
Humidity (%)	71
Average yearly rain fall(mm)	2424
Human population density	480/km2
Management system	Semi-intensive
Breed type	Indigenous

Map and satellite image of study area
(Map Source: http://www.banglapedia.org and image source: Google map)

Source: https://en.wikipedia.org; https://www.timeanddate.com/weather/@1336136/climate ;https://www.banglapedia.org

Farmer selection

Buffalo farmers were randomly selected from three villages. Farmers had at least one milking buffalo with calf and reared buffalo under semi-intensive management system. Farm visit, farm observation, secondary review, community discussion were held in the from January to July 2017.

Preparation of questioner

Structured questionnaire was developed according to variable of the objectives. Variables like productive and reproductive performances, feeding and management practices with related problem for buffalo farming were considered. The questionnaire was pre-tested in the selected area. The preliminary schedule was edited on the basis of experience gained in pre-testing and then the questionnaire was finalized. The schedule contains both open and closed-ended question.

Data collection

Qualitative and quantitative information were collected from semi-intensive farm. Data were collected directly from 30 farms by the experience enumerators. Researcher monitored the enumerators and support as required by direct visit and mobile communication. Moreover, more than 40 milking buffalo farmers were directly contacted by the researcher for validation of the information. Discussion was also conducted with the cowboys (hired labours) who are responsible for the care and management of the buffalo and the farm as a whole, to confirm and recheck the information that were collected from the household buffalo farms which fulfil the triangulation methods.

Period of Study

Farm visit, farm observation, secondary review, community discussion were held in the period of six moths which was from January to July 2017.

Sample collection and analysis

Information regarding the amount and types of feeds and fodders being offered randomly to thirty the lactating buffaloes. The quantity of dry matter (DM), digestible crud protein (DCP) and total digestible nutrient (TDN) available to dairy buffaloes were calculated from the records of feeds and fodder using value as given by Kearl (1982) and Feedipidia.org (2018). Their requirements for DCP and TDN were worked out according to Kearl (1982).

During this visit, 15 individual milk samples (50 ml/sample) were also collected from study area. The milk samples were immediately placed in a home freezer, transported in a cool box and again placed in a regular freezer in the Dairy Chemistry Laboratory, Department of Dairy Science, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh until further analyses. Milk samples were analyzed for fat, protein, lactose, SNF, ash content and Electric Conductivity (EC) by auto-milk analyzer (Lactoscan, Ultrasonic Milk Analyzer; Model MIA-SLP-60, S/N-70148; MILKOTONIC Ltd., Bulgaria 6000. Stara zagora).

Data Analysis

After collecting data from field, these were edited and coded. The data was then transfer to MS Excel 2007 for processing and summarizing. The tabular technique mainly used to analyze the data and derived meaningful finding by using simple statistical measures like mean, percentage and ratio by using SPSS16 version.

RESULTS AND DISCUSSION

Buffalo herd composition

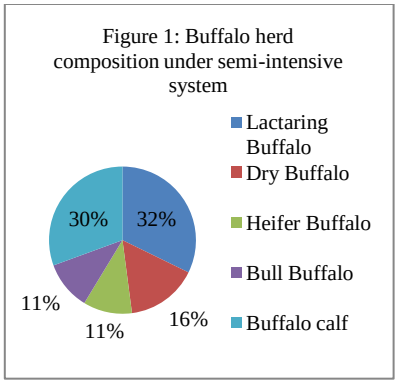
Farmers kept different type of buffalo in the herd. The average herd size was found to be 1.80±0.12. The herd was composed mainly of lactating buffalo, dry buffalo, buffalo heifer, buffalo bull and buffalo calf. The average number of lactating

buffalo, dry buffalo, buffalo heifer, buffalo bull and buffalo calf were 1.01±1.01, 0.78±1.72, 0.89±1.85, 1.06±1.62 and 1.02±1.94, respectively under semi-intensive system (Table 2 and Figure 1). This result supports to the findings of Uddin et al., (2016) who reported that 82% of the farmers having 1 to 3 buffalo reared under semi intensive system in coastal areas of Bangladesh. However Huque and Borghese (2013) found that average herd size in household subsistence farming (HF) and semi-intensive farming (SIF) buffaloes were about 1-3 and 4-15, respectively. Faruque (2000) found that the percentage of milking buffaloes, dry buffaloes, heifer buffaloes, bulls and calves were 35, 15, 16, 2 and 32, respectively in the upper part of coastal area reared under semi intensive management system which is very similar of our finding though number of bulls were relatively few in his study. But Akbar et al., (2009) mentioned that there was sufficient number of bull for breeding purpose in coastal areas.

Table 2. Average number of buffalo holding under semi-intensive system in Bhola district

Type of buffalo	Mean±SD (N)	Min	Max
Lactating Buffalo (No/HH)	1.85±1.01 (39)	1	4
Dry Buffalo(No/HH)	1.72±0.78 (19)	1	3
Heifer Buffalo(No/HH)	1.8±0.89 (13)	1	3
Buffalo Bull (No/HH)	1.62±1.06 (13)	1	4
Buffalo calf (No/HH)	1.94±1.02 (37)	1	4
Overall	1.80±0.12		

N= Number of observation; SD= Standard Deviation



Housing system of buffalo

Different types of housing were seen in the study area. Some farmers' constructed floor by brick, some sheds have roofs using tin or golpata (Nipa fruticans). Most of the house had no boundary wall and roof. Many buffaloes were kept on raised place in the open yard at day-night. Uddin et al., (2016) observed that dairy buffaloes were kept under semi-intensive system in the wet season and only 15% farmers provided shed having only roof but no concrete floor. Akbar et al., (2009) mentioned that most of the dairy buffalo were not housed in extensive system of bathan areas but buffaloes which were in the plain land sometime had an enclosure with only roof

made by straw or tin without wall and floor was always muddy. The average grazing time of buffalo was 6.04±1.52 hour in a day and rest of the time (5.91±1.70 hour/day) it was kept in confinement shed situated in household yard (Table 3). The average wallowing time of buffalo was found 2.78±1.34 hour/day (Table 3). Saadullah (2012) described that the buffalo farmers had their own wallowing place, but sometimes the whole village herd down together in mud wallows. Siddiki (2017) noted that majority (85%) of the buffalo farmers followed average grazing period of 6-8 h in a day and lowest grazing period (<6h) was found in Trishal and Lalpur Upozila (10%) which was similar to our findings.

Table 3. Average scavenges confinement and wallowing time (hrs/day)

Variable	Mean±SD	Minimum	Maximum
Grazing duration(hrs day^{-1})	6.04±1.52	2	8
Confinement (hrs day^{-1})	5.91±1.70	3	10
Wallowing (hrs day^{-1})	2.78±1.34	1	6

Feeding system

The available feed stuff were straw e.g. paddy straw (Oryza sativa); local green grass e.g. Dol (Saccrolepsis indica), Dubla (Cynodon dactylon), Halancha (Enhydra fluctuens), Sesbania, Water hyacinth (Eichhornia Crassipes) and kheshari (Lathyrus sativus); Concentrate feed e.g. oil cakes, wheat bran, rice polish, soybean meal and broken maize in the study area. Islam et al., (2002) identified more than fifty different types of local green grasses from different Agro Ecological Zones (AEZs) in Bangladesh among which most of those were same found in the present study. They noticed that baksha, lota, poa, khesari, beju, matikalai, kolmi, gamma, badam, durba, chailla, helencha, shama were mostly common and more potential native grasses. 89%, 100% and 57 % farmers provided dry roughage (straw), green roughage (local grass) and concentrate feed respectively to lactating buffaloes under this system. Among those, the average dry roughage, green roughage and concentrate feed supply were 10.90 ±2.85, 4.98±2.89 and 1.51±0.80 Kg DM day^{-1} head^{-1}, respectively. Nahar et al., (2015) found that 22 - 23% farmers supplied only straw, 95.55% farmers supplied straw with roughages, 8.89% farmers supplied only concentrate under extensive system in Bhola district. In the Ganges-Brahmaputra flood plain, dairy buffaloes were reared in semi-intensive system in which farmer raised buffaloes with minimum inputs. They were allowed to graze on natural pasture or road side in day time and were corralled at night (Akbar et al., 2009). The household subsistence farming (HF) buffaloes were reared under stall feeding with 6-7 hours grazing around backyard or public land with very little feed supply. The semi-intensive farming (SIF) buffaloes were raised in combination of seasonal based

household during rice cultivation and free range system during common land free which was mostly upper part of coastal areas (Huque and Borghese, 2013). According to investigation of Uddin et al., (2016), in the household farming, after morning milking, buffaloes were allowed to graze in fallow or road side land up to evening that covers approximately 8-9 hours per day. From the evening to next morning, buffaloes were tied up in homestead and they were offered mainly rice straw with little concentrate mixtures (wheat bran, rice bran, rice polish etc). The findings of the present study do not agree with the findings of Uddin et al., (2016) who mentioned the natural grass is the main source of feed in contrast to straw. This transforming perhaps to happen for newly introduces of semi-intensive system for lactating buffaloes in upper land of the coastal areas. Besides different crops were occupied most of the fellow land.

Table 5. Average feed supply (DM $kg^{-1}day^{-1}head^{-1}$) of lactating buffalo under semi-intensive system in Bhola district

Items	Mean±SD	Minimum	Maximum
Concentrate feed	1.51±0.80 (57)	0.44	2.64
Straw	10.90 ±2.85 (89)	4.50	16.0
Green grass (cut and carry)	4.98±2.89 (100)	1.6	11.30
Total supply	16.16±3.28	6.4	20.3

Figure parenthesis in the bracket indicates percentage of farmers

Nutritional status

Feeding practice deprives the potential high milk producers and also overburdens the low producers with nutrients (Habib et al., 2007). The average estimated levels of nutrients supplied to lactating buffaloes in coastal (Bhola) area of Bangladesh presented in Table 6.

Table 6. Average estimated levels of nutrients supplied to lactating buffaloes in coastal area in Bangladesh

Name of the feed resources	Amount DM ($kg\ d^{-1}$)	DCP($kg\ d^{-1}$)	TDN($kg\ d^{-1}$)
Coastal area: Bhola			
i. Broken Maize(Zea mays)	0.750	0.040	0.563
ii. Soybean meal(Glycine maximum)	0.560	0.228	0.459
iii. Rice bran (Oryza sativa)	0.200	0.015	0.120

Name of the feed resources	Amount DM (kg d-1)	DCP(kg d-1)	TDN(kg d-1)
A. Total concentrate mixture (i+ii+iii)	1.510	0.283	1.142
B. Straw (Oryza sativa)	10.900	0.022	4.578
C. Grass (native mix)	4.980	0.060	0.697
D. Total(A+B+C)	17.390	0.365	6.417

Daily average digestible crude protein(DCP) supply in the lactating buffaloes in Bhola district were 364 g d^{-1} which were undersupplied as compared to requirement of Kearl (1982) standard (Table 7; Fig 2) considering average body weight 242.0±45.1 and milk fat percent (7.3±2.66). Other studies aimed at evaluating the nutritional status of dairy animals in India based on survey of different districts/regions showed variable trends-most of them showing undersupply of DCP as compared to standard requirements (Vidya et al., 2013; Bakshi et al., 2010; Jawale et al., 2007; Singh et al., 2003). These findings agreed with our observation. However daily average DCP intake in the buffaloes in Patan district of India was observed 1.049 kg d^{-1} that indicates the buffaloes got adequate DCP as per the requirement (Chavda and Parnerkar, 2016). Daily average total digestible nutrient (TDN) supply to the lactating buffaloes in Bhola areas of Bangladesh were observed 6.417 kg d^{-1} (Table 6) which indicated that the buffaloes got few amount of low TDN (-0.353 kg d^{-1}) than requirement of Kearl (1982) standard (Table 7; Fig 3). Chavda and Parnerkar (2016) got surplus amount of average TDN intake (10.17 kg d^{-1}) in the buffaloes in Patan district of India. The findings of Chavda and Parnerkar (2016) are supported by the observations of Patange et al., (2002) and Singh et al., (2003) indicating a surplus of TDN supply. However, deficit supply of TDN in lactating buffaloes was also reported by Chaturvedi et al., (2009) and Singh et al., (2008) in their study.

Table 7. Deficit (-) and surplus (+) of DCP and TDN in lactating buffaloes in different agro-climatic zone in Bangladesh

Areas	Total requirement of DCP (g)	Total supply of DCP (g)	Deficit (-) /surplus (+) of DCP	TDN requirement (kg d^{-1})	TDN supply (kg d^{-1})	Deficit (-) /surplus (+) of TDN (kg d^{-1})
Coastal area	697.000	364.790	-332.210	6.770	6.416	-0.353

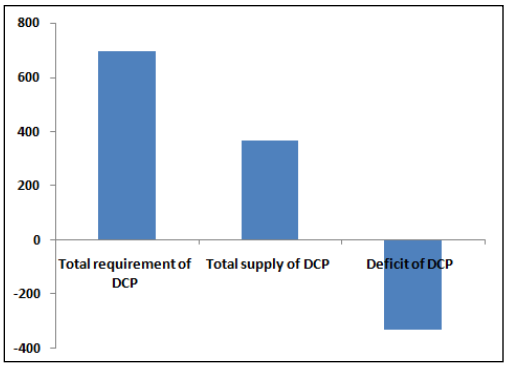


Figure 2. Total requirement and supply of DCP (gm d^{-1})

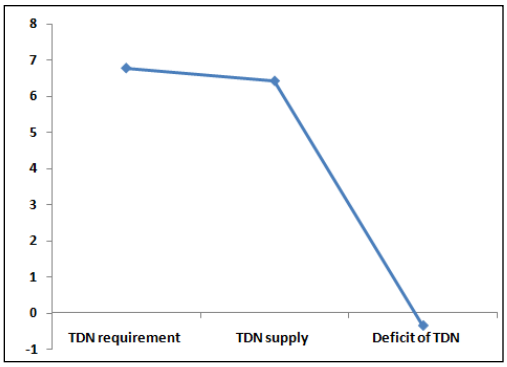


Figure 3. Total requirement and supply of TDN (kg d^{-1})

Productive and reproductive performance

Productive and reproductive efficiency are influenced by different management system, nutrition and environment factors. A very low protein diet can cause cessation of oestrus (Agrawal, 2003). Though actual reproductive parameters is very difficult to find out without record or close supervision but farmer's experience would be asset for those information.

The average lactation length of indigenous buffalo cows were 197 days under semi-intensive system in the study area (Table 8) which was low as compare to Karim et al., (2013); Faruque and Amin (1995). It might be happen for week management practice of the farmers as this system newly introduced in upper land in Bhola. Karim et al., (2013) found 286 days of lactation period in similar kind of buffaloes under extensive production system in Mathbaria and Pirozpur, which was 290 days in Pathorghata and Barguna. Faruque and Amin (1995) also reported that the lactation yield of indigenous buffalo in Khulna region were 280 liters. The findings of this study were also less similar to the findings of other authors (Bezerra et al., 2014; EI-Kirabi1995). The average milk yield (L d^{-1}) and lactation yield (L $lactation^{-1}$) were found as 2.39±0.83 and 469.52±163.71, respectively (Table 8). The average dry period (day), weaning age (day), service per conception (Number), age at first pregnancy (month), age at first caving (month), calving interval (month), gestation period (month), post partum heat period (month) were 42.80±26.44, 201.88±77.63, 1.11±0.32, 35.37±9.44, 46.56±6.80, 14.21±2.09, 10.04±0.23 and 3.94±1.51, respectively (Table 8). Similar findings were also reported by other authors (Karim et al., 2013; Shabede et al., 2003).

Table 8. Productive and reproductive trait of lactating buffalo under semi-intensive system

Parameters	Mean ±SD	Minimum	Maximum	Highest frequency percentage
Lactation Length (d)	197.44±29.06	150	270	180 (37%)
Milk yield (L d^{-1})	2.39±0.83	1	5	2.3(18.2%)
Lactation yield (L $lactation^{-1}$)	469.52±163.71	196	916	392(15%)
Dry Period (d)	42.80±26.44	30	90	30 (60%)
Weaning age(d)	201.88±77.63	7	365	180 (24%)
Service Per Conception (Number)	1.11±0.32	1	2	1 (88%)
Age at first Pregnancy (month)	35.37±9.44	33	48	34 (34%)
Age at first caving(month)	46.56±6.80	34	58	46(28%)
Calving interval (month)	14.21±2.09	11	18	16 (15.4%)
Gestation period (month)	10.04±0.23	10	11	10(80%)
Post Partum heat period (month)	3.94±1.51	2	6	3(29.2%)

L, liter; d, day.

Milk composition

Milk composition of indigenous lactating buffalo under semi-intensive system is shown in Table 9. Milk composition attributed for breed, physiology of animal, environment, and management system (Ravikala et al., 2014). Nahar et al., (2014) found different milk composition of buffalo, though those were little lower or higher for different selected areas of Bangladesh. The average fat percentage of buffalo milk from Noakhali (8.16), Sirajgang (7.54), Potuakhali (7.18) and Bagerhat (6.92) (Nahar et al., 2014) which was similar value of fat % of our present study (7.30). The range of protein, lactose and SNF percentage were 3.00-4.36, 3.64-4.8 and 7.52-9.35 respectively. EC (ms cm^{-1}) value for present study was shown as 2.73±3.53 with the range of 2.00-3.53mS cm^{-1}. Fahmid et.al., (2016) observed that EC value had less than 5.5 mS cm^{-1} which considered as healthy milk production.

Table 9. Milk composition of lactating buffalo under semi-intensive system

Variables	Mean±SD (N=15)	Minimum	Maximum
TS(%)	15.60±2.55	12.81	19.63
Fat(%)	7.30±2.66	4.07	11.97
SNF(%)	8.30±0.54	7.52	9.35
Lactose(%)	4.03±0.32	3.64	4.8
Ash(%)	0.62±0.06	0.53	0.75
Protein(%)	3.64±0.41	3.00	4.36
Electric conductivity (EC) (mS cm^{-1})	2.73±3.53	2.00	3.53

Marketing

All of the farmers sold milk to Ghosh. About 57.89 percent farmers received advance money (BDT3000-10000) on monthly basis from the Ghosh and 42.11 percent farmer didn't receive the same. The higher milk selling price was BDT 55.71±5.34 for the farmer who didn't take advance from Ghosh but selling price was relatively low (BDT 52.72±4.10) who had taken advance (Table 10). It also noted that milk market was more volatile in case of the farmers who didn't take advance from Ghosh as CV% was higher (9.59%) than other (7.77%). The present finding is in agreement with the earlier findings of (Raha, 2010) who reported that price of milk was set below by BDT 5 $liter^{-1}$ in the case of advance payment.

Table 10. Milk marketing scenario in Bhola district (USD1=BDT78)

Group	% of farmers	Amount of advance money (BDT $Month^{-1}$) Min-Max	Average milk price (BDT L^{-1})	SD value	CV%
Farmers who taken advance	57.89	3000-10000	52.72	4.10	7.77
Farmers who didn't taken advance	42.11	-	55.71	5.34	9.59
Overall	100				

Technology adaptation

Adaptation levels of technologies for dairy buffalo farmers were very poor due to lack of public awareness and inadequate knowledge about buffalo husbandry (habitat, feeding, breeding & health care). Only 17.4 % farmer adopted for providing concentrate feed to their animal. Adaptation level of technologies e.g. use of urea-molasses straw/blocks, cultivation of fodder crops, use of Artificial Insemination(AI), practice for de-worming, practice for vaccination and provide vitamin-mineral premix from farmers were 0 ,0, 4.3,8.7,0 and 8.7%, respectively. Average adaptation capacity of technologies were 16.34, 11.53, 12.01, 13.46 23.07, 17.30 and 6.25% for use of urea-molasses straw/blocks, cultivation of fodder crops, use for AI, practice for de-worming, practice for vaccination and provide vitamin-mineral premix from farmers, respectively. Among those technologies, the capacity of technology was higher for practise of de-worming and vaccination though those were not followed regularly (Table 11). Creation of public awareness by different media; i.e. Radio, TV, Internet, Newspaper about the impotence of buffalo milk and meat as well as the good practice of dairy buffalo management might be improved the adaptation level of technologies.

Table 11. Technology adaptation of dairy buffalo farmers

Technical intervention	Level of adaptation(Frequency)			Average capacity(index) of technology
	Never	Tried but not adopt	Fully adopted	
Provide concentrate feed	69.6	13	17.4	16.34
Use of urea-molasses straw/blocks	95.7	4.3	-	11.53
Cultivation of fodder crops	91.3	8.7	-	12.01
Use for Artificial Insemination	82.6	13	4.3	13.46
Practice for de-worming	-	91.3	8.7	23.07
Practice for vaccination	34.8	65.2	-	17.30
Provide vitamin-mineral premix	52.2	39.1	8.7	6.25

Breeding

Recently government buffalo project has started AI in Bhola district, but it is not popular because of insufficient AI worker as well as unavailable of buffalo semen and low conception rate. Farmers didn't get AI worker in right time when buffaloes showed heat. Traditionally farmers kept buffalo bull to bred buffalo cows in these areas. It means that there were two breeding systems in Bhola district. A total of

95.7% buffalo cow received natural breeding whereas AI covered only 4.3% of buffalo cows. Akbar et al., (2009) reported that the sufficient number of breeding bull was kept by the farmer in coastal areas and there were no fertility problem. However, inbreeding and abortion due to use same bull was common. They also noted that low oestrous detection (i.e. 30%) was a major challenge that limited efficiency of AI use. According to farmer's observation, buffalo cows showed heat in different time. A few number of buffalo cows (4.2-5.2%) showed heat in day time but higher number of the buffalo cows showed heat in early morning (54.2%), followed to early night (22.2%) and late night (9.3%) (Table 12). Saadullah, (2012) stated that the buffaloes showed their maximum activity during the night and breeding take place mainly during night. Therefore present study has been supported to the information of Saadullah, (2012) though a few number of buffalo cows showed heat in day time (4.2-5.2%).

Table 12. Type of breeding and time of heat showed by buffalo cows

Variable	Value
Type of breeding	
Natural breeding (% of buffalo)	95.7
Artificial insemination (AI) (% of buffalo)	4.3
Time of showing heat	
Morning (% of buffalo)	54.2
Noon (% of buffalo)	4.8
Afternoon (% of buffalo)	5.2
Evening (% of buffalo)	4.2
Early night (% of buffalo)	22.2
Late night (% of buffalo)	9.3

Hygienic measure for buffalo rearing

Farmers kept manure near to the animal shed in small hole, situated from 2-20 feet distance from the shed. However sometime they did not make small hole and manure through the open places. A total of 22 % farmers did not follow good practice for waste management. The udder health situation of milking buffaloes was aggravating as mastitis was rising as of the notification of farmers (7%). Islam et al., (2016) isolated pathogens (i.e. Coagulase Negative Staphylococci (CNN), *Staptococcus spp*. and Bacillus spp. and *Staphylococcus aureus*) from milk sample in Bangladesh including coastal areas that were responsible for mastitis in lactating buffaloes. Only

hand milking was followed practiced in the study areas. They washed their hands, milking pots and also cleaned milking parlour/platform before milking. All of the farmers allowed calves to suckle udder of buffalo by the calf for stimulating hormonal affects before starting milking.

CONCLUSION

The productive and reproductive performance of indigenous dairy buffalo was not better to high producing dairy buffalo's. Scientific management and improved breeding system could minimize this situation. Optimum use of feed resources and their treatment whenever needed becomes evident from the present study. Improved adaptation level of technologies would be ensured by creating public awareness and by providing door-step service to the buffalo farmers. It is therefore, can be concluded that technological transformation is important to boost up of the productivity of the dairy buffaloes under semi-intensive system.

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ASSESSMENT OF CARBON STOCK AND NUTRIENT CONTENTS IN SOILS OF NORTHERN AND EASTERN PIEDMONT PLAINS OF BANGLADESH

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ABSTRACT

Under the changing climate documentation of soil carbon and nutrients is indispensable for sustainable crop production which is scarce in the agro-ecological zone (AEZ) of Northern and Eastern Piedmont Plains in Bangladesh. Therefore, the study was conducted collecting and analyzing a total of 240 soil samples considering 0-20 cm soil depth from two upazilas viz. Purbadhola and Akhaura under the mentioned AEZ to quantity carbon stock and nutrient contents of soils. Organic carbon stocks in soils of Purbadhola and Akhaura upazila were 45.97 and 97.04 Gg, respectively, while in the Northern and Eastern Piedmont Plains was 8.56 Tg. The soil pH was very strongly acidic to slightly acidic (4.4-5.8), organic carbon contents (0.53-1.31%) were very low to medium, while the overall soil fertility rated as very low to medium. Balanced fertilization using organic and inorganic sources in general and liming for upland crops might improve fertility and productive capacity of soils in the study area. The study opens up avenues to find out means and ways of increasing carbon contents in soils of Northern and Eastern Piedmont Plains and might help the policy makers to debate on future global carbon trading issues.

Keywords: Agro-ecological zones, carbon contents, land types.

INTRODUCTION

Carbon is a vital element that accomplishes all bio-physico-chemical properties in soils. Organic carbon harbors microbial community, develops and maintains soil structure, regulates cation exchange capacity and nutrient dynamics in soils (Rahman,

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2014; Rahman et al., 2016). Soil has the potential to store three times more carbon than the terrestrial vegetation, which depends on soil and crop management practices (Tarnocai et al., 2009). Carbon storage in soils is affected by changes in vegetation and plant growth, removal of biomass by harvest and destruction through plowing and other land use changes. Soil C is further sensitive to climatic and environmental changes such as moisture availability, changing rainfall and temperature patterns, nitrogen availability and its dynamics in crop fields (von Lutzow et al., 2009). The subtropical climatic environment of Bangladesh where generally farmers apply more nitrogen fertilizers for higher crop yields. High temperature and high soil moisture coupled with the presence of high nitrogen favors faster decomposition of organic matter (Hossain et al., 2016).The global concerns about the effects of climate change have generated urgent research avenues on both soil organic and inorganic C stocks. It is reported that a good soil should have at least 2.5% OM, while it is less than 1.5%, and some soils even less than 1% in Bangladesh (BARC, 2012). Depletion of soil organic carbon and its fertility has been recognized as the major cause that hindering crop production in Bangladesh. It is anticipated that because of climate change the production of different crops in Bangladesh would greatly be reduced and thus the country would be in food deficit condition. Selection of best and suitable cropping systems potential in storing and maintaining carbon in soils is necessary for sustaining soil health and also for limiting the negative effect of global warming in crop production. Soil and crop management practice like minimum or zero tillage, application of different available organic materials and composts, balanced fertilization, crop rotations etc. might have the high potential to increase carbon contents in soils. The sequestration of atmospheric CO_2 in the soil and biomass reduces greenhouse effect which is indispensable to improve soil quality, increase agronomic productivity and use efficiency of different production inputs like fertilizers and water thus helps maintain or restore the capacity of soil to carry out its production and environmental functions on a sustainable basis. The Northern and Eastern Piedmont Plains of Bangladesh comprise gently sloping land at the foot of northern and eastern hills, where alluvial sediments derived from the hills have been deposited. Soils of the area are loams to clays in texture and OM content is very low to low (BARC, 2012). The area might have the potential in sequestering C and supplying different nutrients in soil but information is scarce. Therefore, the study was conducted to evaluate existing carbon stock and C, N, P and K contents of Northern and Eastern Piedmont Plains which might be helpful in improving soil health adopting different management practices at farmer's level.

MATERIALS AND METHODS

Study area

The study was conducted in two upazilas (Purbadhala and Akhaura) and three mouzas under each upazila of the agro-ecological zone Northern and Eastern Piedmont Plains (AEZ 22).The selected mouzas were Naterkona, Khatoari and

Meghshimul from Purbadhala, while Basudebpur, Noapara and Anandapur from Akhaura.

Cropping patterns in the study area

The major cropping patterns under four different land types recognized in Purbadhala and Akhaura upazila were shown in the Table 1.

Table 1. Major cropping patterns in Purbadhala and Akhaura upazila under the Northern and Eastern Piedmont Plains (AEZ 22)

Land type	Cropping patterns
High land	Boro rice-Fallow-T. Aman rice
Medium high land	Boro rice-Fallow-T. Aman rice
Medium low land	Boro rice-Fallow-Fallow
Low land	Boro rice-Fallow-Fallow

Sampling protocol

Soil samples were collected during January to February 2011 based on land types and soil depths. A total of 240 soil samples were collected from Purbadhala and Akhaura upazila of the AEZ 22 considering ten sampling spots per mouza, four samples per spot comprising 4 soil depths (0-5, 5-10, 10-15 and 15-20 cm). Samples collected were analyzed for organic carbon and other nutrients.

Study parameters and methods of analysis of soil samples

Soil bulk density was determined by core sampler method (Blake and Hartge, 1986). After calculating the soil bulk density collected soil samples were analyzed in the chemistry laboratory, Department of Soil Science, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur, Bangladesh for organic carbon and other nutrients. Soil pH was determined by Glass Electrode pH Meter method with soil water ratio 1:2.5 (McLean, 1982), organic matter by Wet Oxidation method, total N by Kjeldhal systems (Bremner and Mulvaney, 1982), available P by Olsen's method (Olsen and Sommers, 1982), and K by Ammonium acetate extraction method (Barker and Surh, 1982).

Carbon stock calculation

The carbon stock in soils of AEZ 22 was calculated using the equation 1, while the total carbon stock was calculated using equation 2.

Carbon stock (t ha^{-1}) = carbon concentration (%) x bulk density (g cm^{-3}) x depth (cm) ---- (1)

Total carbon stock (t) = Carbon stock (t ha^{-1}) x Area (ha) --------- (2)

The area coverage of different land types of the AEZ were collected from fertilizer recommendation guide (BARC, 2012).

RESULTS AND DISCUSSION

Soil physical and chemical properties in different mouzas of Purbadhola upazila

The physical and chemical properties of three selected mouzas of Purbhadhala upazila under the Northern and Eastern Piedmont Plains were studied. The land types and physico-chemical properties of Natrokona mouza were presented in Table 2. Three land types were observed in selected mouzas viz. medium high, medium low and low. There were two main cropping patterns observed in Naterkona mouza which were boro rice-fallow-T. aman rice in medium high land and boro rice-fallow-fallow in medium low and low land. The bulk density in medium high land was found 1.42 g c.c.$^{-1}$, whereas it was 1.31 g c.c.$^{-1}$ in medium low land and 1.09 g c.c.$^{-1}$ in low land. The lowest bulk density was found in low lands. It might be due to higher moisture content and flocculent soft layer in the top soils of low land, which contributed to less dry mass compared to medium low and medium high lands. The pH was found strongly acidic in all three types of land. Organic carbon status both in medium high and medium low lands were observed low as these values were 0.53 and 0.66, respectively which corresponds to organic matter of 0.91% and 1.14%, respectively. Whereas comparatively higher organic carbon (1.31%) was recorded in low lands, which is medium as per fertility ranking (BARC, 2012). Because of the low land is saucer shaped, which receive runoff materials and organic constituents and thus upon time it becomes enriched with organic matter. However, an important finding is that even though soil organic carbon content is high but because of lower soil bulk density the resultant carbon stock is low in the low land. The nitrogen contents in all types of lands were found low possibly high rates of mineralization of soil organic matter and subsequent leaching loss of nitrate nitrogen and volatilization of ammonia under prevailing tropical and sub-tropical climatic conditions. Nitrogen contents in soils of Naterkona mouza were varied from 0.10 to 0.14%. Phosphorus contents in all forms and types of lands were observed low. The potassium contents in all types of lands ranged from 0.16 to 0.17 c-mol (+) kg^{-1}. According to BARC (2012) such potassium level in soils are rated as low for upland crops and medium for wetland rice crop.

Table 2. Nutrient contents in soils of Naterkona mouza of Purbadhola upazila

Land type	Soil series	Cropping pattern	BD (g c.c.$^{-1}$)	OC (%)	pH	N (%)	P (µg g^{-1})	K (c-mol (+) kg^{-1})
MHL	Kongsho	Boro rice-fallow- T. aman rice	1.42±0.15	0.53	4.8-5.5	0.11±0.03	3.00±0.39	0.16±0.01
MLL	Sushong	Boro rice-fallow-fallow	1.31±0.20	0.66	4.6-5.1	0.10±0.01	3.10±0.30	0.17±0.00
LL	Sushong	Boro rice-fallow-fallow	1.09±0.00	1.31	5.0-5.2	0.14±0.00	3.14±0.00	0.17±0.00

Table 3 denotes the land types and physico-chemical properties of Khatuary mouza of Purbhadhala upazila. The major land form in Khatuary mouza was observed bill

and the land types were medium high and medium low. Two major cropping patterns were identified in the Khatuary mouza and these were boro rice-fallow-T. aman rice in medium high land and boro rice-fallow-fallow in medium low land. In medium high land the soil bulk density was 1.45 g c.c.$^{-1}$, while in the low land the value was 1.34 g c.c.$^{-1}$. The soil organic matter content was 0.73% in medium high land and 0.57% in the medium low land. The soil pH in medium high land was recorded 4.8-5.5 and in medium low land 4.4-5.1, which was strongly acidic in both the cases. The nitrogen content in medium high land and medium low land were 0.11 and 0.10%, respectively which can be ranked as low according to the soil fertility ranking of BARC (2012). Phosphorus contents in soils were 3.57 and 4.02 µg g^{-1} in medium high and medium low land, respectively and rated as very low (BARC, 2012). The potassium contents in soils were 0.16-0.17 c-mol (+) kg^{-1} which evaluated as low.

Table 3. Nutrient contents in soils of Khatuary mouza of Purbadhola upazila

Land type	Soil series	Cropping pattern	BD (g c.c.$^{-1}$)	OC (%)	pH	N (%)	P (µg g^{-1})	K (c-mol (+) kg^{-1})
MHL	Kongsho	Boro rice-fallow- T. aman rice	1.45±0.14	0.73	4.8-5.5	0.11±0.03	3.57±0.37	0.10±0.03
MLL	Sushong	Boro rice-fallow-fallow	1.34±0.22	0.57	4.4-5.1	0.10±0.02	4.02±0.42	0.15±0.01

In Meghshimul mouza, there were two land types recognized viz. high and medium low. The cropping patterns in highlands were boro rice-fallow- T. aman rice, while boro rice-fallow-fallow followed in the medium low land. The soil bulk densities of high and medium low lands were 1.34 and 1.23 g c.c.$^{-1}$, respectively. The pH of high land was slightly acidic in nature and strongly acidic soil was found in medium low land. In high and medium low land the organic carbon contents were 0.82 and 1.01%, respectively. The status of organic matter content was low as per BARC ratings (BARC, 2012). The nitrogen content of high and medium high land was found 0.11% that was low. In high land phosphorus content was 15.08 µg g^{-1}, which was low but in medium low land it was very low due to strongly acidic soil. In both land types the potassium content was attributed medium (Table 4).

