PERFORMANCE OF POTATO (*Solanum tuberosum* L.) VARIETIES ON DIFFERENT FERTILIZER TREATMENTS

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CERTIFICATE

This is to certify that thesis entitled, "**PERFORMANCE OF POTATO (*Solanum tuberosum* L.) VARIETIES ON DIFFERENT FERTILIZER TREATMENTS"** submitted to the Department of Soil Science, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE in SOIL SCIENCE, embodies the result of a piece of bonafide research work carried out by ARUN CHANDRA ROY, Registration No.06-1993 under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that any help or source of information, as has been availed of during the course of this investigation has duly been acknowledged by him.

Dhaka, Bangladesh

A.T. M. Shamsuddoha
(Professor)
Supervisor

DEDICATED

TO

MY BELOVED PARENTS

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ABSTRACT

Potato crop has strict requirement for a balanced fertilization management, without which growth and development of the crop are poor and both yield and quality of tubers are diminished. Therefore, the study was done to make evaluated the effect of fertilizer management practices on the growth, yield and tuber quality characteristics in three potato varieties. Treatments included four doses of fertilizers (Viz., F_0, F_1, F_2 and F_3) and three potato cultivars (Viz., Cardinal, Diamant and Granola). Vegetative growth, yield parameters and tuber related parameters were studied during the experiment.

Regarding varieties, the minimum days (19.38 days) required for 100% emergence, highest plant height (24.84 cm) at 30 DAP, higher foliage coverage (53.30%) at 40 DAP, highest number of main stem per hill (3.32), higher fresh weight of haulm (162 g/hill), highest dry weight of haulm (9.54 g/hill), highest number of tuber per hill (14.67), maximum weight of tubers per hill (243 g), maximum dry weight of tuber (13.19 g) and maximum yield per plot (7.31 kg/plot) were found in potato cultivar Granola. Whereas all the studied parameters were minimum in Diamant. Similarly, Cardinal produced the highest percentage (24.60%) of large tuber by number. Regarding fertilizer management practices, the minimum time (18.23 days) required for 100% emergence, the highest plant foliage coverage, tuber qualities and yield (24.67 t/ha) were found in F_2 treatment where the treatment doses of N, P, K, S, Mg, Zn and B were 100, 30, 120, 10, 10, 4 and 0.8 kg ha^{-1}, respectively. According to the results it can be concluded that Cardinal produce have the capability to produce higher tuber yield with quality grade of potato. On the other hand, fertilizer management practices had significant effect on growth, yield and grade of potato. Among the fertilizer treatments, F_2 can be suitable dose for higher yield with better quality of potato in case of each of cardinal, granola and diamant variety. It is concluded that high yields and enhanced quality tubers can only be sustained through the application of optimal nutrient doses in balanced proportion of F_2 treatment in potato cultivar Granola.

Keywords: *Potato, cultivar, fertilizers, yield, growth and development*

ABBREVIATIONS AND ACRONYMS

TCRC = Tuber Crop Research Center

BADC = Bangladesh Agricultural Development Corporation

BARI = Bangladesh Agricultural Research Institute

DAT = Days after transplanting

FAO = Food and Agricultural Organization

LSD = Least Significant Difference

Max = Maximum

Min = Minimum

NS = Not Significant

Ppm = Parts per million

t/ha = Ton per hectare

N = Nitrogen

P = Phosphorus

K = Potassium

S = Sulphur

Mg = Magnesium

Zn = Zinc

B =Boron

FYM = Farm Yard Manure

SRDI = Soil Resource Development Institute

AEZ = Agro Ecological Zone

RCBD = Randomized Complete Block Design

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CHAPTER 1

INTRODUCTION

Potato (*Solanum tuberosum* L.) is one of the major food crops of the world. Potato provides a critically important element to the diets of many people in Bangladesh as a source of vitamin C and amino acid not provided by rice. It is a source of cash income to farmers and laborers which complements other staple crops. It contain practically all the essential dietary constituents. Carbohydrates are the major constituents of potato. Besides, it contains essential nutrients such as proteins and minerals like calcium, phosphorus and iron, and vitamins (B_1, B_2, B_6 and C) (Ensminger *et al.*, 1983). There is great potential of exporting potatoes from Bangladesh both for seed and table purposes to South-East Asia and to Middle East countries. Potatoes can even be exported to some of the European countries during March-May when fresh potatoes are not available in these countries.

The root and tuber crops commonly grown in Bangladesh comprise potato, sweet potato, aroids, yam, arrowroot and cassava. Among them, potato and sweet potato are the principal crops. It is used primarily as a vegetable and has potential as a staple food. Bangladesh ranks fifth in area in the world. From each hectare of land, it produces about 16-19 tons of potatoes. In European and American countries the potato productivity is about 30-40 tons per hectare (Griffiths and Zitter, 2008). Potato is one of the principal cash crops and it also contributes to Bangladeshi economy in several ways.

Yield increases as a result of new and improved production agro- technologies involve fertilization. Low use of fertilizers and serious imbalances in the N, P, K application ratio are partially responsible for low yields in India. Current fertilization rates are insufficient to sustain high yields and to replenish nutrient removal by the crop. According to Grewal et al (1992), potato yield could be increased by almost 50% only by improved nutrient management.

Marketable yield is a function of total biomass production, the percentage of biomass that is partitioned to the tubers, the moisture content of the tubers and the proportion of tubers that are acceptable to the market, in terms of size and lack of defects (Ewing, 1997). Great opportunities exist to increase potato yield and quality by improving nutrient management.

Potato demands high level of soil nutrients due to relative poorly developed and shallow root system in relation to yield (Perrenoud, 1983). Compared with cereal crops, potato produces much more dry matter in a shorter cycle (Singh and Trehan, 1998).

This high rate of dry matter production results in large amounts of nutrients removed per unit time, which generally most of the soils are not able to supply. Hence, nutrient application from external sources as fertilizers becomes essential. High yields can only be sustained through the application of optimal NPK doses in balanced proportion.

Potato crop is a heavy remover of soil potassium and is the nutrient taken up in the greatest quantity - the tubers remove 1.5 times as much potassium as nitrogen and 4-5 times the amount of phosphate (Perrenoud, 1993). Potato is regarded as an indicator crop for K availability because of the high K requirement (Roberts and McDole, 1985). Few soils could produce high potato yields for very many seasons without replenishing removed K.

Potato is a very sensitive crop to nitrogen fertilization. Excess nitrogen may prolong the vegetative phase and thus, interfere with the initiation of tuberization, decreasing yield and dry matter accumulation in the tubers. On the other hand, a low nitrogen application rate may produce premature senescence in the plants due to early translocation of nitrogen from the leaves to the tubers (Saluzzo *et al*., 1999**;** Kleinkopf *et al*., 1981).

Tuber Crop Research Center (TCRC) during the last decade and recommended 20 varieties after screening for cultivation under Bangladesh conditions (Hussain, 1993). These existing varieties occupy in about 68% of the total potato growing areas of this country (Anonymous, 1998).

Hence, the study was undertaken to evaluate the performance of 3 potato varieties under Bangladesh conditions with response to different fertilizer management practices.

Objective of the study:

1. To optimize the fertilizer dose on different potato varieties.
2. To study the effects of fertilizer on yield and other traits.
3. To study the effects of different varieties of potato with major fertilizers.
4. To study the yield potentiality of different potato.

CHAPTER 2

REVIEW OF LITERATURE

Rainys *et al.*, (2005) studied the effects of farmyard manure, straw, NPK/ha, micronutrients on the yield, starch and dry matter content of early (Goda and Voke), moderately early (Lady Rosetta) and moderately late (Saturna and Heres) potato cultivars in Lithuania during 2000-02. Tuber yield was significantly affected by the fertilizers, genotype and weather conditions. Over the three years, the highest yield was obtained (21.8-27.4 t/ha) among the cultivars. The cultivars had the highest yields in 2000 (19.3-36.0 t/ha).

Makaraviciute (2003) conducted an experiment during 1997-99 in Lithuania, 10 potato cultivars, i.e., Venta and Ukama, Voke, Mirta and Karolin early Hertha, Saturna and Agria, Aistes and Speci, were grown on plots with different fertilizers. The different fertilizers, varietal properties and meteorological conditions during the potato vegetation period significantly influenced the yield and quality of different potato cultivars. The highest potato tuber yields (20.1-29.6 t/ha) were harvested when one component and complex mineral fertilizers with microelements were applied, while the lowest tuber yield (14.6-21.7 t/ha) was obtained when manure (60 t/ha) was used in spring.

Fang (2003) conducted a field test with cv. Dabaihua in a semiarid region of China, to investigate the yield-related indices under different K application rates. Seven treatments were with N: P_2O_5: K_2O ratios of 0:0:0 (control 1), 90:90:0 (control 2), 90:90:30, 90:90:45, 90:90:60, 90:90:75 and 90:90:90 kg/ha. The tuber yields in the treatments with K fertilizer were significantly higher than those in the control treatments. The highest tuber yiled was recorded at 90 kg K_2O/ha, marked with 75 and 60 kg K_2O/ha, and the lowest in the control 1.