Table 4. Nutrient contents in soils of Meghshimul mouza of Purbadhola upazila

Land type	Soil series	Cropping pattern	BD (g c.c.$^{-1}$)	OC (%)	pH	N (%)	P (µg g^{-1})	K (c-mol (+) kg^{-1})
HL	Sushong	Boro rice-fallow- T. aman rice	1.34±0.16	0.82	5.6-5.8	0.11±0.03	15.08±0.46	0.16±0.01
MLL	Kongsho	Boro rice-fallow-fallow	1.23±0.26	1.01	4.8-5.2	0.11±0.03	3.72±0.52	0.16±0.01

BD - Bulk density, OC- Organic carbon, N- Nitrogen, P- Phosphorus, K- Potassium, MHL – Medium high land, MLL – Medium low land, LL – Low land

Soil physical and chemical properties in different mouzas of Akhaura upazila

The physical and chemical properties of three selected mouzas viz. Basudebpur, Noapara and Anandopur of Akhaura upazila under the Northern and Eastern Piedmont Plains were assessed. In Basudebpur mouza, there was one land form, which was ascribed as Pahartolir danga. The land types and soil properties were shown in Table 5. Two land types were recognized viz. high and medium high where both land types were under the Pritimpasha soil series. Farmers of this mouza practiced mainly one cropping pattern, which was boro rice-fallow- T. aman rice. The bulk density of high land was 1.34 g c.c.$^{-1}$, while in medium high land it was 1.33 g c.c.$^{-1}$. The organic carbon contents in high land and medium high land were 0.83 and 0.95%, respectively and rated as low according to BARC (2012). The soils of high land and medium high land were strongly acidic and slightly acidic, respectively. The nitrogen contents in high and medium high land were 0.16% and 0.15%, respectively, which were low (BARC, 2012). The phosphorus contents in high and medium high lands were 2.31 µg g^{-1} and 2.66 µg g^{-1}, respectively which were very low. The potassium content in high land was 0.12 c-mol (+) kg^{-1} and in medium high land 0.13 c-mol (+) kg^{-1} and rated as low.

Table 5. Nutrient contents in soils of Basudebpur mouza of Akhaura upazila

Land type	Soil series	Cropping pattern	BD (g c.c.$^{-1}$)	OC (%)	pH	N (%)	P (µg g^{-1})	K (c-mol (+) kg^{-1})
HL	Pritimpasha	Boro rice-fallow-T. aman rice	1.34±0.12	0.83	4.6-5.2	0.16±0.05	2.31±0.43	0.12±0.04
MHL	Pritimpasha	Boro rice-fallow-T. aman rice	1.33±0.13	0.95	5.6-5.7	0.15±0.03	2.66±0.42	0.13±0.01

The land form in the Noapara mouza was also identified as Pahartolir danga, where two different types of lands were identified viz. medium high and low (Table 6). Boro rice-fallow-T. aman rice cropping pattern was followed in medium high land and boro rice-fallow-fallow followed in low land (Table 6). Low land remains submerged several months of the year and flooding occurs within 180 to 300 cm during the flood season. Therefore, only boro rice crop is grown in low land as this rice is grown in the dry season when water depth reduced and sometimes land becomes dry. The bulk densities of medium high and low lands were 1.42 and 1.25 g c.c.$^{-1}$, respectively. During collection of soil samples low lands were under water and therefore, same core contained less amount of dry soil mass in low land compared to medium high lands. Therefore, soil bulk density was lower in low lands than that of medium high lands. The organic carbon contents in both medium high and low lands were found about 1% and rated as medium. The pH of medium high and low land were identified slightly acidic and strongly acidic, respectively. The nitrogen content in medium high land was 0.11%, while it was slightly higher (0.15%) in lowland.

However, as per soil fertility ranking given by BARC (2012) nitrogen status was rated low in both types of land. The phosphorus content in both types of land was found low (Table 6).

Table 6. Nutrient contents in soils of Noapara mouza of Akhaura upazila

Land type	Soil series	Cropping pattern	BD (g c.c.$^{-1}$)	OC (%)	pH	N (%)	P (µg g^{-1})	K (c-mol (+) kg^{-1})
MHL	Pritimpasha	Boro rice-fallow-T. aman rice	1.42±0.23	1.10	5.5-5.8	0.11±0.05	2.48±0.76	0.11±0.04
LL	Pritimpasha	Boro rice-fallow-fallow	1.25±0.19	1.08	4.5-5.2	0.15±0.04	2.37±0.18	0.15±0.04

In Anandopur mouza, there were two different types of land found viz. medium high and medium low. Both types of lands were under the common single land form Pahartolir danga and the soil series was Pritimpasha (Table 7). Boro rice-fallow-T. aman rice cropping pattern was followed in medium high land, while it was boro rice-fallow-fallow in the medium low land. The soil bulk densities in medium high and medium low lands were 1.48 and 1.54 g c.c.$^{-1}$, respectively (Table 7).

Table 7. Nutrient contents in soils of Anandopur mouza of Akhaura upazila

Land type	Soil series	Cropping pattern	BD (g c.c.$^{-1}$)	OC (%)	pH	N (%)	P (µg g^{-1})	K (c-mol (+) kg^{-1})
MHL	Pritimpasha	Boro rice-fallow-T. aman rice	1.48±0.17	1.0	5.5-5.7	0.15±0.03	2.78±0.36	0.14±0.01
MLL	Pritimpasha	Boro rice-fallow-fallow	1.54±0.29	0.84	4.5-5.5	0.13±0.04	2.57±0.41	0.14±0.01

BD - Bulk density, OC- Organic carbon, N- Nitrogen, P- Phosphorus, K- Potassium, HL – High land, MHL – Medium high land, MLL – Medium low land, LL – Low land

The organic carbon content in soils of medium high land of Anandopur mouza under Akhaura upazila was 1.0%, which is rated as low. However, this was comparatively higher than that of low land, which was 0.84%. The organic carbon status was low to medium in soils under both land types. In medium high land two rice crops boro rice and T. aman rice are cultivated and thus more rice straw added to soil as crop is harvested leaving about 15-20 cm in the field which contributed higher organic carbon in soils under medium high land compared to medium low land. In medium high and medium low lands the soil reactions were slightly acidic and strongly acidic, respectively (Table 7). The nitrogen content was identified as low in both land types. The phosphorus contents were very low, which were 2.78 µ g g^{-1} in medium high land and 2.57 µ g g^{-1} in low land. The potassium content in soil was found 0.14 c-mol (+) kg^{-1} in both of the land types.

The soil reaction under the Northern and Eastern Piedmont Plains was found slightly acidic to strongly acidic, which is the result of very high level of iron in the study area (SRDI, 2009). Furthermore, because of high iron contents in the study area soil inherent and applied phosphate fix with iron thereby reduces the availability of phosphorus in soils for plant uptake. The fixation of phosphorus in the acid soils makes phosphorus management difficult for crop production. However, as rice is the only crop growing in the study area, soil pH is not a serious concern. Rice is water loving crop and pH tends to increase in submerged condition. But if farmers plan to grow upland crops or vegetables then liming is needed for better crop production. Therefore, liming is recommended in the study area to raise soil pH and make suitable for upland crops. Maximum availability of phosphorus generally occurs in a pH range of 6.5 to 7.5 (BARC, 2012). The soil organic carbon increases with the raising of pH as soil having low pH retards tree growth because of nutrient deficiencies, which leads to a decline in the inputs of soil organic matter into the soil from trees compared to soils with a higher pH (Augusto et al., 2002; Laganiere et al., 2010). Soil organic carbon contents in the study area were found low to medium. Organic matter contents were found higher in the medium low and low land compared to high and medium high lands. However, it may differ with the location, soil and crop management practices, microclimates and many other factors. Intensive crop cultivation systems using higher rates of inorganic fertilizers favor faster degradation of organic matter in soils. The climatic condition of Bangladesh is characterized by high temperature and high rainfall which further augment decomposition of organic matter in soils. Supply of organic matter to soils also greatly reduced because of unavailability of organic materials and deliberate removal of crop residues from fields during crop harvesting.

Carbon stock in soils of Purbadhola and Akhaura upazila and in the Northern and Eastern Piedmont Plains

Four types of land viz. high, medium high, medium low and low land were observed in Purbadhola upazila where the average organic carbon accumulations in 0-20 cm soil layer were 25.40, 16.42, 18.81 and 28.44 t ha^{-1}, respectively and the carbon stocks were 0.97, 0.76, 19.28 and 24.97 Gg, respectively (Table 8).The total carbon stock in Purbadhola upazila was 45.97 Gg. In Akhaura upazila there were also four land types observed viz. high, medium high, medium low and low land and the average organic carbon accumulations were 23.56, 26.61, 24.80 and 30.00 t ha^{-1}, respectively, where the carbon stocks were 29.00, 67.24, 14.63 and 12.27 Gg, respectively (Table 9). In low land the average organic carbon content was the highest but the area was higher in medium high land so the carbon stock was the highest in medium high land. In Akhaura upazila the total land was 3649 ha and carbon stock was 97.04 Gg. In low land the average organic carbon content was the highest, but the area coverage was higher in medium low land and it is observed in both Purbadhola and Akhaura upazila. So, the carbon stock was the highest in medium low land in both the upazilas.

Table 8. Organic carbon stocks in different mouza of Purbadhola upazila under the agro-ecological zone Northern and Eastern Piedmont Plains in Bangladesh

Land type	Carbon content in different mouza (t ha^{-1})			Average organic carbon (t ha^{-1})	Area* (ha)	Carbon stock (Gg)
	Naterkona	Khatuary	Meghshimul			
HL	-	-	25.40±0.74	25.40	38	0.97
MHL	15.08±2.60	17.76±1.70	-	16.42	46	0.76
MLL	15.28±3.96	19.40±2.79	21.76±2.16	18.81	1025	19.28
LL	28.44±0.00	-	-	28.44	878	24.97
Total	58.80	37.16	47.16	-	1987	45.97

1 Gg = 10^9 g, * SRDI (2009)

Table 9. Organic carbon stocks in different mouza of Akhaura upazila under the agro ecological zone of Northern and Eastern Piedmont Plains in Bangladesh

Land type	Carbon content in different mouza (t ha^{-1})			Average organic carbon (t ha^{-1})	Area* (ha)	Carbon stock (Gg)
	Basudebpur	Noapara	Anandopur			
HL	23.56±0.64	-	-	23.56	123	29.00
MHL	24.40±0.55	27.20±1.51	28.24±2.11	26.61	2527	67.24
MLL	-	-	24.80±1.26	24.80	590	14.63
LL	-	30.00±0.44	-	30.00	409	12.27
Total	47.96	57.20	53.04	-	3649	97.04

1 Gg = 10^9 g, * Source: SRDI (1998), HL – High land, MHL – Medium high land, MLL – Medium low land, LL – Low land

In the Northern and Eastern Piedmont Plains of Bangladesh (AEZ 22) the area coverage under high, medium high, medium low and low were 133240.14, 125164.98, 64601.28 and 40375.80 ha, respectively (Table 10). The accumulated organic carbon across 0-20 cm soil depth under high, medium high, medium low and low land were 24.48, 22.52, 20.28 and 28.92 t ha^{-1}, respectively. The carbon stocks in high, medium high, medium low and low land was 3.26, 2.82, 1.31 and 1.17 Tg, respectively (Fig. 1). The total area of Northern and Eastern Piedmont Plains was 363382.20 ha and the calculated carbon stock was 8.56 Tg.

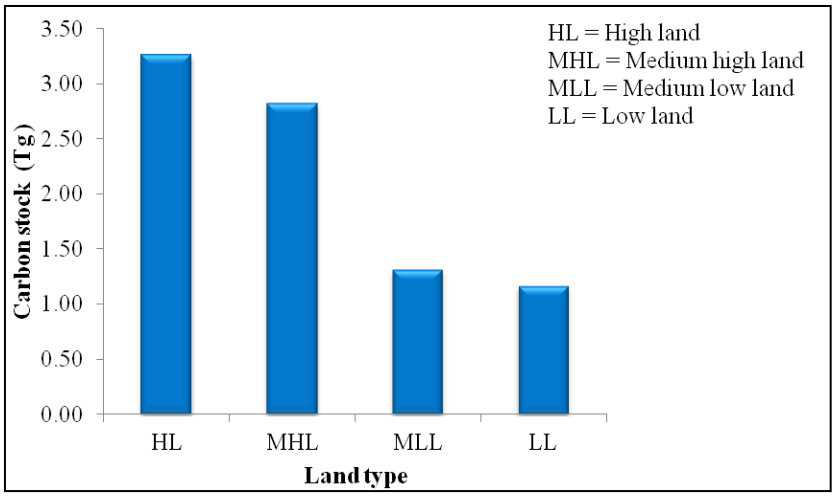

Figure 1. Carbon stocks in soils of different land types in Northern and Eastern Piedmont Plain (AEZ 22)

Table 10. Organic carbon stock in soils of Northern and Eastern Piedmont Plains of Bangladesh

Land type	Area* (ha)	Organic carbon (t ha^{-1})
HL	133240.14	24.48
MHL	125164.98	22.52
MLL	64601.28	20.28
LL	40375.80	28.92
Total	363382.20	-

* Source: BARC (2012), HL – High land, MHL – Medium high land, MLL – Medium low land, LL – Low land

There is no rating of carbon stock across the soil profile in Bangladesh, however as carbon contents are rated as very low to medium stocks can also be rated as very low to medium. Adoption of resource conservation strategies and best management practices might ensure supply and maintenance of organic matter in soils. It is reported that reduced tillage combined with rotations or cover crops that include deep rooted and high residue producing plants is most effective to enhance soil organic matter in soils (Franzluebbers, 2010, Rahman et al., 2017). Organic matter governs bio-physico-chemical properties of soils and thus maintains and regulates soil quality and nutrient cycling. Organic matters also plays a vital role in the mitigation of global warming and climate change as organic matter can serve both as a source and sink for atmospheric carbon dioxide (Grant et al., 2004). Regular application of available organic materials like rice straw and other crop residues, poultry manure, cowdung,

household wastes etc. can increase carbon contents in soils which might contribute in developing soil health and ensures sustainability of production systems in the study area.

CONCLUSIONS

The organic carbon contents in 0-20 cm depth of high, medium high, medium low and low lands of Purbadhola were 25.40, 16.42, 18.81 and 28.44 t ha^{-1}, respectively, while in case of Akhaura these values were 23.56, 26.61, 24.80 and 30.00 t ha^{-1}, respectively. The total carbon stock in soils of Purbadhola, Akhaura upazila and in the AEZ were 45.97 Gg, 97.04 Gg, 8.56 Tg, respectively. The soil reaction was very strongly acidic to slightly acidic, organic carbon contents were very low to medium, nitrogen low, phosphorus very low and potassium low to medium. The soils of the Northern and Eastern Piedmont Plains was found slightly acidic to strongly acidic, organic carbon contents were very low to medium, nitrogen low, phosphorus very low and potassium low to medium. The study revealed that carbon stock and nutrient contents in soils of the Northern and Eastern Piedmont Plains were low, which should be increased adopting different soil and crop management practices best suited to the area concerned.

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ABUNDANCE, DAMAGE SEVERITY AND MANAGEMENT OF GUAVA MEALYBUG, *FERRISIA VIRGATA* Ckll

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ABSTRACT

The research was carried out to know the abundance and damage severity of mealybug on sarupkathi variety of guava and to evaluate the efficacy of jet powder and Fighter 2.5EC for suppressing populations of mealybug during January to October 2014. Results revealed that the highest number of guava mealybug was observed on middle leaf (42/leaf) while the lowest number was on lower leaf (13/leaf). The highest percent leaf area covered by mealybug was found on middle leaf (78%) while the lowest was on fruit (18%). Maximum temperature and relative humidity had a positive correlation on the mealybug population while the rainfall showed a negative correlation. The highest percent mortality was observed in T_2 treatment (Jet powder applied @ 5.0 g L^{-1} of water) at 24 HAT (hours after treatment) (86.05%) and 48 HAT (93.83%), respectively. At 72 HAT, the highest percent mortality was observed T_3 treatment (Jet powder applied @ 7.5 g L^{-1} of water). In case of insecticidal control, the highest percent mortality was observed in T_2 (100%) and T_3 (100%) treatments, respectively followed by T_1 (98.03%) at 24 HAT. Similar trends were also observed among all treatments at 48 HAT and 72 HAT, respectively. No significant differences were found among three doses of Fighter 2.5EC. The lowest percent mortality of mealybug population was found in T_4 (Water spray forcibly) at 24 HAT, 48 HAT and 72 HAT, respectively. No mortality was recorded in untreated control at different HAT in both application of soap solution and insecticides.

Keywords: *Ferrisia virgata*, *Psidium guajava*, jet, fighter 2.5EC, meteorological factors

INTRODUCTION

Guava (*Psidium guajava*: Myrtaceae) known as the apple of the tropics and is one of the most common and popular delicious fruits in Bangladesh. It is very rich in

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vitamin C. Some varieties of guava such as Kazipiara, Kanchannagar, Mukundapuri and Swarupkathi grow everywhere in the country in the homestead gardens but commercially cultivated in Barisal, Sylhet and Chattogram regions. There are several species of mealy bugs that can be pests of greenhouse, nursery, and landscape plants. Nearly 246 families of various plants on which 5000 species of mealybug feed that have been reported all over the world (Ben-Dov, 1994). According to Afzal *et al*. (2009) and Aheer *et al.* (2009), mealybugs feed on nearly 149 plant species, suck plant sap and cause leaves to distort and fall. Mealy bugs are causing loss to different fruit plants namely citrus, guava, grapes, pomegranate, chiku, jamun and aonla. Guava mealybug (*Ferrisia virgata* Ckll.) is one of the most commonly occurring pests found on the fruit crops causing damage to guava and several host plants (Wabale et al., 2010). Mealybugs damage plants by inserting their threadlike mouthparts into any part of the plant and sucking out sap (Frank, 2011). Both nymphs and adult females of these mealybugs suck cell sap from different parts of the plant like the leaves, twigs, tender shoots, branches and fruits thereby reducing the vigour of plant as well as the drying up the tender shoots. They excrete honeydew, a sweet sticky liquid on which sooty moulds often grow causing infested plants to turn black. Considering above facts, the present research work was undertaken to know the abundance and damage severity of mealybug on guava and to evaluate the efficacy of detergents and insecticides for suppressing population of mealybug.

MATERIALS AND METHODS

The study was carried out in the Department of Entomology, Patuakhali Science and Technology University (PSTU) during January to October 2014. Geographically, the research farm is located at $22^{0}37'$ N latitude and $89^{0}10'$ E longitudes. The area is covered Gangetic Tidal Floodplains and falls under Agroecological Zone "AEZ- 13". The area lies at 0.9 to 2.1 metre above mean sea level (Iftekhar and Islam, 2004). The experimental area experiences sub-tropical climate with high temperature and it decreased when the season proceeded towards rabi (October to March).

Abundance and damage severity of guava mealybug

A total of 10 plants were selected as host of mealybug. The age and height of the plants were 5 years and 9 feet, respectively. Infested plants were examined using a magnifying glass. Infested leaves, twigs and fruits were collected from the plants and placed separately in poly bags for further examination in the laboratory. The collected specimens were counted, processed, mounted and labeled for preservation. Number of mealybugs per 5 leaves on different leaf categories viz upper, middle and lower, twig and fruits of each guava plant were recorded. The data were collected on weekly intervals. The percent leaf area covered by mealybugs was recorded by eye estimation.

Collection of meteorological data

Meteorological data on maximum and minimum temperature, relative humidity and rainfall were collected from the Patuakhali district meteorological office.

Evaluation of the efficacy of detergent and insecticide for controlling mealybug

The trial was conducted in completely randomized design with three replications. The infested leaves of different plant canopies were collected from highly infested guava plants and brought back to the laboratory. Thirty mealybugs of nymphs and adults were released on each leaf which was kept in Petri dish. Three doses of Jet powder were used as three treatments where T_1 = 2.5 g L^{-1} of water, T_2 = 5.0 g L^{-1} of water and T_3 = 7.5 g L^{-1} of water along with a control. On the other hand, three doses of Fighter 2.5 EC were used as three treatments where T_1 = 1.0 ml L^{-1} of water, T_2 = 1.5 ml L^{-1} of water and T_3 = 2 ml L^{-1} of water along with a control. The spraying was done with hand sprayer. After spraying the treated leaves were put on soaked filter paper by keeping these in Petri dish separately. The Petri dishes were arranged in three rows following CRD. One row of Petri dishes constituted one replication and a total of 15 Petri dishes were used in this experiment. However, control leaves received no treatment. Observations were recorded on the mortality of mealybugs at 24, 48 and 72 hours interval and cumulative data were calculated for interpretation.

Statistical analysis

Data were analyzed following single factor ANOVA using MSTAT-C computer software. Means were separated by LSD test. The correlations were worked out between mealy bug population and weather parameters of study period.

RESULTS AND DISCUSSION

The number of mealybug population on various parts of guava plant is presented in Fig. 1. The highest number of mealybug per plant was recorded on middle leaf (42) followed by upper leaf (26) while the lowest number was on fruit (6) followed by twig (9) and lower leaf (13).

Figure 2 revealed the damage severity of mealybug through area covered by mealybug on different parts of guava plant. The highest percent leaf area covered by mealybug was found on middle leaf (78%) followed by upper leaf (63%) while the lowest was in fruit (18%) followed by twig (25%) and lower leaf (33%).

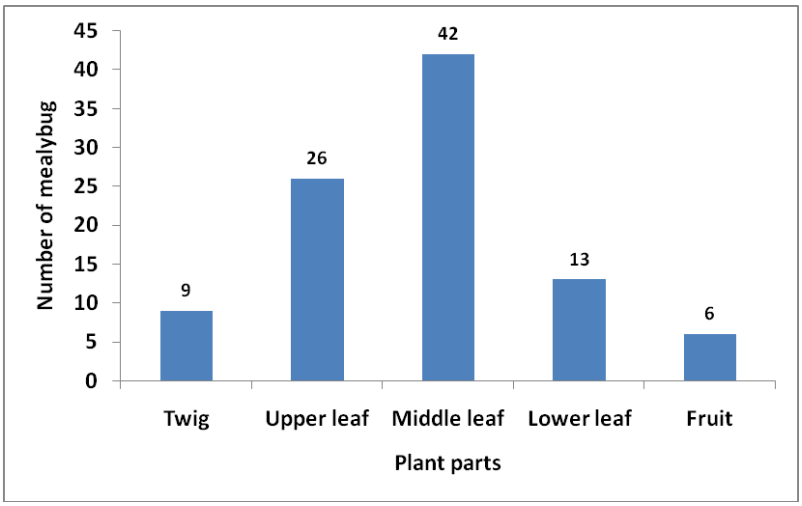

Figure 1. Abundance of mealybug on different plant parts of guava

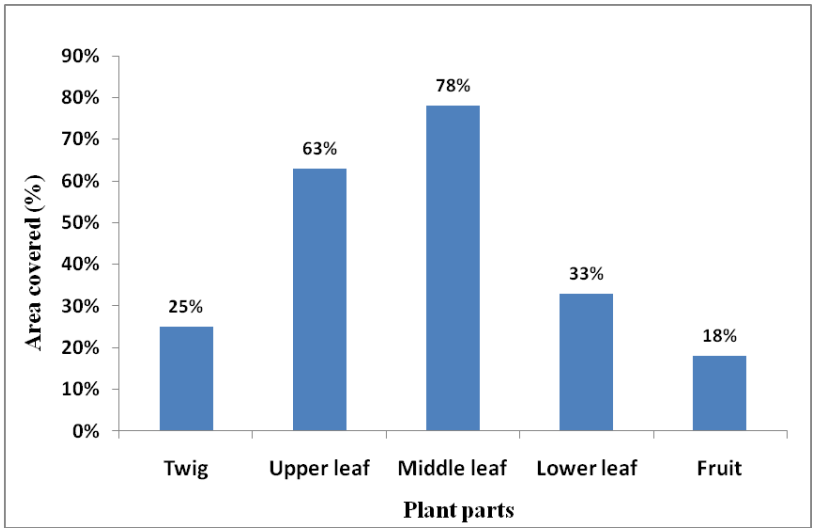

Figure 2. Area covered by mealybug on different parts of guava

The variation in the number of mealybug on different plant parts might be due to the variation of various chemical compounds in guava. It has been reported that leaves on the same plant or even in the same twig may display up to four-fold differences in concentrations of various compounds (Schultz, 1983). The results of the present study are in agreement with the findings of Sultana *et al.* (2015) who reported the similar trend of mealybug population on different leaf categories of guava. This finding was also supported by Wabale *et al*. (2010).

Relationship of mealybug population with weather factors

Temperature, humidity and rainfall have had tremendous effect on mealybug population. There was a positive correlation (r = 0.620) between population of guava mealybug and average maximum temperature. It indicates that the populations of mealybug gradually increased with increasing temperature. The contribution of the regression (R^2 = 0.385) was 39% (Fig. 3). The population of mealybug was also positively correlated with average relative humidity (r = 0.613). It indicates that the populations of mealybug gradually increased with increasing average relative humidity. The contribution of the regression (R^2 = 0.376) was 38% (Fig. 4). On the other hand, there was a negative correlation (r = 0.767) between population of guava mealybug and average rainfall. It indicates that the populations of mealybug gradually decreased with increasing average rainfall. The contribution of the regression (R^2 = 0.588) was 59% (Fig. 5). The findings are supported by Mani and Thontadarya (1978) who stated that maximum temperature had a positive correlation the mealybug population while the relative humidity showed a negative correlation. The influence of relative humidity was contradict with the findings of the present study. Manjunath (1985) reported that the bug was present throughout the year, there being peak period of infestation during February to March. Babu and Azam (1987) reported that the mealybug population was abundant by March on grapevine. Rainfall appeared to have a tremendous negative effect on mealybug population. The population of guava mealybug gradually decreased after May with increasing rainfall and was the lowest in the month of July due to high rainfall (Fig. 5). Koli (2003) reported that mealybug showed non-significant negative correlation with rainfall on grapes.

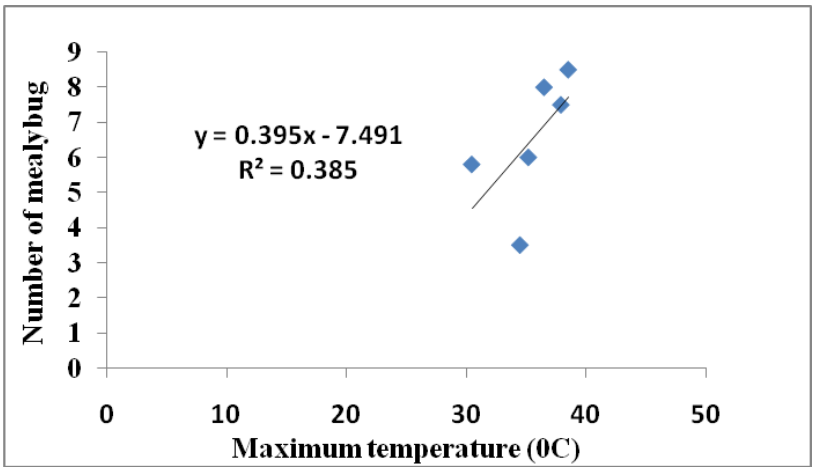

Figure 3. Relationship between mealybug population with maximum temperature in guava

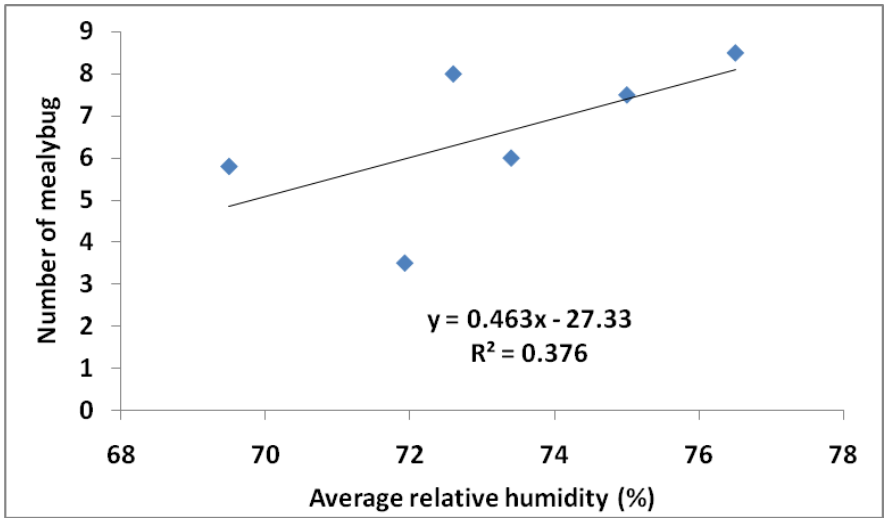

Figure 4. Relationship between mealybug population with average relative humidityin guava

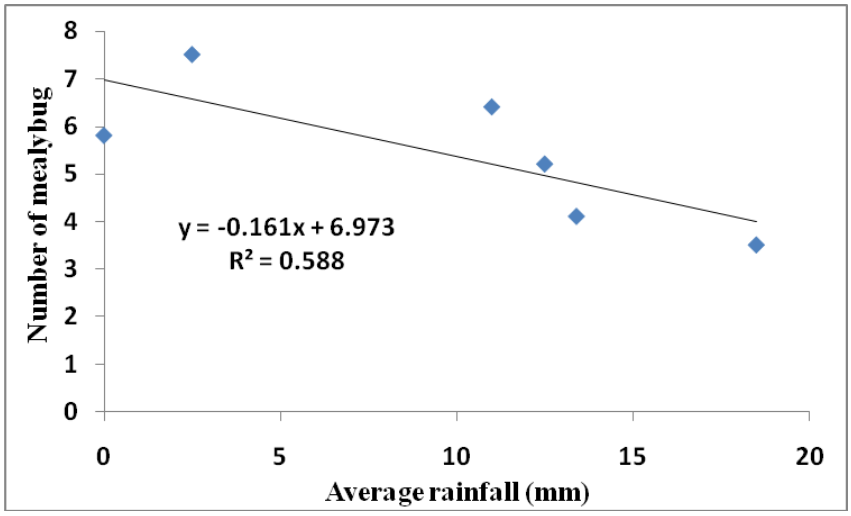

Figure 5. Relationship between mealybug population with average rainfall on guava

Management of mealybug

Effect of different doses of wheel powder and water on mortality of mealybug

The mortality of mealybug population ranged from 0.00% to 86.05% after 24 hours of treatment application (Table 1). Significantly the highest (86.05%) mortality was

observed T_2 treatment (Jet powder applied @ 5.0 g L^{-1} of water) followed by T_3 (81.21%) (Jet powder applied @ 7.5 g L^{-1} of water) and T_1 (74.49%) (Jet powder applied @2.5 g L^{-1} of water). The lowest percent (19.81%) mortality of whitefly population was found in T_4 (Water spray forcibly). No mortality was recorded in untreated control. After 48 hours of treatment application, the highest (93.83%) mortality was observed T_2 treatment (Jet powder applied @ 5.0 g L^{-1} of water) which was statistically similar to T_3 (92.82%) (Jet powder applied @ 7.5 g L^{-1} of water) followed by T_1 (87.19%) (Jet powder applied @2.5 g L^{-1} of water). The lowest percent (4.18%) mortality of mealybug population was found in T_4 (Water spray forcibly). No mortality was also recorded in untreated control. After 72 hours of treatment application, the highest (97.65%) mortality was observed T_3 treatment (Jet powder applied @ 7.5 g L^{-1} of water) which was statistically similar to T_2 (95.90%) (Jet powder applied @ 5.0 g L^{-1} of water) followed by T_1 (93.48%) (Jet powder applied @2.5 g L^{-1} of water). The lowest percent (3.18%) mortality of mealybug population was found in T_4 (Water spray forcibly). No mortality was also recorded in untreated control. Application techniques and force of liquid on the target surface may influence the effectiveness of detergents. The efficacy of Jet powder in the mortality of mealybug population is for the eliminating properties of the waxy layer of the pest along with viscosity. Use of detergents against sucking like mealybugs and whitefly has been reported by other authors. Spraying a steady stream of water with reasonably high pressure on the host plant to knock-off mealybugs. Once on the ground, the fallen ones will be available to ground predators and this will also make their return to the plant difficult. Spraying with a soap and water solution is reported to control mealybugs. Good spray coverage and good timing is important when using soapy solutions and oils. To be effective they must come in contact with the mealybugs. Crawlers are the easiest to kill, since they are more susceptible and are more exposed than eggs, older nymphs and adults. Use of mild solution of soap, mixing an inexpensive liquid dish washing detergent @ 1 tablespoon per gallon of water, and thoroughly spraying the underside of infested leaves can control the guava whitefly (CABI, 1999). Puri et al. (1994) reported that the detergent Nirma, Rin, Surf and Wheel powder at concentration of 0.25, 0.5 and 1 % reduced the sweet potato whitefly *Bemisia tabaci* (Gennadious) adults by 69-91% and nymph by 97-99%.

Table 1. Effect of jet powder on the mortality of mealybug infesting guava at different time interval in laboratory condition

Treatment	Dose	Mortality (%) at different hours after treatment (HAT) application		
		24 HAT	48 HAT	72 HAT
T_1	2.5 gL^{-1} of water	74.49c	87.19c	93.48b
T_2	5.0 gL^{-1} of water	86.05a	93.83a	95.90ab
T_3	7.5 gL^{-1} of water	81.21b	92.82ab	97.65a

Treatment	Dose	Mortality (%) at different hours after treatment (HAT) application		
		24 HAT	48 HAT	72 HAT
T_4	Water spray	19.81d	4.18d	4.18c
T_5	Untreated	0.00e	0.00e	0.00d
LSD (5%)		1.74	1.02	1.81
CV (%)		3.41	3.07	3.23

Means in a column followed by same letter(s) did not differ significantly at 5 % level by LSD
Values are averages of three replications.

Efficacy of various doses of Fighter 2.5 EC on the mortality of mealybug

At 24 HAT, the highest percent mortality was observed in T_2 (100%) and T_3 (100%) treatments, respectively followed by T_1 (98.03%). No significant differences were found among three doses of Fighter 2.5EC. The lowest percent mortality (18.00%) was recorded in T_4 treatment when only water was applied forcibly on infested leaves. No mortality was observed in untreated control. Similar trends were also observed among all treatments at 48 HAT and 72 HAT, respectively (Table 2).

Table 2. Efficacy of various doses of Fighter 2.5 EC on the mortality of mealy bug infesting guava at different time interval in laboratory condition

Treatment	Dose	Mortality (%) at different hours after treatment (HAT) application		
		24 HAT	48 HAT	72 HAT
T_1	1.0 ml L^{-1} of water	98.03a	100.00a	100.00a
T_2	1.5 ml L^{-1} of water	100.00a	100.00a	100.00a
T_3	2.0 ml L^{-1} of water	100.00a	100.00a	100.00a
T_4	Water spray	18.00b	22.00b	22.00b
T_5	Untreated	0.00c	0.00c	0.00c
LSD (5%)		0.06	0.03	0.02
CV (%)		1.06	1.07	1.05

Means in a column followed by same letter(s) did not differ significantly at 5 % level by LSD
Values are averages of three replications.

From the results of Table 1 and 2 it was observed that Jet powder applied at the rate 5.0 g L^{-1} of water at 24, 48 and 72 hours after application provided the effective control of mealybug population in laboratory condition. Likewise, three doses of Fighter 2.5 EC were found to be effective in controlling mealybug in laboratory condition.

The results of the present study are in agreement with the findings of Sultana et al. (2015). The effective control of guava mealybug by using insecticides is also

reported by Baskaran et al. (1999). They found that, *F. virgata* was the dominant coccid species, infesting 98 per cent of guava trees, followed by *M. hirsutus*. Monocrotophos (0.072%), malathion (0.25%), dimethoate (0.06%) and phosalone (0.175%) were evaluated for *F. virgata* control. Dimethoate and malathion were most effective in controlling *F. virgata*. Guava leaf disks were offered to *F. virgata* after treating with phosalone (0.175%), phosphamidon (0.086%), monocrotophos (0.072%), dichlorvos (0.1%), malathion (0.25%) and dimethoate (0.06%) by leaf dipping and leaf spraying. The leaf dip assay was most effective, recording cent per cent mortality at 24 h after treatment. Beevi et al. (1992) tested ten insecticides as sprays in laboratory against eggs of mealy bug, *M. hirsutus*. Hatching was least in eggs treated with neem oil (0.3%) followed by moncrotophos (0.04%), methyl demeton (0.04%) and fish oil rosin soap (2.5%) + dichlorvos (0.2%).