Suman (2003) conducted an experiment with potato cv. fufri Sutlej in Hisar, India in 2001, involving three fertilizer levels (100:60:60, 150:75:75 and 150:90:90 kg

NPK/ha), three plant spacing (10, 15 and 20 cm) and two crop durations (75 and 85 days). Decrease in plant spacing increased stems per unit area, plant height, haulm weight, total as well as number of different size tubers per unit area, and yield of total as well as of >25-50, >50-75 and >75 g size tubers. The fertilizer rates used could not affect any of these parameters. With an increase in crop duration, there was a significant increase in haulm weight and yield of >75 g and total tubers, while the other parameters were not affected.

Fifteen exotic potato varieties were evaluated in Bangladesh for yield potential over three generations. Both the yield was significantly higher in 2nd generation than 1st and 3rd generations. The average reduction of yield over 1st generation was found to be higher in Alkon, Granola, Obelix, and Origo ranging (-10.3 to -38.8%) but very lower in Mondial (-0.7%) and Producent (-0.5%).On an average, the high increase in yiled in subsequent generatins over 1st generation was boticed in Bartina, Diamant, Liseta, and Morene (17.3 to 64.5%). Similarly the degeneration was observed in Granola, Obelix, Origo and Producent (1.1 to 40.5%) whiles the yield increased in Bartina, Diamant, Liseta, Escort, Morene and Thebes (17.5 to 38.8%). Considering the parameters studied, varieties viz., Ajiba, Bartina, Liseta, Mondial, Morene and Thebes showed acceptable performance in comparison to recommended variety Diamant (Rasul *et al.*, 1993).

Nandekar (2003) evaluated the yield of seven potato cultivars in Chandangaon, Chhindwara, Madhya Pradesh, India, during the rabi season of 1994/95 and 1995/96. H.P.S. 1/13 (32.5 t/ha) had the highest yield, marked with H.P.S. 1/67 (31 t/ha) and H.P.S. 11/13 (29.5-36.5 t/ha). The yields of these cultivars were higher by 30.5, 25.4 and 20.0% respectively than the yield of Kufri Badshah (24.7 t/ha).

A field experiment was conducted during rabi 1999-2000 in Akola, Maharashtra, India to investigate the effects of roe spacing (45 and 60 cm), tuber size (6-25 and 26-45 g) and NPK level (100:75:50 and 125:100:75 kg/ha) on yield and yield components of potato cv. Kufri Jyoti. Weight of tubers per plant and average weight of tubers per plant were significantly higher with 60cm row spacing, whereas number of fresh tubers, haulm yield and biological yield were significantly higher

with 45cm row spacing. Tuber yield was not affected by the two row spacing treatments. Tuber size of 26-45g recorded significantly higher tuber yield but average weight of tuber was significantly higher with 6-25g tuber size. Application of 125:100:75 kg NPK/ha recorded higher number of fresh tubers per plant, haulm yield and biological yield.

Silva *et al.*, (2005) conducted this study to establish the relationship between the duration of the growth cycle and the yield potential of potato genotypes in southern Minas Gerais State, Brazil. This study evaluated the tuberization process, the dry matter partitioning at the different plant development stages, and estimated genetic parameters for these traits. One hundred twenty-one genotypes were evaluated in two experiments which were harvested at 80 days after planting (DAP) and at the end of the growth cycle. In a second study, 23 genotypes were harvested at 58, 83, 108, and 133 DAP. Results suggest that a possible strategy to increase potato tuber yield in the tropics is to select for late clones. Late clones can be harvested around 100 DAP with no reduction in tuber yield and tuber dry matter content.

Nine advanced generation promising potato hybrids along with control varieties Kufri Chandramukhi and Kufri Badshah were evaluated for tuber yield at 75 and 90 days after planting during the 1990-91 and 1991-92 crop seasons in Satpura, Madhya Pradesh. Wide variability was observed among genotypes for tuber yield at 90 DAP.

The hybrids MS/79-10, JN1758 and J155857 produced greater yields than Kufri Chandramukhi at 75 DAP. J155857 also produced a higher yield than the high-yielding control Kufri Badshah at 90 DAPS.

Vos *et al.* (2000) managed comparably to conventional farming practices in the Nederland. There were four nutrient treatments (T_1-T_4). Treatments T_1 received chemical fertilizer only. T_2 received processed organic manure, supplying 50% of the crop N requirement, supplemented by chemical fertilizers. In treatments, T_1 AND T_2 the soil was grow during winter. In T_3 and T_4 the crops were fertilized as in T_1 and T_2

respectively, nitrogen catch crops were grown in autumn and winter. The initially high soil fertility indices for both P and K declined over the experimental period. Catch crops and organic manure did not affect crop yields or nutrient balances, except that their combination in T_4 resulted in 1.5t/ha extra dry matter yield of sugar beet roots. Between spring and harvest, potato and sugar beet showed positive N balances and the cereals negative N balances.

Koppel (2001) set an experiment with special emphasis organic agriculture on the choice of cultivars where adaptation regional soil, climate and production systems are important characteristics. The necessary traits for a potato variety suitable for organic farming include stronger rooting system, quicker haulm development, high and durable resistance to the main diseases and pests. A trial consisting of 45 potato cultivars and advanced clones was established at Jogeva Plant Breeding Institute in Estonia in 2000 to identity the most suitable cultivar for organic fanning in the country. Organic manure at 60 t/ha and mechanical weed control were used no pest and disease control measures were undertaken in both years. Both growing seasons were very suitable for late blight development.

High late blight pressure was the main cause of yield reduction from 9.9 to 37.4 t/ha. The higher marketable tuber yields were obtained from the early cultivars or from the late cultivars that are resistant to late blight.

Ghosh and Das (1998) reported that the potatoes grown at Sriniketan (West Bengal) in winter 1995-96 and 1996-97 were given different biofertilizers and growth regulators. Treatments included combinations of Buckup (Well matured cattle manure containing vesicular arbuscular mycorrhizas and phosphate solu7bilizing bacteria), Elecra (liquid organic manure extracted from marigold plants), Bioplin (liquid suspension of Azotobecter), Micrin (liquid organic manure containing humic and fulvic acid), Vitormone (liquid suspension of several dormant Azotobecter species) and protein hydrolysate (plant growth regulators containing amino acids). Plant height and number of shoots/plant increased considerably when the crop received both biofertilizer and growth regulators together. Crop growth rate, tuber bulking rate, large

and medium sized tubers and total tuber yield were greatest from combinations of both biofertilizers and growth regulator. Among the single applications, Vitormone gave the greatest yield improvement (22.6%) followed by protein hydrolysate (22.1%). Combined application of Bioplin along with protein hydrolysate or Micrin and Elecra along with Vitormone, gave 38-42% yield improvement over controls.

Blecharezyk and Skrzypezak (1995) observed that FYM reduced tuber dry matter and starch contents, but increased their yield. Another field experiment was conducted by Khalak and Kumaraswamy (1994) in red loam soil at Bangalore, potatoes cv. Kufri Jyoti to assess the effect on dry mater accumulation and growth attributes of potato as influenced by irrigation and fertilizer (50, 100, or 150 kg/ha each of N, P_2O_5 and K_2O). They found that leaf area index, leaf area duration, total dry matter accumulation increased with the rate of $N+P_2O_5+K_2O$ application.

Siddique and Rashid (1990) stated that under Bangladesh Agricultural University farm condition, fertilizer does of 207 kg Urea, 139 kg TSP and 242 kg MP for indigenous potato varieties. Hussain (1985) reported that use of oil cake at the rate of 700-900kg/ha is better for higher potato production. Kehr *et at.,* (1964) mentioned that potato tubers develop and maintain their normal shape better in soils with high organic matter. A field experiment was carried out by Sarker *et al.* (1996) at the Gangachra Series of Mithapukur, Rangpur to assess the effect of fertilizers alone and in combination with cow dung on the growth and yield of potato. They found that the highest tuber yields of 29.97 and 28.72 t/ha were produced by the combined effect of 150kg N + 60kg P + 120kg K + 20 kg S + 40 kg Zn + 2 kg B + 15 kg Mg/ha + 5 t/ha of cow dung respectively.

Belous (1996) worked on fertilizer for zero, single or double doses, 40 t FYM + 60 Kg N + 60Kg P+60 Kg K, 80 t FYM + 120 Kg N -f 120 Kg P+120Kg K and 120t FYM +180kg P +180 Kg K per hectare. They found that NPK without FYM was highly effective especially if straw or green manure had been ploughed in and the use of FYM greatly reduces the effectiveness of complete NPK.

Guarda and Tassoni (1994) carried out an experiment on a clay-loam soil where they applied 0, 100, 200 or 300Kg N/ha in organic or mineral forms. Farmyard manure was applied in two split doses (30% immediately often planting and the rest 50 days later). They found that yield responses to N rate were dissimilar between the N sources. However, potatoes given organic nitrogen yielded 1-2t/ha less than where mineral nitrogen was applied.

In another experiment Zavalin *et al.* (1993) also stated that them optimum potato yield of 27.l t /ha was given by the plants having 9.0 Kg N+ 60KgP + 120 Kg K+ 50t peat manure compost/ha. Karmanpov *et al.* (1982) conducted an experiment with 0-135 Kg N, 0-210 Kg P_20_5 and 0-165 Kg K_2O/ha on a leached chernozem soil given 20 t FYM /ha in the penza region and found that application of 135 Kg N +210 Kg P_2O_5+165 Kg K_2O/ha gave the highest average yields of 36 t/ha without irrigation and 42 t with irrigation.

Krishnamurthy et *al., (*2001) conducted field experiments in Bangalore, Karnataka, India, during the rabi seasons of 1996-97 and 1997-98 and investigated the effect of integrated use of organic manures and fertilizers on potato crops grown from true seed. The experiments consisted of 12 treatments combinations of organic sources: green pus at four t/ha (organic manure), biofcrtilizcrs (Azotobcctcr chroococcum), city compost and control (no organic manure) and fertilizer levels (100, 125 and 150 % of recommended dose of NPK). The highest seed yield of 20.8% was recorded with green and followed by city compost (13.9%) and biofertilizer application (11.6%).

The highest total tuber yield of 28.7 t/ha was observed with city compost, followed by green plus (27.4% t/ha) and biofertilizer (20.4% t/ha). Application of 150 %recommended dose of NPK recorded the highest seed yield of 33.3 Kg /has and tuber yield of 29.8 t/ha, closely followed by application of 125% of recommended

doses of NPK. Combination of city compost and 150% recommended dose of NPK recorded the highest seed and tuber yield compared to all other treatment combinations.

Toomsoo and leedu (2002) investigated the effect of a combined fertilizer. Hydro complex (12:11:18), on the yield of Potato cv. Anti, grown in potato spring wheat springy barley rotation, in a long term field experiment established in autumn 1989, in Tartu, Estonia. Five rates of mineral N (0, 40, 80, 120 and 160 Kg/ha) were used against three backgrounds of organic manure (no manure, cattle manure + Liter and straw). The results of three experimental years (1999-2001) showed that the yield of cv. Anti was stable during 1999-2001. Yield was found to depend on the fertilizer rather than on the weather conditions. The optimum N rate was 95-120 Kg/ha. In rainy seasons, the use of chemicals to control potato late blight *(Phytopthora infestans)* was very important to improve the yield of potato cv. Anti.

Krupkin *et al.* (1994) carried out an experiment to study effect of poultry manure, a mixture of poultry manure plus hydrolysis lignin, and a compost of poultry manure plus hydrolysis lignin organic fertilizers for potatoes, carrots and cabbage with and without irrigation. The results should that these organic fertilizers improved yield and quality of the crop, especially on soil having a low content of nitrate N, but had only little effect on soils well supplied with nitrate N. the lignin based fertilizers i.e. a mixture of poultry manure hydrolysis lignin and a compost of poultry manure plus hydrolysis lignin were similar in their effect to poultry manure.

Datta and Chakraborty (1995) conducted a field experiment with or 100 Kg/ha each of N, $P2O5_iK_2O$, and manure with 5 tons rice husk ash, 0.5 tons mustard oilcake or 10 tons FYM/ha. The highest potato tuber yield (27 t/ha) was obtained from the

highest NPK rate used. Amongst the manures the tuber yield were in the under of FYM > rice husk ash> mustard oil cake.

Adhikari *et al,* (1992) in a field trial on potatoes cv. Kufri gave 150 g nitrogen as urea or ammonia sulphate + 40 tons cowdung manure 302 tons mustard oilcake or 20 tons poultry litter or 230 kg nitrogen as urea or ammonium sulphate + 20 tons cowdung manure 1.6 tons mustard oilcake or 10 tons poultry litter /ha to gave total nitrogen application in each treatment of about 310 Kg /ha. Tuber yield percentage of tuber > 45 mm and net profit were maximum with the application of 150 Kg nitrogen as ammonium sulphate + 20 tons poultry litter/ha.

Neher (1999) conducted a field experiment at the Horticulture Farm, Bangladesh Agricultural University, Mymensingh during the period from November 1997 to February, 1998 in order to study the effect of fertilizer viz., no fertilizer, organic, inorganic, organic +inorganic and irrigation viz. no irrigation, irrigation at 20, 15 and 10 days interval. The results demonstrated that fertilizer management practices had significant effects on the yield and yield contributing characters. The maximum plant highest (52.0cm), fresh weight of haulm (0.102 Kg/hill), dry weight of haulm (10.078 g/hill), weight of tuber (396g/hill) and yield of tuber (27.09t/ha) were recorded when inorganic fertilizer managements were applied. However, the maximum number of main stems (3.65) per hill and dry matter of tubers (21.08%) were obtained from organic fertilizer management practices. Inorganic fertilizer management practices gave the highest percentage of >55mm (20.27) and 46-55mm (47.49) grade tubers. Inorganic fertilizer management practices gave significantly better result compared to other treatment.

Arafa (2004) conducted an experiment of different NPK treatments oil growth, yield, quality and chemical components of two potato cultivars. The effects of 3 levels of NPK fertilizers, i.e. 125+30+100, 150+45+150 and 175+60+200 kg/ha, on the growth, yield and its components, quality as well as chemical compositions (N, P, K,

Fe, Mn_3 Zn, reducing, no reducing and total sugars) of foliage and tubers of 2 potato cultivars (lady Rosetta and Hermis)'were investigated under sandy soil conditions in Ismaalia Governorate, Egypt, during the summer seasons of 2002 and 2003.

The second level of NPK significantly increased plant height, number of branches per plant, fresh and dry weights of plant foliage, numbers of tubers per plant, tuber weight, plant yield, total yield, marketable yield, large (more than 55 mm in diameter) tuber percentage and chemical composition of foliage and tubers. Hermis compared with Lady Rosetta significantly increased the vegetative growth, yield and its components as well as chemical composition of plant foliage and tubers. The data concerning the interaction showed that Hermis in combination with the second level of NPK significantly increased all the studied character; Lady Rosetta in combination with the highest level of NPK increased the percentage of medium sized (35-55mm in diameter) tubers and dry matter content of tubers.

Marks and Krzysztofik (2001) observed the effect of different forms of organic manure and cultivation techniques on the quality of potato tuber yield. The application of organic manure (processed biomass form) and patch growing of potatoes improved the quality of potato yield compared with farmyard manure and ridge cultivation.

Gladkikh *et al.* (2001) conducted a trial with mineral fertilizer (various rates and combinations of N, P and K) and organic fertilizer in a farm of pet/manure compost. The crop rotations comprised tomatoes, cabbage, carrots, potatoes and cucumbers. The results were given from the 10^{th} rotation (1993-98). Yields were greatest in the treatments with complete mineral fertilizer, and with combined mineral and organic fertilizer.

CHAPTER 3

MATERIAL AND METHODS

3.1. Site of the experiment

The experiment was conducted at Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, during the period from September 2011 to December 2011. The location of the site is 23°74' N latitude and 90° 35'E longitude with an elevation of 8.2 meter from sea level.

3.2. Climate

The climate of the experimental site is subtropical, characterized by heavy rainfall during the months from April to September (Kharif season). The total rainfall of the experimental site was 209 mm during the period of the experiment. The average maximum and the minimum temperature were 26.5°C and 12.9°C respectively during the experimental period. Rabi season is characterized by plenty of sunshine. The maximum and minimum temperature, humidity and rainfall during the study period were collected from the Bangladesh Meteorological Department (climate division) and have been presented Appendix I.

3.3. Characteristics of soil

The soil of the experimental area belongs to the Modhupur Tract. The analytical data of the soil sample collected from the experimental area were determined in the SRDI, Soil Testing Laboratory, Dhaka have been presented in Appendix II.

The experimental site was a medium high land and pH of the soil was 5.6. The morphological characters of soil of the experimental plots as indicated by FAO (1988) are given below -

AEZ No. 28

Soil series -Tejgaon.

General soil- Shallow red brown terrace soil.

3.4. Planting materials

The seed tubers of selected potato varieties were collected from Bangladesh Agricultural Development Corporation (BADC) office, Kashimpur, Gazipur.

3.5. Treatments of the experiment

There were two factors in this experiment. They were as follows:

3.5.1. Factor A: Different variety treatments

i. Cardinal (V1)
ii. Granola (V2)
iii. Diamant (V3)