CONCLUSIONS

The highest number of guava mealybug was observed on middle leaf of guava. Populations of mealybug increased with increasing temperature and relative humidity and decreased with increasing rainfall. Application of jet powder @ 5.0 g L^{-1} of water and three doses (1.0 ml, 1.5 ml and 2.0 ml L^{-1} of water) of Fighter 2.5 EC at 24, 48 and 72 HAT were found effective in controlling mealybug population in laboratory condition.

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ECONOMICS OF BLACK GRAM CULTIVATION AND ITS IMPACT ON FARMERS LIVELIHOOD IN TWO SELECTED DISTRICTS OF BANGLADESH

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ABSTRACT

The present study is an attempt to assess the existing agronomic practices of black gram cultivation, its impact on farmers livelihood and constraints of black gram production and marketing. Primary data from 85 farmers were collected during February to March 2016 through face to face interviews. Descriptive statistics and Garret ranking method were used to analyze the data. The majority of the farmers had sown seeds during the last week of September to first week of October. The average seed rate was found to be 19.36 kg per hectare which indicated that all farm households used below recommended dose of seeds (35-40 kg/ha). The average yield of black gram was found higher than the national average. The average net income was observed to be Tk. 26990 and Tk. 19845 in Sherpur and Jamalpur respectively. The average gross margin was observed to be Tk. 37629 on total variable cost basis. It was also found that average returns to labour was Tk. 1000/man-day in Sherpur and Tk. 692/man-day in Jamalpur district respectively. It was also observed that all kinds of livelihood assets of the selected farmers increased significantly through black gram farming. The results revealed that the main constraints faced by black gram grower were lack of irrigation facility, non availability of HYV seeds, low output price, labour scarcity, lack of knowledge about improved varieties with their production technology, excessive rainfall after flowering and weak research-extension farmers linkage etc. Farmers also faced some marketing related problems such as limited buyers, price instability, lack of storage facilities and high market toll. Farmers cultivated black gram because of higher yield, higher income, and easy growing.

Keywords: Black gram, garret method, farmers livelihood

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INTRODUCTION

Agricultural sector is the backbone of Bangladesh economy providing employment to 45 % of the total population and contributes about 14.79% of GDP (BER, 2017). Pulses constitute an integral part of human diet and are potential source of protein for the millions of people of Bangladesh. Pulses provide significant nutritional and health benefits, and are known to reduce several non-communicable diseases such as colon cancer and cardiovascular diseases (Yude et al, 1993; Jukanti et al, 2012).

They contribute 2.3% value added to agriculture in Bangladesh (Niaz et al., 2013). Pulses are considered as "the meat of the poor" because still pulses are the cheapest source of protein (Hamjah, 2014). Pulses are popular and common food, people take this food almost alternate a day, so, this can play an important role to reduce the malnutrition for the poor people of the country if it becomes available to that type of people. The per capita consumption of pulse in Bangladesh is only 14.3 g day^{-1}, which is much lower than WHO recommendation of 45 g day^{-1} and Indian Council of Medical Research recommendation of 60 g day^{-1} (HIES, 2010; Afzal et al., 1999). With the increase production of nutrient-rich crops like more pulses and oilseeds, farmers can ensure reduction of poverty at grass root-level with increase nutritional food security at local levels (Rahman and Zilani, 2009). Among the pulses, Blackgram is very much popular in Bangladesh and ranks 3rd in terms of consumption and total area in which different varieties of this crop are cultivated (BBS, 2014). Black gram is very nutritious as it contains high levels of protein (25 g), potassium (983 mg), calcium (138 mg), iron (7.57 mg), niacin (1.447 mg), thiamine (0.273 mg), and riboflavin (0.254 mg) per 100g. Among the pulses, 45-50 % area covered by black gram in Jamalpur and 75-80% area in Sherpur district. Total cultivated area in Bangladesh is 9805360 hectares of which 44.63%, 18.28% and 10.20% are suitable, moderately suitable and marginally suitable for black gram production (BARC, 2016).

An estimated 6.5 million people live on the char and associated erosion and flood prone areas which are 5% of the total population of Bangladesh. On the other hand, total char area is 5% of the total land area of Bangladesh (EGIS 2000) where in Jamalpur and Sherpur district, it covers 40-42% and pulse crops grown mainly in this char land. In the existing farming systems, pulse crops fit well due to its short duration, drought tolerance, less care and minimum input requirement. Cultivation of different pulses is decreasing day by day. According to department of agricultural extension, pulse area decreased 15-20% in year 2013-14 from year 2012-2013 in Jamalpur and 30-36% area decreased in year 2013-2014 from year 2010-2011 at Sherpur district respectively. Not only that the country is facing acute shortage of

pulses due to accelerated increase of requirements with its rapid population growth. But price of pulses increasing and government of Bangladesh spent more foreign exchange every year in importing pulses to meet up the local demand. Though, pulses are excellent sources of proteins, but they are treated as minor crops and receive little attention from farmers and policymakers. So the decrease in pulse production is a major concern to the government. Considering the above circumstances, pulse production should be increased rapidly to improve the national nutritional status along with less outflow of precious foreign currency.

Many studies (Miah et al., 2004; Islam et al., 2011, 2013 and 2015; Kumar et al., 2009-2010; Gowda et al., 2013; Kumar and Bourai, 2012; Hamjah, 2014; Niaz et al., 2013) focusing on different pulse crop have been conducted earlier in Bangladesh and India are very general and consider the problem from national or regional points of view while no work has been done to understand the problems of black gram in specific locations or districts of Bangladesh. For these reasons, the present study has been undertaken to know the economy of black gram cultivation and its impact on farmers livelihood in Jamalpur and Sherpur districts.

MATERIALS AND METHODS

The present study was conducted in purposively selected two black gram cultivated upazila in Sherpur and Jamalpur district on the basis of maximum area under this crop. Simple random sampling techniques was followed to select the sample size. At first, in each district one upazila (Nakla upazila of Sherpur and Jamalpur sadar upazila of Jamalpur) and from each upazila two char villages were selected based on intensive black gram producing areas in consultation with upazila agricultural officer and Sub Assistant Agricultural Officer to collect primary data and information. Then, a list of all black gram growers in each selected villages was prepared and finally, a total of 85 farmers taking 40 from Sherpur and 45 from Jamalpur district was randomly selected. Primary data were collected by using a predesigned and pre-tested questionnaire in February-March, 2016. The impact on livelihoods was measured through finding comparative position of physical, social, financial, human and natural assets of the farmers before and after adoption of the intervention. The collected data was coded, edited, summarized, tabulated and analyzed to fulfill the objectives of the study. Labour use efficiency was measured to see the rate of return from labour employed by using the following formula as Huq et al., (1998).

$$\text{Return to labour} = \frac{Gross return - All\ cost\ except\ cost\ of\ labour}{No.of\ labour\ employed}$$

Constraint analysis

The Garrett's Ranking Technique (Mahesh, 2000) was used to rank the constraints for both production and marketing of black gram. As per this method, respondents have

been asked to assign the rank for all factors and the outcome of such ranking has been converted into score value with the help of the following formula:

% position = $100(R_{ij} - 0.50)/N_j$

Where,

R_{ij} = Rank given for i^{th} factor by j^{th} individual

N_j = Number of factors ranked by j^{th} individual

The % position of each rank thus obtained was converted into scores by referring to the table given by Garrett. Then for each factor, the scores of each individual are added and then total value of scores and mean values of score is calculated. The factors having highest mean value is considered to be the most important factor.

RESULTS AND DISCUSSION

Level of technology used

For achieving higher yield and profitability, appropriate input use and time of operation is important. It is revealed that the number of ploughing varied from farm to farm and location to location. About 13.04% and 17.86% farmers ploughed their land to cultivate black gram in Sherpur and Jamalpur district, respectively (Table 1). Rest of the farmers produced black gram without ploughing their lands. Ploughing on the survey plot started in the 3rd week of September. In all areas, farmers ploughed their lands with the help of power tiller.

Table 1. Distribution of % of farmers according to land preparation

Location	Land preparation (ploughing)		Variance between respondents
	With	Without	
Sherpur	13.04	86.96	2.02%
Jamalpur	17.86	82.14	10.09%

Sowing of seeds

Farmers followed broad casting method for sowing black gram seeds in all areas. Maximum farmers sowed the seeds during last week of September to first week of October (Table 2). After removal of water from their land, farmers broad casted black gram seeds in their field. The time of seed sowing depended on when flood waters receded. As there was sufficient moisture available in the soil, ploughing did not have much effect on yields.

Table 2. Distribution of farmers according to different dates of sowing

Date of sowing		Sherpur	Jamalpur	Variance between respondents
Month	Week	% of the farmer		
September	3	8.69	3.57	0.63%
September	4	21.31	23.41	2.05%
October	1	63.78	58.73	9.26%
October	2	6.22	14.29	2.09%
Total		100	100	

Variety used

Black gram varieties sown by the farmers are presented in Table 3. All of the farmers of Sherpur used seeds of BARI Mas-3 where in Jamalpur 45% farmers used local variety. On an average, the highest (about 66%) % of the farmers used purchased seeds from the market followed by own seed (34%). The average seed rate per hectare of black gram cultivation was found to be 19.36 kilogram which was below the recommendation of 35-40 kilogram. Variety-wise yield was also observed and presented in Table 4. It was observed that BARI Mas-3 performed better in comparison to local variety sown in the survey plots.

Table 3. Variety used by the farmers

Variety	Sherpur	Jamalpur	Variance between respondents
	% of the farmer		
Local	-	44.71	5.64%
BARI Mas-3	100	55.29	6.36%
Total	100	100	
Source of seed			
Purchased seeds	56.52	75	11.76%
Own seeds	43.48	25	7.24%
Seed rate (kg/ha)	19.93	18.78	2.36%
Rec. seed rate (kg/ha)	35-40		

Table 4. Variety-wise yield of black gram

Yield (Kg/ha)	Sherpur	Jamalpur	Variance between respondents
Local	-	953.67	6.07%
BARI Mas-3	1153.19	1188.64	5.23%

Use of chemical fertilizer: Use of chemical fertilizer by the farmers varied from location to location. Most of the farmers (about 71%) used urea followed by DAP (17%), TSP (6%), and MoP (2%) for black gram cultivation (Table 5). It is noted that there is no farmers found in both the areas used manure in their black gram field. It was found that the average dose of urea application was about 49 and 103 kg per hectare in Sherpur and Jamalpur district respectively. In Jamalpur district, the application of urea per hectare was found doubled than recommended dose. It was also found that, the farmers of Jamalpur district did not use MoP and DAP fertilizer. Among the different kinds of fertilizer used, the rate of urea application was found higher than those of other fertilizers and recommended dose also. In Sherpur area, farmers used all types of fertilizer with excessive rate of DAP (Table 5). Bangladesh Agricultural Research Institute recommended urea 40-50 kg, TSP 85-95 kg, MoP 30-40 kg, and bio-fertilizer 4-5 kg ha^{-1} for its varieties to produce 1.5-1.9 t ha^{-1} black gram (Anonymous, 2011).

Table 5. Location-wise fertilizer application by the sample farmers

Fertilizer	Sherpur	Jamalpur	Variance between respondents
	% of the farmer		
Urea	52.17	89.29	7.73%
TSP	4.34	7.14	1.74%
MoP	4.35	-	0.75%
DAP	34.78	-	1.39%

Table 6. Average labor requirement (man-days/ha) for cultivation of black gram

Location	No. of labour/ha	variance between respondents
Sherpur	38.58	5.31%
Jamalpur	45.05	4.52%

Economic profitability of black gram cultivation

Profitability is one of the major criteria for determination of acceptance of a crop. A perusal of (Table 7) revealed that on an average cost of black gram cultivation was Tk. 55449 and Tk. 55502 ha^{-1} in Sherpur and Jamalpur district, respectively. Study found that human labour, threshing, ploughing and cost of seeds cover the major fractions (70-74%) of the total cost. Location-wise, there was no wide variation in the cost of black gram cultivation per hectare. Return to labour was found highest in Sherpur (Tk. 1000 $head^{-1}$) which indicate efficient utilization of labour input as it was the single highest cost involved input in black gram cultivation. Return to labour in Jamalpur was also found efficient, as it was also greater than that of the wage rate of labour. Benefit cost ratio was found better in both areas. It is thus revealed that pre boro period of black gram cultivation is a good profit earning enterprise.

Table 7. Cost of production, return to labour and benefit cost ratio of black gram in the study areas

Location	Average cost ha^{-1}	Average income ha^{-1}	Return to labour	Benefit cost ratio			Coefficient of variation (in cost)
				Min.	Max.	Average	
Sherpur	55449.47	82439.44	1000.23	1.36	1.88	1.49	13.40%
Jamalpur	55502.01	75346.67	692.14	1.29	1.47	1.36	15.11%

Comparative economic analysis with competitive crop

The summary results of gross return, variable cost and gross margin per hectare and BCR (undiscounted) of black gram and mustard are presented in Figure 1. It shows that ha^{-1} gross return and gross margin of black gram were much higher than those of the mustard farming although the cost of production per hectare black gram farming was higher than that in mustard (Figure 1). From these discussions it is clear that both black gram and mustard farming were profitable, but black gram was more profitable than the mustard production in the char area of Jamalpur and Sherpur district. Thus, the standard of living of farmers as well as resource-poor people would be increased substantially since pulse and oilseed farming are highly remunerative to the char people.

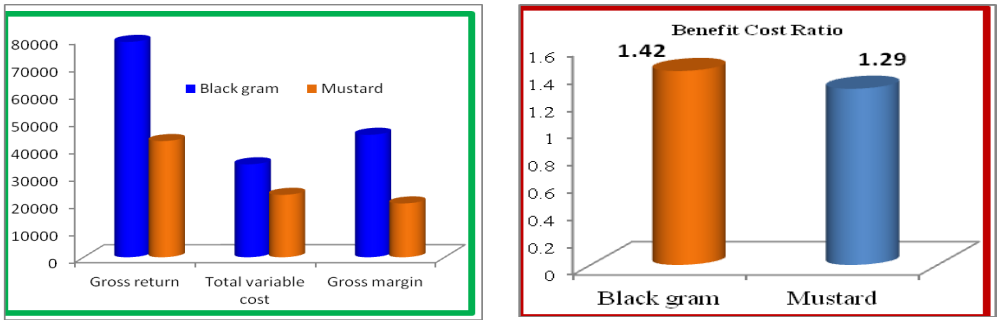

Figure 1. Comparative economic analysis with competitive crop

Source: Akter and Hossain, 2014

Impact of black gram cultivation on farmers livelihood

Livelihood asset: "A livelihood comprises the capabilities, assets and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from stresses and shocks and maintain or enhance its capabilities and assets both now and in the future, while not undermining the natural resource base" (DFID, 2000). A livelihood is the set of capabilities, assets and activities that furnish the means for people to meet their basic needs and support their well being. Therefore the sustainable livelihood framework identifies five types of assets or capitals upon

which livelihood are built, namely human capital, social capital, natural capital, financial capital and physical capital.

Table 8 shows the improvement of livelihood assets of selected farmers in the study areas. Majority of the farmers reported that quality of the components of human capital has increased over the periods through gaining education and knowledge, improving health condition, more access to nation, better training and development of skill in all the selected areas. Almost all farmers involvements in different social groups, their managerial capacity through black gram production had improved in the study areas.

Farmers' income had increased and they were able to have more cash savings and liquid assets through black gram farming along with crop farming, livestock rearing and fisheries. The condition of other major components of housing as well as safe sanitation such as drinking water and paka toilet also developed considerably.

The livelihood diversification is a process of change which varies from farmer to farmer and over the space and time (Ghosh et al., 2011). Therefore, the adoption of any technology is not exclusive, but one of the factors influencing the changes in livelihood of farmers. The rural livelihoods are also wide-ranging (Ashley et al., 2003). Both crop diversification and farm sector diversification lead to livelihood diversification influencing the rural economy; therefore, the adoption of appropriate agricultural technology holds the key for development of rural economy (Mehta, 2009).

Table 8. Changes in human capital, social capital, natural capital, financial capital and physical capital of farm household

(All are in % of respondents' number)

Components	Increase	Decrease	Constant
Human capital			
Health and sanitation	61	14	25
Education	59	-	41
Knowledge/efficiency	23	-	77
Access to information	60	-	40
Social Capital			
Involved in social group/activities	45	6	49
Political involvement	31	11	58
Self managerial capability	59	2	39
Social access	57	6	37
Decision making ability	67	3	30
Women empowerment	37	-	63

Components	Increase	Decrease	Constant
Natural Capital			
Cultivable land	24	8	68
pond	10	-	90
Tube-well water access	47	-	53
Financial capital			
Cash in hand	12	-	88
Cash at Bank	11	-	89
Jewelry	19	8	73
Physical Capital			
Building	3	-	97
Tin roof	49	-	51
Motor cycle / bicycle/ motor van	23	5	72
Electricity	39	-	61
TV/Radio	22	6	72
Mobile phone	53	-	47

Major categories of constraints to black gram cultivation

Although black gram was observed to be a profitable crop, there exist lots of constraints to its higher production. The respondent farmers were asked about the various constraints faced by them in black gram production. The identified constraints were listed out and the farmers asked to rank those problems. The Garrett's ranking technique was used to combine the ranks given by all the farmers and to find out the final ranks. These results are presented in Table 9 and discussed below.

Infrastructural constraints

Infrastructural constraints comprised of four related constraints viz lack of irrigation facilities, non availability of high yielding varieties (HYV) of seeds at the time of sowing and non availability of plants protection chemicals in the market. Among these constraints, lack of irrigation facilities and non availability of HYV seeds of black gram at the time of sowing were the two major constraints faced by the farmers in production of black gram, in order to importance as perceived by the farmers (Table 9).

Socio-economic constraints

Table 9 reveals that six constraints were identified by the farmers as related to their socioeconomic conditions. Low price of black gram, Labour scarcity with high cost and high market toll on output were the major constraints in this category.

Technological constraints

An analysis of the data presented in Table 9 reflects that lack of knowledge about improved varieties of black gram, seed rate, spacing, sowing date was ranked I, in order to importance as perceived by the farmers. Lack of knowledge about insect pest and disease management, lack of knowledge about fertilizer dosage and recommended method of its application, lack of knowledge about seed treatment and weed management were other major technological constraints identified by the farmers in the study areas. Similar have also been reported by Yadav et al., (2002).

Table 9. Major constraints in black gram cultivation as perceived by the farmers

Constraints	Total score	Mean score	Rank
Infrastructural constraints			
a. Lack of irrigation facilities	2817	704.25	I
b. Non availability of plant protection chemicals in the market	2612	653	IV
c. Non availability of HYV seeds at the time of sowing	2684	671	II
d. Non availability of good quality seed and fertilizers	2621	655.25	III
Socio-economic constraints			
a. Low output price	3123	520.50	I
b. Labour scarcity with high cost	3083	513.83	II
c. Non availability of credits in time	2847	474.50	IV
d. High market toll on output	3075	512.50	III
e. Lack of subsidy for inputs	2582	430.33	VI
f. High cost of inputs	2731	455.17	V
Technological constraints			
a. Lack of proper knowledge about improved varieties, seed rate, spacing and sowing date	3115	623	I
b. Lack of knowledge about seed treatment	2695	539	IV
c. Lack of knowledge about fertilizer dosage and time of application	2932	586.4	II
d. Lack of knowledge about weed management	2543	508.6	V
e. Lack of knowledge about insect pest and diseases management	2830	566	III
Environmental constraints			
a. Excess rainfall after flowering	1604	534.55	I
b. Low soil moisture at the time of sowing and fruiting	997	332.33	III

Constraints	Total score	Mean score	Rank
c. Terminal draught	1425	475.11	II
Institutional constraints			
a. Weak research-extension farmer linkages	1811	603.55	I
c. Lack of regulated market	1411	470.33	II
b. Non availability of suitable literature	1149	383.11	III

Environmental constraints

Table 9 reveals that three constraints were identified by the farmers as related to the meteorological conditions. Excessive rain after flowering, terminal draught and low soil moisture at the time of sowing and fruiting were the three major constraints in this category. Similar have also been reported by Joshi et al., (2002).

Institutional constraints

Regarding institutional constraints it was observed that there was a weak research-extension farmer linkage and there was no regulated market nearby where the villagers could sell their produce (Table 9). Weak research-extension-farmer linkage was ranked I and lack of regulated market was ranked II. The third in order in this category was non availability of suitable literature.

Marketing constraints of black gram cultivation

The farmers also faced some marketing related constraints in the study areas. An analysis of the data presented in Table 10 reflects that limited buyer is the main problem in the local market followed by price instability, absence of storage facilities and high market toll on output (Table 10).

Table 10. Marketing related constraints faced by the farmers

Constraints	Total score	Mean score	Rank
Limited buyers or buyers syndicate	3330	666	I
Price instability	2975	595	II
Lack of storage facilities	2560	512	III
High market toll	2480	496	IV

Farmers' attitudes towards black gram cultivation

Almost all the farmers in the survey areas reported that they will increase black gram area in the next season. When asked about the intention to grow black gram in future, 63 % farmers reported that higher yield and income encouraged them for continuing

black gram cultivation. While 33 % farmers in all the areas reported that they will grow black gram as it is easy to grow.

CONCLUSION

Black gram provided high return to investment. This crop is gaining popularity in the study areas very quickly due to its high yield potential. Appropriate level of input use and time of operation is important for achieving higher yield and profits, but the technology employed by the farmers were not at the level of recommendation. A good opinion came out from the sample farmers in the study areas that higher yield and income encouraged them for continuing black gram cultivation.

RECOMMENDATION

Traditional cultural practices are being followed by the farmers so, it is necessary to provide information regarding proper time of sowing, seed rate, fertilizer dose, etc. to the farmers. The findings of the present study provides the empirical feedback to NARS institute (such as BARI, BINA), Agricultural universities who work to develop high yielding varieties, DAE, BADC and various non-governmental organizations working in agricultural and allied departments to strengthen the research-extension farmers linkage by providing credible and timely information to the farming community.

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EFFECTS OF MICRONUTRIENT APPLICATION ON DIFFERENT ATTRIBUTES OF POTATO IN FLOODPLAIN SOILS OF BANGLADESH

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ABSTRACT

Different crops have variations in their responses to applied micronutrients in soil. A study was conducted on floodplain soil of Bangladesh to explore the response of potato to application of micronutrients in soil. The experimental site was located at farmers' field in Chandina upazila under Cumilla district of Bangladesh covering the soils of Old Meghna Estuarine Floodplain (AEZ 19) during 2011-12. Randomized complete block design with 3 replications of each treatment was used in the experiment, where seven treatments including a control were tested. Additive element trial technique was followed while designing the treatments taking six micronutrients i. e. Zn, B, Cu, Mn, Fe and Mo at the rate of 3, 2, 2, 3, 5 and 1 kg ha^{-1}, respectively. Macronutrients, such as N, P, K and S were applied at recommended rates to all plots. The highest tuber yield (28.7 t ha^{-1}) was produced by the combined application of Zn and B. Only Zn application was sufficient to obtain the highest content of protein as well as content of almost all the nutrients in potato tuber. Antagonistic relation between Zn and P in soil-plant system was recorded in the study. Zinc and boron application influenced different growth and yield parameters of potato while the other four added micronutrients did not have any significant effect but combined application of Zn, B, Cu, Mn, Fe and Mo had beneficial role for better plant growth and production. Proper management of zinc and boron fertilizers including optimization of application rates of those nutrients can help to uphold the yield and quality of potato in floodplain soil.

Keywords: Micronutrients, potato, floodplain soil, Bangladesh.

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INTRODUCTION

The agro-based economy of Bangladesh has two main challenges which are vast population to feed and small arable land area. To produce more food for the ever increasing population the arable land is being intensively used. Cropping intensity of this country in 1983-84 was 171% which has become 194% in 2015-16 (BBS, 2017). Moreover, cultivation of HYV and hybrid varieties of different crops is deteriorating soil fertility day by day due to exhaustive nature of those varieties. As a consequence new nutrient deficiency in soil is emerging. Chronologically N, P, K, S, Zn and B deficiencies have arisen in this country's soils (Islam, 2008). Occurrence of Cu, Mo and Mn deficiencies in crops are reported sporadically (Bhuiyan et al., 1998 and Khanam et al., 2000). Some reasons of micronutrient deficiency in Bangladesh were highlighted by Jahiruddin and Islam (2014) and those are organic matter depletion, unbalanced use of fertilizers, minimum or no use of manure, high cropping intensity, high pH (e.g. calcareous soils), nutrient leaching and light textured soils (Jahiruddin and Islam, 2014). Farmers of Bangladesh are not habituated with the use of micronutrient in crop cultivation that challenge balanced fertilization and creates negative impact in crop production (Rijpma and Jahiruddin, 2004).

Micronutrients help increase the efficiency of the use of macronutrients. Again, continual use of micronutrients may lead to an accumulation of toxic levels of those that may threaten crop quality. Hence, judicious application of micronutrients is very much essential; whereas micronutrients have received less attention in different research and extension projects. Different institutions have carried out a number of field trials with micronutrients at different regions of the country. These researches were concentrated mainly on cereal crops, but those were scanty with vegetables. Experiments with micronutrient have been conducted mainly on rice (Jahiruddin et al., 1994), wheat (Hossain, 2005) and maize (Alam et al., 2000), among the cereals. Among the vegetables, potatoes have been an important constituent of food for centuries and are an integral part of the diet, both for rich and poor population. Some field trials on micronutrients in vegetables cultivation have been made (Nasreen et al., 2009).

Impact of a micronutrient deficiency is commonly measured as loss of crop yield; nevertheless quality of harvested products is also important. For the sake of improved human and animal health, micronutrient levels in foods need to be enhanced. Bell and Dell (2008) estimated that more than three billion people in the world are suffering from micronutrient malnutrition. A nutrient balanced diet is the aim of any sustainable food security program. Studies have revealed that micronutrient deficiency led disorders occur in over half of the total human population globally. As per available literature, an adult human body has about 2-3 g of zinc, about 0.1% of which is replenished daily. The recent studies in molecular physiology strongly suggest that in some cases the iron deficiencies in humans may be associated with zinc deficiency (Upadhayay et al., 2012). The soil resource of Bangladesh mostly comprises with floodplain soils and the Old Meghna Estuarine Floodplain (AEZ 19)

has coverage of huge agricultural land area. With a view of considering the above points, a study was conducted for evaluating the effect of micronutrient application on different traits of potato in floodplain soil of Bangladesh.

MATERIALS AND METHODS

Experimental site

Farmer's field in Gabura village under Chandina upazila of Cumilla district in Bangladesh was the site of the experiment. The soil of the experimental field belonged to the Old Meghna Estuarine Floodplain (AEZ 19) having Chandina soil series under Non-Calcareous Dark Grey Floodplain Soil type. The nutrient status including other parameters in initial soil is shown in Table 1. The popular potato variety 'Diamant' was used in the trial.

Table 1. Initial status of nutrients and other parameters in soil of experimental field

Characteristics	Status
Organic matter (%)	1.68
pH	6.1
Total N (%)	0.10
Available P (mg kg^{-1})	14.8
Exchangeable K ($cmol_c$ kg^{-1})	0.07
Exchangeable Ca ($cmol_c$ kg^{-1})	3.95
Exchangeable Mg ($cmol_c$ kg^{-1})	2.73
Available S (mg kg^{-1})	7.5
Available Zn (mg kg^{-1})	0.79
Available B (mg kg^{-1})	0.28
Available Cu (mg kg^{-1})	2.28
Available Fe (mg kg^{-1})	257
Available Mn (mg kg^{-1})	8.9

Treatments

Seven treatment combinations including a control were tested in the experiment. The treatments were T_1 (Control), T_2 (Zn), T_3 (Zn+B), T_4 (Zn+B+Cu), T_5 (Zn+B+Cu+Mn), T_6 (Zn+B+Cu+Mn+Fe) and T_7 (Zn+B+Cu+Mn+Fe+Mo). Micronutrients were

applied as $ZnSO_4.7H_2O$, H_3BO_3, $CuSO_4.5H_2O$, $MnCl_2$, $FeSO_4.7H_2O$ and Na_2MoO_4 at the rates of 3 kg Zn, 2 kg B, 2 kg Cu, 3 kg Mn, 5 kg Fe and 1 kg Mo ha^{-1}, respectively. To apply different macronutrients, urea, TSP, MoP and gypsum were used at recommended rates (125, 25, 100 and 10 kg ha^{-1} for N, P, K and S, respectively) equally for all plots (FRG, 2005).

Experimental design and layout

The experiment was set up with randomized complete block design having three replications of each treatment. The treatments were randomly distributed to the plots in each block. The individual plots measuring 5 m × 4 m were surrounded by 40 cm wide and 10 cm height earthen bunds. One meter wide and 10 cm deep irrigation channel was made in-between two blocks. The land was prepared well before planting. The layout of the experiment and randomization was done in accordance with the standard statistical methods.

Planting potato seeds and intercultural operations

Furrows were made with a plough and sprouted seed tubers were planted in the furrows maintaining a spacing 55 cm × 15 cm. All the tubers in the furrows were covered with soil. The first earthing-up was done after the second dose of urea application at 30 DAP. The 2nd earthing-up was done at 40 DAP. Irrigation was provided once at 35 DAP. To control late blight disease, ridomyl was sprayed at 10-day intervals starting from 25 DAP until maturity. To control rodent, phostoxin tablet (fumigant) was inserted into the hole of the rodents and then opening of the hole was blocked with soil.

Data recorded

Potato tubers were harvested when they attained edible stage. Six square meter area from each plot was harvested to record tuber and haulm yields. The weights of tuber were taken just after harvest. The haulm yield was expressed on sundry basis. Data on plant height were recorded from 10 randomly selected representative plants from outside the harvested area within a plot, as described by Gomez and Gomez (1984).

Collection and preparation of plant samples for chemical analysis

Plant samples (tuber and haulm) were collected at the time of harvesting. The haulm samples were air dried immediately after collection and the dry samples were chopped off into smaller pieces. The collected plant samples were then oven dried at 65°C for 24 hours. To obtain homogenous powder, the samples were finely ground by using a grinding-mill to pass through a 60-mesh sieve. The processed plant samples were chemically analyzed for determination of N, P, K, S, Zn and B concentrations following the methods stated in Table 3. Nutrient uptake was calculated from the yield and respective nutrient concentration data using the following formulae-

-For N, P, K and S:

Nutrient uptake by tuber (kg ha^{-1}) = Nutrient content in tuber (%) × Oven dry yield (t ha^{-1}) × 10

Nutrient uptake by haulm (kg ha^{-1}) = Nutrient content in haulm (%) × Oven dry yield (kg ha^{-1})/100

-For Zn and B:

Nutrient uptake (g ha^{-1}) = Nutrient content in tuber (µg g^{-1}) × Oven dry yield (t ha^{-1})

Nutrient uptake (g ha^{-1}) = Nutrient content in haulm (µg g^{-1}) × Yield (kg ha^{-1})/1000

Protein concentrations of potato tuber were calculated from N concentration of tuber by using the following formulae-

% Protein = % N of the produce × 6.25. (FAO/WHO/UNU, 1985)

Table 2. Methods used for plant analysis

Elements analysed	Analytical methods used
N	Micro-Kjeldahl method (Bremner and Mulvaney, 1982)
P	Colorimetric method (Yoshida *et al*., 1976).
K	Ammonium acetate extraction method using flame photometer (Yoshida *et al*., 1976)
S	Turbidimetric method (Chapman and Pratt, 1961)
Zn	DTPA extraction method using atomic adsorption spectrophotometer (Yoshida *et al*., 1976)
B	The B concentration was determined by spectrophotometer following azomethine-H method (Keren, 1996)

Data analysis

The collected data were compiled and tabulated, which were subjected to statistical analyses following standard methodology and the mean differences were adjudged by Duncan's Multiple Range Test (Gomez and Gomez, 1984).

RESULTS

The effects were evaluated in terms of tuber yield, haulm yield, plant height, protein & zinc concentration of tuber, and nutrient uptake by tuber & haulm.

Plant height

Plant height of potato was significantly affected by the treatments showing a range of 45.2-56.7 cm (Table 3). The highest plant height was observed in T_7 treatment which had statistical similarities to those of all other treatments except control.

Tuber yield

Tuber yield of potato was significantly influenced by the micronutrients treatment (Table 3). The highest tuber yield (30.3 t ha^{-1}) was recorded in T_6 treatment, which was statistically similar to those of all other treatments except T_1 and T_2. The lowest tuber yield (21.0 t ha^{-1}) was produced by control treatment. The T_2 treatment produced tuber yield (25.3 t ha^{-1}), which was higher than that of control but similar to T_3 and T_4 treatments. Like tuber yield, haulm yield was also significantly influenced by the treatments and it varied from 9.64 kg ha^{-1} in T_1 to 1.23 kg ha^{-1} in T_7 treatment. All treatments other than control produced statistically similar haulm yield.

Protein content of potato tuber

Nutritional quality of potato tuber with regards to protein and zinc concentrations varied significantly due to application of different micronutrients (Table 4). Protein concentration ranged from 1.31% in control treatment to 1.81% in T_5 treatment. Except control, all treatment effects had statistical similarities to each other which indicated that addition of micronutrients other than Zn did not add any extra benefit. It is also noted that Zn helped protein synthesis in tuber, which improves food quality.

Table 3. Effects of micronutrients on plant height and yield of potato

Treatments	Plant height (cm)	Tuber yield (t ha^{-1})	Haulm yield (t ha^{-1})
T_1: Control	45.2b	21.0c	9.64b
T_2: Zn	56.7a	25.3b	1.18a
T_3: Zn+B	56.3a	28.7ab	1.18a
T_4: Zn+B+Cu	55.0a	28.9ab	1.16a
T_5: Zn+B+Cu+Mn	55.8a	29.5a	1.18a
T_6: Zn+B+Cu+Mn+Fe	55.8a	30.3a	1.20a
T_7: Zn+B+Cu+Mn+Fe+Mo	56.7a	29.8a	1.23a
CV (%)	5.23	7.79	5.92
Significance level	**	**	**
SE (±)	1.65	1.24	0.04

Means followed by same letter in a column are not significantly different at 5% level by DMRT.

SE (±) = Standard error of means, CV= Co-efficient of variation, ** = Significant at 1% level

Table 4. Effects of micronutrients on protein and zinc concentrations of potato tuber

Treatments	Protein (%)
T_1: Control	1.31b
T_2: Zn	1.64a
T_3: Zn+B	1.68a
T_4: Zn+B+Cu	1.67a
T_5: Zn+B+Cu+Mn	1.81a
T_6: Zn+B+Cu+Mn+Fe	1.66a
T_7: Zn+B+Cu+Mn+Fe+Mo	1.67a
CV (%)	9.15
Significance level	*
SE (±)	0.09

Note: Protein and zinc concentration of potato tuber is expressed as fresh weight basis.

Means followed by same letter in a column are not significantly different at 5% level by DMRT.

SE (±) = Standard error of means, CV = Co-efficient of variation, * = Significant at 5% level

Nutrient concentration and their uptake by potato

Nutrient concentrations of potato tuber were expressed as fresh weight basis (Table 5). Other than P in tuber and S in both tuber and haulm, the nutrient concentrations of potato affected significantly by the treatments applied. In almost all cases (except K in tuber and B in both tuber and haulm), application of only Zn was found to be sufficient for the highest concentrations. The uptake of different nutrient elements as calculated from respective nutrient concentration and yield data is presented in Table 6 and discussed below :-

Nitrogen uptake

There were significant differences in the N uptake by potato (tuber + haulm) due to different treatments. The highest uptake of tuber N and total uptake of N (86.3 and 107 kg ha^{-1}, respectively) was found in T_5 (Zn+B+Cu+Mn) treatment, while that of haulm N (22.1 kg ha^{-1}) was in T_7 (Zn+B+Cu+Mn+Fe+Mo) treatment. Except T_1, all other treatments had statistically similar effects on N uptake.