3.5.2. Factor B: Fertilizer management practices

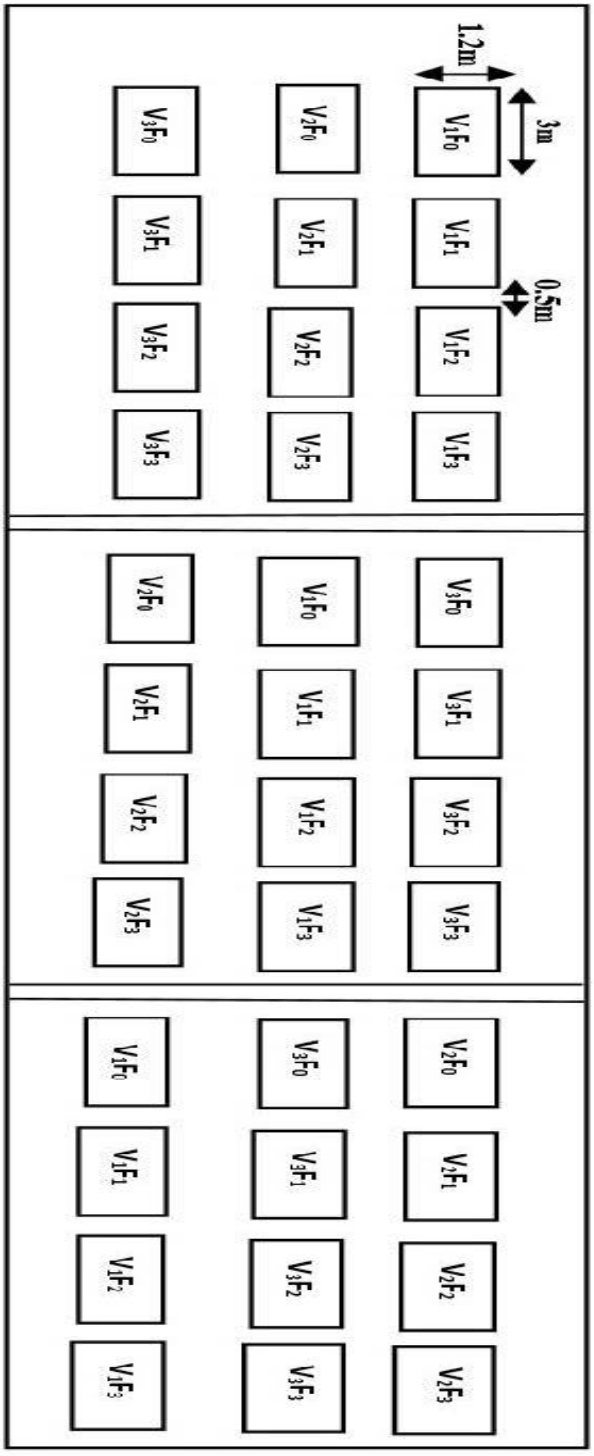
i. $N_0+P_0+K_0+S_0+Mg_0+Zn_0+B_0$ (F_0) (kg/ha)
ii. $N_{50}+P_{20}+K_{60}+S_5+Mg_5+Zn_2+B_{0.4}$ (F_1) (kg/ha)
iii. $N_{100}+P_{30}+K_{120}+S_{10}+Mg_{10}+Zn_4+B_{0.8}$ (F_2) (kg/ha)
iv. $N_{150}+P_{40}+K_{180}+S_{15}+Mg_{15}+Zn_6+B_{1.2}$ (F_3) (kg/ha)

3.6. Preparation of the main field

The land was opened on 12th September 2011 with a power tiller and was exposed to the sun for 7 days prior to next ploughing. It was prepared afterwards by ploughing and cross ploughing followed by laddering. Big clods were broken by hand mallet. The we.eds and stubbles were completely removed from the field. The soil particles were well pulverized and the land was leveled evenly during final land preparation.

3.7. Design and layout of the experiment

The two-factor experiment was laid out in the Randomized Complete Block Design (RCBD) with three replications. The total number of plots was 36. Each for a combination of varieties and different fertilizer management practices. The treatment combinations of the experiment were assigned randomly.



3.8. Application of fertilizers

The following doses of manures and fertilizers were used in the experiment following the recommendation doses below:

Fertilizer (kg/ha) →	N	P	K	S	Mg	Zn	B
F_0	0	0	0	0	0	0	0
F_1	50	20	60	5	5	2	0.4
F_2	100	30	120	10	10	4	0.8
F_3	150	40	180	15	15	6	1.2

One third urea, MP, and full doses of TSP, Mg, Zn, B were used as a basal dose. The rest of the urea and MP were applied in two installments at 30 and 60 days after planting.

3.9. Preparation of planting materials

The seed tubers were procured from BADC sales centre Kashimpur, Gazipur and kept under diffused light condition in order to obtain healthy and well sprouted whole seed tubers, which were used for planting.

3.10. Planting of seed tuber

Sprouted, healthy and disease free seeds were planted in furrows on the 19th September 2011 at 5-7cm depth maintaining a spacing of 60cm x 20cm. After planting, the seeds were covered with soil.

3.11. Intercultural operations

3.11.1. Weeding

Weeding was done in all the plots as and when required to keep the plant free from weeds.

3.11.2. Earthing up

Earthing up was done twice during the growing period. The first earthing up was done after 30 days of planting and the second one after 25 days of first earthing up.

3.11.3. Plant protection

Dithane M-45@ 2.25 kg/ha was sprayed after complete emergence of the crop at an interval of 15days to protect the incidence of late blight disease. Furadan 5G was applied against soil insects during final land preparation at the rate of 10 kg/ha.

3.12. Collection of Data

Data were recorded on the following parameters from the sample plants during the course of experiment.

3.12.1. Days required to 100%emergence

This was achieved by recording the number of days taken for the emergence of 40 planted in each plot.

3.12.2. Height of plant

Plant height was recorded at 30, 45, 60 and 75 days after planting (DAP). The height was measured from the base of the plant to the longest end of the stem and was expressed in centimeter (cm).

3.12.3. Foliage coverage (%)

The area covered by the plants canopy in a unit plot of 2.4m x 2m was calculated and converted into percentage.

3.12.4. Number of main stems per hill

The number of main stems per hill of the sample plants was recorded at the time of harvesting, and the average number of stems produced per hill was recorded.

3.12.5. Fresh weight of haulm per hill

The average weight of haulm was recorded from selected plants for each plot at the time of harvesting.

3.12.6. Dry weight of haulm per hill

The fresh haulms of the sample plants were sun dried for two days and then oven dried at 65°C for 72 hours.

3.12.7. Number of tubers per hill at harvest

The number of tubers from 10 selected plants was counted and average number of tubers was calculated.

3.12.8. Weight of tubers per hill at harvest

The weight of tubers from 10 selected hills was recorded and average weight of tubers per hill was calculated.

3.12.9. Mean tuber weight

Mean tuber weight was recorded from total weight of tubers from sample plants divided by total number of tubers from these plants at harvest.

3.12.10. Dry weight of tubers (%)

Two hundred grams of potatoes from sample plants were sliced, sun dried for 2 days and then dried at 70°C in an oven for 72 hours. Just after oven drying the dried pieces were weighed and were expressed in percentage.

$$\text{Dry weight of tuber (\%)} = \frac{\text{Dry weight}}{\text{Fresh weight}} \times 100$$

3.12.11. Yield of tuber per plot

To obtain yield per hill weight of tuber was taken from ten harvested sample plants and the tuber yield per unit plot was found out as total tuber weight of all the plants from each unit plot.

3.12.12. Yield of tuber per hectare

The yield of tuber per hectare was calculated from that of per plot yield.

3.12.13. Grade of tubers

Tubers collected from ten plants in each plot the potato was graded by number and by weight on the basis of diameter: >55mm, 40-55mm, 28-40mm and <28mm. The data were converted into percentage.

3.13. Harvesting

The crop was harvested after 90 days on 14th December 2011 when the 80-90 percent of the plants showed leaf senescence and the tops started drying up. Ten sample plants were harvested at first with the help of a spade from each plot and the whole plot was harvested with the help of country plough. Enough care was taken to avoid injury of potatoes during harvesting.

3.14. Statistical analysis

The collected data were statistically analyzed to find out the significance of the difference among the treatments. The analysis was performed by F-test and the significance of the difference between pairs of treatment means were evaluated by the Least Significance Difference (LSD) test at 5% level of significance.

CHAPTER 4

RESULTS AND DISCUSSION

The effect of potato varieties and fertilizer management practices and their interaction on the growth, yield and yield contributing characters have been presented and discussed in this chapter under the following headings and in tables 1-6 and figures 1-4.

4.1. Time required for 100% emergence of the plant

The time required for 100% emergence of the crop was significantly influenced by different fertilizer management practices, but insignificant among the varieties and interactions between varieties and fertilizer management practices (Table 1). Regarding varieties, the minimum days (19.38 days) required for 100% emergence in Cardinal followed by the others. Meanwhile, Diamant required the maximum time (19.9 days).

In case of the effect of different levels of fertilizer management practices on the 100% emergence of potato plant the minimum time (18.23 days) required was noted in F_2 treatment, which was statistically similar with that of F_1 and F_3. Meanwhile the maximum time 22.1 days was required in F_0 treatment (Table 1).

Interaction effect of varieties and fertilizer management practices was found to be insignificant.

Table 1. Effects of fertilizers on days required for 100% emergence, plant height and foliage coverage of three potato varieties.

Treatment	Days required for 100% emergence	Plant height (cm) at different days after planting (DAP)				Foliage coverage (%) at different days after planting (DAP)			
		30 DAP	45 DAP	60 DAP	75 DAP	40 DAP	50 DAP	60 DAP	70 DAP
Varieties (V)									
V_1	19.38a[z]	23.10ab	35.94a	47.98a	50.69a	48.03b	51.00b	57.03b	60.96b
V_2	19.80a	24.84a	37.91a	51.78a	53.21a	53.30a	59.11a	64.65a	71.46a
V_3	19.90a	22.60b	38.47a	49.78a	51.38a	47.85b	52.18b	56.66b	62.97b
Fertilizers (F)									
F_0	22.21a	16.74b	28.74b	35.88c	32.85b	31.76c	31.95b	34.36b	38.14b
F_1	19.14b	24.70a	39.48a	51.01b	55.55a	53.11b	58.18a	64.77a	70.52a
F_2	18.23b	26.95a	42.14a	57.12a	60.21a	58.62a	64.96a	71.53a	77.95a
F_3	19.20b	25.67a	39.40a	54.93ab	58.36a	55.43ab	61.28a	67.12a	73.92a
Significance									
V	NS	NS	NS	NS	NS	0.005	0.003	0.002	0.001
F	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
V × F	NS	NS	NS	NS	NS	0.058	NS	NS	NS

V_1: Cardinal, **V_2:** Granola, **V_3:** Diamant, **F_0:** $N_0+P_0+K_0+S_0+Mg_0+Zn_0+B_0$,
F_1: $N_{50}+P_{20}+K_{60}+S_5+Mg_5+Zn_2+B_{0.4}$, **$F_2$:** $N_{100}+P_{30}+K_{120}+S_{10}+Mg_{10}+Zn_4+B_{0.8}$,
F_3: $N_{150}+P_{40}+K_{180}+S_{15}+Mg_{15}+Zn_6+B_{1.2}$. [z] Means with different letter (s) the same column differed significant separated by Tukey's test at $P \leq 0.05$. NS non-significance at $P \leq 0.05$.

4.2. Plant height

Plant height was recorded at different days after planting (DAP) viz.30, 45, 60 and 75. Different cultivars showed significant variation in plant height at 30 DAP but insignificant at 45, 60 and 75 DAP (Table 1). At 30 DAP the highest plant height (24.84 cm) was measured in Granola while the lowest (22.60 cm) in Diamant (Table l). At 60 and 75 DAP the highest plant height was measured in Granola while the lowest in Cardinal (Table l). Hussain and Rashid (1974) reported the plant height ranges from 21.32-25.61cm in potato cultivars.

Plant height due to different levels of fertilizer management practices was significantly influenced at different days after planting (Table 1). The maximum plant heights for 30, 45, 60 and 75 DAP were recorded from F_2 whereas the minimum plant heights for 30, 45 60 and 75 DAP were recorded from F_0 treatment (Table 1). It was observed that F_2 fertilizer treatment played a significant role in maximizing plant height. This effect was probably due to the fact that fertilizers supplied adequate plant nutrients for better vegetative growth of potato plants which ultimately increased plant height. Widiajanto and Widsodo (1982) found the lowest plant height 23.1cm and the highest one was 72cm. The interactions between varieties and fertilizer management practices were found to be statistically insignificant on plant height for 30, 45, 60 and 75 DAP.

4.3. Foliage coverage

Good foliage indicates good growth, development and productivity of plants. In the present study the area covered by foliage was significantly influenced by varieties at 40, 50, 60 and 70 DAP. At 40 DAP, Granola produced the maximum foliage coverage (53.30%) and the minimum area was covered (47.85%) by Diamant which was statistically similar with that of Cardinal (Table 1). Such trends of foliage coverage were found at 50, 60 and 70 DAP for different varieties, where the maximum foliage coverage was found in Granola for 50, 60 and 70 DAP and it was statistically significant over both of cardinal and diamant varieties.

Foliage coverage also significantly influenced by fertilizer management practices at 40, 50, 60 and 70 DAP. At 40 DAP, F_3 produced the maximum foliage coverage (58.62%) and the minimum area was covered (31.76%) by F0 treatment. Similar trends of foliage coverage were found in different fertilizer management practices for 50, 60 and 70 DAP (Table 1). For 50, 60 and 70 DAP, F_3 produced the maximum foliage coverage and the minimum area was covered by F_1 treatment.

Varieties and fertilizer management interaction practices showed insignificant effect on foliage coverage at different days after planting. For 40, 50, 60 and 70 DAP the highest foliage coverage was found 58.62, 64.96, 71.53 and 77.95, respectively in the treatment combination of Cardinal with F_2.

Table 2. Effects of fertilizers on number of main stem, fresh weight of haulm and dry weight of haulm per hill of three potato varieties.

Treatment	Number of main stem per hill	Fresh weight of haulm per hill (g)	Dry weight of haulm per hill (g)
Varieties (V)			
V_1	3.27a	125a	8.20b
V_2	3.32a	162b	9.54a
V_3	3.30a	114b	8.47ab
Fertilizers (F)			
F_0	1.78c	73c	7.02c
F_1	3.47b	129b	8.57b
F_2	4.31a	140a	10.14a
F_3	3.63b	131b	9.21ab
Significance			
V	NS	0.001	0.020
F	0.001	0.001	0.001
V × F	NS	0.001	NS

V_1: Cardinal, V_2: Granola, V_3: Diamant, F_0: N_0+P_0+K_0+S_0+Mg_0+Zn_0+B_0,
F_1: N_{50}+P_{20}+K_{60}+S_5+Mg_5+Zn_2+$B_{0.4}$, F_2: N_{100}+P_{30}+K_{120}+S_{10}+Mg_{10}+Zn_4+$B_{0.8}$,
F_3: N_{150}+P_{40}+K_{180}+S_{15}+Mg_{15}+Zn_6+$B_{1.2}$. [Z] Means with different letter (s) the same column differed significant separated by Tukey's test at $P \leq 0.05$. NS non-significance at $P \leq 0.05$.

4.4. Number of main stem per hill

The number of main stems per hill was found to be statistically insignificant among different varieties. The maximum number of main stem per hill (3.32) was produced by Granola, while the minimum number of main stem (3.27) was found in Cardinal (Table 2).

The number of main stems per hill was significantly affected by the different fertilizer management practices. The number of main stems per hill was the highest (4.31) in F_2 fertilizer treatment and the lowest (1.78) was found in F_0 fertilizer treatment (Table 2). F_2 fertilizer treatment showed the statistically significant increase in number of main stems per hill over all other treatments including control.

Statistically insignificant interaction effects of varieties and fertilizer management practices were found on the number of main stems per hill. The maximum numbers of stems were given 3.32 by the treatment combination of Granola with F_2 and the lowest was recorded 3.27 from the treatment combination of cardinal with F_0.

4.5. Fresh weight of haulm (g/hill)

Significant variation was found among different varieties in fresh weight of haulm per hill. The potato variety of Granola produced the highest (162 g/hill) fresh weight of haulm. On the other hand, the lowest (114.0 g/hill) was found in Diamant (Table 2).

Fresh weight of haulm per hill varied significantly with different fertilizer management practices. The highest fresh weight of haulm (140.0 g/hill) was observed from F_2 fertilizer treatment and the lowest (73.0 g/hill) was produced by F_0 treatment (Table 2).

Different varieties and fertilizer management practices in respect of fresh weight were found statistically significant. The highest fresh weight of haulm was recorded from Granola with F_2 and the lowest from Diamant with F_0 treatment combination.

4.6. Dry weight of haulm

There was a significant effect of potato varieties on the dry weight of haulm per hill. The highest dry weight of haulm (9.54 g/hill) was found from Granola. The lowest dry weight of haulm (8.2 g/hill) was recorded in Cardinal treatment (Table 2). This might be due to genetic ability, which increased plant height, number of leaves and chlorophyll content of the plant (EI-Okash *et al.*, 1993).

Different fertilizer management practices showed significant variation in respect of dry weight of haulm per hill. The maximum dry weight of haulm (10.14 g/hill) was obtained from F_2 fertilizer management practices. The minimum (7.02 g/hill) was obtained from F_0 fertilizer management practices (Table 2).

There was significant interaction between varieties and fertilizer management practices on the dry weight of haulm. The maximum dry weight of haulm was obtained from the combination of Granola with F_2, and the minimum dry weight of haulm was obtained from the combination of Cardinal with F_0.

Table 3. Effects of fertilizers on tuber characteristics of three potato varieties.

Treatment	Number of tubers per hill	Weight of tubers per hill (g)	Mean weight of tuber (g)	Dry weight of 100 g tuber (g)
Varieties (V)				
V_1	11.57b	219b	181.5a	11.81b
V_2	14.67a	243a	162.0b	13.19a
V_3	10.46c	206c	183.0a	12.81a
Fertilizers (F)				

F_0	6.48d	93d	131.6b	11.06c
F_1	13.07c	243c	189.2a	12.63b
F_2	15.53a	296a	192.2a	13.62a
F_3	13.85b	258b	189.1a	13.11ab
Significance				
V	0.001	0.001	0.001	0.001
F	0.001	0.001	0.001	0.001
V × F	0.001	0.001	0.001	0.053

V_1: Cardinal, V_2: Granola, V_3: Diamant, F_0: N_0+P_0+K_0+S_0+Mg_0+Zn_0+B_0,
F_1: N_{50}+P_{20}+K_{60}+S_5+Mg_5+Zn_2+$B_{0.4}$, F_2: N_{100}+P_{30}+K_{120}+S_{10}+Mg_{10}+Zn_4+$B_{0.8}$,
F_3: N_{150}+P_{40}+K_{180}+S_{15}+Mg_{15}+Zn_6+$B_{1.2}$. [Z] Means with different letter (s) the same column differed significant separated by Tukey's test at $P \leq 0.05$. NS non-significance at $P \leq 0.05$.

4.7. Number of tuber per hill

The number of tubers per hill was significantly affected by potato cultivars. The highest number (14.67) was found in Granola cultivar and the lowest number (10.46) was found in Diamant cultivar (Table 3).

The number of tubers per hill was significantly influenced by different fertilizer management practices. The highest number of tubers per hill (15.53) was given by F_2

fertilizer treatment, while the lowest (6.48) was produced by the plants grown in F_0 fertilizer management practice (Table 3). The increase in number of tubers per hill might be due to increased photosynthetic activity and translocation of photosynthates to axillary shoots, which might have helped in the initiation of more stolon (Anand and Krishnappa, 1988).