Table 5. Effects of micronutrients on the nutrient concentration of potato

Treatments	N (%)		P (%)		K (%)		S (%)		Zn (µg g^{-1})		B (µg g^{-1})	
	Tuber	*Haulm*	*Tuber*	*Haulm*	*Tuber*	*Haulm*	*Tuber*	*Haulm*	*Tuber*	*Haulm*	*Tuber*	*Haulm*
T_1: Control	0.209b	1.56b	0.063	0.214a	0.414c	1.66b	0.044	0.207	6.98b	85b	6.71b	37.2b
T_2: Zn	0.263a	1.77a	0.052	0.180c	0.469b	1.90a	0.051	0.238	8.56a	102a	7.29b	39.5b
T_3: Zn+B	0.269a	1.79a	0.052	0.204ab	0.520a	1.87a	0.050	0.235	8.60a	108a	8.86a	53.0a
T_4: Zn+B+Cu	0.267a	1.81a	0.053	0.193bc	0.515a	1.85a	0.049	0.220	8.45a	107a	8.54a	51.6a
T_5: Zn+B+Cu+Mn	0.289a	1.77a	0.055	0.208ab	0.501ab	1.90a	0.050	0.232	8.27a	107a	8.73a	49.9a
T_6: Zn+B+Cu+Mn+Fe	0.266a	1.78a	0.054	0.190bc	0.511a	1.91a	0.050	0.232	8.64a	109a	8.88a	53.7a
T_7: Zn+B+Cu+Mn+Fe+Mo	0.267a	1.80a	0.053	0.212a	0.505a	1.89a	0.050	0.228	8.51a	108a	8.59a	52.4a
CV (%)	9.12	2.34	8.69	4.90	3.80	2.43	5.91	7.86	6.21	7.86	6.81	7.74
Significance level	*	**	NS	**	**	**	NS	NS	*	*	**	**
SE (±)	0.014	0.024	0.003	0.006	0.011	0.026	0.002	0.011	0.30	4.71	0.32	2.15

Note: Nutrient concentration of potato tuber was expressed as fresh weight basis.

Means followed by same letter in a column are not significantly different at 5% level by DMRT

SE (±) = Standard error of means, CV= Co-efficient of variation,

*= Significant at 5% level, **= Significant at 1% level, NS=Non-significant

Table 6 Effects of micronutrients on the nutrient uptake of potato

Treatments	N uptake (kg ha^{-1})			P uptake (kg ha^{-1})			K uptake (kg ha^{-1})		
	Tuber	*Haulm*	*Total*	*Tuber*	*Haulm*	*Total*	*Tuber*	*Haulm*	*Total*
T_1: Control	43.7b	15.1b	59b	13.3	2.06d	15.3	87c	16.0b	103c
T_2: Zn	66.5a	20.9a	87a	13.1	2.12cd	15.2	119b	22.3a	141b
T_3: Zn+B	77.0a	21.2a	98a	14.9	2.42abc	17.3	149a	22.1a	171a
T_4: Zn+B+Cu	77.2a	21.0a	98a	15.4	2.24bcd	17.7	149a	21.5a	170a
T_5: Zn+B+Cu+Mn	86.3a	20.9a	107a	16.3	2.46ab	18.7	148a	22.4a	171a
T_6: Zn+B+Cu+Mn+Fe	80.6a	21.4a	102a	16.5	2.29bcd	18.8	155a	23.0a	178a
T_7: Zn+B+Cu+Mn+Fe+Mo	79.6a	22.1a	102a	16.0	2.61a	18.6	151a	23.2a	174a
CV (%)	14.7	6.23	11.4	14.8	7.05	13.3	10.7	6.5	9.6
Significance level	**	**	**	NS	**	NS	**	**	**
SE (±)	6.21	0.73	6.15	1.29	0.02	1.33	8.5	0.81	8.8
T_1: Control	9.3b	1.98b	11.3b	146c	83b	229c	141b	35.6c	177b
T_2: Zn	12.9a	2.81a	15.7a	217b	120a	337b	184b	46.6b	231b
T_3: Zn+B	14.3a	2.78a	17.1a	246ab	128a	374ab	254a	62.8a	316a
T_4: Zn+B+Cu	14.1a	2.55a	16.6a	243ab	125a	369ab	247a	59.9a	306a

Treatments	N uptake (kg ha^{-1})			P uptake (kg ha^{-1})			K uptake (kg ha^{-1})		
	Tuber	*Haulm*	*Total*	*Tuber*	*Haulm*	*Total*	*Tuber*	*Haulm*	*Total*
T_5: Zn+B+Cu+Mn	14.7a	2.74a	17.4a	241ab	126a	367ab	258a	58.7a	317a
T_6: Zn+B+Cu+Mn+Fe	15.2a	2.80a	18.0a	263a	132a	395a	270a	64.9a	335a
T_7: Zn+B+Cu+Mn+Fe+Mo	14.9a	2.80a	17.7a	254ab	133a	387ab	257a	64.6a	321a
CV (%)	11.6	9.70	10.8	9.30	11.3	8.3	12.5	10.5	11.5
Significance level	**	*	**	**	**	**	**	**	**
SE (±)	0.91	0.02	1.02	12.4	7.9	16.8	16.6	3.42	19.0

Means followed by same letter in a column are not significantly different at 5% level by DMRT.

SE (±) = Standard error of means, CV= Co-efficient of variation, *= Significant at 5% level, **= Significant at 1% level, NS=Non-significant

Phosphorus uptake

Total uptake of P as well as tuber P uptake did not vary significantly with the micronutrient treatments but haulm uptake of P was affected. Tuber P uptake ranged from 13.1 kg ha^{-1} in T_2 to 16.5 kg ha^{-1} in T_6 treatment, while the haulm P uptake varied from 2.06 kg ha^{-1} in T_1 to 2.61 kg ha^{-1} in T_7 treatment. The highest P uptake of 18.8 kg ha^{-1} (tuber + haulm) was recorded for T_6 treatment and the lowest P uptake (15.2 kg ha^{-1}) was due to T_2 treatment. It was noted that, tuber P uptake in T_1 was higher than that in T_2 treatment. Such exception was due to the higher P concentration in T_1 as compared to T_2 treatment.

Potassium uptake

Uptake of K by potato significantly increased due to application of micronutrients to soil. The highest uptake of tuber K and total uptake of K (155 and 178 kg ha^{-1}, respectively) was observed in T_6 treatment and the highest haulm K uptake (23.2 kg ha^{-1}) was recorded in T_7 treatment. The treatment having the highest K uptake by tuber and the highest total K uptake was statistically identical with all other treatments except T_1 and T_2.

Sulphur uptake

The S uptake by potato was also affected significantly by the various micronutrient treatments. The highest uptake of tuber S and haulm S (15.21 and 2.81 kg ha^{-1}, respectively) was found in T_6 and T_2 treatments.

Zinc uptake

The Zn uptake by potato was significantly influenced by the treatments used. The highest uptake of tuber and total Zn (263 and 395 g ha^{-1}, respectively) was observed in T_6 treatment and it was statistically similar to all other treatments except T_1 and T_2. On the other hand, Zn uptake in haulm was the highest (133 g ha^{-1}) in T_7 treatment which was statistically similar to those of all other treatments except T_1.

Boron uptake

Like zinc uptake, boron uptake by potato also significantly increased over the control as an effect of different micronutrient treatments. The highest uptake of 270 and 64.9 g ha^{-1} by tuber and haulm, respectively, was observed in T_6 treatment which was statistically similar to that recorded with all other treatments except T_1 and T_2.

DISCUSSION

The effect of micronutrients application on different traits of potato was studied through field trials followed by chemical analysis in the laboratory. Plant height at harvest was affected significantly due to application of different treatments. Only Zn was found to affect plant height. Pregno and Armour (1992) stated that application of B did not increase plant height of potato. Tuber yield of potato was significantly influenced by different micronutrient treatments. Tuber yield increased significantly by the application of Zn but to obtain the highest yield B was needed to apply. This result has similarities with the findings of some other scientists. Dwivedi (1991) showed that $ZnSO_4$ applications can increase potato yield by 37% and spraying with Zn increased potato yield. Trehan and Grewal (1981) stated that in potato cultivation, Zn and B can help in increasing the foliage coverage at initial growth stages and in the later stages, the translocation of assimilates is responsible for higher yield. Chaudhary et al. (2001) found that potato responded quadratically to Zn application. Puzina (2004) observed that potato fertilization using boric acid caused an increase in tuber size and weight by increasing of cell diameter in the tuber.

Like tuber yield, application of only Zn was sufficient to achieve the statistically highest haulm yield. The application of 20 ppm Zn increased the dry weight of stem, root and main stolen (Langille and Batteese 1974). Bari et al. (2001) showed that application of 1.1 kg B ha^{-1} from borax increased potato fresh haulm weight $hill^{-1}$ and yield of tuber ha^{-1}. Considering nutritional aspects, protein contents of vegetables is a matter of concern in the present situation. In this study, only Zn was sufficient to achieve the highest protein concentration of potato tuber. According to Mousavi et al. (2012) zinc is essential micronutrients for protein production in plants; also zinc is main composition of ribosome and is essential for their development. Zinc is active element in biochemical processes and has a chemical and biological interaction with some other elements. Phosphorus is the most important element which interferes on zinc uptake by plants. Micronutrient application influenced the uptake of N, K, S, Zn and B by potato. P uptake by the crops did not affect significantly. This might be due to antagonistic relationship between Zn and P in soil-plant system. Except Zn and B, the other micronutrients did not play positive role on nutrient uptake by the crops. Sandeep et al. (2014) reported that application B and Zn enhanced potato tuber yield and also influenced uptake of N, P, K, S, Zn and B. El-Banna and Abd El-Salam (2005) reported that foliar spraying of potato plants with B at 75 ppm significantly recorded the highest concentrations of N, K and B in plants. Arisha et al. (1999)

found that foliar spray of B as boric acid with recommended doses of NPK increased concentration and total uptake of N, P and K. El-Mahdy (2007) showed that foliar spray of B at rate 75 ppm increased concentration of N, P, K and B and its uptake.

CONCLUSION

In floodplain soil application of zinc and boron fertilizers can help to boost up potato yield as well as ensure nutritional concerns. It is needed to conduct further exclusive research to optimize application rates of these nutrients to potato in floodplain soil.

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GENDER ROLE IN VEGETABLE PRODUCTION IN RURAL FARMING SYSTEM OF KANCHANPUR, NEPAL

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ABSTRACT

Agriculture is the primary occupation for the majority of Nepalese populace for their livelihood; the case is especially true for rural areas of Nepal. While both male and female engage in diverse agricultural activities, gender-specific roles in agricultural decision-making are significant. A survey study was conducted in three wards of Kanchanpur district (Majhgau-14, Bhuda-02, and Baghphata-19) to examine the gender-specific labor input in vegetable production activities. Eighty households were chosen by random sampling and a scheduled interview was carried out. Most of the activities such as fence construction, transplanting, fertilizer use, harvesting, cleaning, and grading were found typically female's responsibility. However, males were found dominantly involved in land preparation. Also, males were found to have relatively more access to, and control over farm resources and played dominant role in decision making than women. The findings of this study revealed that there are gender-specific domains in rural farming system. Therefore, there is a need to develop gender friendly technology and policy while formulating specific project planning and development efforts.

Keywords: Access, Decision, Farming system, Gender, Vegetable, Women

INTRODUCTION

Gender refers to the socially assigned roles and behaviors of men and women. It is social meaning of biological sex differences. Gender roles are the responsibilities that women and men perform. These responsibilities are determined by the socio-economic and cultural environment and not by the biological factors (Mollel and Mtenga, 2000). The different roles played by men and women in the society are because of the gender disparity. And this causes bias in the distribution of resources, work, wealth, decision-making, as well as the enjoyment of entitlements and rights within the family and in public life (Welch et al., 2000).

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Women are involved in many aspect of rural life: household chores, livestock activities, farm work and caring for family members. They mainly contribute for the household consumption and food preparation. Therefore the role of women in advancing agricultural development and food security is considered vital (FAO, 2011). About 43% of workers engaged in agricultural activities around the globe are women (Akter et al., 2017). In Asian and African countries, about half of all agricultural workers are women (Agarwal, 2015). However, regardless of their greater contribution, they possess constraints in the multiple activities they pursue – less land ownership, access to credit, extension and other services, and ability to hire labor (Doss et al., 2008). The gender gap measured on the basis of agricultural produce per unit of cultivated land ranges from 4 to 25 percent, depending on the country and the crop (World Bank and ONE, 2014). This gap exists because women frequently have unequal access to key agricultural inputs such as land, labor, knowledge, fertilizer, and improved seeds (Sheahan and Barrett, 2014; Kassieet al., 2015). The authors revealed that women farmers generally face greater difficulty in obtaining fertilizers and water, particularly in African and Asian countries. Women generally do not have access to land and pursue farming on land owned by their husband or other male family members. Also, if women do have access to land, they seldom have the rights to lease or sell it (Agarwal, 2015). Because of these constraints and women's sub-ordinate position in the society, the contribution of women in the field often go unrecognized.

In Nepal the female headed household comprise of only 25.7% (CBS, 2018). And participation of women in economic activities is 55.2% versus 71.6% of men indicating a poor status of Nepalese women (CBS, 2009). Women are mostly involved in non-productive activities such as household chores and other farm activities which do not account value for their work. In an ideal Nepalese household, man generates income and his wife involves in domestic activities. Usually, men are responsible to earn either through farming or through non-farm activities, while women are responsible for child bearing/rearing, household chores and tending animals (Bhattarai, 2002). Inclined male out migration in the search of better job opportunities have resulted in increased work burden over women's. Now, women have to perform the work of house and that of farm. Women perform almost all the task except ploughing and transporting of the final produce, which are exclusively performed by men (Venkateswaran, 1995; Aggarwal et al., 2013). However, the contribution of gender in vegetable production is found reversed. Role of women in homestead vegetable cultivation activities is found dominant in comparison to men (Sultana, 1993; Rana et al., 2018).

Rana et al. (2018) stated that labor work for vegetable activities is solely the responsibility of women in Sindhuli district of Nepal. The homestead vegetables are majorly used for home consumption and are not considered as a cash oriented job. Sultana (1993) reported that every family member contribute for homestead vegetable production, but the most of labor input like land preparation, transplanting,

watering and harvesting was done by women. However, men preferably helped for fertilizer and pesticide application. Similarly, Akanda (1994) in his study found that rural women had high participation in vegetable cultivation. This research survey was carried with an aim to understand the real situation of women in the vegetable cultivation in the rural community of Kanchanpur district of Nepal.

METHODOLOGY

A survey study was conducted in three villages of Kanchanpur district (Majhgau-14, Bhuda-02 and Baghphata- 19) to examine gender participation in vegetable production activities. Eighty households were chosen by random sampling technique and a scheduled interview was carried out during September-October, 2017. All the data were assembled in IBM SPSS 20. Different descriptive and inferential statistics were used for the analysis.

RESULTS

Socio-demographic characteristics

Age, ethnicity, gender, education and occupation of the respondents were measured and categorized. The frequency distributions of the socio-demographic characteristics of the respondents are presented in Table (1). 42.5% of the respondents were male and 57.5% were female. 76.2% respondent belong to ethnic group, *Janjati* and 23.8% belong to *Brahmin/ Chhetri*. The mean age of respondent was 41.27±11.741. Among the total respondent most of the respondent i.e. up to 43.8% were illiterate, 20.0% respondent have pursued their study up to primary level and 36.30% respondent have pursued their study up to secondary level. More number of females were found to be illiterate (33.75%) compared to men (13.75%). Most of the respondents (90.0%) were engaged in agriculture as their primary occupation whereas 10.0% were engaged in service. Greater numbers of females i.e. 58.75% were involved in agriculture than compared to men (32.5%).

Gender involvement in training related to agriculture

Most of the female farmers of Bhuda (13.75%) received week long training on Integrated Pest Management. However, most of the male farmers of Majhgau area received month long (13.75%) and weeklong training (12.5%) on off season vegetable cultivation and Integrated Pest Management. Table (2) shows the involvement of male and female in training in the surveyed area. A significant difference was found in the participation of male and female member in the training activities (chi square value = 10.544*).

Land Ownership

In the rural Nepal land is the determining factor of the position and prestige of individuals in the society. According to our study the invaluable asset (land) mostly belonged to the male member and the females owned little or no land. Figure (1)

shows that 88.8% of male have the ownership of land while only a very marginal amount (11.2%) of land are owned by the female.

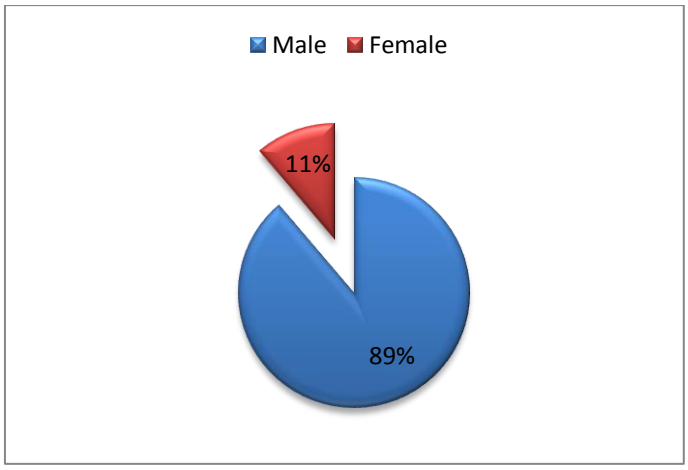

Figure 1. Ownership of Land

Gender based division of labor involved in vegetable production

Table (3) reveals the division of labor in different activities of vegetable production. Females were found to involve more in transplanting (83.8%) and cleaning and harvesting (83.8%) activities, which are considered to be less skilled.

DISCUSSION

Most of the women in rural part of Nepal are found to be illiterate. Bhandari et al. (2015) also found that most of the female members in rural area are illiterate and are involved in agricultural activities. Mostly the women's belonging to ethnicity *Janjati* are found to be illiterate than the *Bramin*/*Chhetri*. The *Janjati* community is one of the disadvantaged community of Nepal which is generally found to live in poverty condition (Patel, 2012). They generally have less access to resources and capital and perform the ritualized culture of subsistence farming. Subedi (2008) also reported that *Janjatis* have comparatively low access of knowledge and information as compared to *Bramin* and *Chhetri*.

Most of the respondents of *Janjati* community were found to involve in agriculture than other job. Farmers of Majhgau area, who resides by the Shuklaphata Wildlife Reserve, were involved in business of home stay and provide tourist a homely environment. This occupation has strengthened their income which consequently helped them to buy useful assets for off season vegetable farming. Farmers of Bhuda were actively involved in commercial seasonal vegetable farming. In Bagphata area, some farmers were found to take land on lease and practice seasonal vegetable farming.

The training received by the farmers was found to be the stimulating agent for pursing the commercial vegetable farming. With the skill gained from the training they have now carried out, off season vegetable cultivation and are practicing integrated pest management techniques. Greater number of male farmers was involved in commercial vegetable farming in Majhgau area; consequently, they have greater access to agricultural services and trainings. However, female farmers of Bhuda were actively involved in farming since the male performed other jobs. Therefore, female farmers have greater access to the resources and training. However, in Bagphata area less number of male and female have received training. The farmers who didn't received the training were found to be involved in subsistence farming. Male member of the household make the decision about the person (either male or female member of family) participating in the training. If the males are themselves primarily involved in job other than agriculture, then trainings are received by females. However, if male farmers are themselves dominantly involved in agriculture, then they participate in the training.

UN (2015) found that though most of the men are performing job but they are informally involved in agricultural activities. And they become the principle decision makers of the overall activities including agriculture. Similarly, Zewdu et al. (2016) revealed that in most cases, men are the heads of households and are therefore the principal decision- makers in the household however some consultation with women may take place.

The patriarchal system continues to be the accelerating factor for domination of male to the women, in the rural part of Nepal. This attitude gives men relatively a greater power and position in a house as well as in the society. Kes and Swaminathan (2006) also reported that at a general level, women's work is primarily confined in the domestic sphere, while men are viewed as working outside the domestic sphere as the main breadwinners. This refers to that the work of majority of women's tends to be economically invisible. Joshi (2018) states that women's labor in household and voluntary work is culturally and economically devalued and unrecognized. Males dominate women due to their greater contribution in economy of family. Consequently, they have greater ownership of valuable assets like land. In our study, greater frequencies of males were found to have ownership of land as compared to female. Similar results were found by Zewdu et al. (2016).

Fence construction for vegetable farming is considered very important to prevent it from the attack of livestock. In Bhuda and Bagphata area, the livestock left open in the road were found to cause the damage. However, in Majhgau area, the wild animals from Sukhlaphata Wildlife Reserve cause serious damage of crop. And often fencing does not prove to be efficient preventive measure. Though fence construction is considered a skillful work requiring greater physical strength, but females were found to have greater role in fence construction. It is because greater number of females was found to involve in vegetable cultivation. The findings of our study were

in consistent with that of Abebe and Mulu (2017). However, in Majhgau area where greater number of males was involved in vegetable farming, they dominantly performed the fence construction activity.

Land preparation for vegetable cultivation is exclusively carried out by males (FAO, 2011). Similarly, Zewdu et al.,(2016) reported that males were found to be more involved in ploughing and harvesting of horticultural crop.We also found that males play greater role in ploughing and land preparation. However, less number of males were involved during harvesting of vegetable. The farmers having large area under vegetable cultivation performed the tillage by hiring the male labor who plough the land using tractor. Similarly, land is also prepared by ox driven tillage which is operated exclusively by man, because of the superstitious belief that female must not drive such equipment. However, for farmers with small land area, land preparation is done by females using tools like spade, shovel and *kuto*. Practice of hiring female labor for land preparation was found null.

Females played greater role in management of vegetable nursery. Also, females were found to play a dominant role in transplanting. Least number of males were found to be involved in transplanting. It is considered as a less skilled work and female oriented work. Similarly, cleaning and harvesting is also considered as a female oriented work. Olowa and Olowa (2015) also found that women are more involved in weeding, watering, transplanting, harvesting and marketing. UN (2015) reported that men are most likely to be employed as skilled agriculture workers, while women mostly work in elementary occupations, such as unskilled laborers in agriculture. Also, Khachaturyan and Peterson (2018) reported that women majorly perform weed control and harvesting.

More number of females were found to be involved in fertilizer application. Similarly, greater females were found to be involved in marketing of vegetable produce. Similar results were found by (Olowa and Olowa, 2015; Abebe and Mulu, 2017). Females and males were found to sell the produce to the *Sabji Mandi*, the main vegetable hub of Mahendranagar and sometimes sell them to the nearby retailer shops.

CONCLUSION

This study analyzed gender participation in different vegetable production activities in Kanchanpur district of Nepal. From the study, it can be concluded that that most of the females of rural area are illiterate and predominantly involved in agriculture. Females labor input in vegetable farming was higher in the overall activity than men. Specially, in fence construction, fertilizer use, transplanting, harvesting and cleaning of vegetables, women were exclusively found to be involved. However, males have greater involvement in land preparation. Despite of greater role of females in vegetable cultivation, their contribution is supportive in nature while male have a dominative role because of greater decision making power and land ownership.

Providing training to the rural women is found to be a good way to strengthen women's access to the resources and decision making in agriculture. Projects and programs that addresses the complementary roles of male and female farmers, secured land tenure, greater access to extension services and training and increment in decision making power are recommended to improve women's role in agriculture.

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ANNEX

Table 1. Frequency distribution of socio-economic characteristics of the respondents

Social Category	Villages			Total
	Majhgau (n=34)	Bhuda (n=22)	Bagphata (n=24)	
Gender				
Male	19 (55.9%)	3 (8.8%)	12 (35.3%)	34 (42.5%)
Female	15 (32.6%)	19 (41.3%)	12 (26.1%)	46(57.5%)
Ethnicity				
Bramin /Chhetri	4 (21.1%)	0 (0%)	15 (78.9%)	19 (23.8%)
Janjati	30 (49.2%)	22(36.1%)	9(14.8%)	61 (76.2%)
Age		20-70		Mean = 41.27±11.741
Education				
Illiterate	9 (26.5%)	14 (63.6%)	12 (50.0%)	35 (43.8%)
Primary	8 (23.5%)	8 (36.4%)	0 (0%)	16 (20.0%)
Secondary	17 (50.0%)	0 (0%)	12 (50.0%)	29 (36.30%)
Primary Occupation				
Agriculture	29 (85.3%)	22 (100.0%)	21 (87.5%)	72 (90.0%)
Service	5 (14.7%)	0 (0%)	3(12.5%)	8 (10.0%)
Secondary Occupation				
Agriculture	3 (8.8%)	0 (0%)	3 (12.5%)	6 (7.5%)
Enterprise	2 (5.9%)	0 (0%)	0 (0%)	2 (2.5%)
No job	29 (85.3%)	22 (100.0%)	21 (87.5%)	72 (90%)

Source: Field Survey, 2017

Table 2. Gender involvement in training activities

	Gender		Residence		
			Majhgau	Bhuda	Bagphata
Training Related to Agriculture	Male	Not at all	0(0%)	0(0%)	6(6.25%)
		Training of week long	9(12.5%)	3(3.75%)	3(3.75%)
		Training of month long	10(13.75%)	0(0%)	3(3.75%)
	Female	Not at all	2(3.75%)	3(3.75%)	6(6.25%)
		Training of week long	6(6.25%)	12(13.75%)	0(0%)
		Training of month long	7(10%)	4(6.25%)	6(6.25%)

Source: Field Survey, 2017

Table 3. Gender involvement in vegetable production

Labor Farm activities	Male (in percentage %)	Female (in percentage %)	Both (Male + Female) (in percentage %)
Fence construction	43.7	37.5	18.8
Land preparation	55	33.8	11.2
Nursery Management	21.3	56.2	22.5
Transplanting	0	83.8	16.2
Fertilizer use	31.3	66.2	2.5
Vegetable harvesting	7.6	70	22.4
Cleaning/ harvesting	0	83.8	16.2
Selling No selling = 14 (17.5%)	30	46.2	6.2

Source: Field Survey, 2017

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MORPHOLOGICAL AND MOLECULAR CHARACTERIZATION OF *RHIZOCTONIA Oryzae sativae* IN BANGLADESH

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ABSTRACT

Aggregate sheath spot disease of rice caused by *Rhizoctonia oryzae-sativae* has emerged in higher incidence in North-Western region of Bangladesh. Thirty isolates of *R. oryzae-sativae* were studied by using morphological and molecular marker. Isolates were confirmed using specific primer where a single band of 1200bp was amplified. Two distinct groups relatively slow and faster were found in mycelal growth. Molecular characterization was done using four primers and DNA band ranged from 0.25 to 2.21 kb. A combined dendrogram was constructed which separated the isolates into three groups at 69.6% similarity level. All isolates placed in two major clusters except isolate RA-1 placed in cluster group III but were not grouped according to their geographic origins. Fast growing isolates have been placed in Group II while slow growing isolates in cluster group I. The similarity coefficient values of the dendrogram profile ranged from 0.36 to 0.98 with an average of 0.67. Diversity of different isolate showed that significant variation was present among the isolate and were not genetically identical.

Keywords: Aggregate sheath spot *Rhizoctonia oryzae-sativae*; variable number tandem repeat (VNTR); repetitive-element polymerase chain reaction (Rep-PCR)

INTRODUCTION

Sheath diseases of rice are the major constraints of rice production in Bangladesh. Among them *Rhizoctonia* sheath diseases of rice are predominant comprise of sheath blight, sheath spot and aggregate sheath spot. Significant yield losses in rice growing regions of the world have been reported by (Kobayashi et al., 1997 and Johanson et al., 1998). The emergence of *Rhizoctonia* sheath diseases as economically important

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rice diseases in recent that attributed to the intensifications of rice-cropping; development of high-yielding rice cultivar with dwarf plant type, high-tillering along with high plant densities. In contrast, only a few studies have been concerned with *Rhizoctonia oryzae-sativae* in Bangladesh. Aggregate sheath spot of rice caused by *Rhizoctonia oryzae-sativae*, occurs in Bangladesh and in other countries including United states (Gunnel et al., 1984), Japan, Vietnam, India, Thailand, Iran, Venezuela, Uruguay and Australia (Cedeno et al., 1998, Rahimian et al.,1989, Gunnel et al., 1992, Lanoiselet et al., 2007). *Rhizoctonia oryzae-sativae* belongs to the AG-Bb anastomosis group of binucleate *Rhizoctonia* spp. (Gunnel et al., 1992). *Rhizoctonia oryzae-sativae* has been distinguished from other *Rhizoctonia* spp. by amplified fragment length polymorphism (Taheri et al., 2007) specific primers (Johanson et al., 1998) and fatty acid analysis (Lanoiselet et al., 2005). However, intraspecific genetic diversity of *Rhizoctonia oryzae-sativae* had examined by only a few workers in the world (Chaizuckam and Davis, 2010). Somatic incompatibility has been used as a marker to identify isolates of *Rhizoctonia oryzae-sativae* in order to determine the survival of overwintering inoculum and dissemination of the fungus in rice field in Japan (Guo et al., 2006). Isolates that have somatic incompatibility reactions produced growth inhibition zones or barrage zones due to plasmolysis of fused cells; this reaction occurs between genetically distinct isolates, whereas a compatible reaction produces confluent growth and living fusion of cytoplasm between isolates (Sneh et al., 1991). Compatible reactions usually observed in self pairing and may indicate that the isolates are genetically similar. Somatic compatibility was tested to characterize *Rhizoctonia oryzae-sativae*. The powerful tools have been used in genetic analysis of numerous organisms, including animals, plants, gene flow, intraspecific phylogeny, mating systems and gene mapping (Barroso et al., 2000, Douhan et al., 2003). Since breeding for disease resistance has become an important program taken up by many workers, an attempt was made in this study to differentiate the pathogen of the isolates and establish the type of resistance in term of vertical or horizontal, as defined, and offered by the rice cultivars against the pathogen studies at the DNA level have also advanced our understanding of the structure of *Rhizoctonia* populations (Vandermark., 1999). Molecular tools are being increasingly used to characterize fungal plant pathogen and to evaluate level of genetic diversity within and between species and to identify particular pathotype. Scientific information on aggregate sheath spot of rice is scanty in Bangladesh and the population diversity need to be studied. However, knowledge of the population of pathogenic *Rhizoctonia oryzae-sativae* is essential for integrated control strategies; along with the understanding of the influence of other characteristics, including virulence, host range and adaptability to environmental conditions. Perhaps this is the first comprehensive report in which thirty isolates of *R. oryzae-sativae* collected from rice fields in Bangladesh. Worldwide, aggregate sheath spot and sheath spot have received little attention compared with the disease sheath blight, caused by *Rhizoctonia solani*. However, aggregate sheath spot is clearly becoming increasingly

important in temperate rice-growing regions. Furthermore, the recent report of the potential yield losses caused by both diseases has demonstrated the potential threat both diseases represent to temperate rice industries. Multi-disciplinary approaches using diagnostics techniques were undertaken to characterize of morphological and genetic variability among the collected isolates of *Rhizoctonia oryzae-sativae* isolates of different locations of Bangladesh.

MATERIALS AND METHODS

Collection, purification and identification of *R. oryzae-sativae*

A total of 30 isolates of *R. oryzae-sativae* were isolated from rice sheaths with aggregate sheath spot symptoms in disease prone area of Bangladesh (Table 1). Single hyphal tip method was followed for isolation and purification was confirmed by constricted hyphae and bi-nucleate cells (Mordue., 1974). All isolates was also confirmed by molecular identification (Johanson et al., 1998). DNA was extracted from 30 isolates of *R. oryzae-sativae* following the methods of (Raeder and Broda., 1985). For direct detection and identification of *R. oryzae- sativae*, PCR was performed using *R. oryzae-sativae* specific primers on 30 isolates. The PCR was conducted with the combination of forward Primer GMROS-6 (5'-GAA AGA GAG AGA GGT CGC CTC-3') and reverse primer R635 (5'-GGT CCG TGT TTC AAG ACG G-3'). PCR amplification was used to complete the reaction. Aliquots (10µl of the amplification products) were subjected to electrophoresis using 2% agarose gel with TBE buffer at 100 V for 1:20 min, stained with ethidium bromide and visualized using a UV trans-illuminator.

Cultural and morphological characterization

Mycelial disks of 6 mm diameter of 3 days old colonies were transferred aseptically to PDA plates for 2 weeks with three replications. Qualitative cultural characteristics viz., Sclerotial size placing the sclerotia were examined. Data were analyzed using MSTATC (version 2.10), in a two-way Analysis of Variance (ANOVA) of 30 treatments. Mean separation was performed using least significant difference (LSD) test at α=0.05.

Somatic compatibility test

Mycelial plugs having 6 mm diameter from 3 days old culture and placed on 9 cm diameter petri plates were approximately 2 cm apart from each other. Three isolates per plate were placed and preserved for 10 days. Isolates failed to show a barrage reaction at the colony junction were classified as same somatic compatibility groups (SCGs), while isolates exhibiting a barrage reaction were classified into different SCGs. Thirty isolates were tested in all possible combination with three replications.

Molecular characterization

For molecular characterization three primers, MR (GAG GGT GGC GGT TCT), RY (CAG CAG CAG CAG CAG) and GF (TCC TCC TCC TCC TCC) were used for

VNTR analysis. BOXA1R primer (5'-CTACGGCAAGGCGACGCTGACG-3') used for REP-PCR analysis. Genotypic data were obtained by considering different product sizes as different alleles at each locus, which were measured by AlphaEase FC 4.0 software and then scored for the presence (1) or absence (0) of the bands at the certain position for each isolate. A similarity matrix based on Dice's similarity coefficient was used and cluster analysis of the matrix was done using unweighted pair group method with arithmetic mean (UPGMA) by numerical taxonomy and multivariate analysis system (NTSYS-PC) version 2.20e. Under SIMQUAL program similarity matrix was constructed using Dice coefficient method.

RESULTS

Identification of isolates, cultural and morphological characterization, SCGs test.

All isolates identified as *R. oryzae-sativae* by the presence of constricted hyphae and binucleate cells (Table 1) and using specific primers. A single band of 1200 bp was amplified using forward primer GMROS-6 with the combination of reverse primer R635 (Fig. 2).

Morphological studies showed variability in colonies among the isolates on PDA were white initially but turned to pale brown later. Abundant aerial mycelium were produced by JA-1 and JA-3 while the others produced a few or moderate quantity of aerial mycelium. All isolates produced sclerotia in culture and their colors were varied from light brown, brown to dark brown. Mean sclerotial size varied from 0.56mm (small; 0.5mm - <1 mm) to 1.99mm (large 1mm - 2mm). All isolates produced superficial sclerotia except TA-1, TA-3, MY-1, MY-2, MY-3, JA-2, SH-3, NA-1, NA-2. These isolates produced sclerotia both on mycelia and embedded in agar. Some isolates scattered all over the plate, while some were aggregated only at the center. The growth rate of isolates measured between 6.10 -10.90 mm per day in which maximum and minimum growths were observed in MY-1 and NE-2 respectively (Table 1). Accordingly, the studied isolates by least significant difference test indicated that there was a significant difference ($\alpha = 0.050$) within fungal isolates growth rates in which isolates were categorized into two distinct groups indicating low (DI-1, DI-2, DI-3, TH-1, TH-2, TH-3, RA-1, RA-2, RA-3, NE-1, NE-2, Ne-3, GA-1, GA-2, GA-3) and high (MY-1, MY-2, MY-3, TA-1, TA-2, TA-3, JA-1, JA-2, JA-3, SH-1, SH-2, SH-3, NA-1, NA-2, and NA-3) growth rate.