There was a statistically significant interaction effect of variety and fertilizer management practices on the number of tubers per hill. The maximum number of tubers per hill was produced by Granola with F_2 fertilizer management practices. The lowest number of tubers per hill was produced by the treatment combination of Diamant with F_0.

4.8. Weight of tuber per hill

Weight of tubers per hill was significantly affected by the potato varieties. The highest weight of tubers per hill was found in Granola (243.0 g) (Table 3). On the other hand, the lowest weight of tubers per hill was found in Diamant (206.0 g) (Table 3).

The variation in weight of tuber per hill due to different fertilizer management practices was observed to be statistically significant. The maximum tuber weight per hill (296.0 g) was recorded when the crop was grown with F_2 fertilizer treatment, while the minimum tuber weight (93.0 g) was found in F_0 fertilizer treatment (Table 3).

There was statistically a significant interaction effect of varieties and fertilizer management practices on the weight of tuber per hill. The maximum tuber weight per

hill was produced from Granola with F_2 fertilizer treatment, while the minimum was obtained from Diamant with F_0 fertilizer treatment.

4.9. Mean tuber weight

Statistically significant influence was observed due to the effect of variety on the tuber weight. The mean tuber weight was maximum (183.0 g) in Diamant potato variety. The minimum mean tuber weight was 162.0 g in Granola (Table 3). The genetical capability of cultivars possibly enhanced vegetative growth and fresh plant weight thus contributing enough to produce bigger sized tuber.

The variations in mean tuber weight due to different fertilizer management practices were observed to be statistically significant. The maximum mean tuber weight (192.2g) was obtained when the crop was grown under F_2 fertilizer treatment. The minimum mean tuber weight (131.6 g) was found in the treatment of F_0 fertilizer (Table 3).

Interaction effect of variety and fertilizer management practices was statistically significant on the mean tuber weight. The maximum mean tuber weight 192.2 g was found in Granola with F_2 fertilizer and the lowest was 131.6 g from Cardinal with F_0 fertilizer treatment.

4.10. Dry weight of tuber

Dry weight of tuber was statistically significant as affected by different potato cultivars (Table 3). The dry weight of tuber was maximum (13.19 g) in Granola potato variety. The minimum mean tuber weight was 11.81 g in Cardinal (Table 3). The genetic capability of cultivar Granola possibly enhanced vegetative growth and fresh plant weight thus contributing enough to produce bigger sized tuber.

Dry weight of tuber was significantly affected by different fertilizer management practices. The maximum dry weight of tubers (13.62 g) was obtained

from F_2 fertilizer management practices whereas F_0 fertilizer treatment gave lowest dry weight (11.06 g) of tuber (Table 3).

There was statistically significant interaction effect of variety and fertilizer management practices. The maximum dry weight was obtained in Granola with F_2 treatment combination and the minimum dry weight of tuber was obtained in Cardinal with F_0 treatment combination.

4.11. Tuber Yield (Kg/plot)

Tuber yield was significantly influenced by potato varieties and different levels of N+P+K+S+Mg+Zn+B (Figure 1 and 2). Perusal of data indicated that response of all the cultivars to fertilizer management practices increased yield per plot markedly as the doses of N, P, K, S, Mg, Zn and B rate increased upto a certain level and then decreased.

However, the maximum yield per plot (8.88 kg/plot) was found in F_2 treatment and the minimum (2.57 kg/plot) was found in F_0. This might be because of F_2 contained higher amount of potassium compared to the control.

Considering potato cultivars, the maximum tuber yield per plot (7.31kg) was found in Granula and the minimum (6.06 kg/plot) was found in Diamant. Potato cultivars differ in their yield potential; hence there is a differential response to fertilizers even if they belong to same maturity group. Duynisveld *et al*., (1988) and Sharifi *et al*., (2007) have also reported that different cultivars behave differently in terms of yield to the applied fertilizer rates of nitrogen.

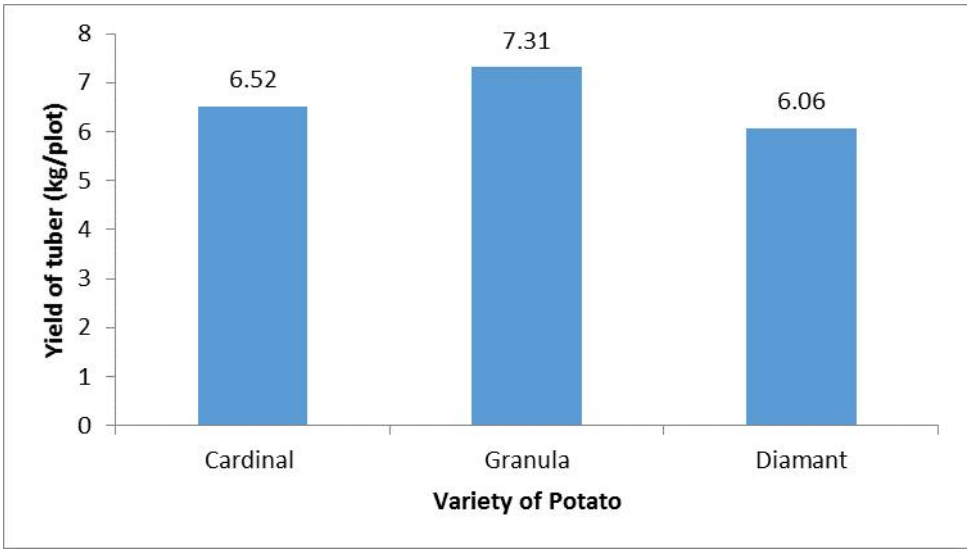


Figure 2. Effects of varieties on yield of tuber per plot

where V_1: Cardinal, V_2: Granola, V_3: Diamant

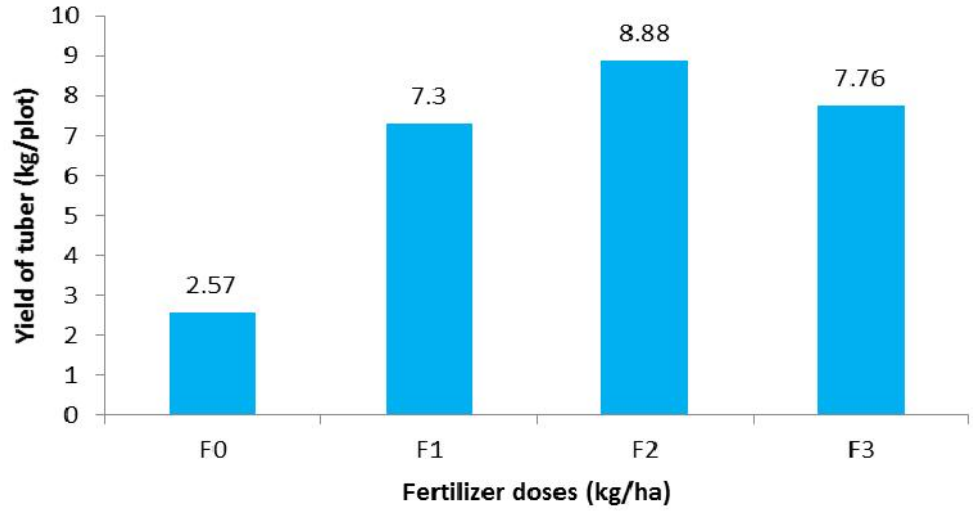


Figure 3. Effects of Fertilizer management on yield of tuber per plot

where F_0: $N_0+P_0+K_0+S_0+Mg_0+Zn_0+B_0$, F_1: $N_{50}+P_{20}+K_{60}+S_5+Mg_5+Zn_2+B_{0.4}$, F_2: $N_{100}+P_{30}+K_{120}+S_{10}+Mg_{10}+Zn_4+B_{0.8}$, F_3: $N_{150}+P_{40}+K_{180}+S_{15}+Mg_{15}+Zn_6+B_{1.2}$.

4.12. Tuber Yield (t/ha)

When per plot yield was converted into per hectare and was expressed in ton, it was significantly influenced by potato varieties and fertilizer rates (Table 4 and 5**)**. Maximum tuber yield, which was significantly higher over other varieties, was obtained from Granola (20.3 t/ ha) followed by Cardinal (18.2 t/ ha) and Diamant (16.84 t/ha) irrespective of fertilizers rates. This may be attributed to the genetical variability of cultivars. As a result yield per plot as well as per hectare were increased.

The variations among the fertilizer treatments were also statistically significant. The maximum yield (24.67 ton/ha) was found in F_2 treatment and lowest yield (7.15 ton/ha) was found in the control treatment. Similar results were found by Blecharczyk and Skrzpezak (1995) and Sarker *et al.,* (1996). Duynisveld *et al*., (1988) and Sharifi *et al*., (2007) have also reported that different cultivars behave differently in terms of yield and bulking rate, to the applied nitrogen. Therefore, F_2 fertilizer treatment might play strong role in potato production in Bangladesh.

Table 4. Effects of varieties on yield of tuber per hectare

Treatment	Yield of tuber (t/ha)
Variety (V)	
V_1	18.12b
V_2	20.30a
V_3	16.84c
Significance	
V	0.001

V_1: Cardinal, V_2: Granola, V_3: Diamant

[Z] Means with different letter (s) in the same column differed significant separated by Tukey's test at $P \leq 0.05$. NS non-significance at $P \leq 0.05$.

Table 5. Effects of Fertilizer management on yield of tuber per hectare

Treatment	Yield of tuber (t/ha)
Fertilizer (F)	
F_0	7.15c
F_1	20.30bc
F_2	24.67a
F_3	21.57b
Significance	
F	0.001

F_0: N_0+P_0+K_0+S_0+Mg_0+Zn_0+B_0, F_1: N_{50}+P_{20}+K_{60}+S_5+Mg_5+Zn_2+$B_{0.4}$,
F_2: N_{100}+P_{30}+K_{120}+S_{10}+Mg_{10}+Zn_4+$B_{0.8}$, F_3: N_{150}+P_{40}+K_{180}+S_{15}+Mg_{15}+Zn_6+$B_{1.2}$.

[Z] Means with different letter (s) the same column differed significant separated by Tukey's test at $P \leq 0.05$. NS non-significance at $P \leq 0.05$.

4.13. Size grades of tubers

4.13.1. Grade size <28 mm in diameter

Different potato varieties showed significant difference in the percentage of small tubers either by number or by weight (Table 6). Potato variety Diamant produced the highest percentage (54.24%) of small tubers by number followed by the other cultivars. Meanwhile Cardinal variety produced the lowest percentage (40.50%) of small tubers by number. The highest percentage (34.19%) of small tubers in weight was produced by Diamant and the lowest percentage (23.19%) was produced by Granola.

The variations among the fertilizer treatments were statistically significant in the percentage of small tuber production either by number or weight. The maximum number of small tubers (68.58%) was found in the control and the lowest (35.22%) was found in F_3 treatment. Similar trend of small tuber production by weight was found among the fertilizer treatments. The highest percentage (68.30%) of small tubers in weight was produced by the control and the lowest percentage (10.68%) was produced by F_2. Similar results were found by Blecharczyk and Skrzpezak (1995) and Sarker *et al.,* (1996). Duynisveld *et al*., (1988) and Sharifi *et al*., (2007) have also reported that different cultivars behave differently in terms of yield and bulking rate, to the applied nitrogen.

The interaction effect of potato variety and different fertilizer management practices was found statistically significant both by number and by weight. The highest percentage of medium tubers by number and weight were found in the treatment combination of variety Diamant with fertilizer management F_0 and the lowest was found in Cardinal with F_2.

Table 6. Effects of fertilizers on tuber grades of three potato varieties.

Treatment	Tuber grades by diameter							
	Small ≈28 mm		Medium 28-40		Large 40-55 mm		Extra Large >55 mm	
	Number (%)	Weight (%)	Number (%)	Weight (%)	Number (%)	Weight (%)	Number (%)	Weight (%)
Varieties								
V_1	40.50c	29.32b	34.07b	42.39b	24.60a	24.56a	4.70b	3.70b
V_2	42.44b	23.34c	35.68a	46.57a	24.35a	23.31a	5.95a	5.86a
V_3	54.24a	34.19a	23.05c	39.59c	21.21b	24.55a	3.55c	2.55c
Fertilizers (F)								
F_o	68.58a	68.30a	25.25d	25.90d	16.67c	5.82d	0.26c	0.01d
F_1	40.73b	20.72b	37.54a	52.51a	19.63c	22.36c	5.24b	4.38c
F_2	35.22d	10.68d	27.88c	43.36c	31.85a	39.13a	7.55a	6.66a
F_3	38.37c	16.10c	33.05b	49.63b	25.41b	29.25b	5.87b	5.11b
Significance								
V	0.001	0.001	0.001	0.001	0.001	NS	0.001	0.001
F	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
V × F	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001

V_1: Cardinal, V_2: Granola, V_3: Diamant, F_1: $N_0+P_0+K_0+S_0+Mg_0+Zn_0+B_0$,
F_2: $N_{50}+P_{20}+K_{60}+S_5+Mg_5+Zn_2+B_{0.4}$, F_3: $N_{100}+P_{30}+K_{120}+S_{10}+Mg_{10}+Zn_4+B_{0.8}$,
F_4: $N_{150}+P_{40}+K_{180}+S_{15}+Mg_{15}+Zn_6+B_{1.2}$. [Z] Means with different letter (s) the same column differed significant separated by Tukey's test at $P \leq 0.05$. NS non-significance at $P \leq 0.05$.

4.13.2. Grade size, 28-40mm in diameter

Various potato cultivars produced significantly different medium size tubers (28-40 mm) either by number or by weight. The percentage of medium tubers among the varieties ranged between 23.05% to 35.68% by number and 39.59% to 46.57% by weight (Table 6). The highest percentage of medium tuber by number and by weight was found in Granola variety and the lowest was found in Diamant. Rashid et al. (1981) found that potato varieties had significant variations in productions of tubers of 28-45 mm diameter size

Different fertilizer management practices showed significant differences in the production of the medium tubers by number or by weight. The percentage of medium tubers as influenced by different fertilizer management was from 25.25% to 37.54% by number and 25.90% to 52.51% by weight (Table 6). The highest percentage of medium tuber both by number and by weight was found in the F_1 and the lowest was found in F_0 fertilizer treatment.

The interaction effect of potato varieties and different fertilizer management practices was found statistically significant both by number and by weight. The highest percentage of medium tuber both by number and by weight was found in Granola with F_0 treatment combination and the lowest was found in Diamant with F_1 treatment.

4.13.3. Grade size 40-55mm in diameter

Different potato varieties showed significant effect on the production of 40-55mm size by number but did not have significant effect by weight (Table 4). The highest percentage (24.60%) of large tuber by number was produced by Cardinal potato cultivar and the lowest (21.21%) was in Diamant.

The maximum percentage (24.56%) of large tubers by weight was produced by Cardinal and the minimum (23.31%) in Diamant.

Fertilizer management practices resulted significant differences in the percentage of large grade tuber either by number or by weight. The percentage of large tubers as influenced by different fertilizer ranged from 16.67% to 31.85% by numbers and 5.82% to 39.13% by weight (Table 6). The highest percentage of large tuber was found in F_2 treatment both by number and by weight. Meanwhile the lowest percentage of tuber both by number and weight was found in the control.

The interaction effect of varieties and fertilizer management practices was statistically significant on large tuber by weight and by number. The highest percentage of large tuber by number or weight was found in the treatment combination of variety Cardinal with F_2 treatment and the lowest was found in variety Granola with F_0 treatment.

4.13.4. Grade size, 55 mm in diameter

Various potato cultivars showed significant variation in the production of extra-large tubers (55mm) either by number or by weight. The highest number of extra-large tubers (5.95%) was found in Granola and the highest weight of extra-large tubers (5.86%) was produced by the same cultivar. Meanwhile, the minimum number of extra-large tubers (3.55%) was found in Diamant and the minimum weight of extra-large tubers (2.55%) was produced by the same variety.

Different fertilizer management practices indicated significant different percentage of extra-large tubers both by number and by weight (Table 6). The highest percentages of extra-large tubers both by the number (7.55%) or weight (6.66%) was found in F_2 treatment and the lowest percentages of extra-large tubers both the number (0.26%) or weight (0.01%) was found in the control.

The interaction effect of varieties and fertilizer management practices on the extra-large tuber (55mm) was found to be significant both by number and by weight. The highest percentage of extra-large tubers by number or weight was found in the treatment combination of variety Granola with F_2 and the lowest was found in variety Diamant with F_0 treatment combination.

CHAPTER 5

SUMMARY AND CONCLUSION

Summary on the effect of potato varieties and fertilizer management practices and their interaction on the growth, yield and yield contributing characters have been given bellow.

Regarding varieties, the minimum days (19.38 days) required for 100% emergence in Cardinal followed by the others and Diamant required the maximum time (19.9 days). The minimum time (19.14 days) required was noted in F_2 and the maximum time (22.1 days) was required in $F_{0.}$ At 30 DAP; the highest plant height (24.84 cm) was measured in Granola while the lowest (22.60 cm) in Diamant. At 45, 60 and 75 DAP; the highest plant height was measured in Granola while the lowest in Diamant for 45, 60 and 75 DAP. Regarding fertilizer management practices, the maximum plant heights for 30, 45, 60 and 75 DAP were recorded from F_3 whereas the minimum plant heights for 30, 45 60 and 75 DAP were recorded from F_0

At 40 DAP, Granola produced the maximum foliage coverage (53.30%) and the minimum area was covered (47.85%) by Diamant. Similar trends of foliage coverage were found at 50, 60 and 70 DAP for different varieties. The maximum foliage coverage was found in Granola for 50, 60 and 70 DAP and the minimum were found in Cardinal. Regarding fertilizer management practices, at 40 DAP, F_3 produced the maximum foliage coverage (58.62%) and the minimum area was covered (31.76%) by F0 treatment. Similar trends of foliage coverage were found in different fertilizer management practices for 50, 60 and 70 DAP. The maximum number of main stem per hill (3.32) was produced by Granola, while the minimum number of main stem (3.27) was found in Cardinal. Regarding fertilizer management practices, The number of main stems per hill was the highest (4.31) in F_2 fertilizer treatment and the lowest (1.78) was found in F_0 fertilizer treatment.