Somatic compatibility test

Only three pairs of isolates displayed somatic compatible reactions; one pairs from Tangail district (TA-1+ TA-3), one from Gazipur (GA-2+GA-3) districts and one pair between Mymensingh (MY-1+SH-3) and Sherpur districts. There were 27 SCGs from 30 isolates indicated 90% diversity among the isolates.

Table 1. Source of isolates of *R.oryzae-sativae* and their cultural characteristics

Isolates	Origin	Agroecological zone(AEZ)	Longitude and Latitude (^{0})	Growth rate (mm/day)[a]	Sclerotial characteristics		Virulence test	
					Intensity [b]	Mean size[c]	RLH (cm)[d]	Incidence (%)[e]
DI-1	Dinajpur	01	88.63 E	7.20 HI	+	0.72	6.97 LM	44.19 N
DI-2			25.62 N	7.33 H	+	0.56	9.44 GHI	48.78 KLM
DI-3				7.17 HIJ	+	0.61	7.85 IJKL	45.83 MN
TH-1	Thakurgaon	01	88.45 E	6.80 IJKL	+	0.92	8.07 JKL	45.65 MN
TH-2			26.02 N	6.43 LM	+	0.85	6.58 M	47.83 LMN
TH-3				6.57 KLM	+	0.77	7.03 LM	51.85 HIJK
RA-1	Rajshahi	11	88.06 E	6.90 HIJKL	+	0.90	8.41 IJK	52.94 GHIJ
RA-2			24.36 N	7.00 HIJK	+	0.69	7.83 JKLM	57.45 F
RA-3				7.10 HIJ	+	0.75	8.34 IJK	51.16 IJKL
My-1	Mymensingh	09	90.40 E	10.90 A	+++	1.52	14.90 B	56.52 FG
MY-2			24.74 N	10.20 BC	++	1.79	14.38 BC	62.26 BCDE
MY-3				10.33 B	+++	1.81	18.62 A	58.54 DEF
GA-1	Gazipur	28	90.41 E	7.20 HI	+	0.68	7.89 JKL	65.58 B
GA-2			23.99 N	7.67 HIJK	+	0.82	8.95 HIJ	62.96 BC
GA-3				6.80 IJKL	+	0.75	8.28 IJKL	59.09 CDEF
TA-1	Tangail	09	89.92 E	9.20 FG	+++	1.95	11.77 EF	69.90 A
TA-2			24.42 N	9.43 EFG	+++	1.25	8.75 IJK	57.78 F
TA-3				9.67 DEF	+++	1.68	12.21 E	58.70 DEF
NE-1	Netrokona	09	90.82 E	6.57 KLM	+	0.75	8.21 IJKL	52.83 GHIJ
NE-2			24.88 N	6.10 M	+	0.68	7.79 JKLM	49.06 JKLM
NE-3				6.67 JKL	+	0.60	7.47 KLM	48.21 KLM
JA-1	Jamalpur	09	89.94 E	9.63 DEF	++	1.99	10.57 FG	57.50 F
JA-2			24.92 N	9.80 CDE	+++	1.89	12.75 DE	58.33 EF
JA-3				9.53 DEFG	+++	1.73	14.26 BC	62.50 BCD
SH-1	Sherpur	09	90.01 E	9.90 BCDE	+++	1.81	9.41 GHI	58.93 DEF
SH-2			25.01 N	10.00 BCD	++	1.35	14.30 BC	62.50 BCD
SH-3				10.03 B	++	1.58	10.26 GH	53.33 GHI
NA-1	Narsingdi	09	90.79 E	9.50 DEFG	+++	1.45	13.52 CD	50.98 IJKL
NA-2			23.99 N	9.10 G	++	1.64	15.07 B	65.22 B
NA-3				9.73 CDE	+++	1.73	12.61 DE	55.56 FGH

[a] Colony diameter after 3 days on PDA.Values in growth rate columns followed by the same letter are not significantly different at $\alpha = 0.05$ after ANOVA-LSD test

[b]intensity : + slight; + + moderate; + + + profuse

[c]size: in mm; small (0.5mm - <1 mm); large (1mm - 2mm)

[d] Values in RLH columns followed by the same letter are not significantly different at $\alpha = 0.05$ after ANOVA-LSD test

[e] Values in incidence columns followed by the same letter are not significantly different at $\alpha = 0.05$ after ANOVA-LSD test

DNA fingerprint analysis

Genetic variation was determined among 30 *R. oryzae-sativae* isolates using VNTR (MR, GF, RY) and BOXA1R primers. All the primers amplified reproducible bands and its bands' sizes ranged from 0.26 to 2.21 kb for VNTR primers and 0.25 to 2.02 kb for BOXA1R primer. The maximum and minimum number of bands was obtained from GF and RY respectively. VNTR primers amplified 30 bands from which GF showed the highest polymorphism (100%) and the lowest polymorphism showed by RY (75%). Out of 11 bands 1 was monomorphic resulting 90% polymorphism by BOXA1R primer. From all the 41 distinct and clear bands were scored of which only 4 bands were shared by all and 37 bands were polymorphic resulting 90% of scored bands being polymorphic. The gel picture of GF primer is presented in Fig. 3.

Cluster analysis

Application of the UPGMA clustering method gave the cophenetic correlation coefficient, where r = 0.82 indicates a good fit correlation value. The similarity coefficient values varied from 0.36 to 0 .98 with an average of 0.67, indicating variation among the isolates. 29 isolates grouped into 2 clusters at 69.6% similarity level. Cluster I composed of 14 isolates. This cluster consists of all comparatively slow growing isolates. Cluster II composed of 15 isolates and consisted of all comparatively fast growing isolates. One separate solitary group resulted from the VNTR and REP-PCR marker data for RA-1which comprised Cluster III (Fig. 4). The highest genetic similarity was found between MY-1 and SH-3 (98%) followed by TA-1 and TA-3 (97%) while lowest genetic similarity shared between RA-1 and SH-1(36%) followed by RA-1 and JA-1(38%).

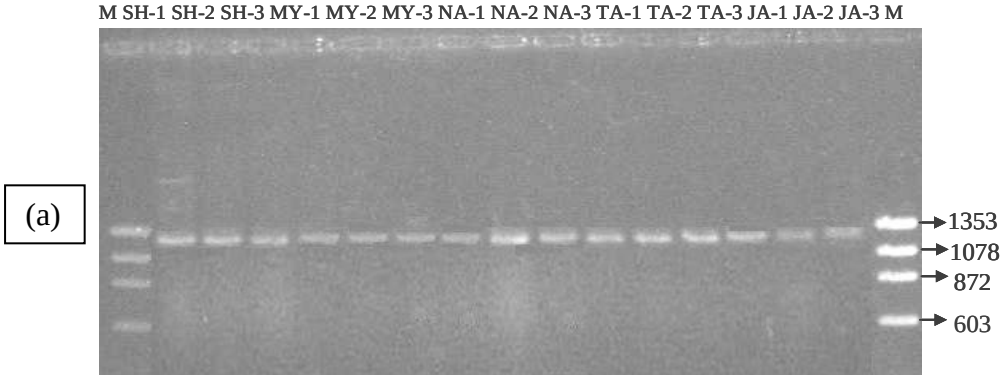

Figure 1. PCR amplification of total genomic DNA from 15 isolates of *R.oryzae-sativae*, using specific primer.

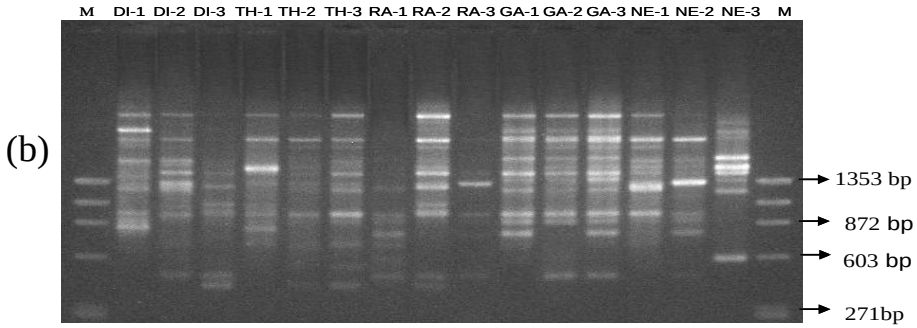

Fig.2. PCR amplification of total genomic DNA from 15 isolates (SH-1-JA-3) of *R.oryzae-sativae* using the primer pairs of GMROS-6 with R635: Lanes: M, PhiX174/*HaeIII* markers (Promega) (one gel picture shown in here)

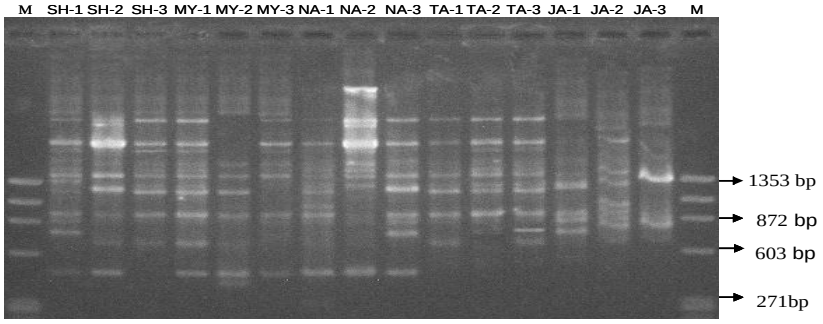

Fig.3. DNA Fingerprint profiles of 30 isolates of *R.oryzae- sativae* obtained with GF primer; (a) Isolates DE-1-NE-3 (b) Isolates SH-1-JA-3; Lanes: M, PhiX174/*HaeIII* markers (Promega).

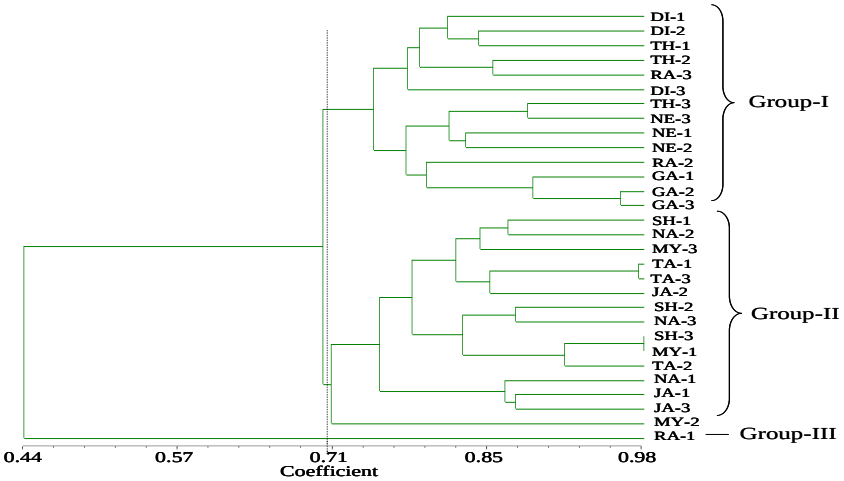

Fig.4. Dendrogram obtained from the combined data set of 30 *R. oryzae-sativae* isolates with VNTR and Rep-PCR markers

DISCUSSION

In this study, the morphological qualitative characters like aerial mycelium colour of sclerotia and position of sclerotia (scattered, aggregated, on mycelia and on mycelia+embedded in agar) were found and consonant with (Chaijuckam et al., 2010 and Hossain et al., 2017). SCGs displayed high resolution by showing 90% diversity. Isolates with same multilocus genotypes were always in the same SCG (TA-1+TA-3) agreed with the findings of Chaijuckam et al. (2010). But in some isolates (MY-1+SH-3) with the almost same genotypes having same SCG were found in different rice field, meant that clones in populations were separated by up to 69 km. Dissemination of asexual propagules is made possible by the transport of sclerotia or other asexual fungal structures in soil, flash flood, or by contaminated seeds over relatively long distance. In Texas, (Rosewich et al., 1999) identified isolates of *Rhizoctonia solani* in populations were separated by up to 280 km using an RFLP fingerprint probe.

The tested isolates of *R. oryzae-sativae* were classified genetically into three groups by using VNTR and rep-PCR primers at 69.6% similarity level. However, some relationship was observed between genetic variation and morphological characteristics, which clustered the isolates of Dinajpur, Thakurgaon, Rashahi, Gazipur and Netrakona in group I with low growth rate and some sclerotial categories. These results are in accordance with (Singh et al., 2002, Sharme et al., 2005 and Khodayari et al., 2009) reported that most of the microsclerotia forming isolates of *R. solani* were grouped together using RAPD and ISSR and ERIC primers. Group I isolates were from different agroecological zones. Low growth rate, small sclerotia and short RLH of group I isolates indicated a possibility of natural suppression on these isolates, and the influence of the environment on disease development might be a report for future epidemiological studies. The occurrence and distribution of rice sheath diseases is influenced by weather factors, physiological responses and agricultural practices (Datta, 1981). Nevertheless, further studies are required to provide a more extensive analysis of the existing population structure of the species at different areas in Bangladesh. The isolates did not cluster into according to their geographical origin. In addition, group I suggested also the possibility of gene flow of up to a distance of 378 km (maximum distance; Gazipur-Thakurgaon), this is an agreement with the observations of found gene flow up to a distance of 716 km in *Rhizoctonia solani* by Rep-PCR fingerprinting (Aye et al.,2012). However, rest of the isolates clustered in group II (same AEZ, maximum distance Mymensingh-Narsingdi 135 km.) with relatively fast growth rate, while isolate RA-1 collected from Rajshahi made a solitary cluster though having low growth rate and same sclerotial characteristics. RA-1 isolate exhibited null alleles in several primers, possibly caused by a mutation at the 3' end of the primer binding sites (Butler, 2005).

Comparison of two molecular marker systems showed the highest number of scored DNA bands and a higher percentage of polymorphism were produced by the GF primer indicated VNTR was more efficient compared to that of Rep-PCR. Because, fingerprints generated by BOXA1R seemed to overlap adjacent bands (Versalovic et al., 1994). Though the primers and isolates used were relatively few in number, it could be effectively establish the molecular variability among the isolates of Bangladesh. However, at 90% similarity level, the isolates were categorized into 26 groups, which indicated a high genetic diversity of rice aggregate sheath spot fungus as revealed by VNTR and Rep-PCR primers. Variation in the isolates of *R. oryzae-sativae* indicated that various genotypes of *R. oryzae-sativae* present in Bangladesh and should be included in screens of resistance genes in rice and fungicides.

Conflict of interest

There is no conflict of interest among the authors.

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SURVEY ON USAGE OF MEDICINAL PLANTS: A CASE FROM CHITWAN DISTRICT OF NEPAL

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ABSTRACT

The aim of this study was to know the commonly available medicinal plants and to document their usages. Study was carried out around periphery of 'Gyaneswor Community Forest' of Bharatpur-16 of Chitwan district of Nepal. Altogether, forty household were selected by random sampling, and key informant interview was carried out with community forest personnel's and leading farmers. Most of the respondents of Bharatpur-16 were found to be dependent on medicinal plants for their primary health care. Because of no side effect, easy availability and cost effectiveness of medicinal plants, most people were found satisfied using it. However, the use of and preference for medicinal plant was found limited to minor diseases only. The findings of this study revealed that there are many medicinal plants in our periphery that can be used as an alternative for allopathic medicines, but they need to be systematically managed and conserved.

Keywords: Allopathic; Ayurvedic; Cultivation; Community forest; Medicine; Processing

INTRODUCTION

Nepal consists of vast biological diversity. It is ranked as 31st richest country in the world, in terms of biodiversity and 10th richest country in the Asia region (MoAD, 2017). Despite of its small coverage area in world map, the unique and rich geography, ecology and climatic condition is attributed due to the wide altitudinal range that measures from about 60 m in plains to 8848 m to the top of the world. MoAD (2017) reported that Nepal is blessed with 12 of 867 global terrestrial eco-regions, eight climatic zones (ranging from tropical to nival) and a total of 118 ecosystems. Similarly, National herbarium and plant laboratories, Kathmandu document 1, 50,000 specimens of plants.

Among which, large number of plants were regarded to have pharmacologically active ingredients. About 700 of the total plant species reported constitutes medicinal properties, of which 238 plants species have been chemically tested for their medicinal importance.

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Several authors gave different report about the medicinal plants available in Nepal. Pandey (1961) for the first time reported 73 medicinal and aromatic plants (MAPs). Then, Department of Medicinal Plants (DMP, 1970) reported 483 species; Malla and Shakya (1984) mentioned 630 species, Manandhar (2002) reported 1002 species, Shrestha et al. (2002) reported 1614 species, Baral and Kurmi (2006) reported 1792 species, Ghimire et al. (2008) revealed a total of 1950 species and recently Rokaya et al. (2012) report 1792 to 2331 plants as potential medicinal and aromatic plant among 6653 species of angiosperm plant.

The commonly available plants are considered to have high value in terms of medicinal and pharmacological importance. The World Health Organization (WHO) (2002) mentioned that about 25% of modern medicines are developed from plants sources used traditionally. World Health Organization recorded approximately over 21,000 plant species for their medicinal uses throughout the world. Also, WHO (2011) estimate that 65-80% of population from developing countries uses medicinal and aromatic plants as remedies. Similarly, the trend of using commonly available plants for minor diseases is a usual practice in Nepal. In some part of Nepal, peoples are also found to be fully dependent on plants products for major diseases and health problems like snake bite, diabetes, stone and other. Manandhar(2002) reported that medicinal plants are responsible for maintaining the health of 70-80% population of Nepal. Also, MoAD(2017) revealed that rural people in Nepal use at least 1,463 species of herbal medicinal plants.

Chitwan, an inner valley of Province No. 3 is one of the potential areas for establishment of native tropical medicinal and aromatic plants. Shukla (2015) and Malla (1994), reported that the geo-physical and ecological factors of Chitwan district is suitable for the development of rich and varied vegetation and it accommodate, most of the tropical medicinal plant species. Community forest is becoming the best conservation strategy for the vivid bio-diversity. Therefore, a survey study was carried out around the periphery of the 'Gyneshwor Community Forest' of Bharatpur-16 to find out the commonly available medicinal plant and their usage in daily life of people living there.

METHODOLOGY

Study area

An ethno-botanical survey was carried out in Bharatpur-16, of Chitwan district. Chitwan is an inner valley region that lies in the longitudes of 83°54' 45’’to 84°48’15’’E and latitudes of 27°21'45’’ to 27°52' 30’’N (Google Earth, 2018).Elevation of the district ranges from 244m to 1945m(DDC, 2014). It is considered to be one of the potential districts to grow medicinal plant. Thegeo-physical and ecological factors of Chitwan are suitable for the development of rich and varied vegetation and it accommodate, most of the tropical medicinal plant species(Shukla, 2015; Malla, 1994). Our study area, Bharatpur-16, Brahampur is

located in northwest part of Chitwan district. It is 8 km away from Narayanghat, the main market hub of the district. A community forest namely 'Gyneshwor Samudayik Ban' is situated in the study area which covers a total area of 280 hectare (Munteanu, 2010). The forest is enriched with different kind of pharmaceutically important medicinal plants like Kurilo (*Asparagus racemosus)* Wild. The community forest provides the user group an opportunity to collect the high value medicinal plants from forest at high time to utilize them for various purpose such as to treat the disease, etc.

Research Design

Survey was carried out during Jan-Feb, 2018 in Gyneshwor Community Forest periphery. About forty community forest user households around the forest periphery were selected randomly and a scheduled interview was carried out. Key informant survey (KIS) was carried out with the personnel of community forest and leading medicinal plant cultivator/farmer. Similarly, for secondary data collection several online open access peer reviewed national and international journals, reports, conference proceedings, related website and technical bulletins were reviewed. Also the publication of District Agriculture Development Office Chitwan (DADO), District Forest Office (DFO) Chitwan, and other local INGO and NGOs were studied. The obtained data were entered in the Microsoft Excel 2010 and IBM Statistical Package for the Social Sciences **(**SPSS) for descriptive analysis. Graphs are generated through both SPSS and Microsoft-Excel 2007.

RESULTS AND FINDINGS

On the basis of information collected, the followings findings and discussion are presented in different table, diagrams, figures and graphs and interpreted them accordingly:

Demographic features

A total of 40 informants (18 males and 22 females) aged between 24 to 75 were interviewed in which 45% respondent were male and 55% were female. The average age of informants was 46 year old. Illiteracy rate was found 37.5% and the literacy rate was 67.5%. Studies showed that majority of peoples in the community periphery were involved in agriculture, with total of 75% farmers, 17.5% service holder and 7.5% entrepreneur. About 85% of the population was found to grow medicinal plants in their kitchen garden and 87.5% population was involved in collection and marketing of medicinal plants from the community forest (Field Survey, 2018).

Preference for Medicinal Plant

Majority of respondent (90%) preferred medicinal plant for the treatment of disease over processed medicine. However, all of them were not found to be involved in preparing medicines for treatment of diseases and disorders. Only 77.5% population have prepared medicine using medicinal plant for curing cuts, burns and diseases,

while 22.5% population had never used medicinal plant for preparing medicine (Figure-2).

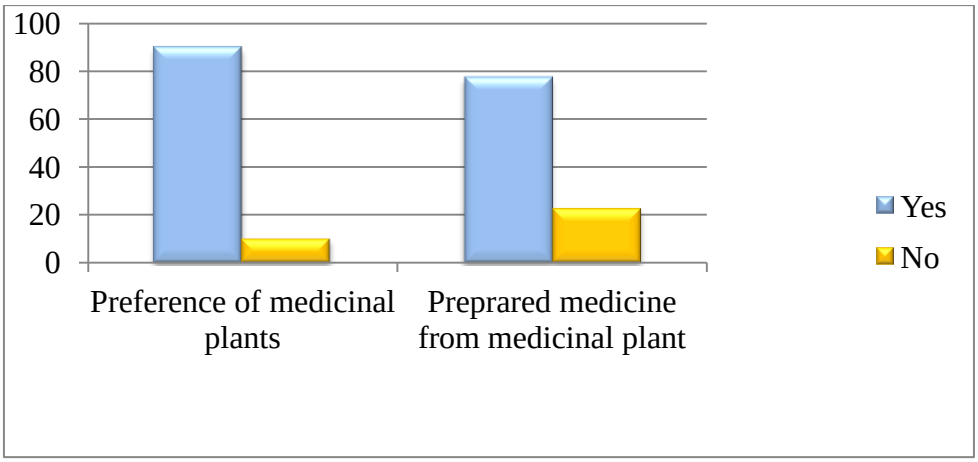

Figure 2. Respondent Preference for Medicinal Plant

Preference for Ayurvedic Medicines (Allopathic Medicine)

For minor diseases, like common cold, minor allergies, burns, cuts, cough and others 82.5% population preferred to use Ayurvedic medicines and the rest 17.5% population preferred to use allopathic medicine. However, for treatment of major diseases like cancer, stone, diabetes only 10% preferred to use Ayurvedic medicine and 90% population preferred to use allopathic medicine (Fig. 3).

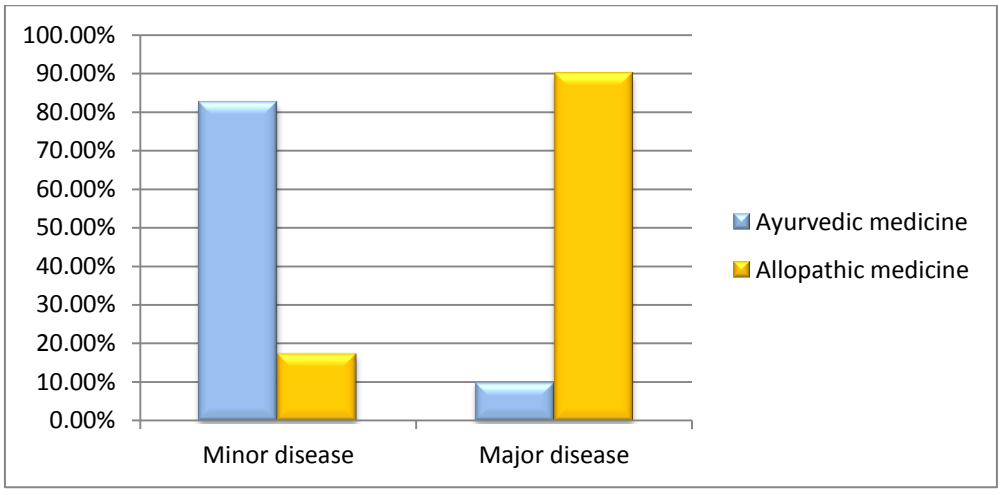

Figure 3. Percentage of respondent preferring ayurvedic medicine over allopathic medicine for major and minor diseases

Taxonomic Diversity in the community and Plants Used for medicine

Forty-four medicinal plant species belonging to 29 families were found to be used by the local community. Among which 14 plant species were used to treat stomach disorders like stomachache, diarrhea, dysentery, constipation and others, 9 plant species were used for wound healing, 8 plant species were used for treatment of cold, 7 plant species were found to be used for cough, 3plant species were found to be used for fever. Similarly, 4plant species were used to recover diabetes, 3 plant species were used to maintain blood pressure, 3 species were used for treating stone, 3 plant species were used as blood purifier, 3 plant species were used for menstrual problem, 2 species were used for improving lactation of females after pregnancy, 2 species for toothache and 1 species was found to be used for treating cancer.

Satisfaction Gained by using Medicinal Plants

The medicinal plant users were found satisfied with its effect to a great extent. Majority of respondent about 62.5% reported a complete healing effect of medicinal plant for treatment of minor disease. However, 35% of the respondent felt moderate healing effect and 2.5% respondent felt appreciable effect of medicinal plant for curing minor diseases (Figure 4). Similarly, for major diseases, 20% of the respondent reported to feel a moderate healing effect with the use of medicinal plants.About32.5% population was found to feel appreciable healing effect and 47.5% population was found to feel negligible healing effect. Almost the entire respondent about 97.5% said that they never noticed any side effect of medicinal plants. However, only 2.5% of respondent reported to the side effect of medicinal plant (Figure 5). Respondent told that a medicinal plant, locally called Dahikamala (*Rhustyphina* L.) was found to lower the blood pressure, if taken in excess amount.

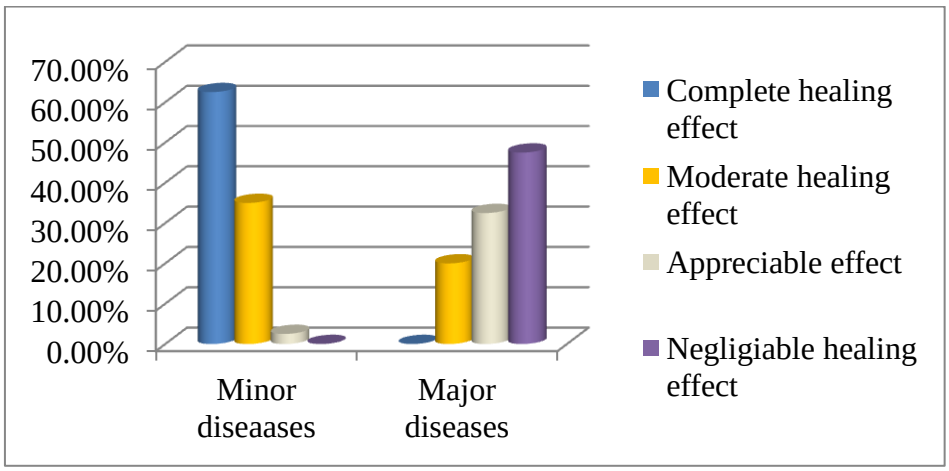

Fig. 4. Various category of healing effect among respondent

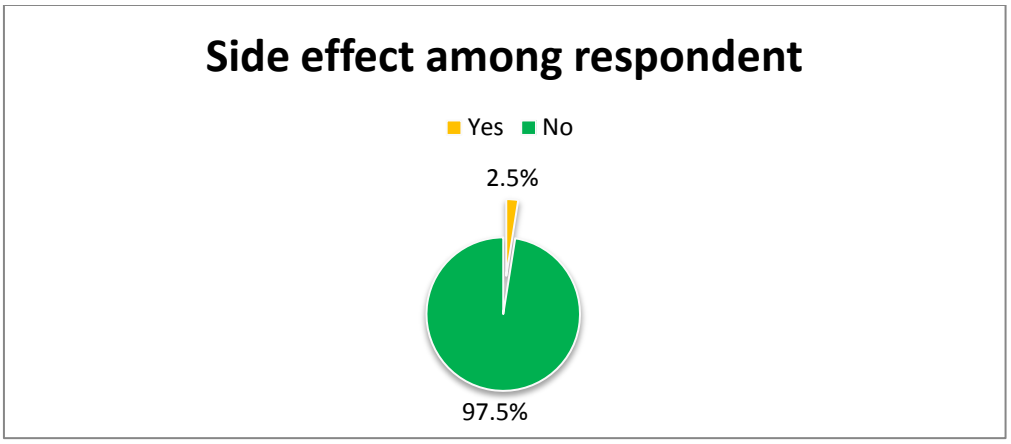

Figure 5. Percentage of Respondent Experiencing the Side Effect of Medicinal Plant

The usages of commonly available medicinal plants are described in the table below:

Table 1. Commonly Cultivated Medicinal Plant in Study Area

S. N.	Common Name	Biological Name	Family	Used for	Used parts	Propagated by
01.	Besar (Turmeric)	*Curcuma longa* (L.)	Zingebeaceae	Rhizome powder is boiled with water for treating common cold Paste is used in inflammation, wound healing	Rhizome	Rhizome
02.	Tulsi	*Ocimum sanctum* (L.)	Lamiaceae	Leaf decoction used for cough and cold, respiratory disorders and reduces stress	Whole plant	Seed
03.	Neem	*Azadirachtain dica*A. Juss.	Meliaceae	Leaf bark decoction used to cure fever, leaf extract used for skin diseases and as botanical insecticide	Leaf, bark	Seed, Cutting
04.	Ghiukumari, Aloe	*Aloe vera*(L.)	Liliaceae	Leaf gel used to treat cut, wounds and burns Used as cosmetic	Leaf	Leaf, offset
05.	Sarpagandha, Snake plant	*Rauvolfiaserpentina* (L.) Benth ex Kurz	Apocynaceae	Treatment of high blood pressure. Root powder is applied on area of snake or insect bite. Root decoction used for uterine contraction	Roots, leaves	Seed, stem cutting, Root cutting
06.	Kurilo, Asparagus	*Asparagus racemosus*Willd.	Asparagaceae	Powdered root is considered as tonic. Consumption of roots supports milk production in females. Also considered beneficial for treating kidney stone	Root, tuber, stem, fruit	Seed, Cutting

S. N.	Common Name	Biological Name	Family	Used for	Used parts	Propagated by
07.	Dhaniya, Cilantro	*Coriandrums ativum*(L.)	Umbelliferae	Leaves and seeds are used as appetizer. It stimulates digestion.	Whole plant	Seed
09.	Aduwa, Ginger	*Zingiberoffici nale*Roscoe	Zingeberaceae	Rhizome water is used for cold, throat sore Used for stomach disorder	Rhizom e	Rhizome
10.	Pipla, Long Pepper	*Piper longum* (L.)	Piperaceae	Powdered leaf along with honey is useful for cold, cough Infusion of root used for stomachache, bronchitis	Root, Leaf	Seed, stem cutting
11.	Amala, Indian gooseberry	*Phyllanthusof ficinalis*(L.)	Phyllanthaceae	Juice of fruit or fresh fruit is consumed to reduce blood sugar Barks and fruits are useful for diarrhea, dysentery	Fruit, Barks	Cutting
12.	Jira, Cumin	*Cuminuncymi num*(L.)	Umbelliferae	Cumin seed are used for diarrhea, colic disorder, bloating. It is used to start menstruation earlier.	Seed	Seed
13.	Tejpatta, Indian cassia	*Cinnamomum tamala*(Buch - Ham.) T. Nees& C.H. Eberm	Lauraceae	Powder of bark is mixed with honey for treating cough, asthma Paste of bark is applied over wound, inflammation	Leaves, Barks	Cutting, Seed
14.	Titepati	*Artemisia vulgaris* (L.)	Asteraceae	Stomach disorder , Leaf paste applied on wounds, cuts	Whole Plant	Seeds and basal cutting
15.	Datura	*Datura metal* (L.)	Solanaceae	Paste of roasted leaves are applied over wound Leaf smoke is used to treat asthma	Leaf, seed	Seed, Root cutting
16.	Bryophyllum	*Bryophyllump innatum*(Lam .) Oken	Crassulaceae	Decoction of leaves is used for kidney stone, stomachache Leaf juice applied for ear pain Extract of aerial part treat cancer Root used for blood pressure	Leaf, Root	Leaf
17.	Asare, Curry leaf	*Murrayakoen igii*(L.) Sprengel	Rutaceae	Juice of leaf is used to treat diarrhea Paste of leaf applied in hair helps hair growth Juice or paste of leaf is applied to cuts, burns, wound	Leaf	Seed, Stem cutting

S. N.	Common Name	Biological Name	Family	Used for	Used parts	Propagated by
18.	Methi, Fenugreek	*Trigonellafoe num-graecum*(L.)	Fabaceae	Paste of fenugreek leaf is applied in hair to reduce dandruff Seeds are useful for diabetic patient They improve lactation after delivery	Leaf, Seed	Seed
19.	Pudina, Mint	*Mentha sp.* (L.)	Lamiaceae	Mint leaf are used for toothache Mint leaves are added to steam bath for relieving running nose	Leaf	Cutting

Table 2. Usage of Collected medicinal plants from the community forest

S.N.	MAPs collected	Scientific Name	Family	Uses	Used part	Propagated by
01.	Abhijalo	*Drymariacordata*(L.)	Caryophyllacea e	To treat gastric trouble, Pneumonia	Whole plant, fresh leaves	Grow wild
02.	Chiraito	*Swertiachirayita*(Roxb. ex Fleming) Karsten	Gentianaceae	Increases metabolism, swiftly lowers fever and constipation.	All parts	Seed
03.	Dahikamala	*Rhustyphina*(L.)	Anacardiaceae	Berries are used as astringent and blood purifier. Roots are used to treat boils.	Roots	Seed
04.	Gandhe	*Ageratum conyzoides*(L.)	Asteraceae	Aqueous extracts of leaves or whole plants are to treat colic, colds, fevers and diarrhea.	Whole plant	Grow wild
05.	GhodTapre	*Centellaasiatica* (L.) Urban	Apiaceae	Used for fatigue, anxiety, improving memory and intelligence.	Whole plant	Grow locally and wild
06.	Lajjawatijhar	*Mimosa pudica*(L.)	Fabaceae	Root is used in treatment of dysentery, vaginal and uterine complaints, and skin diseases.	Root and leaves	Propagated by vegetative means
07.	Pahelolahara	*Clematis buchananiana* (de Candolle)	Ranunculaceae	Juice of the root is used in the cough and to cure peptic ulcer.	Roots	Cuttings
08.	Tulsi	*Ocimum sanctum (*L.)	Lamiaceae	Leaf decoction used for cough and cold,respiratory disorders and reduces stress.	Whole plant	Seed
09.	Ashwagandh a	*Withaniasomnifer a* (L.) Dunal	Solanaceae	It is used to lower blood pressure and to increase hemoglobin and hair melanin.	Roots	Seed
10.	Gurjo	*Tinosporacordifoli a* (Thunb.) Miers	Menispermacea e	Used in different metabolic disorders and gases	Whole part	Cutting

S.N.	MAPs collected	Scientific Name	Family	Uses	Used part	Propagated by
11.	Jwano	*Trachyspermummmi* Sprague	Apiaceae	Fruits are used to cure abdominal tumors, piles, lack of appetite.	Seeds	Seeds
12.	Kutiko	*Neopicrorhizascrophulariiflora*(Pennell) Hong	Scrophulariaceaae	Used for indigestion, fever, jaundice, etc	Rhizome	Rhizome and Root
13.	Neem	*Azadirachtaindica* A.Juss.	Meliaceae	Leaf bark decoction used to cure fever, leaf extract used for skin diseases and as botanical insecticide	Leaf, bark	Seed or cuttings
14.	Mint	*Menthasp*.(L.)	Lamiaceae	Mint leaf are used for toothache Mint leaves are added to steam bath for relieving running nose	Leaf and stem	Cutting
15.	Hadchur	*Viscum album* (L.)	Viscaceae	To lower blood pressure and heart rate, and induce sleeping.	All parts of the plant	Vegetative or seed propagation
16.	Raktachandan	*Pterocarpussantalinus*(L.f.) Kuntze	Fabaceae	Heart-wood are for heart diseases, blood purifier, headache and skin diseases.	Heart wood	Seeds
17.	Rato Mushroom	*Amanita muscaria*(L.) Lam.	Amantiaceae	Against diarrhea	Whole plant	Spores
18.	Bhang	*Cannabis indica*(L.)	Cannabaceae	Useful in combating menstrual discomfort and reproductive problems.	Leaves	Seed
20.	Tejpatta/ Indian Cassia	*Cinnamomumtamala*(Buch.-Ham.) T.Nees & C.H.Eberm	Lauraceae	Powder of bark is mixed with honey for treating cough, asthma Paste of bark is applied over wound, inflammation	Leaves, Barks	Cutting, Seed
21.	Jamun	*Syzygiumcumini*(L.) Skeels	Myrtaceae	Leaves are used for treatment of diabetes, and menstrual problems.	Fruits, Seeds, Leaves, bark	Air layering and softwood grafting
22.	Nerbanshe/ Nirmanse	*Delphinium denudatum*Wall	Ranunculaceae	Against sugar patients, Relieve stomach pain and it is good blood purifier.	Root, Seed	Seeds are propagating materials
23.	Chutro	*Berberisaristata*DC	Berberidaceae	Roots are used for Poisonous remedy	Roots, Fruits,Stem and Leaves	Seed
24.	Dalchini	*Cinnamomumverum*J.Presl	Lauraceae	Paste of this herb is used to reduce pain, inflammation and eye related disorders.	Bark, Leaves and berry fruit	Cuttings, Layering and by dividing the root ball
25.	Gheukumari	*Aloe vera (L.)* Burm.f.	Liliaceae	Leaf gel used to treat cut, wounds and burns Used as cosmetic	Leaf	Leaf, offset

S.N.	MAPs collected	Scientific Name	Family	Uses	Used part	Propagated by
26.	Kurilo	*Asparagus racemosus*Willd.	Asparagaceae	Powdered root is considered as tonic Consumption of roots supports milk production in females Also considered beneficial for treating kidney stone	Root, tuber, stem, fruit	Seed, Cutting
27.	Lude	-?????	-	Root is used in the form of juice, paste, decoction to treat intrinsic hemorrhage, diarrhea, hoarseness of voice,cough.	Root	-
28.	Pipla	*Piper longum*(L.)	Piperaceae	Powdered leaf along with honey is useful for cold, cough Infusion of root used for stomachache, bronchitis	Root, Leaf	Seed, stem cutting
29.	Sarpagandha	*Rauvolfia serpentine* (L.) Benth. ex Kurz	Apocynaceae	Treatment of high blood pressure Root powder is applied on area of snake or insect bite Root decoction used for uterine contraction	Roots, leaves	Seed, stem cutting, Root cutting
30.	Sotuwa	*Paris polyphylla*Sm.	Melanthiaceae	Used against any poisonous bite, burn, cut or injury.	Rhizome	Seed
31.	Rudhilo	*Pogostemonbenghalensis*(Burm.f.) Kuntze	Lamiaceae	Leaves are used to clean wounds and promote their healing. Used for lactating cows	Leaf, Root	Found wild
32.	Harro	*Terminaliachebula* Retz	Combretaceae	Paste of fruits is used to clean wounds, to provide relief to eyelids in cases of conjunctivitis.	Bark, Fruit	Cutting
33.	Bojho	*Acoruscalamus*Linn. calamus	Acoraceae	Used for cold and cough, cure piles, loss of appetite, urinary stones, and to improve memory.	Rhizome, leaf	Rhizome

DISCUSSION

The user groups of community forest were found have good knowledge of medicinal plants and their usage. They used 44 medicinal plants for treating 62 ailments. A single plant was found to have multiple benefits. A similar result for the usages of medicinal plant was reported by Singh et al., (2012). The authors reported 66 medicinal plant species to treat various disorders, including gastro-intestinal disorder and dermatological disorders majorly in Rupandehi district. Similarly, Uprety et al. (2010) found 56 plant species in Rasuwa district, which were used for treating gastro-intestinal problems, fever and headache. Bhattarai et al., (2006) found 91 locally used medicinal plants which were used to treat 93 ailments in Manang district.

Mostly, the farmers and elderly people prepared medicine from medicinal plant. The respondent who were involved in job or business were less involved in the preparation of medicines from medicinal plant. They mostly used the allopathic medicines. However, most of the respondent, irrespective of their occupation preferred ayurvedic medicines for the treatment of minor diseases. Since the user groups have not noticed much side effect of medicines prepared from medicinal plants therefore, they use such plant instantly for treatment. Similar results were reported by Joshi et al. (2011). The authors reported that the use of medicinal plant was limited to minor health related problems like cuts, wounds, gastro-intestinal problems, fever, headache, cough and others in Macchegaun, Kathmandu.

Our finding revealed that the majority of the people preferred allopathic medicines for the treatment of major diseases. It is because of the slow acting effect of ayurvedic medicine. Only a few peoples prefer to use ayurvedic medicine even for the major disease. The respondent explained that they have experienced positive effect of ayurvedic medicine for curing major diseases. They believed that continuous use of medicinal plants in proper way can cure the so called medically incurable diseases like cancer. Unlike the processed medicine, the medicinal plants gave a natural healing without the worries of any side effect. Gewali (2008) also reported that the folk medicines have no or little side effects. Similarly, Koirala and Khaniya (2009) reported that though the effect of medicines prepared from medicinal plants is slow, but medicines do not have any side effects. Further, they reported that such medicines are proved to be successful in treatment of many major diseases like hepatitis (any type), multiple sclerosis, any type of arthritis, many cancerous diseases like breast cancer, prostate cancer, and also many cases of tumor and cysts, metastatic conditions, immunity, etc. In our finding, we found that peoples used the medicinal plants to cure cancer, kidney stone, uterine stone, asthma, piles, conjunctivitis, jaundice, pneumonia, poisonous bite and others (Table 1 and 2). Further, common availability of medicinal plants in their kitchen garden, field and community forest makes its use cost effective over the allopathic medicines. Koirala and Khaniya (2009) also reported that the effect of medicinal plant is not only observed in human health but also in better living standard and income. Harvesting and gathering of the medicinal and aromatic plants provide subsistence living income.

CONCLUSION

The peoples living around the community forest periphery were found to use the medicinal plants for curing of minor and major diseases. Less side effect, easy availability and cost effectiveness of the medicinal plants make it a preference over allopathic medicines, for most of the rural household. Peoples were found to be satisfied by the effectiveness of medicinal plants. However, the usage of medicinal plants completely grounds on the indigenous knowledge and traditional beliefs of the peoples. Such knowledge differs from community to community and also with religion, culture and geography.

Therefore, a chemical screening and evaluation of such medicinal plants must be carried out so as to identify the bioactive compound for further preparation of drugs. It is suggested that providing training on cultivation and identification of the important medicinal and aromatic plants would be beneficial to commercialize, conserve and utilize the commonly available medicinal plants.

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STUDY ON THE EFFECT OF INSEMINATION TIME ON PREGNANCY RATE OF BANGLADESHI BUFFALO IN INTENSIVE FARMING

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ABSTRACT

The study was designed to evaluate the insemination time and pregnancy rate of Bangladeshi buffalo at Lal Teer Livestock Breeding and Research Farm, Bhaluka, Mymensingh, Bangladesh during January 2017 to June 2018. A total of 30 cyclic buffaloes were included in this study. The animals were inseminated under four different times, i.e. inseminated i) between 0-6 hours after seeing first sign of estrous, ii) between 6-12 hours after seeing first sign of estrous, iii) between 12-18 hours after seeing first sign of estrous and v) between 18-24 hours after seeing first sign of estrous. The pregnancies (positive or negative) were confirmed by rectal palpation and transrectal ultrasonography after 60 days of artificial insemination (AI). The total pregnant animals in this study were 40%. The highest pregnancy rate (60%) was observed in insemination between 12-18 hours after seeing first sign of estrous and the lowest pregnancy rate (0%) was observed in insemination between 0-6 hours after seeing first sign of estrous. The findings of the study suggest that, the conception rate of buffalo depend on the time of AI, detection of proper estrus symptoms and site of semen deposition.

Keywords: Bangladesh, buffalo, insemination, pregnancy

INTRODUCTION

Buffalo is a multipurpose domestic animal has extraordinary capacity utilization of less digestible feeds (straw, sugar cane wastes, crop residues etc.) helps the livelihood of people by providing excellent quality food milk and meat. Buffaloes are economically and culturally important livestock species especially in developing countries (Hagos and Mokhtar, 2015). It plays a significant role through contributions in social and cultural aspects (Desta, 2012). Buffalo milk can be converted into many kinds of cheese, primarily mozzarella (Aspilcueta-Borquis et al., 2012). Furthermore, buffaloes are valuable work animals (Perera, 2008), commonly used as

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draught animals in crop fields. The water buffalo is the second most important species in the world in terms of milk production, after dairy cows (Coroian et al., 2013) and good source of milk and meat in all over the world. Comparing to cow, buffalo milk is higher in protein, fat, lactose and energy.

India is the highest buffalo populated country in the world comprising 112.91million buffalo (58.11% of the world). India is the world's topmost milk producing country in the world where buffalo forms the backbone of India's dairy industry which share 67.99% of world's buffalo milk production (Chakravarty, 2013). Pakistan is the second most buffalo populated country in the world, contributes 16.83% of world buffalo population (FAO, 2012). The famous Pakistani breeds are Nili, Ravi, Nili-Ravi, Kundi etc. (Khan, 2001). Pakistan is the 2nd largest buffalo milk producing country in the world, contributes 23.96% of total buffalo milk production.

Bangladesh is a south Asian country where the economy is based primarily on agriculture, and livestock is an essential component of the rural economy. The buffalo is an important part of livestock in Bangladesh. The total buffalo population of the country is 1.457 million (DLS, 2015) of which coastal regions posses about 40% (Faruque et al., 1990). Most of the populations are reverine type with the exception of some swamp type found in Bangladesh. In Bangladesh, buffalo used primarily for draught purpose or dairy and meat production is a secondary option. There is no recognized breed of water buffaloes in Bangladesh and are mainly indigenous non descriptive types. Though total milk production of Bangladesh is about 6.09 MT in 2014 out of which about 3 to 4% is produced by the buffalo in spite of the number buffalo growth rate are increasing during last 10 years (DLS, 2015). The consumption of milk and meat was increased by @ 4.0% and 12.7% during 2005 to 2010. At the same time, rice consumption was decreased by 5.0%. Presently, it is increasing the number of consumer of buffalo milk because of its white color, high fat content and flavor. As a result there is a high demand for buffalo milk in the country, but milk yield per dairy buffalo is very low which is 600-1000 liter per 250-270 days lactation period (Faruque et al., 1990). This indicates that Bangladesh have great opportunity to produce buffalo milk because of its high consumer preference and demand. However, the sector is not poetically utilized yet due to many constraints. In Bangladesh, buffalo has never been addressed and always neglected species despite their important role in the national economy (Huque and Borghese, 2012).

According to the national health strategy, an adult people need 250 ml milk and 120 gm of meat every day. However, presently the availability is only 43.44% and 67.17%, respectively (DLS, 2015). Under these circumstances, to meet up the deficiency of milk and meat, the government and private organizations should put efforts together to enhance the present milk and meat production status. Recently, the demand for animal derived products such as milk, meat, butter, cheese, ice-cream, baby foods, locally made sweets are increasing which are heavily dependent on milk plus sugar.

It is known by all buffalo is a silent heat animal and not showing promt heat symptoms as like cattle and if the farmer/owner is not suited/familiar to identify them, then it arises problems. Undetected heat result longer calving intervals, lower lifetime milk production and fewer calves. In buffalo, usually/normally, the onset of heat/estrus is midnight (12.0 am to 1.0 am) and it lasts for 18-20 hours but sometimes to 36 hours. The animal owners and/or the inseminators should inseminate the buffalo in the right time for higher conception rates following proper heat detection technique. Usually, good fertility can be obtained inseminate between 6-18 hours after ovulation. The detection of oestrus has been very important for the buffalo herd's profitability. By an early and correct detection of oestrus (heat), artificial insemination has been carried out at the right time.

The time of insemination is very important to obtained maximum fertility and conception. Consequently, to know proper heat detection technique and accurate breeding time has been becoming more important to help the farmer to profitable buffalo farming. Therefore, the present studies was undertaken to investigate the accurate breeding time to improve conception and pregnancy rate of buffalo and to improve the livelihood of farmers and ensure high level of food security through buffalo production

MATERIALS AND METHODS

Location and climatic conditions

This research was conducted at Lal Teer Livestock Breeding and Research Farm (LTL) which is located at Bhaluka of Mymensingh district in Bangladesh. The farm is situated between 24º 01´ and 24º 47´ North latitude and between 89º 15´ and 89º 49´ East longitude. The temperature is moderate to high throughout the year with only slight variation between seasons and ranging between 12^{o}C and 35^{o}C. Summer begins in mid-April and lasts up to mid-June. Winter normally lasts from December to late February. The monsoon (rainy) season commences towards the end of June and continues to September. The level of rainfall is highest during monsoon and the lowest in March.

Experimental animals

Domestic indigenous buffalo of Bangladesh belongs to the *Bubalus bubalis* with most of the population are reverine type with exception of some swamp type found in eastern part and crossed or wild Arni type (*Bubalus arnee)* found in southern coastal areas (Faruque et al., 1990; Huque and Borghese, 2012). The LTL has a total of 35 breeding buffalo available excluding breeding bulls, calves and heifers. The present study was conducted a total of 30 cyclic buffalo which was Indigenous Murrah type, Plain land Riverine type and wild Arni/Crossed type.

The Indigenous Murrah type is mainly dual type and is distributed in western part and different from other breeds. Their coat color is usually black and the horns are short, tight, turning backward and upward and finally spirally curving inward. The body sound built, heavy and wedge shaped. The cows are good sized and possess better milking ability. Males are bigger in size than female. The Plain land Riverine type is also dual type and mainly found in the sandy islands of the river Brahmaputra and the Jamuna of the central part of the country. The coat color is usually black and horns are medium in size and curving inward. Body sound built, medium and wedge shaped. The wild Arni type is gray to black in color with off-white "socks" and one or two white chevrons on the neck. The horns curve backward in a crescent.

The photograph of Indigenous Murrah, Plain land Reverine and Wild Arni is presented in Photo 1, 2 and 3 respectively.

Photo 1. Photograph of Indigenous Murrah Buffalo

Photo 2. Photograph of Plain land Riverine Buffalo

Photo 3. Photograph of wild Arni Buffalo

Herd Management

The animals were managed intensively in pens with sufficient cross-ventilation and protected from hot-sun and heavy rainfall to avoid abrupt fluctuation of their body temperature during the whole period. Each buffalo (maintenance + pregnant) was fed with a total of 1.04 kg concentrate mixture containing 0.25 kg broken maize, 0.17 kg wheat bran, 0.30 kg mustard oil cake, 0.12 kg rice polish, 0.11 kg molasses, 0.01 kg vit-min. premix, 0.01 kg di-calcium phosphate, 0. 02 kg oyster shell, 0.05 kg iodine salt, (15.0% crude protein, 74.0% TDN, 2.48 Mcal ME); 2.0 kg straw and 8-10 kg green grass per day. The dry and early pregnant animals were allowed to graze 2-3 hours/day. Most commonly available green fodders were Napier, Sorghum, Maize, and Berseem. Fresh drinking water was provided *ad libitum*. Routine veterinary attention was provided to each animal. No buffalo was affected with remarkable diseases. The buffalos were regarded as clinically healthy and free from any significant abnormalities. They were vaccinated routinely against Foot and mouth disease (FMD), Anthrax, Hemorrhagic Septicemia (HS) and Black Quarter (BQ). Buffalos were dewormed with a combined preparation of Tetramisole Hydrochloride and Oxyclosanide (Levanid$^{(R)}$, The ACME Laboratories Ltd, Dhaka, Bangladesh) twice in a year. To control external parasites, the farm areas were sprayed once a week with broad spectrum disinfectant.

Experimental design

This research was done at LTL during the period of January 2017 to June 2018 with the assistance of some technical persons and farm workers of this farm. Heat detection was based on visual observations, performed three times a day (morning 06.00, midday 12.00 and afternoon 15.00), involving 20 minutes of watching reports from the high skilled research assistant and trained farm workers. In addition, we followed the estrus cycle of calving buffalo, e.g., 1st cycle at the day of 19-23, 2nd cycle at the day of 40-44 and 3rd cycle at the day of 61-65 after parturition. During

these periods, the milked animals were not milking. When an animal was found with different external and internal symptoms of heat, this animal was considered to be in oestrus. All of the symptoms were captured with Sony Handycam and stored on hard drives to use them when necessary. All of the symptoms have been followed by research assistant and farm workers to prevent bias.

In this research, we inseminated the animals under four different times, i.e. inseminated i) between 0-6 hours after seeing first sign of estrous, ii) between 6-12 hours after seeing first sign of estrous, iii) between 12-18 hours after seeing first sign of estrous and v) between 18-24 hours after seeing first sign of estrous at LTL farm. Pregnancies (positive or negative) were confirmed by rectal palpation on day 60 post A.I. by a trained veterinarian; and repeat breeders were inseminated accordingly.

Control

Each day around noon the animals which had been registered to be in oestrus by at least one of the four methods in the previous 24 hours were checked to make sure there were no false positives.

This was done by gynaecological examination with an ultrasound to determine if there was either a corpus luteum (CL) or follicle (>10mm) present in the ovaries, but also if there was a tonus of uterus and outflow of mucus. If there was a CL present there can be no oestrus at the same moment (false positive). If there was no CL but a follicle present (>10 mm) the animal was considered to be in oestrus (true positive).

RESULTS AND DISCUSSION

For accurate breeding time, we inseminated (artificially) a total of 30 cyclic buffaloes under four different times and observed final conception (positive or negative) following pregnancy diagnosis. After confirmation of proper heat, we inseminated the selected buffalo artificially by trained and skilled inseminator. After 60 days of insemination, we confirmed pregnant buffalo by rectal palpation with skilled veterinarian. The photograph of Indigenous Murrah, Plain land Reverine and Wild Arni is presented in Photo 1, 2 and 3 respectively. The picture for preparation of artificial insemination, the use of hormone in artificial insemination, the artificial insemination in heated buffalo, the pregnancy diagnosis by rectal palpation and the pregnancy diagnosis with ultrasonography is presented in Photo 4, 5, 6 and 7 respectively.

Photo 4. Preparation for artificial insemination

Photo 5. Artificial insemination (heated buffalo)

Photo 6. Pregnancy diagnosis by rectal palpation

Photo 7. Pregnancy diagnosis with ultrasonography

We confirmed that the percentage of total pregnant animals was 40% (Table 1). The results for percentage of pregnant animals at insemination between 0-6 hours after seeing first sign of estrous was 0% (0/5), insemination between 6-12 hours after seeing first sign of estrous was 50% (5/10), insemination between 12-18 hours after seeing first sign of estrous was 60% (6/10) and insemination between 18-24 hours after seeing first sign of estrous was 10% (1/5) respectively. The differences of conception and pregnancy rate between inseminating times may be proper estrus of buffalo, time of A.I., site of semen deposition.

Table 1. No. of pregnant buffalo with insemination at different times

Sr.	A.I. time	No. of Animal	Pregnant animal	% of pregnancy
1	inseminate between 0-6 hours after ovulation	5	0	0 %
2	inseminate between 6-12 hours after ovulation	10	5	50 %
3	inseminate between 12-18 hours after ovulation	10	6	60 %
4	inseminate between 18-24 hours after ovulation	5	1	10 %
	Total	30	12	40.0 %

Source: Based on research report

In the review, we found that a number of controlled or breeding programs have been developed for synchronizing groups of lactating cattle/buffalo. Controlled breeding can be directed to cows that pass a corpus luteum test as determined by rectal

palpation of the ovaries and for further administering PGF2α to these animals. It was observed that all the cows and buffaloes were in heat after 16-24 hrs in 2nd dose of Receptal injection. It has been observed that cows in early and late stages of the cycle tend to exhibit heat within 48-72h after receptal administration.

The spermatozoa need some time in the female reproductive tract to undergo for maturation (capacitation). The life of the ovum in the fallopian tube is short and ovulation occurs approximately 28-32 hours from the time of onset of estrus. Good fertility can be obtained between 6-12 hours after ovulation or nearer to the end of mid heat. Therefore the best time is to inseminate in the evening if the estrus is observed in the morning and if observed in the evening the insemination should be done the next day morning. In buffaloes the estrus period is long when compared to cattle. It will be 24-36 hours. Therefore insemination in buffaloes should be done in about 24 hours after the onset of heat. Therefore if the buffalo comes to heat in the morning insemination should be done next day morning. Similarly if it comes to heat in the evening insemination should be done next day evening.

Dalton et al., 2001 conducted an experiment to determine the effect of insemination time on fertilization status and embryo quality in single-ovulating cows. All cows were continuously monitored by Heat Watch and received AI with one 0.5-mL straw (25×10^6 sperm) of semen from one of three bulls at 0, 12, or 24 h after the onset of standing heat. He found that, fertilization rates were greatest in embryos recovered following the 24-h AI treatment.

In various management schemes, it is unrealistic to expect heat detection and AI to occur more than once daily. In this management strategy AI should occur as soon after detection as possible, as the short lifespan of the ovum must be considered the limiting factor. Heat detection and AI studies, however, have reported similar fertility results for once-daily AI and AI following the A.M.-P.M. guideline (Foote, 1978; Nebel et al., 1994).

CONCLUSION

In this study, the animals were inseminated under four different times. Pregnancies (positive or negative) were confirmed by rectal palpation on day 60 post AI by a trained veterinarian; and repeat breeders were inseminated accordingly. The total pregnant animals were found 40%. The highest pregnancy rate (60%) was observed in insemination between 12-18 hours after seeing first sign of estrous and the lowest pregnancy rate (0%) was observed in insemination between 0-6 hours after seeing first sign of estrous. It is concluded that, appropriate semen storage, semen handling, and site of semen deposition in the female reproductive tract are critical factors related to achieving a successful breeding program.

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PERFORMANCE OF DIFFERENT ORGANIC FERTILIZERS IN IMPROVING GROWTH AND YIELD OF BORO RICE

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ABSTRACT

A field experiment was conducted at two locations i.e. at Soil Science Field of Bangladesh Agricultural University and at Farmer's field of Fakirakanda village of Mymensingh Sadar to evaluate the effects of different organic fertilizers on the growth and yield of rice (BRRI dhan28). The experiments at each location containing seven treatments were laid out in a randomized complete block design with three replications. The treatments were T_0: Control, T_1: 75% RFD; T_2: 100% RFD, T_3: 75% RFD + Kazi Jaibo Shar (5 tha^{-1}), T_4: 75% RFD + Kazi Jaibo Shar (3 t ha^{-1}), T_5: 75% RFD + Poultry manure (3 t ha^{-1}) and T_6: 75% RFD + Cow dung (5 t ha^{-1}). Application of poultry manure as well as Kazi Jaibo Shar showed positive effects on yield attributes, grain and straw yields of rice, nutrient (N, P, K and S) contents and uptake by grain, straw and in total. The performance of 75% RFD with poultry manure @ 3 t ha^{-1} was the best in producing yield components, grain and straw yields of rice. At both locations, the performance of same dose (3 t ha^{-1}) of poultry manure and Kazi Jaibo Shar was almost similar in producing growth and yield contributing characters, grain and straw yields, - nutrient content and uptake by rice while each of these manures compensated up to 25% of recommended chemical fertilizers. Therefore, considering the soil health, poultry manure or Kazi Jaibo Shar @ 3 t ha^{-1} is recommended for growth and yield enhancement in rice.

Keywords: Cow dung, poultry manure, Kazi Jaibo Shar, rice, yield, nutrient uptake

INTRODUCTION

Bangladesh is predominantly an agrarian country where agriculture sector contributes about 17 percent to the country GDP and employs more than 45 percent of total labour force (BBS, 2016). Rice (*Oryza sativa*) is the most important cereal crop and

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the staple dietary item for the people in Bangladesh and the agriculture sector of the country is largely dominated by rice cultivation. The total area and production of rice are about 11.38 million hectares and 34.71 million metric tons, respectively (BBS, 2016). The average yield of rice in Bangladesh is comparatively lower than those of other South East Asian countries like China, Japan, Korea and Indonesia etc. which might be due to soil fertility depletion as well as poor fertilizer management. Due to ever-rising population, food security has become a key concern in Bangladesh. Consequently, maintenance of soil fertility is necessary for sustainable agriculture and future food security (Majumdar et al., 2016). Hence, to achieve improved and sustainable crop production, the strategy of organic matter and balanced fertilizer management is essential.

Increasing cropping intensity, use of modern varieties (high yielding varieties and hybrids), cultivation of high biomass potential crops, nutrient leaching and unbalanced fertilizer application, with no or little addition of organic manure have resulted in nutrient mining from Bangladesh soils (BARC, 2012). To stop nutrient mining, it is not justified to increase the use of only inorganic fertilizers but the use of organic sources of plant nutrients viz. cow dung, poultry manure, compost, green manure should also be considered. Many farmers use higher amount of inorganic fertilizers while they seldom use organic fertilizers e.g. compost, poultry manure, cow dung. This practice creates imbalance use of fertilizers, which in turn produces a negative impact on crop production. The beneficial aspects of cow dung, poultry manure and compost in increasing crop growth and productivity and maintaining soil fertility have been proven. To increase the efficiency of manure and fertilizer in rice cultivation, it is necessary to identify the suitable combination of manure and fertilizer (Mitu et al. 2017). In recent years, the use of organic fertilizers as alternatives of chemical fertilizers in order to enhance rice production has gained much significance. Kazi Jaibo Shar is a newly developed organic fertilizer based on poultry manure, which is enriched with various nutrient elements. The present study was conducted to clarify the effectiveness of different organic fertilizers at various locations for improving growth, yield and nutritional quality of rice for use as substitute of inorganic fertilizers.

MATERIALS AND METHODS

A comparative study was performed at two different locations viz. Soil Science Field laboratory of Bangladesh Agricultural University, Mymensingh and a farmer's field at Fakirakanda village of Mymensingh Sadar during the boro season of 2017-2018. The soils of the experimental sites belong to the Sonatala series under the AEZ 9 (Old Brahmaputra Floodplain). The soil of BAU farm was silt loam in texture having

pH 6.27, organic matter content 1.95%, total N 0.136%, available P 3.16 ppm, exchangeable K 0.095 % and available S 10.5 ppm whereas the soil of farmer's field was loam in texture with pH 6.39, organic matter content 2.5%, total N 0.168%, available P 4.76 ppm, exchangeable K 0.13 me% and available S 12.47 ppm.

. The treatments at both locations were T_0 (Control), T_1 (75% RFD), T_2 (100% RFD), T_3 (75%RFD + KaziJaiboShar5 t ha^{-1}), T_4 (75% RFD + Kazi Jaibo Shar 3 t ha^{-1}), T_5 (75% RFD + Poultry manure 3 t ha^{-1}) and T_6 (75% RFD + Cow dung 5 t ha^{-1}). Experiments was laid out in a Randomized Complete Block Design (RCBD) with three replications and the size of unit plot was 4 m × 3m. BRRI dhan 28 was used for both of the experiments. Thirty-five days old seedlings of rice were transplanted in the experimental plots on 06 February, 2018 by maintaining a spacing of 20 cm × 20 cm.

The doses of nitrogen (N), phosphorus (P), potassium (K), sulphur (S) and zinc (Zn) were 150, 20, 65, 18 and 2 kg ha^{-1} following the Fertilizer Recommendation Guide (BARC, 2012) in form of urea, triple super phosphate (TSP), muriate of potash (MoP), gypsum and zinc oxide, respectively. The full doses of chemical fertilizers except urea were applied before transplanting as basal dose to all the experimental plots. Organic manures viz. poultry manure, cow dung and Kazi Jaibo Shar were also applied during final land preparation. Urea was applied in three equal splits as top dressing; first installment at 12 days after transplanting (DAT), second installment at 30 DAT i.e. at maximum tillering stage and third installment at 50 DAT i.e. booting stage of the crop.

Different intercultural operations such as irrigation, weeding, pest control were performed as and when required. The rice was harvested at full maturity on 10 June 2018.The data on growth and yield parameters such as plant height, number of effective tillers $hill^{-1}$, panicle length, number of filled and unfilled grains $panicle^{-1}$, 1000-grain weight, dry and fresh weight of root were recorded at harvest. The grain and straw yields were measured plot wise and expressed as t ha^{-1} on sundry basis.

The collected grain and straw samples from each plot were dried in an oven at 65°C for about 48 hours and then ground by a grinding machine. Later, the ground samples were sieved through a 20-mesh sieve. The ground plant materials were stored in paper bags separately and placed in a desiccator. The plant samples were chemically analyzed for determination of N, P, K and S contents. The total N, available P, exchangeable K and available S of plant samples were determined following semi-micro Kjeldahl method (Bremner and Mulvaney, 1982), modified Olsen method (Olsen *et al.*, 1954), NH_4OAc extraction method (Knudsen *et al.*, 1982), and $CaCl_2$ extraction method (Williams and Steinbergs,1959), respectively.

After chemical analysis of grain and straw samples of rice, the nutrient uptake was calculated from the nutrient content and yield of the crop using the following formula;

$$TU = \frac{NC \times Y}{100}$$

where, TU = total nutrient uptake (kg ha^{-1}), NC = nutrient concentration (%), and Y = yield (kg ha^{-1}).

All the data were statistically analyzed by F-test and the mean differences were ranked by Duncan's New Multiple Range Test (DMRT) (Gomez and Gomez, 1984). Differences at $p<0.05$ were considered significant.

RESULTS AND DISCUSSION

Growth parameters of BRRI dhan28

Application of Kazi Jaibo Shar had significant effects on the growth parameters of BRRI dhan28 viz. plant height, root length, fresh and dry weight of root $plant^{-1}$ at both BAU farm as well as in Farmer's field (Table 1). At BAU farm, the highest value for plant height (99.40 cm) was observed in T_5 treatment (75% RFD + Poultry manure 3 t ha^{-1}) which was statistically similar with those of T_3 treatment (75% RFD + Kazi Jaibo Shar 5 t ha^{-1}) and T_4 (75% RFD + Kazi Jaibo Shar 3 t ha^{-1}) treatments. The shortest plant of 82.33 cm was found in T_6 treatment (75% RFD + Cow dung 5 t ha^{-1}). The tallest plant of 83.33 cm at farmer's field was found in T_2 (100% RFD) which was statistically identical with those of T_3, T_4 and T_5. Root length was statistically similar in six treatments but significantly better to control at both locations. For both fresh and dry weight of roots, the highest values (23 and 8.27 g, respectively) were observed in T_4 treatment with the lowest values in control (14.33 and 3.87 g, respectively). The growth parameters of BRRI dhan28 grown at Farmer's field had more or less similar trend (Table 1). The maximum values for root length (14.27 cm), fresh weight of root (23.63 g) and dry weight of root (7.70 g) $plant^{-1}$ were recorded from T_4 (Table 1) where Kazi Jaibo Shar was applied @ 3 t ha^{-1} with 75% RFD. Tazmin et al. 2015 and Islam et al. 2012 also reported that application of manure and fertilizers enhanced the yield contributing the character of rice.

Table 1. Effect of different organic fertilizers on growth parameters of BRRI dhan28

Treatments	BAU farm				Farmer's field			
	Plant height (cm)	Root length (cm)	Fresh weight of root (cm)	Dry weight of root (cm)	Plant height (cm)	Root length (cm)	Fresh weight of root (cm)	Dry weight of root (cm)
T_0	83.00c	9.63b	14.33c	3.87c	67.93bc	7.70b	15.67c	3.20b
T_1	98.40ab	13.70a	19.60ab	6.80ab	78.00ab	13.20a	21.70a	6.50ab
T_2	87.93bc	14.07a	21.80a	6.83ab	83.33a	12.60a	22.83a	7.17a
T_3	90.37abc	14.67a	19.13ab	5.33bc	82.73a	12.53a	22.03a	6.60ab
T_4	96.07ab	13.77a	23.00a	8.27a	82.80a	14.27a	23.63a	7.70a
T_5	99.40a	13.97a	19.07b	7.53ab	80.73ab	13.80a	23.47a	7.23a
T_6	82.33c	13.60a	17.90b	4.93bc	62.47c	12.10a	18.90b	3.77b
CV (%)	6.54	11.82	18.94	22.84	9.49	15.45	6.78	27.74
SE(±)	4.87	1.29	3.02	1.13	5.95	1.55	1.17	1.42

$T_{0:}$ Control; T_1: 75% RFD; T_2: 100% RFD; T_3: 75% RFD + Kazi Jaibo Shar (5 tha^{-1}); T_4: 75% RFD + Kazi Jaibo Shar (3 t ha^{-1}); T_5: 75% RFD + Poultry manure (3 tha^{-1}); T_6: 75% RFD + Cow dung (5 tha^{-1}); CV = Co-efficient of variation; SE = Standard error of means

Yield parameters of BRRI dhan28

Number of effective tillers $hill^{-1}$, panicle length, number of filled grains $panicle^{-1}$ and number of unfilled grains $panicle^{-1}$were significantly affected by different treatments while 1000-grain weight remained statistically unaffected (Table 2). At BAU farm, the treatment T_5 (75% RFD + Poultry manure 3 t ha^{-1}) produced the highest number of effective tillers $hill^{-1}$ (15.60) and the longest panicle (23.60 cm) which were statistically similar with those of treatments T_1 (75% RFD), T_2 (100% RFD), T_3 (75% RFD + Kazi Jaibo Shar 5 t ha^{-1}) and T_4 (75% RFD + Kazi Jaibo Shar 3 tha^{-1}). Interestingly, the maximum number of filled grains $panicle^{-1}$ (99.47) and the minimum number of unfilled grains $panicle^{-1}$(12.27) were recorded in T_4 treatment. For most of the yield parameters (except 1000-grain weight), the lowest values were observed in control treatment. A little difference was found in the yield contributing characters of rice cultivated at Farmer's field where the highest number of effective tillers $hill^{-1}$ (16.03) was recorded in T_4 which has no statistical difference with that of T_5. Similar with the result of BAU farm, the tallest panicle of 23.60 cm and the maximum number of filled grains $panicle^{-1}$ (96.33) were observed in T_5 which were statistically identical with those of T_2, T_3 and T_4 treatments. Notably, the lowest number of effective tillers $hill^{-1}$ (10.67), the lowest panicle length (18.27 cm) and the lowest number of unfilled grains $panicle^{-1}$(8.60) were recorded in T_6 treatment where cow dung was applied @ 5 t ha^{-1} with 75% RFD. Better yield components such as higher panicle length, increased number of effective tillers $hill^{-1}$ and increased number of filled grains $panicle^{-1}$ with poultry manure with inorganic fertilizers were

also suggested by Islam et al 2018, Ali et al., 2018, Sarker et al., 2015 and Hossaen et al. (2011). Better growth under combination of organic and inorganic fertilizer treatments resulted in higher yield contributing characters that ultimately led to higher grain and straw yields of rice.