The potato variety of Granola produced the highest (162 g/hill) fresh weight of haulm. On the other hand, the lowest (114.0 g/hill) was found in Diamant. Regarding fertilizer management practices, the highest fresh weight of haulm (140.0 g/hill) was observed from F_2 fertilizer treatment and the lowest (73.0 g/hill) was produced by F_0 treatment.

The highest dry weight of haulm (9.54 g/hill) was found from Granola and the lowest dry weight of haulm (9.7 g/hill) was recorded in Cardinal. Regarding fertilizer management practices, the maximum dry weight of haulm (10.14 g/hill) was obtained

from F_2 fertilizer management practices. The minimum (7.02 g/hill) was obtained from F_0 fertilizer management practices.

The highest number (14.67) was found in Granola cultivar and the lowest number (10.46) was found in Diamant cultivar. Regarding fertilizer management practices, the highest number of tubers per hill (15.53) was given by F_2 fertilizer treatment, while the lowest (6.48) was produced by the plants grown in F_0 fertilizers management

The highest weight of tubers per hill was found in Granola (243.0 g) (Table 3). On the other hand, the lowest weight of tubers per hill was found in Diamant (206.0 g). Regarding fertilizer management practices, the maximum tuber weight per hill (296.0 g) was recorded with the crop was grown with F_2 fertilizer treatment and the minimum tuber weight (93.0 g) was found in F_0 fertilizer treatment.

The mean tuber weight was maximum (183.0 g) in Granola potato variety and the minimum mean tuber weight was 162.0 g in Diamant. Regarding fertilizer management practices, the maximum mean tuber weight (192.2g) was obtained when the crop was grown under organic inorganic fertilizer and the minimum mean tuber weight (131.6 g) was found in the treatment of F_0 fertilizer.

The dry weight of tuber was maximum (13.19 g) in Granola potato variety and the minimum mean tuber weight was 11.81 g in Cardinal. Regarding fertilizer management practices, the maximum dry weight of tubers (13.62 g) was obtained from F_2 whereas F_0 fertilizer treatment gave lower dry weight (11.06 g) of tuber.

The maximum yield per plot (8.8 kg/plot) was found in F_2 treatment and the minimum (2.2 kg/plot) was found in F_0. Considering potato cultivars, the maximum tuber yield per plot (7.31) was found in Granola and the minimum (6.06 kg/plot) was found in Diamant. Maximum tuber yield, which was significantly higher over other varieties, was obtained from Granola (20.3 t/ ha) followed by Cardinal (18.2 t/ ha). Regarding fertilizer management practices the maximum yield (24.67 ton/ha) was found in F_2 treatment and lowest yield (7.1 ton/ha) was found in the control treatment.

Diamant produced the highest percentage (54.24%) of small tubers by number followed by the other cultivars. Similar trend of varieties were found for production of small tuber in weight. Regarding fertilizer management practices, the maximum number of small tubers (68.58%) was found in the control and the lowest (35.22%) was found in F_3 treatment. Similar trend of small tuber production by weight was found among the fertilizer treatments.

The highest percentage of medium tuber by number and by weight was found in Granola variety and the lowest was found in Diamant. Regarding fertilizer management practices the highest percentage of medium tuber both by number and by weight was found in the control and the lowest was found in F_0 fertilizer treatment.

Highest percentage (24.60%) of large tuber by number was produced by Cardinal potato cultivar and the lowest (21.21%) was in Diamant. the maximum percentage (24.56%) of large tubers by weight was produced by Cardinal and the minimum (23.31%) in Diamant. Regarding fertilizer management practices, the highest percentage of large tuber was found in F3 treatment both by number and by weight. The highest number of extra-large tubers (5.95%) was found in Granola and the highest weight of extra-large tubers (5.86%) was produced by the same cultivar. Regarding fertilizer management practices, the highest percentages of extra-large tubers both by the number (7.55%) or weight (6.66%) was found in F_2 treatment.

In conclusion, different varieties of had significant effect on growth and yield of potato tuber. According to the results it can be concluded that Cardinal produce have the capability to produce higher tuber yield with quality grade of potato. On the other hand, fertilizer management practices had significant effect on growth, yield and grade of potato. Among the fertilizer treatment, F_3 can be suitable dose for higher yield with better quality of potato.

Therefore, it can be concluded that Cardinal variety of potato can be grown in Bangladesh by applying F_2 fertilizer doses for producing higher yield with better grade of potato.

CHAPTER 6

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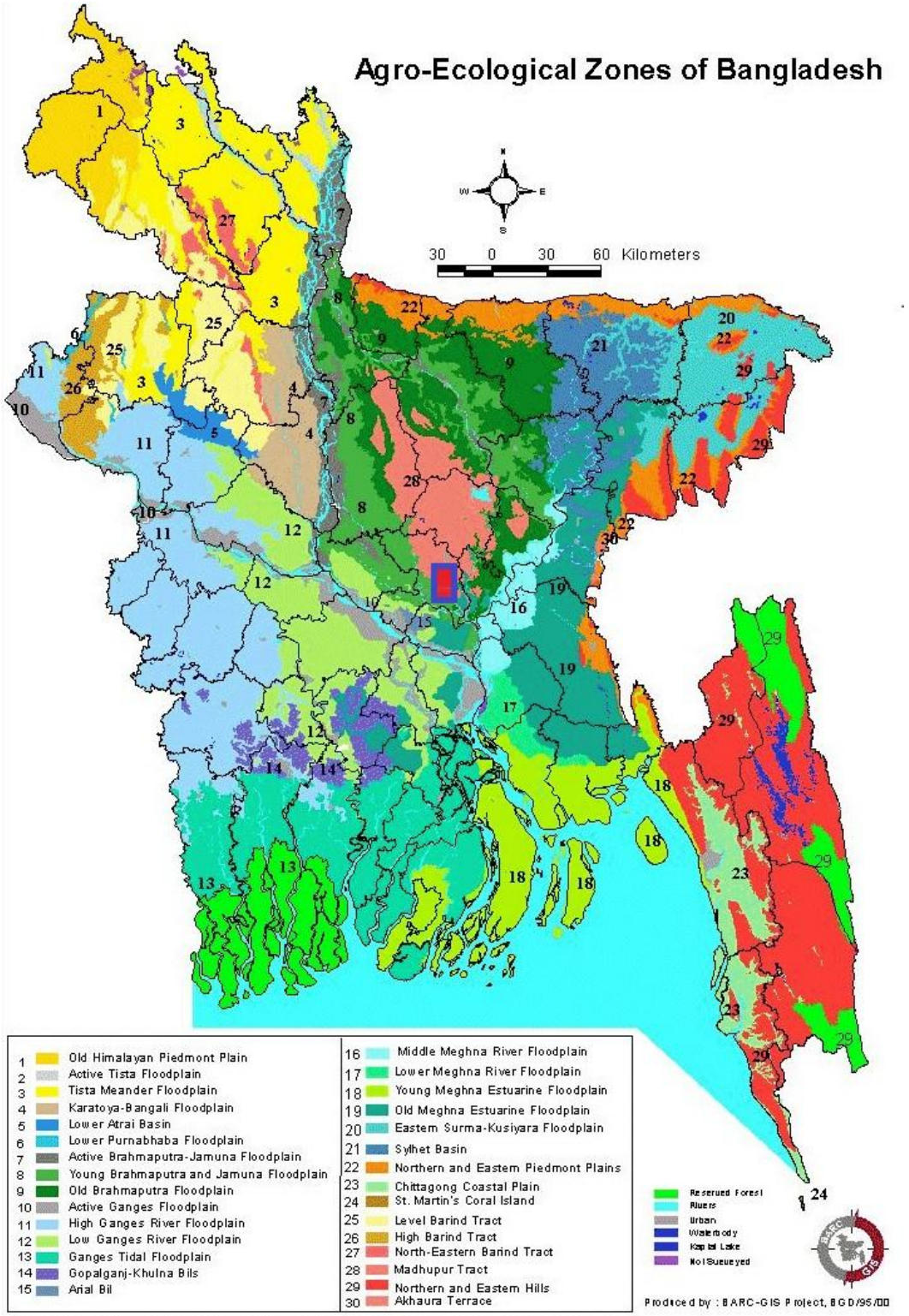
CHAPTER 7
APENDICES

Appendix I:

A. Map of Experimental site



B. Monthly record of air temperature, rainfall, relative humidity and sunshine hours during the period from September 2011 to December 2011

Year	Month	Average air temperature (^{o}C)			Total rainfall (mm)	Average humidity (%)	Total sunshine hours
		Maximum	Minimum	Mean			
2011	September	31.2	25.6	28.4	144	69.41	125.2
	October	30.1	21.2	25.65	64	58.3	167.1
	November	28.5	18.1	23.3	24	49.2	193.3
	December	24.5	13.6	19.05	15	38.6	234.9

Source: Bangladesh Meteorology Department (climate division), Agargaon, Dhaka

Appendix II:

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Experimental Filed, SAU, Dhaka
AEZ	Modhupur tract (28)
General Soil type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained
Cropping pattern	N/A

Source: Soil Resources Development Institute (SRDI), Farmgate, Dhaka.

B. Physical and chemical properties of the initial soil

Characteristics	Value
% Sand	27
% Silt	43
% Clay	30
Textural class	Silty-clay
pH	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20.00
Exchangeable K (me/100g soil)	0.10
Available S (ppm)	45

Source: Soil Resources Development Institute (SRDI), Farmgate, Dhaka.