Table 2. Effect of different organic fertilizers on yield parameters of BRRI dhan28

Treatments	BAU farm					Farmer's field				
	No. of effective tillers hill^{-1}	Panicle length (cm)	No. of filled grains panicle^{-1}	No. of unfilled grains panicle^{-1}	1000-grain weight (g)	No. of effective tillers hill^{-1}	Panicle length (cm)	No. of filled grains panicle^{-1}	No. of unfilled grains panicle^{-1}	1000-grain weight (g)
T_0	8.60c	18.40c	64.80c	17.57bc	21.40	13.33b	19.40b	56.20c	23.00a	22.53
T_1	14.70a	21.60ab	95.07a	28.13a	22.60	13.23b	21.67a	77.00b	17.80ab	24.37
T_2	15.33a	21.27ab	84.07ab	28.57a	21.80	14.33ab	22.27a	80.93ab	15.60bc	24.13
T_3	14.90a	22.07ab	81.27b	13.80bc	24.87	13.40b	22.20a	81.67ab	9.93c	22.70
T_4	14.87a	23.33a	99.47a	12.27c	22.07	16.03a	22.13a	93.33ab	13.33bc	22.73
T_5	15.60a	23.60a	92.00a	15.13bc	22.17	15.47a	22.53a	96.33a	12.20bc	23.97
T_6	12.30b	19.73bc	82.00b	23.83ab	19.73	10.67c	18.27b	76.57b	8.60c	22.87
CV (%)	8.235	6.96	15.53	27.24	8.76	7.41	5.89	12.18	26.24	3.52
SE(±)	0.924	1.22	10.84	4.43	1.58	0.834	1.02	7.98	3.07	0.67

$T_{0:}$ Control; T_1: 75% RFD; T_2: 100% RFD; T_3: 75% RFD + Kazi Jaibo Shar (5 t ha^{-1}); T_4: 75% RFD + Kazi Jaibo Shar (3 t ha^{-1}); T_5: 75% RFD + Poultry manure (3 t ha^{-1}); T_6: 75% RFD + Cowdung (5 t ha^{-1}); CV = Co-efficient of variation; SE = Standard error of means

Yield of BRRI dhan28

Grain yield as well as straw yield of BRRI dhan28 was significantly influenced with application of Kazi Jaibo Shar (Table 3a). At BAU farm, the grain yield ranged from 3.67 to 6.47 t ha^{-1} whereas the straw yield ranged from 4.93 to 7.44 t ha^{-1}. For both grain and straw yields, the maximum values were observed in T_5 treatment (75% RFD + Poultry manure 3 t ha^{-1}) which were statistically similar with those of T_1 (75% RFD), T_2 (100% RFD), T_3 (75% RFD + Kazi Jaibo Shar 5 t ha^{-1}) and T_4 (75% RFD + Kazi Jaibo Shar 3 t ha^{-1}). The minimum values for both yields were found in control (T_0).

Table 3. Effect of different organic fertilizers on grain and straw yields of BRRI dhan28

Treatments	BAU farm		Farmer's field	
	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
T_0	3.67c	4.93c	3.17c	3.80d
T_1	5.97a	6.59ab	5.33b	6.17c
T_2	6.07a	7.24a	5.80ab	7.17ab
T_3	6.06a	7.15a	5.93ab	6.95bc
T_4	6.17a	7.07a	5.77ab	6.90bc
T_5	6.47a	7.44a	6.73a	7.89a
T_6	4.97b	5.87bc	5.70ab	6.23c
CV (%)	7.86	8.10	10.40	6.83
SE(±)	0.361	0.437	0.466	0.359

T_0: Control; T_1: 75% RFD; T_2: 100% RFD; T_3: 75% RFD + Kazi Jaibo Shar (5 t ha^{-1}); T_4: 75% RFD + Kazi Jaibo Shar (3 t ha^{-1}); T_5: 75% RFD + Poultry manure (3 t ha^{-1}); T_6: 75% RFD + Cowdung (5 t ha^{-1}); CV = Co-efficient of variation; SE = Standard error of means well as straw yield, different treatments showed their rank in the order of $T_5>T_4>T_3>T_2>T_1>T_6>T_0$.

Almost similar findings were noted in the yield of BRRI dhan28 grown at Farmer's field where the grain yield varied from 3.17 to 6.73 t ha^{-1} and the straw yield ranged from 3.80 to 7.89 t ha^{-1}. For both grain and straw yields, treatment T_5 produced the highest yields and the control produced the lowest yields. The highest yields from T_5 were statistically identical with the yields from T_2, T_3, T_4 and T_6 for grain and with the yield from T_2 for straw.

At BAU farm, the percent increase in rice yield over control ranged from 35.42 to 76.29 for grain and 19.07 to 50.91 for straw (Fig. 1). On the other hand, the percent increase in rice yield over control at farmer's field varied from 68.14 to 112.30 for grain and 62.37 to 107.63 for straw For both grain and straw yield, T_5 treatment gave the highest yield increase over control, respectively. Yield enhancement of rice by applying poultry manure in association with chemical fertilizers was reported by many researchers (Ali et al., 2018; Islam et al., 2012, 2018; Roy et al., 2018; Bhuiyan et al., 2015; Sarker et al., 2015; Tazmin et al. 2015; Issaka et al. 2014; Sangeetha et al., 2013; Hossaen et al., 2011; Hasanuzzaman et al., 2010; Myint et al., 2010).

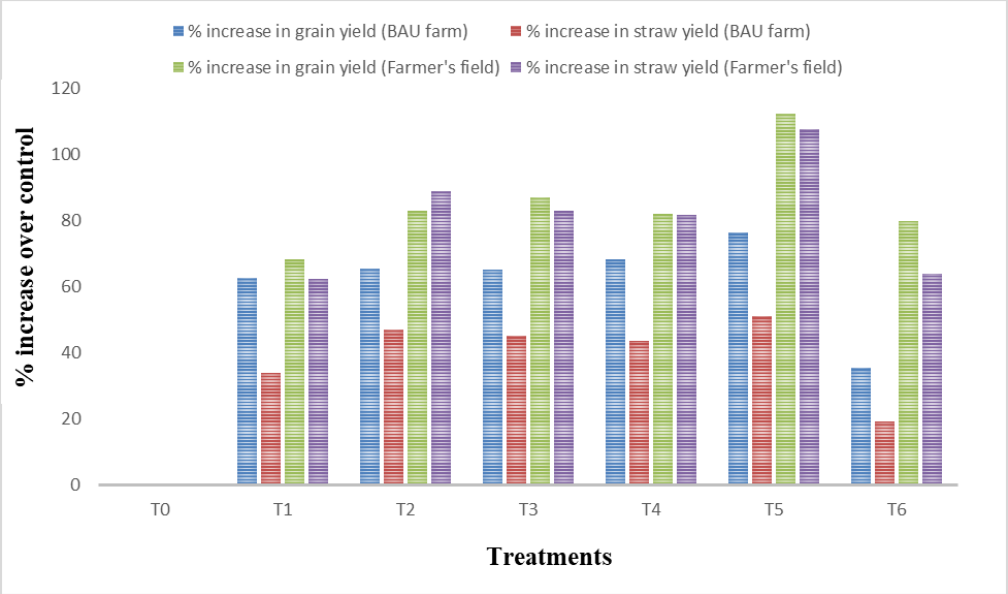

Fig. 1. Percent increase in grain and straw yield of BRRI dhan28 as influenced by application of different organic fertilizers

Nutrient content of BRRI dhan28

Application of Kazi Jaibo Shar exerted positive effects on N, P, K and S contents in rice grain and straw at both locations (Table 4a and 4b). However, a non-significant effect was observed in case of straw N content at BAU farm and straw P content at Farmer's field (Table 4b). For BAU farm, the highest N contents in rice grain and straw (1.21% and 1.05%, respectively) were recorded in T_5 (75% RFD + Poultry manure 3 t ha^{-1}). In grain samples, the highest contents of P (0.407%), K (0.173%) and S (0.358%) were found in treatment T_4 (75% RFD + Kazi Jaibo Shar 3 t ha^{-1}). On the other hand, in straw samples, the maximum contents of P (0.151%), K (1.80%) and S (0.302%) were recorded in T_1 (75% RFD), T_5 and T_4 (75% RFD + Kazi Jaibo Shar 3 t ha^{-1}), respectively.

Table 4a. Grain nutrient content of BRRI dhan28 as influenced by different organic fertilizers

Treatments	BAU farm				Farmer's field			
	% N	% P	% K	% S	% N	% P	% K	% S
T_0	0.98c	0.259d	0.135d	0.271b	0.93c	0.246d	0.129c	0.295c
T_1	1.12b	0.301c	0.145cd	0.299b	1.12b	0.291c	0.144abc	0.313bc
T_2	1.18ab	0.291cd	0.143cd	0.307b	1.16ab	0.277c	0.151abc	0.324b
T_3	1.14b	0.335b	0.155bc	0.353a	1.15ab	0.333b	0.161ab	0.366a
T_4	1.16ab	0.407a	0.173a	0.358a	1.15ab	0.377a	0.167a	0.368a
T_5	1.21a	0.381a	0.168ab	0.356a	1.20a	0.382a	0.165ab	0.357a
T_6	1.04c	0.281cd	0.143cd	0.279b	0.97c	0.273c	0.140bc	0.289c
CV (%)	3.12	5.30	6.32	6.12	3.51	4.43	8.81	4.70
SE(±)	0.0284	0.0139	0.0078	0.0159	0.0315	0.0113	0.0109	0.0127

T_0: Control; T_1: 75% RFD; T_2: 100% RFD; T_3: 75% RFD + Kazi Jaibo Shar (5 t ha^{-1}); T_4: 75% RFD + Kazi Jaibo Shar (3 t ha^{-1}); T_5: 75% RFD + Poultry manure (3 t ha^{-1}); T_6: 75% RFD + Cowdung (5 t ha^{-1}); CV = Co-efficient of variation; SE = Standard error of means

Similar trend was observed for nutrient contents in grain and straw of BRRI dhan28 cultivated at the Farmer's field. For grain samples, the highest N and P contents (1.20% and 3.82%, respectively) were recorded in T_5 treatment while the highest K and S contents (0.167% and 0.368%, respectively) were found in T_4 treatment. On the other hand, for straw samples, the highest values for N, P, K and S contents (1.08%, 0.144%, 1.75% and 0.291%, respectively) were noted in T_3, T_2, T_5 and T_4, respectively. In general, there was no significant difference between T_5 and T_4 for nutrient content in grain and straw samples at both locations. These findings are partially similar to those of Saha et al., 2014; Hossain et al. 2010; Myint et al., 2010 who obtained higher contents of nutrient elements such as N, P, K and S in rice by applying poultry manure with inorganic fertilizers.

Table 4b. Straw nutrient content of BRRI dhan28 as influenced by different organic fertilizers

Treatments	BAU farm				Farmer's field			
	% N	% P	% K	% S	% N	% P	% K	% S
T_0	0.96	0.121cd	1.43d	0.202f	0.91b	0.126	1.36d	0.221e
T_1	0.98	0.151a	1.48cd	0.250c	0.99ab	0.143	1.47cd	0.257bcd
T_2	0.99	0.142ab	1.69abc	0.231d	1.00ab	0.144	1.50abc	0.242cde
T_3	1.02	0.126bcd	1.65abcd	0.251c	1.08a	0.135	1.60ab	0.265abc
T_4	1.01	0.122cd	1.79ab	0.302a	1.02ab	0.131	1.68ab	0.291a
T_5	1.05	0.134bc	1.80a	0.271b	1.07a	0.143	1.75a	0.281ab
T_6	0.97	0.115d	1.56bcd	0.221e	0.97ab	0.124	1.49abc	0.235de
CV (%)	4.47	6.90	7.50	2.18	5.62	10.92	9.28	6.02
SE(±)	0.0365	0.0073	0.0997	0.0044	0.0461	0.012	0.1175	0.0126

$T_{0:}$ Control; T_1: 75% RFD; T_2: 100% RFD; T_3: 75% RFD + Kazi Jaibo Shar (5 tha^{-1}); T_4: 75% RFD + Kazi Jaibo Shar (3 t ha^{-1}); T_5: 75% RFD + Poultry manure (3 t ha^{-1}); T_6: 75% RFD + Cow dung (5 t ha^{-1}); CV = Co-efficient of variation; SE = Standard error of means

Nutrient uptake by BRRI dhan28

Uptake of nutrients (N, P, K and S) by BRRI dhan28 varied significantly due to addition of Kazi Jaibo Shar with inorganic fertilizers (Table 5a and 5b). At BAU farm, the values for grain N-uptake, straw N-uptake and total N-uptake varied from 36.0 to 78.0, 47.3 to 75.7 and 83.7 to 152.3 kg ha^{-1}, respectively (Table 5a). The maximum values for both grain N-uptake and total N-uptake were found in T_5 treatment while the maximum value for straw-N-uptake was observed in T_4. Again, the uptake of grain-P, straw P and total P ranged from 9.7 to 25.0, 6.0 to 10.3, and 15.7 to 34.0 kg ha^{-1}, respectively. In the same manner, T_4 and T_5 performed the best in grain P uptake and straw P-uptake, respectively; while total P-uptake was same for both treatments.

Table 5a. Effect of different organic fertilizers on N and P uptake by BRRI dhan28

Treatments	BAU farm						Farmer's field					
	N uptake (kg ha^{-1})			P uptake (kg ha^{-1})			N uptake (kg ha^{-1})			P uptake (kg ha^{-1})		
	Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total
T_0	36.0d	47.3c	83.7d	9.7c	6.0b	15.7d	29.7c	35.0c	65.0c	8.0d	5.0c	12.3
T_1	66.3b	64.7ab	131.0b	18.0b	10.0a	27.7b	60.0b	60.7b	120.3b	15.3c	9.0ab	24.0d
T_2	71.3ab	71.7a	143.3ab	17.3b	10.3a	28.0b	67.0b	71.7ab	139.0ab	16.0c	10.7a	26.3cd
T_3	68.7ab	73.0a	142.3ab	20.3b	9.0a	29.3b	68.3ab	75.0ab	143.3ab	19.7b	9.3ab	29.3bc
T_4	71.7ab	75.7a	147.4ab	25.0a	9.0a	34.0a	66.3b	70.0ab	136.3ab	21.7b	9.0ab	30.7b
T_5	78.0a	74.7a	152.3a	24.7a	9.3a	34.0a	80.7a	84.0a	164.7a	25.7a	11.0a	37.3a
T_6	52.0c	57.0bc	108.7c	16.0bc	7.0b	23.0c	55.3b	66.0b	130.0b	15.7c	7.7b	23.3d
CV (%)	7.94	9.22	6.86	12.81	8.96	8.20	11.48	11.35	11.57	10.83	14.83	8.81
SE (±)	0.0041	0.005	0.0073	0.002	0.0006	0.0018	0.0057	0.0061	0.0121	0.0015	0.0011	0.0019

T_0: Control; T_1: 75% RFD; T_2: 100% RFD; T_3: 75% RFD + Kazi Jaibo Shar (5 tha^{-1}); T_4: 75% RFD + Kazi Jaibo Shar (3 t ha^{-1}); T_5: 75% RFD + Poultry manure (3 tha^{-1}); T_6: 75% RFD + Cowdung (5 tha^{-1}); CV = Co-efficient of variation; SE = Standard error of means

At farmer's field, the values for grain-N uptake, straw N-uptake and total N uptake ranged from 29.7 to 80.7, 35.0 to 84.0 and 65.0 to 164.7 kg ha^{-1}, respectively (Table 5a). The highest values for grain-N uptake, straw N-uptake and total N uptake were found in T_5 treatment. Furthermore, the uptake of grain-P, straw P and total P varied from 8.0 to 25.7, 5.0 to 11.0, and 12.3 to 37.3 kg ha^{-1}, respectively. Similarly, in all three cases of P-uptake (grain P, straw P and total P), the highest values were observed in T_5 treatment. While, there was no significant variation in N and P uptake between treatment T_4 and T_5 for both grain and straw.

At BAU farm, the values for grain-K uptake, straw K-uptake and total K uptake varied from 4.7 to 10.7, 71.0 to 133.0 and 75.7 to 143.3 kg ha^{-1}, respectively (Table 5b). The maximum values for both straw-K uptake and total K uptake were found in T_4 while the maximum value for grain-K uptake was observed in T_5 treatment. Again, the uptake of grain-S, straw-S and total S ranged from 10.0 to 23.0, 10.0 to 22.7, and 19.7 to 44.3 kg ha^{-1}, respectively. In the same manner with K-uptake, treatment T_4 caused the highest straw-S uptake and total S uptake while T_4 performed the best in grain S-uptake.

In case of Farmer's field, the values for grain-K uptake, straw K-uptake and total K uptake varied from 4.0 to 11.0, 51.7 to 138.0 and 56.0 to 149.0 kg ha^{-1}, respectively while the uptake of grain-S, straw-S and total S ranged from 9.3 to 24.3, 8.3 to 22.0,

and 17.0 to 46.3 kg ha^{-1}, respectively (Table 5b). For both K and S, the maximum values for grain uptake, straw uptake and total uptake were observed in T_5 treatment. Notably, there was no statistical difference between treatment T_4 and T_5 for grain K-uptake as well as S-uptake by grain and straw. In case of all four nutrient elements (N, P, K and S), the lowest uptake was recorded in control treatments at both BAU farm and Farmer's field. The results of our study were partially accorded to those of several comparable studies of some researchers (Roy et al., 2018; Saha et al., 2014; Hossain et al., 2010) who observed increased uptake of N, P, K and S in rice due to application of poultry manure combined with inorganic fertilizers.

CONCLUSION

From the above results, it may be concluded that organic fertilizers – in form of poultry manure has a potential to increase the growth parameters, yield components, grain and straw yields and nutritional quality of rice. The use of Kazi Jaibo Shar as an organic fertilizer for rice also had positive effects on growth, yield as well as nutrient content and uptake by the crop. The performance of Kazi compost @ 3 t ha^{-1} is comparable with poultry manure of the same dose in association with chemical fertilizers, and the effect of each of these manures can compensate up to 25% reduction of recommended chemical fertilizers. Further long-term experimentation in different locations with different crop species is necessary to draw a valid conclusion on effectiveness of these manures.

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RESIDUAL EFFECTS OF DIFFERENT MANURES AND FERTILIZERS APPLIED TO PRECEDING POTATO CROP ON SUCCEEDING MUNG BEAN (*Vigna radiate* L.) CROP IN POTATO-MUNG BEAN-RICE CROPPING PATTERN

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ABSTRACT

The present study was done at Bangladesh Agricultural University farm to evaluate the field performances of different types of manures viz. cowdung (CD), cowdung slurry (CD slurry), trichocompost (TC), vermicompost (VC), poultry manure (PM) and poultry manure slurry (PM slurry) with chemical fertilizers in the potato-mungbean-T. aman rice cropping pattern during 2011-12 and 2012-13. The experiment was laid out in a randomized complete block design, with three replications and eight treatments including T_1 (Control), T_2 [HYG based 100% chemical fertilizer (CF)], T_3 [CD + CF (IPNS basis)], T_4 [CD slurry + CF (IPNS basis)], T_5 [PM + CF (IPNS basis)], T_6 [PM slurry + CF (IPNS basis)], T_7 [TC + CF (IPNS basis)] and T_8 [VC + CF (IPNS basis)]. Trichocompost + CF and vermicompost + CF containing treatments produced higher crop yield followed by poultry manure slurry and cowdung slurry. Integrated use of manures and fertilizers gave on an average 6.7-33.7%, 8.3-33.8% and 2.9-18.3% yield increase in potato, mungbean and T. aman rice, respectively over sole application of chemical fertilizers (data not shown). Use of IPNS improved nutrient content and uptake of mungbean. The present study thus indicates that use of manure, especially trichocompost, vermicompost, PM slurry and CD slurry integrated with chemical fertilizers would help increase crop yield and improve soil fertility. However, Trichocompost + CF was the best option in this regard.

Keywords: Cowdung, poultry manure, trichocompost, vermicompost, slurry, mungbean, crop yield, soil fertility

INTRODUCTION

Agriculture is the mainstay of economy in terms of contribution to GDP as well as improvement of livelihood of majority people in Bangladesh. Regular practicing of

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cereal-cereal cropping pattern on the same land over the years has increased soil fertility depletion and questions raised for its sustainability (Prasad, 2005). The rice-rice cropping pattern, therefore, causes a considerable depletion of soil nutrients threatening long-term productivity. Sustainable crop production in Bangladesh through improvement of cropping pattern in rice based cropping system is regarded as increasingly important in national issues such as food security, poverty alleviation, land degradation and pollution control (Rahman et al., 2018). Therefore, it is crucial to make efforts to find out alternative cropping patterns. Mungbean (*Vigna radiata* L.) is an important legume or pulse crop in Asia, which can be a major component in different cropping systems. Short lived leguminous mungbean plants can be grown in various cropping patterns because they have the ability to adapt environmental stresses like drought, low soil fertility etc (Bourgault et al., 2010) and the inclusion of a grain legume in the cropping pattern will supply substantial amount of biomass and N to soil and thus improve soil fertility and crop productivity on sustainable basis (Ali et al., 2012).

Over the last few decades, enormous pressure has been exerted on the land resources of Bangladesh to meet the demand of its vast population for food and fuel. Due to intensification of agricultural land, use of modern crop varieties, soil fertility has declined and deficiency of nutrient elements such as N, P, K, S, Zn and B has arisen (FRG, 2012). There is no doubt that chemical fertilizers are playing a vital role to meet the nutrient requirement of crops and thereby increase their production. However, recently the non-judicious use of chemical fertilizers is posing both economic and ecological problems, which are often difficult to face, particularly in developing countries (Sutton et al., 2011). The cost of chemical fertilizers is high but the organic manure is easily available and low cost. Therefore, smallholder farmers have shift their attention from chemical alone agriculture to integrated nutrient management strategy which utilizes both organic and inorganic nutrients forms (Singh et al., 2010). Since the nutrient turnover in soil-plant, system is considerably high in intensive farming; neither the chemical fertilizers nor the organic and biological sources alone can achieve sustainable productivity. Only organic sources cannot maintain and synchronize the nutrient supply demand to the growing plant due to lesser quantity of mineral nutrients or time needed for their mineralization to release nutrients for plant uptake. Organic matter acts as a reservoir of plant nutrients, chiefly N, P and S and it improves cation exchange capacity of soil (Brady and Weil, 2012) and therefore important for soil rejuvenation (Jeptoo et al., 2013). Integrated use of composted organic manures with chemical fertilizers could be more effective, economical and sustainable for both agriculture and environment.

In a cropping pattern, the preceding crops and the inputs such as fertilizers, manures, residues etc. applied therein, influence the responses of succeeding crops highly. The present study was therefore undertaken to assess the residual effects of organic manures applied to the first crop, nutrient status and economical status of succeeding mung bean in the potato-mung bean-rice cropping pattern. The present study was

initiated to assess the residual effect of different types of manure applied to proceeding potato crop on yield, nutrient uptake and economic benefits of succeeding crop of mung bean in the potato-mung-bean-rice cropping pattern. It was also found that growing a short duration mung bean after potato and incorporating of its residue in succeeding rice made potato-rice cropping pattern more productive, remunerative and recuperative soil than traditional potato-rice cropping pattern.

MATERIALS AND METHODS

Experimental site and soil characters of the location

The experiment was conducted at the Soil Science Field Laboratory of Bangladesh Agricultural University (BAU), Mymensingh, Bangladesh for two consecutive years, 2011-12 and 2012-13, respectively. The soil belongs to Sonatala series under the AEZ-9 (Old Brahmaputra Floodplain) (UNDP and FAO, 1988). The soil was silt loam in texture having pH 6.29, organic matter content 1.85%, total N 0.124%, available P 3.96 ppm, exchangeable K 0.11 me%, available S 11.9 ppm and CEC 12.5 me%.

Experimental design, treatments and crops

The experiment was laid out in a randomized complete block design, with three replications for first year cycle. The experiment consisted of eight treatments viz. T_1= Control (no manure or fertilizer), T_2 = 100% chemical fertilizer (CF), T_3 = CD + CF, T_4= CD slurry + CF, T_5= PM + CF, T_6= PM slurry + CF, T_7= TC + CF, T_8= VC + CF. The doses of N-P-K-S were 135-25-95-12 kg/ha for the first crop (potato). The residual effect of manures and fertilizers was evaluated on succeeding mung bean crop. Diamont was used as the variety every year in the experimental plots in the mid-November and harvested in the mid-February. After harvesting of potato, the seeds of mungbean (cv. Binamung 8) were sown on 24 March @ 30 kg ha^{-1} and harvested at the end of June.

Manures and fertilizers application

Poultry manure and PM slurry were applied @ 5 t ha^{-1} where as the rest of the manures (CD, CD slurry, TC and VC) were applied @ 3 t ha^{-1}. Potato received full quantities of urea, TSP, MoP and gypsum during land preparation while rotten cowdung, decomposed poultry manure and compost were applied 7 days before transplanting. The rates of ffertilizers for mung bean was calculated and rationalized considering residual effect of plant nutrient (except N) applied to previous crop (potato) (FRG, 2012). Manures were applied to the first crop (potato) and their residual effects were evaluated on the second crop (mung bean). This was repeated for the second year to complete two cropping cycles.

Intercultural operations

Intercultural operations such as weeding, thinning and irrigation were done as and when required.

Data collection

At maturity, the crop was harvested and the different data were recorded. Seed and grain yield was recorded on 14% moisture basis and stover yield at sundry basis.

Chemical analysis of plant and soil samples

The seed and stover samples were collected, dried and ground for analysis of N, P, K and S contents. The ground plant materials were stored in paperbags separately and placed in a desiccators. The total N, available P, exchangeable K and available S of plant samples were determined following semi-micro Kjeldahl method, modified Olsen method, NH_4OAc extraction method and $CaCl_2$ extraction method, respectively. After chemical analysis of seed and stover samples of mung bean, the nutrient uptake was calculated from the nutrient content and yield of the crop using the following formula:

$$TU = NC \times Y/100$$

where, TU = total nutrient uptake (kg ha^{-1}), NC =nutrient concentration (%), and Y = yield (kg ha^{-1})

Statistical analysis

Statistical analysis of the data was done by using computer based statistical program Mstat-C (Michigan State University, East Lansing, MI, USA) following the basic principles stated by Gomez and Gomez (1984). Significant effects of treatments were determined by analysis of variance (ANOVA) and Duncan's Multiple Range Test (DMRT) evaluated the mean comparisons of the treatments at 5% level of significance.

RESULTS AND DISCUSSION

Yield components

During both years of this experiment, all combination of manures significantly increased the yield components viz. number of pods $plant^{-1}$, seeds pod^{-1} over the control (Table 1). The number of pods $plant^{-1}$ varied from 11.1 to 21.3 in 2012 while it ranged from 10.9 to 17.5 in 2013. In both the years, the highest number of pods $plant^{-1}$ was recorded in T_7 treatment (TC + CF) and the lowest in control (T_1). In year 2012, the highest value of number of pods $plant^{-1}$ was statistically similar with T_5 (PM + CF), T_6 (PM slurry + CF) and T_8 (VC + CF) treatments and with T_3 (CD + CF), T_4 (CD slurry + CF), T_5 and T_8 in the year 2013. Generally, effect of manure containing treatments (T_3–T_8) had better performance on number of pods $plant^{-1}$ compared to exclusive fertilizer treatment (T_2). On the other hand, the number of seeds pod^{-1} ranged from 9.0 to 11.1 in 2012 and 9.2 to 12.2 in 2013. In both the years, T_7 produced the maximum number of seeds pod^{-1} while control produced the lowest. The highest number of pods $plant^{-1}$ was statistically identical with all the treatments except control in the first year and with T_4 and T_6 in the second year. This might be

due to the release of more nutrients from manures in the second year. Similar results were shown by Davari et al. (2012), Prajapati et al. (2016) and Meena et al. (2016).

Table 1. Integrated effects manure and fertilizers on pod number plant^{-1}, seed number pod^{-1} and 1000-seed weight of mungbean (Binamoog-8) in the potato – mungbean – T. aman rice cropping pattern

Treatments	Pods plant^{-1} (no.)		Seeds pod^{-1} (no.)		1000-seed weight (g)	
	2012	2013	2012	2013	2012	2013
T_1: Control	11.1d	10.9c	9.0b	9.2d	35.9b	39.7
T_2: 100%CF	18.4c	15.5b	10.3a	11.4c	37.9ab	39.7
T_3: CD + CF	18.2c	15.9ab	10.7a	11.6bc	38.1ab	39.9
T_4: CD slurry + CF	20.1b	16.4ab	10.8a	11.8ab	38.2ab	39.8
T_5: PM + CF	20.5ab	16.3ab	10.6a	11.6bc	38.2ab	39.7
T_6: PM slurry + CF	20.8ab	15.6b	10.9a	11.8ab	39.9a	39.7
T_7: TC + CF	21.3a	17.5a	11.1a	12.2a	40.1a	39.7
T_8: VC + CF	21.3a	16.1ab	10.7a	11.6bc	39.9a	40.1
CV (%)	3.30	9.01	5.76	2.75	3.28	1.10
Level of significance	**	**	*	**	*	NS
SE (±)	0.361	0.5709	0.350	0.1277	0.730	0.178

Means followed by same letter in a column are not significantly different at 5 % level by DMRT. SE (±) = Standard error of means, CV = Coefficient of variation, ** = Significant at 1% level, * = Significant at 5% level NS= Not significant, HYG = High Yield Goal, CF = Chemical Fertilizer, IPNS = Integrated Plant Nutrition System, CD = Cowdung, CD slurry = Cowdung slurry, PM = Poultry manure, PM slurry = Poultry manure slurry, TC =Trichocompost, VC = Vermicompost

Like other parameters, the 1000-seed weight of mung bean was significantly influenced by the different treatments especially in the first year showing a range of 35.9 – 40.1 g (Table 1). The T_7 treatment (TC + CF) showed the highest 1000-seed weight (40.1g) which however was statistically similar with all other treatments except control. Unlike first year result, the 1000-seed weight remained statistically similar for all the treatments indicating no residual effect of IPNS or lone fertilizer treatments. In value, the 1000-seed weight varied from 39.7-40.1 g due to different treatments. The findings are in corroboration with Reddy and Reddy (2005) who reported that growth and yield attributes of radish were significantly affected due to the residual effect of vermicompost in onion-radish cropping system.

Seed and stover yields

Application of different manures with chemical fertilizers had significant residual effect on the seed yield as well as stover yield of mungbean (Table 2). Depending on

the treatments, the seed yield ranged from 0.54 to 1.54 t ha^{-1} in 2012 and 0.67 – 1.69 t ha^{-1} in 2013. In both the years, the highest seed yield was obtained from T_7 treatment (TC + CF) and the highest yield was superior to all other treatments in 2012 and identical with T_6 and T_8 treatments in 2013. The lowest seed yield was recorded with control treatment in both years. In the year 2012, treatments T_4 (CD slurry + CF), T_6 (PM slurry + CF) and T_8 (VC + CF) were statistically similar followed by T_5 treatment (poultry manure + CF). In 2013, generally next to T_7, all other IPNS treatments (T_3-T_6 & T_8) had similar effect and they all were superior to exclusive fertilizer treatment (T_2). On the other hand, the stover yield ranged from 1.41 – 3.64 t ha^{-1} in the first year and 1.76-3.86 t ha^{-1} in the second year (Table 2). In year-1, treatments T_5 – T_8 had similar effect and in year-2, T_3-T_8 had similar effect on the stover yield. These results are in fully similar with the findings of Suthamathy and Seran (2013) who found that application of EM (effective microorganisms) bokashi can provide significant amount of residual nutrients for cultivation of a short durational succeeding crop and the residual benefits depend on the initial nutrient of manure.

Such result indicates that IPNS treatments had mostly similar effect showing that all manures viz. cowdung, poultry manure, trichocompost and vermicompost reasonably had an equal manure value. Every IPNS treatment was generally better than 100% fertilizer treatment (T_2). The lowest stover yield was noted in the control (T_1). It appeared that yield performance of compost (vermicompost and trichocompost) was better than that of cowdung and poultry manure. Again, slurry effect was found better than original cowdung or poultry manure effect. Compared to 100% fertilizer, the addition of manure and fertilizer resulted in a 7-28% increase in seed yield, as observed in the first year. The results with those of Umunna and Anselem (2014), Singh et al. (2014) and Suryantini (2016). Apart from enhancing crop yield, the practice of IPNS has a greater beneficial residual effect than the sole use of mineral fertilizer or organic materials (Demelash et al., 2014). For example, integrated use of inorganic fertilizers and vermicompost in broccoli crop significantly influenced the succeeding cowpea growth, yield and soil fertility (Ranjit, 2014). Vermicompost and trichocompost are good sources of nutrient elements namely N, P, K and S and they contain a large beneficial microbial population and biologically active metabolites which on application alone or in combination with organic or inorganic fertilizers, can give better yield and quality of crops (Rahman 2009; Arancon and Edwards, 2011).

Table 2. Integrated effects of manure and fertilizers on seed and stover yields of mungbean (Binamung-8) in the potato- mungbean – T. aman rice cropping pattern

Treatments	Seed yield (t ha^{-1})		Stover yield (t ha^{-1})	
	2012	2013	2012	2013
T_1: Control	0.54f	0.67d	1.41c	1.76c
T_2: 100%CF	1.05e	1.38c	2.87b	3.61b
T_3: CD + CF	1.16d	1.46bc	2.77b	3.67ab
T_4: CD slurry + CF	1.26bc	1.52b	2.91b	3.74ab
T_5: PM + CF	1.21 cd	1.55b	3.32a	3.66ab
T_6: PM slurry + CF	1.27bc	1.59ab	3.52a	3.80ab
T_7: TC + CF	1.54a	1.69a	3.49a	3.86a
T_8: VC + CF	1.34b	1.56ab	3.64a	3.78ab
CV (%)	4.03	7. 24	6.05	4.91
Level of significance	**	**	**	**
SE (±)	0.0272	0.0421	0.1044	0.0699

Means followed by same letter in a column are not significantly different at 5 % level by DMRT .SE (±) = Standard error of means, CV = Coefficient of variation, ** = Significant at 1% level, HYG = High Yield Goal, CF = Chemical Fertilizer, IPNS = Integrated Plant Nutrition System, CD = Cowdung, CD slurry = Cowdung slurry, PM = Poultry manure, PM slurry = Poultry manure slurry, TC =Trichocompost, VC = Vermicompost

Nutrient concentration

In both the year, the treatments with organic manures significantly increased the contents of nutrients viz. N, K, P and S (except seed S) in mung bean seed and stover compared to control (Table 3 and Table 4). Among all the organic manures, trichocompost showed the highest N concents in seed and stover for both years. For seed N contents, all the treatments were statistically identical except control in 2012 while T_3, T_4, T_7 and T_8 had no difference in 2013. In 2012, TC + CF produced the highest K concentration in seed which was not statistically similar with other treatments in 2012 wheareas in 2013, PM + CF produced the highest seed K which was at per with other treatments except control. The highest stover K in 2012 and 2013 in were observed in CD + CF and TC + CF, respectively. The minimum N and K contents in both seed and stover in both years were noted in control.

Table 3. Effects of different types of manure integrated with fertilizers on the N content (%) and K content (%) of mungbean (seed and stover) in the potato-mungbean- T. aman rice cropping pattern

Treatments	% N content				% K content			
	Seed		Stover		Seed		Stover	
	2012	2013	2012	2013	2012	2013	2012	2013
T_1: Control	3.36b	3.45c	1.22c	0.099d	1.206d	1.414b	1.317c	1.681c
T_2: 100%CF	3.59a	3.54bc	1.31b	1.32c	1.219d	1.609a	1.505ab	1.931ab
T_3: CD + CF	3.56a	3.68ab	1.27bc	1.31c	1.269cd	1.636a	1.550a	1.891b
T_4: CD slurry + CF	3.60a	3.66ab	1.32b	1.52ab	1.295c	1.621a	1.536a	1.872b
T_5: PM + CF	3.58a	3.56bc	1.27bc	1.52ab	1.323bc	1.650a	1.519ab	1.917ab
T_6: PM slurry + CF	3.64a	3.62b	1.46a	1.45b	1.290c	1.601a	1.537a	1.884b
T_7: TC + CF	3.66a	3.77a	1.49a	1.55a	1.452a	1.647a	1.541a	1.991a
T_8: VC + CF	3.52a	3.63ab	1.27b	1.46ab	1.373b	1.611a	1.475b	1.946ab
CV (%)	2.36	3.31	2.71	5.01	2.85	3.34	2.03	3.80
Level of significance	*	**	**	**	**	**	**	**
SE (±)	0.0486	0.0488	0.0207	0.0284	0.0214	0.0218	0.0176	0.029

Means followed by the same letter in a column are not significantly different at 5 % level by DMRT

SE (±) =Standard error of means, CV= Coefficient of variation, **= Significant at 1% level, * = Significant at 5% level, , HYG = High Yield Goal, CF = Chemical Fertilizer, IPNS = Integrated Plant Nutrition System, CD = Cowdung, CD slurry = Cowdung slurry, PM = Poultry manure, PM slurry = Poultry manure slurry, TC =Trichocompost, VC = Vermicompost

In 2012, the maximum P content in seed and stover were observed in T_6 while in 2013, the maximum P content in seed and stover were observed in T_7. In general, for P content in seed and stover in both years, there was no significant difference among the treatments T_5, T_6, T_7, and T_8. In case of mungbean seed S concentration, all the treatments were statistically similar. Interestingly, T_8 and T_7 produced the highest stover S content in 2012 and 2013, respectively and they were statistically identical. The results of the present study are in agreement with those of Sarwar et al. (2009) and Namazi et al. (2015).

Table 4. Effects of different types of manure integrated with fertilizers on the P content (%) and S content (%) of mungbean (seed & stover) in the potato-mungbean- T. aman rice cropping pattern

Treatments	Phosphorus				Sulphur			
	Seed		Stover		Seed		Stover	
	2012	2013	2012	2013	2012	2013	2012	2013
T_1: Control	0.303d	0.368c	0.130e	0.090d	0.121	0.137	0.136d	0.135d
T_2: 100%CF	0.395abc	0.454b	0.175bc	0.141c	0.136	0.151	0.155bc	0.153c
T_3: CD + CF	0.363c	0.476ab	0.134de	0.146c	0.135	0.147	0.166ab	0.152c
T_4: CD slurry + CF	0.377bc	0.475ab	0.163cd	0.172b	0.142	0.154	0.156bc	0.158c
T_5: PM + CF	0.418ab	0.483a	0.178bc	0.208a	0.134	0.137	0.145cd	0.173b
T_6: PM slurry + CF	0.426a	0.490a	0.225a	0.219a	0.143	0.151	0.168ab	0.175b
T_7: TC + CF	0.416ab	0.492a	0.204ab	0.222a	0.139	0.146	0.181a	0.187a
T_8: VC + CF	0.413ab	0.482a	0.207ab	0.188b	0.135	0.144	0.183a	0.178ab
CV (%)	6.26	4.63	9.95	8.67	8.70	9.41	6.26	5.18
Level of significance	**	**	**	**	NS	NS	**	**
SE (±)	0.0141	0.0088	0.0102	0.0061	0.6812	0.0079	0.0058	0.0069

Means followed by the same letter in a column are not significantly different at 5 % level by DMRT

SE (±) =Standard error of means, CV= Coefficient of variation, **= Significant at 1%level, NS= Not significant, HYG = High Yield Goal, CF = Chemical Fertilizer, IPNS = Integrated Plant Nutrition System, CD = Cowdung, CD slurry = Cowdung slurry, PM = Poultry manure, PM slurry = Poultry manure slurry, TC =Trichocompost, VC = Vermicompost

Nutrient uptake

The treatments had significant residual effect on the uptake of N, P, K and S by mung bean. The total N uptake (seed N uptake + stover N uptake) by mung bean in 2012 varied from 35.42 to 108.4 kg ha^{-1} in 2012 and ranged from 40.5 – 123.6 kg ha^{-1} in 2013 (Table 5). In both years, T_7 treatment (trichocompost + chemical fertilizers) clearly showed its superiority over all other treatments. Next to T_7, the T_8 (vermicompost + fertilizers) and T_6 (poultry manure + fertilizers) treatments resulted in higher N uptake, with a record of 94.6 and 111.8 kg ha^{-1} for T_8 and 98.13 and 112.4 kg ha^{-1} for T_6 treatments in two years, respectively. Residual effect of slurry was found better than that of original manure. Again, the effect of 100% fertilizer and IPNS with cowdung was similar.

The K uptake showed a range of 25.08 – 73.75 kg ha^{-1} in 2012 and 39.09 – 104.6 kg ha^{-1} in 2013 (Table 5), with the highest K uptake recorded by T_7 and the lowest K

uptake noted with T_1 (control). After T_7, treatments T_8 and T_6 had higher K uptake, the values being 72.98 and 70.93 kg ha^{-1}, respectively for the first year and the corresponding values being 98.68 and 96.87 kg ha^{-1} for the second year. Treatments T_2 (exclusively fertilizer treatment) and T_3 (cowdung + fertilizer on IPNS basis) exhibited similar K uptake.

Table 5. Integrated effects of manure and fertilizers on N, K, P and S uptake by mungbean (seed + stover) in the potato- mungbean – T. aman rice cropping pattern

Treatments	N uptake (kg ha^{-1})		K uptake (kg ha^{-1})		P uptake (kg ha^{-1})		S uptake (kg ha^{-1})	
	2012	2013	2012	2013	2012	2013	2012	2013
T_1: Control	35.42 e	40.50 d	25.08 e	39.09 d	3.47 e	4.02 f	2.58 c	3.30 e
T_2: 100%CF	75.14 d	96.21 c	55.89 d	91.81c	9.16 c	11.32 e	5.86 b	7.59 d
T_3: CD + CF	74.92 d	101i.9 c	57.02 d	93.30 c	7.893 d	12.30 e	6.15 b	7.71 d
T_4: CD slurry + CF	83.70 c	112.3 b	60.76 cd	94.62 bc	9.497 c	13.64 d	6.35 b	8.22 d
T_5: PM + CF	86.09 c	110.71 b	66.15 bc	95.63 bc	11.01 b	15.11 bc	6.44 b	8.45 bc
T_6: PM slurry + CF	98.13b	112.4 b	70.93 ab	96.87 bc	13.35 a	16.07 ab	7.72 a	9.07 b
T_7: TC + CF	108.4 a	123.6 a	73.75 a	104.6 a	13.53 a	16.89 a	8.46 a	9.68 a
T_8: VC + CF	94.60 b	111.8b	72.98 a	98.68 b	12.99 a	14.63 cd	8.45 a	8.99 ab
CV (%)	4.45	4.92	5.18	4.36	6.99	6.74	8.41	7.04
Level of significance	**	**	**	**	**	**	**	**
SE (±)	2.109	2.034	1.805	1.591	0.408	0.357	0.316	0.393

Means followed by same letter in a column are not significantly different at 5 % level by DMRT.

SE (±) = Standard error of means, CV = Coefficient of variation, ** = Significant at 1% level, HYG = High Yield Goal, CF = Chemical Fertilizer, IPNS = Integrated Plant Nutrition System, CD = Cowdung, CD slurry = Cowdung slurry, PM = Poultry manure, PM slurry = Poultry manure slurry, TC =Trichocompost, VC = Vermicompost

The P uptake by mung bean was markedly influenced by the residual effect of organic manure and fertilizer treatments (Table 5). Total P uptake (seed + stover) by mung bean varied from 3.47 to 13.53 kg ha^{-1} in 2012 and from 4.02 to 16.89 kg ha^{-1} in 2013. Like N and K uptake, T_7 recorded the highest P uptake and the control treatment (T_1) did the lowest. Next to trichocompost containing treatment, poultry manure slurry comprising fertilizer treatment demonstrated the highest P uptake. Overall result indicates that the residual effect of IPNS treatments was better than that of lone fertilizer (T_2) treatment. Like N, K and P uptake, the S uptake by mung bean markedly varied due to residual effects of the IPNS treatments (Table 5). The maximum S uptake was due to use of T_7 (trichocompost plus chemical fertilizers)

treatment and the minimum S uptake due to T_1 (no manure or fertilizer) treatment. Treatment T_7 did not differ significantly from T_6 and T_8 for the first year and from T_8 only for the second year. The treatments with 100% fertilizer and IPNS basis cowdung and cowdung slurry containing treatments had alike S uptake by the crop. It was further observed that slurry effect was better than that of original manure used for the first crop (potato). Rafique et al., 2012 and Kumar et al 2015 also found increased nutrient uptake in mung bean by combined use of organic and inorganic fertilizers.

CONCLUSIONS

The present study suggests that the use of IPNS on potato-mung bean-rice cropping pattern had significant positive residual effects on yield parameters of mung bean such as number of pods plant^{-1}, and number of seeds pod^{-1} and improved seed and stover yield of mung bean. This study also suggests that application of IPNS can increase N, P, K and S content as well as uptake by mung bean. Therefore, application of vermicompost or Trichocompost in combination with inorganic fertilizers can be recommended for better yield and nutritional quality in mung bean.

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DRYING KINETICS AND SORPTION BEHAVIOR OF TWO VARIETIES BANANA (*SAGOR AND SABRI*) OF BANGLADESH

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ABSTRACT

The study was concerned with determining the drying kinetics and sorption behavior of two varieties ripe banana of Bangladesh namely, *Sagor and Sabri*. The fresh ripe banana collected from the local market were sliced into three different thicknesses (4 mm, 6 mm and 8 mm) and dried at 45°C, 55°C and 65°C in a cabinet dryer. The result showed that the drying rate increases with the increase in temperature and decreases with the increase in slice thickness. The sorption properties of dried banana were studied over a wide range of water activity (0.11-0.93). The BET and GAB models were fitted to the sorption data. It was found that both varieties gave sigmoid (type II) shape isotherm and GAB equation gave the much higher value of monolayer moisture content compared to BET equation. The chemical compositions of fresh and dried banana were determined. The dried products gave substantially higher solid content as well as protein, ash and carbohydrate.

Keywords: Drying rate, Sagor, Sabri, temperature, thickness, moisture sorption.

INTRODUCTION

Banana (*Musa sapientum*L.*)* is an important fruit crop in Bangladesh. It belongs to the family Musacaceae. There are only two genera, *viz. Enste* and *Musa* with about 50 species in this family (Azam et al.,2010). *Sagor* (*AAA genome*) and *Sabri* (*AAB genome*) is the most popular dessert banana and widely grown in the north and western areas in Bangladesh (Islam and Hoque, 2004). Bangladesh ranks 14th among the top 20 banana producing countries in the world and this country are producing nearly 1.00 million tons of bananas annually (Hossain, 2014). Banana represents 20% of all fruit crops and only fruit available year round in Bangladesh (BBS, 2014).

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Sagor and Sabri are most cultivated variety in Bangladesh and accounts for 30.8% and 21.2% of total banana production (Fonsa et al., 2017). Banana is rich in carbohydrate and also contains appreciable amount of fiber, polyphenols, antioxidants, vitamins and minerals such as K, P, Ca and Fe (Zotarelli et al.,2012; Silva et al.,2014). Due to high moisture content, banana is very susceptible to deterioration (Monteiro et al.,2016) and at room temperature (20℃) it cannot be preserved more than 7 days from the ripening initiation (Islam et al.,2012). Drying of ripe banana is an interesting alternative to reduce losses and to improve food commercial value which makes this process, a potential agribusiness (Aurore et al., 2009). The ripe banana powder can be used as an ingredient in the low calorific bread, biscuit and spaghetti production (Silva et al.,2014) as well an active ingredient of antimicrobial film production (Orsuwan et al.,2016).

Historically conventional hot air drying has been the most common fruits and vegetable drying technique which requires less area and no weather dependence. Though hot air dehydration is a good technique for faster reduction of moisture, the dehydration kinetics greatly depends on air properties (temperature, humidity, velocity etc.) and the properties of material to be dried (Babalis and Belessiotis, 2004). Controlling of moisture content in dried foods during processing and storage is very important because water has many roles in biochemical reactions and quality of foods.From several researches it has been proven that the knowledge of sorption isotherm is extremely important in food dehydration, especially to determine end product of drying it achieve shelf-stable dehydrated foods (Cardoso and Pena, 2014). A number of equations have been published by various researchers to describe the water sorption isotherms of dried products. BET (Brunauer–Emmett–Teller) and GAB (Guggenheim–Andersen–de Boer) equations are generally applied for the most food products (Rodríguezn et al., 2007). Published research has shown that, the monolayer value of GAB model is always higher than the BET monolayer value (Timmermann, 2003) whereas GAB found asthe bestmodel among of all models due to its applicability to a wide range of water activity (Zouet al.,2016)

Therefore, the goal of this work was the study of the influence of slice thickness and temperature in drying kinetics of bananas in a mechanical dryer, as well as knowing the proximate composition of fresh samples before drying. Sorption behavior of dried bananas was also studied as well as prediction of moisture adsorption by BET and GAB models.

MATERIALS AND METHOD

Samples and Equipment

Fresh bananas of *Sagor* (*Musa sapientum, AAA genome*) and *Sabri*(*Musa sapientum, AAB genome*) were purchased from the local market (Mymensingh, Bangladesh). Fruit selection was done by visual inspection where initially ripened bananas were used for proximate composition analysis and drying. Cabinet dryer (Model OV-165,

Size-three, Gallen Kamp Company) was used for the dehydration of banana slices. The dryer has a heater installation where the air blows by a fan over the trays containing the samples to be dried. The velocity of air was recorded (0.6 m/sec) by an Anemometer, which was maintained throughout the drying period.

Proximate Composition Analysis

Fresh ripe banana of two varieties (*Sagor and Sabri*) were analyzed for moisture, carbohydrate, protein, fat and ash content as per the methods of AOAC (2016) and Ranganna (1992). All the trial were done in triplicate and the results were taken as the average value

Mechanical drying

Fresh *Sagor* and *Sabri* banana were sliced at 4 mm, 6 mm and 8 mm by potato slicer and placed in numbered trays of dryer. For observation of thickness and temperature effect on drying rate, banana slices were dried at three different temperatures (45°C, 55°C and 65°C) at constant air velocity (0.6 m sec^{-1}). The initial moisture content of all samples was determined previously. The mass change of samples during drying over specific time interval was recorded to calculate moisture ratio that needed to calculate the drying rate.

Fick's second law of diffusion is commonly applied for describing mass transfer during drying (Islam et al., 2012; Jena and Das, 2007). The expression is as follows-

$$\frac{\delta \mathbf{M}}{\delta \mathbf{T}} = \Delta^2 \mathbf{D_e} \mathrm{M} \quad \ldots\ldots (1)$$

Where M is the moisture content (dry basis), T is the time(s), De is the effective diffusion co-efficient ((m^2 s^{-1}) and Δ is the mass transfer gradient.

To solve above unsteady state diffusion equation negligible external mass transfer resistance, negligible temperature gradient within the sample being dried and a constant diffusion co-efficient at any constant temperature is assumed. For drying from one major face, equation (1) was suggested by several researchers (Al-Muhtaseb et al., 2010; Roberts et al., 2008) as follows

$$MR = \frac{M_t - M_e}{M_0 - M_e} = \frac{8}{\pi^2} \sum_{n=o}^{\infty} \frac{1}{(2n+1)^2} Exp.\left[\frac{-(2n+1)^2 \pi^2 D_e t}{L^2}\right] \ldots\ldots (2)$$

Where, M_o is the initial moisture content (d.b), M_e is the equilibrium moisture content (d.b), M_t is the moisture content (d.b) at time, t and n is the order of equation.

For low M_e values and for moisture ratio < 0.6 equation (2) is reduces to:

$$MR = \frac{M_t}{M_0} = \frac{8}{\pi^2} e^{-\pi^2 D_e t / L^2} = \frac{8}{\pi^2} e^{-mt} \ldots\ldots (3)$$

Rearranging equation (3) gives:

$$\ln\frac{M_t}{M_0} = \ln\frac{8}{\pi^2} - mt \quad \text{.....(4)}$$

Where,

$$m = \frac{\pi^2 D_e}{L^2} = \text{Drying rate constant, sec}^{-1}$$

Drying rate constant (m) was obtained as the slope of line by plotting moisture ratio (MR) against time (t). Effective diffusion coefficient (De) was calculated by using drying rate constant (m) and slab thickness (L).

The temperature dependence of diffusion coefficient can be calculated using the Arrhenius equation (Aghbashlo et al., 2009; Mghazlia et al., 2017) as follows

$$\ln D_e = lnD_0 - \frac{E_a}{R(T_{abs})2} \text{.....(5)}$$

Where, D_o is the Arrhenius equation constant, E_a is the activation energy of the diffusion of water vapor (Kcal g^{-1}-mol), R is the universal gas constant (1.987 Kcal g^{-1}. mole °K.) and T_{abs} is the absolute temperature (°K) of the drying air. The activation energy of diffusion was calculated from the slope of the plot of $1nD_e$ against inverse absolute temperature ($1/ T_{abs)}$ on linier co-ordinates. The rate constant from Fick's model (Equation 4), and the activation energy from Arrhenius model (Equation 5) were estimated by the linear regression procedure of Excel 2007.

Analysis of sorption behavior

The moisture sorption properties of dried bananas were determined at room (25°C) temperature under conditions of various relative humidity (11-93% R.H) in the vacuum desiccators. The various RH conditions were achieved in vacuum desiccators using saturated salt solutions (ASTM E104-02). The method involved putting accurately weighed 3 gm dried and crushed sample in a previously weighed Petridish into desiccators contained saturated salt solutions. An external pump was used to evacuate the desiccators less than 50 torr. After placing into desiccators, the sample weight was taken continuously until it reached to a constant weight. All the trials were done in triplicate and the results were taken as average value.

The monolayer moisture content for the moisture adsorption process was determined using the BET and GAB linear model, shown in table 1, by linear regression using the Microsoft Office Excel 2007 software. The coefficient of determination (R^2) were used to compare the goodness of fit of both modes.

Table 1. Models used to fit the sorption isotherms of banana flours

Sorption model	Mathematical equation	Description
BET	$\frac{a_w}{(1-a_w)m} = \frac{1}{m_0 C} + \frac{C-1}{m_0 C} a_w$(linear form)	Here m is the moisture content (g/100g dry matter), a_w is the water activity.
GAB	$m = \frac{m_0 . C . k . a_w}{[(1-k.a_w).\ (1+(C-1).k.a_w)]}$ or, $\frac{a_w}{w} = \alpha a_w^2 + \beta a_w + \gamma$ (polynomial form)	*Parameters to be estimated by fitting*:m_0.(monolayer moisture) and C and K (model constants)

RESULT AND DISCUSSION

Proximate composition of dried bananas

Dried *Sagor* and *Sabri* banana slices were grinded to flour and analyzed for proximate analysis. The Proximate composition of banana flours of the two varieties is presented in Table 2.

Table 2. Proximate compositions of dried *Sagor* and *Sabri* variety

Components	Sagor variety	Sabri variety
Moisture content (%d.b)	17.65± 0.19[a]	17.77± 0.22[b]
Protein (N×5.85) (%)	3.26± 0.10[a]	3.40± 0.08[b]
Fat (%)	0.06± 0.07[a]	0.07± 0.04[b]
Ash (%)	1.66± 0.10[a]	4.57± 0.09[b]
*Carbohydrate (%)	95.04	91.96

d.b: dry basis , N: Nitrogen content The values are mean ± S.D of three independent determinations. The means with different superscripts in same row differ significantly ($p \leq 0.05$).* Calculated value.

It was observed that dried *Sagor* variety gave slight lower moisture content (17.65% d.b) than *Sabri* variety (17.77% d.b) while carbohydrate content of *Sagor* variety is quite higher than that of *Sabri* variety (95.04% vs. 91.96%. In contrast to carbohydrate content, *Sabri* variety gave slight higher protein content (3.40% vs. 3.26%), fat content (0.07% vs. 0.06%) but more than double ash content (4.57% vs 1.66%) compare to *Sagor* variety. Lower amount of fat content may be due to oxidation during drying while higher ash content may vary with stage of ripening.

Some researchers investigated starch and sugar content separately which both are carbohydrates. Cardoso and Pena (2014) reported 70.07% starch, 3.16% ash, 4.89% protein and 1.63% fat in dried banana powder. Starch (in terms of carbohydrate) content reduces and sugar content increases with the progress of ripening of banana (Cardoso and Pena, 2014). Menezes et al. (2011)found 3.14% ash, 0.89% fat, 3.60% protein, 76.77% starch and 1.81% reducing sugars where Mota et al. (2000) reported 0.82% lipid and 2.6% protein for *Sagor* (*Musa spp. AAA*) variety.

Drying characteristics of banana slices

Thickness dependence of drying rate constant and drying time

To observe the influence of thickness on drying rate constant, 4mm, 6mm, 8mm thick banana slices were dried in a mechanical dryer at constant dry bulb temperature of 65ºC. The results were analyzed using equation (4) and the moisture ratio (MR) versus drying time (t, in hour) was plotted on a semi-log co-ordinate and obtained following equations and figures (1 & 2). For all curves co-efficient of determination (R^2) was more than 0.96 that indicates very well linear fit of data.

For sagor variety

MR = 0.8771 $e^{-0.298t}$(for 4 mm slices)

MR = 0.9366 $e^{-0.221t}$ (for 6 mm slices)

MR= 1.0018$e^{-0.153t}$ (for 8mm slices)

For sabri variety

MR = 0.8917 $e^{-0.33t}$ (for 4 mm slices)

MR = 0.9199 $e^{-0.249t}$ (for 6 mm slices)

MR= 1.0172 $e^{-0.185t}$ (for 8mm slices)

Obtained equation implies that drying rate constant decreasing with increasing slice thickness.

From Fig. 1 & 2 it was observed that thickness had profound influence on drying time. When thickness of the sample at a constant temperature increased, the drying time to a specific moisture ratio also increased with resultant decrease in drying rate constant. It was also noticeable that for a self-stable moisture ratio (MR = 0.7) 4 mm thick slice required the least time (2.00 hr) followed by 6 mm thick slice (3.1 hr), while the highest time (4.9 hr) was required to dry 8 mm thick slice of sagor sample at 65ºC. But, in case of sabri this values were found 1.9 hr, 2.9 hr and 4.7 hr respectively. It has been reported by several researches similar influence of slice thickness on drying rate constant. Ertekin(2004) and Islam (2012) also reported that drying rate constant decreases with increase of slice thickness.

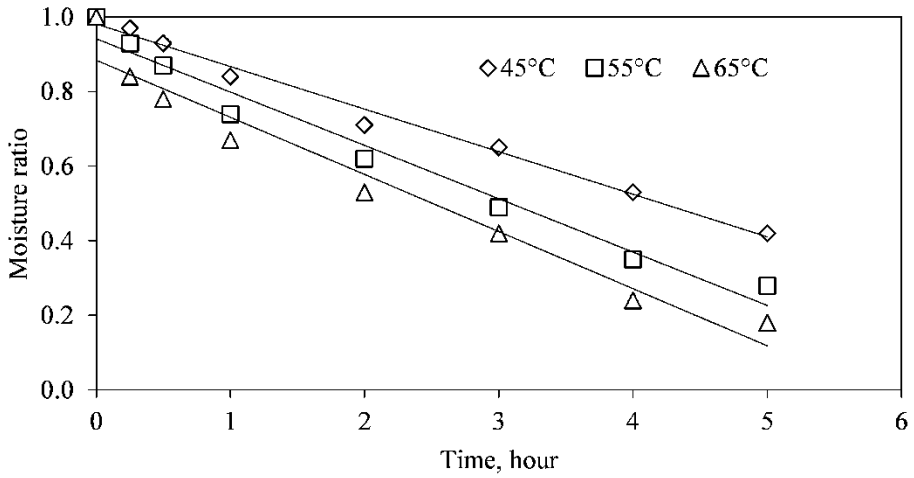

Figure 1. Influence of thickness on drying rate of banana (*Sago*r) at 65ºC in a mechanical dryer

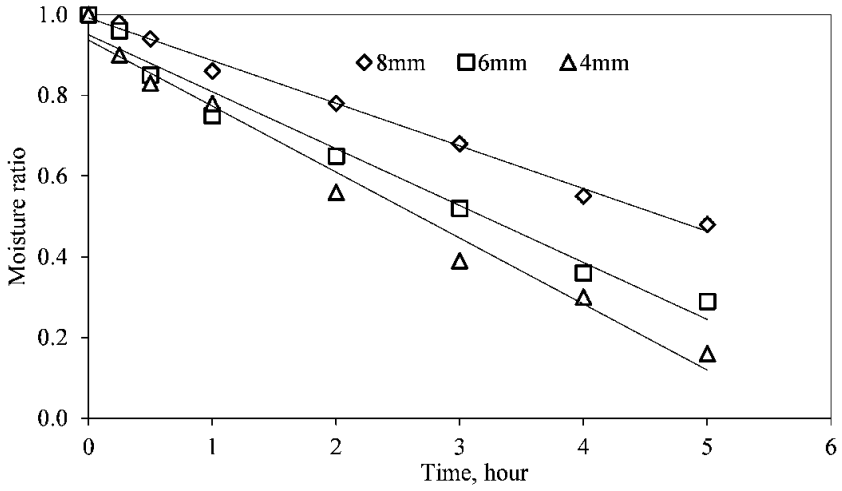

Figure 2. Influence of thickness on drying rate of banana (*Sabri*) at 65ºC in a mechanical dryer

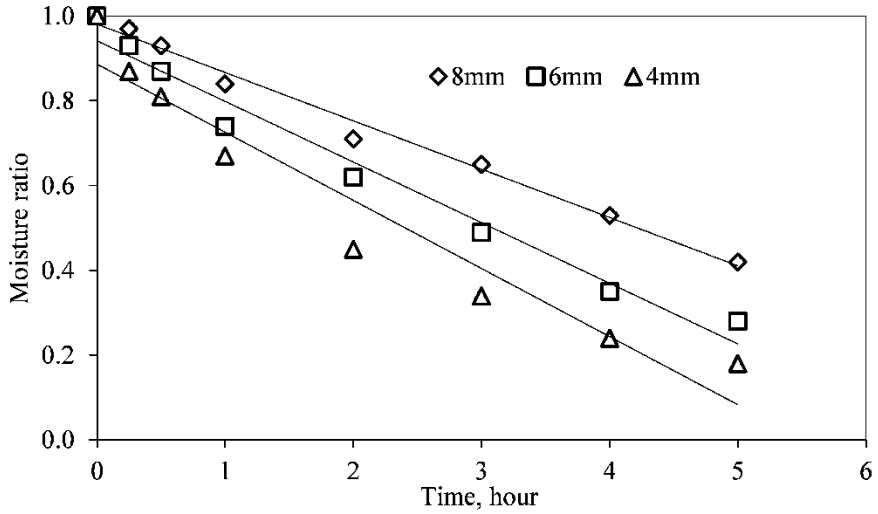

Figure 3. Influence of temperature on drying rate for 4 mm thick slice of *Sagor* variety

Effects of temperature on drying rate

To analyze the effect of temperature on drying rate, banana 4 mm slices were dried in a cabinet dryer at three different air-dry bulb temperatures (45ºC, 55ºC, 65ºC). The MR values were plotted against drying time (t) on semi-log coordinates those are shown in Fig. 3 & 4. Drying rate constants were calculated as per equation (4) and diffusion co-efficient of different banana slices were calculated from the rate constant and slice thickness. The activation energy as the parameter of temperature influence on drying kinetics was calculates as per equation (5) and given in table 3.

Table 3. Diffusion co-efficient and activation energy of 4mm thick banana slices under different drying conditions

Thickness (cm)	Variety	Temperature, ºC	Rate constant, cm(sec $^{-1}$)	Diffusion co-efficient (cm^2 sec^{-1})	Activation Energy, Ea (Kcal/g.mol)
0.4	*Sagor*	45ºC	5.64×10^{-5}	9.14×10^{-7}	3.65
		55ºC	7.00×10^{-5}	1.13×10^{-6}	
		65ºC	8.27×10^{-5}	1.32×10^{-6}	
	Sabri	45ºC	6.74×10^{-5}	1.09×10^{-6}	3.11
		55ºC	8.36×10^{-5}	1.36×10^{-6}	
		65ºC	9.17×10^{-5}	1.49×10^{-6}	

Fig.3 and Fig 4 and table 3 imply that when temperature increased, gradient or slope of the line also increased with respect to period of drying.This can be explained also by diffusion co-efficient. Table 3 shows that diffusion co-efficient increases with increase of time for a specific slice thickness. It implies that at specific moisture ratio (MR) drying rate increases with increasing temperature. At the very high temperature and low humidity, drying rate may initially increase, but as drying progresses resultant case hardening, that would reduce drying rate drastically and deteriorate the quality of the product. Thus selection of optimum temperature for drying is very significant during drying particularly mechanical drying with counter current operation (Islam,1980).

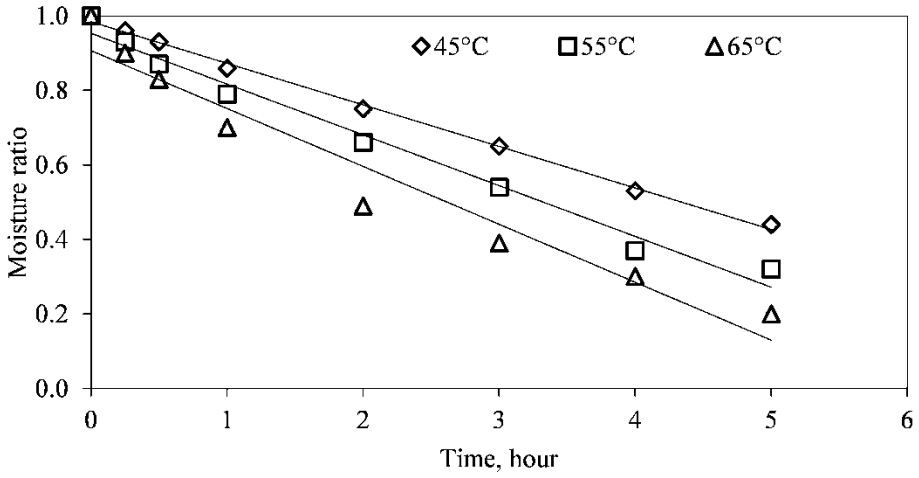

Figure 4. Influence of temperature on drying rate for 4 mm thick slice of *Sabri* variety

The amount of activation energy indicated the temperature sensitivity and energy needed to initiate moisture diffusion within the slice. It was observed that activation energy for 4mm thick *sagor* variety (3.65 Kcal g^{-1} mol) is higher than 4mm thick slice of *sabri* variety (3.65 Kcal g^{-1} mol). The difference in activation energy may be due to difference in their cellular structure and chemical composition (Islam, 1980). However our calculated activation energy is within the general range of 1.53- 12.23 Kcal mol^{-1}reported by Zogzas et al.(1996) and nearer to mango powder (3.48 Kcal mol^{-1})reported by Kabiru et al.(2013) and grape seed (3.66 Kcal g^{-1} mol),reported by Roberts et al.(2008).

Sorption behavior of dried bananas

The adsorption isotherms for dried *Sagor* and *Sabri* varieties at 25 °C are shown in Figure 5. The sorption behavior of bananas can be adequately represented by a sigmoid shape, characteristic of a type II isotherm. According to the classification of BET (Brunauer et al., 1938), most products exhibit an S- shaped isotherm.

Figure 5 shows, there is a little moisture absorption tendency at water activity below 0.75 and the sample absorbed higher amount of moisture at water activity above 0.75. At the water activity of 0.93, samples absorbed highest moisture. The exponential behavior of moisture absorption of both flours indicates the flour would be required improved storage condition mainly control humid environment. The lower portion of the isotherms indicates microbial stability at lower humid condition especially below 0.6. In sorption analysis it was observed that though initial moisture content was quite nearer both varieties followed almost same trend of moisture absorption during entire period. These results were also compared with those obtained by different authors (Cardoso and Pena, 2014; Silva et al., 2014) and a good agreement, with some differences were found between them.

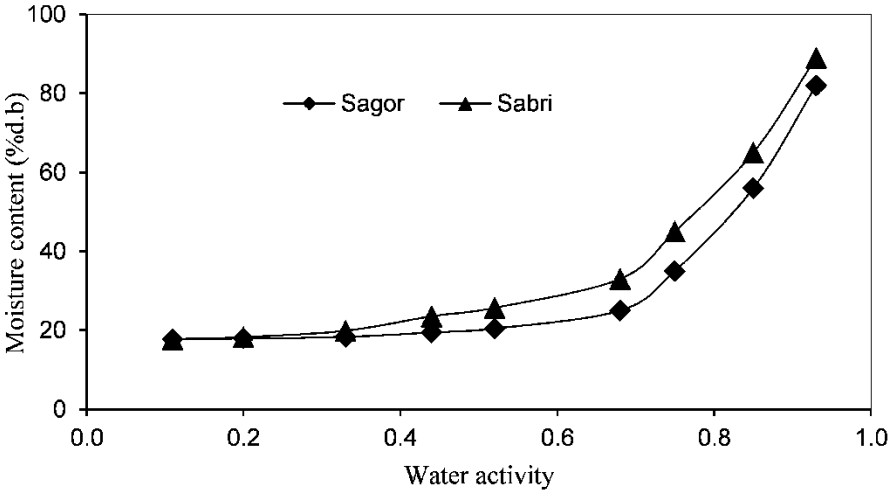

Figure 5. Sorption behavior of banana flours

Modeling of sorption data

BET (Brunauer, Emmet, and Teller) and GAB isotherm (Guggenheim-Anderson-De Bore) models were used to find monolayer moisture contents are shown in table 4. The value of regression coefficient (R^2) indicates the goodness of fit and effective model for sorption isotherm prediction of banana.

It was found that the calculated monolayer moisture content using GAB model for both varieties is litter higher than that of the BET model. According to regression coefficient value (R^2> 0.99), GAB model provided the best fit to the absorption of both *Sagor* and *Sabri* variety. Cardoso and Pena (2014) were made a similar recommendation for GAB and Oswin model in case banana (*Musa spp.* AAA) flour. Similar observations were made by Silva (2014) and Timmermann (2003) for GAB model.

Table 4. Model parameters for sorption isotherm of banana

Sorption model	Monolayer moisture content in %d.b (R^2 value of regression line)		Constant (C)	
	Sagor	*Sabri*	*Sagor*	*Sabri*
BET	12.73 (0.976)	10.042 (0.987)	31.692	91.273
GAB	13.34(0.997)	10.064 (0.998)	46.559	87.408

CONCLUSION

The study was conducted to determine the effects of thickness and temperature on drying rate of ripe bananas (*Sagor* and *Sabri* varities) during mechanical drying. A smaller thickness of 4 mm with higher temperature of 65°C was found the best condition for drying of both verities. Proximate composition of dried bananas was also investigated. According to the moisture absorption data, both varieties gave sigmoid (type II) shape isotherm and more susceptible to decay after 0.75 water activity. Finally, the GAB model was highlighted over BET model for its ability to predict moisture sorption isotherm of both banana flours at room temperature (25°C).

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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

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