STUDY ON GROWTH AND YIELD PERFORMANCE OF SOME EXOTIC SWEET POTATO VARIETIES IN RESPONSE TO DIFFERENT RECOMMENDED FERTILIZER DOSES

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CERTIFICATE

This is to certify that the thesis entitled **"STUDY ON GROWTH AND YIELD PERFORMANCE OF SOME EXOTIC SWEET POTATO VARIETIES IN RESPONSE TO DIFFERENT RECOMMENDED FERTILIZER DOSES"** submitted to the Department of Agricultural Botany, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka in partial fulfilment of the requirements for the degree of **Master of Science (MS) in Agricultural Botany**, embodies the results of a piece of bona fide research work carried out by **Md. Mokhlesur Rahman, Registration No. 12-05067** 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 been duly acknowledged by the Author.

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THIS THESIS IS LOVINGLY DEDICATED TO

MY PARENTS

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STUDY ON GROWTH AND YIELD PERFORMANCE OF SOME EXOTIC SWEET POTATO VARIETIES IN RESPONSE TO DIFFERENT RECOMMENDED FERTILIZER DOSES

ABSTRACT

Addition of soil amendments and side-dressing of fertilizers is very crucial to provide soil optimal for healthy growth and higher yield of sweet potato. Therefore, the present experiment was conducted at the Sher-e-Bangla Agricultural University Farm, Dhaka-1207 during May 2018 to April 2019 to observe the yield performance of sweet potato varieties as well as to optimize fertilizer dose for sweet potato cultivation. In this experiment four sweet potato varieties (three exotic and one local) *viz*., Annoh-Beni, Annoh-Kogane, Kokei, BARI Sweet potato12, and three fertilizer doses *viz*., control (no chemical fertilizer and no compost), BARI recommended fertilizer dose and maruhisa (chemical fertilizer + improved compost) were included as treatments following randomized complete block design with three replications. Morpho-physiological characters, yield attributes and yield of sweet potato were significantly influenced by variety and fertilizer doses. At vegetative growth stages, the highest plant height (186.60 cm) was found in 100 DAP in BARI Sweet potato 12 with BARI recommended fertilizer doses. Whereas, the highest number of branch plant^{-1} (7.40), number of leaves plant^{-1} (118.60) were found in BARI Sweet potato 12 with maruhisa (chemical fertilizer + improved compost). The highest tuber length (20.61cm), tuber plant^{-1} (.97 kg), and yield (32.55 t ha^{-1}) were recorded from the treatment Kokei with maruhisa (Chemical fertilizer + improved compost). While the highest tuber diameter (17.75) was found in BARI Sweet potato 12 with BARI recommended fertilizer dose. The lowest value of tuber length (9.48 cm), tuber plant^{-1}(), and yield (6.86 t ha^{-1}) were recorded from the treatment Annoh-Kogane in control condition. The highest dry weight (39.33) was recorded in the combination Annoh-Kogane with maruhisa (Chemical fertilizer + improved compost), and the lowest (32.66) one in BARI Sweet potato 12 in control condition. The highest TSS (14.26 %) was found in Kokei in control treatment, and the lowest (11.56 %) one in Annoh-kogane in BARI recommended dose. Both on the results, Kokei with maruhisa (Chemical fertilizer + improved compost) was the best fertilizer dose in term of yield attribute and yield of sweet potato.

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ABBREVIATIONS USED

GDP	Gross Domestic Product
BBS	Bangladesh Bureau of Statistics
%	Percent
0C	Degree Celsius
DAE	Department of Agricultural Extension
AEZ	Agro Ecological Zone
ANOVA	Analysis of Variance
BARI	Bangladesh Agricultural Research Institute
cm	Centimeter
cm^2	Centimetre Square
CV	Co-efficient of Variation
DW	Dry weight
e.g	For example
et al.	And others
FAO	Food and Agriculture Organization
FAOSTST	Food and Agriculture Organization Statistics
g	Gram
G	Granule
Kg	Kilogram
LSD	Least Significant Difference
m	Metre
mg	Milligram
min	Minute
ml	Millilitre
mm	Millimeter
no.	Number
SAU	Sher-e-Bangla Agricultural University
SI	Serial
SP	Sweet potato
t/ha	Ton per hectare
TSS	Total Soluable Solid
viz.	Namely

CHAPTER-I
INTRODUCTION

Bangladesh is a developing country with agro-based economy which accounts for 13.35% of country's GDP and source of employment of 45.1% of its people (BBS, 2020). That is why agriculture is the main economic culture of Bangladesh. People depend upon agriculture for their employment, poverty alleviation, human resource development and food security. To meet these demands a lot of crops are grown in our country traditionally.

Sweet potato [*Ipomoea batatas* (L.) Lam], a member of convolvulaceae family, is a perennial crop usually grown as an annual and a starchy staple food crop in the tropical, sub-tropical and frost-free temperate climatic zones of the world (Onwueme & Sinha, 1991). It ranks fifth as the most important food crop after rice, wheat, maize and cassava in developing countries (Som, 2007). The crop is known as a highly tolerant tuberous root crop to high temperatures, poor soils, floods and exhibits some resistance to pests and diseases. Sweet potato is usually planted sole or intercropped with other staples such as maize, cassava, yam or okra in West African countries where it is effective in suppressing weed growth in such fields (Eneji *et al.*, 1995).

Though sweet potato crop is easy to cultivate, it is faced with some production and economic constraints. Labor costs are high in some localities; yields remain poor on account of low fertility status of the over-cropped soils, while post-harvest losses and low purchase prices have reduced production and deterred investment. Onunka *et al.* (2012) confirmed that yields of sweet potato is presently restricted by many factors among which are low soil fertility, varietal selection, planting date, weather condition, soil type, weed, insect and disease pressure and crop management practices among others. The crop thrives in marginal soils but improved soil fertility increases its growth and yield performance.

Fertilizer is one of the most important inputs of increasing the productivity of crops (Anon., 1997). In order to obtain good yield, modern varieties of different crops require relatively high quantity of fertilizer compared to the traditional cultivars. However, the economic condition of Bangladesh farmers often does not support them to use required quantity of fertilizers due to its high cost. On the other hand, the organic matter content of most of the soils of Bangladesh is very low (0.8-1.8%) as compared to desired (2.5% and above) levels (Hossain *et al*., 1995).

Therefore, it becomes an immense need to formulate an optimum fertilizer recommendation that would produce satisfactory yields and would maintain soil health to ensure sustainable crop production. One of the alternatives to economize the use of chemical fertilizer is to incorporate crop residues or farmyard manure in combination with chemical fertilizers (Sarker *et al*., 1996). Bhuiya and Akanda (1982) reported that organic matter in combination with chemical fertilizer showed excellent response to rice cultivation. The Integrated Plant Nutrient System (IPNS) emphasizes the need to develop fertilizer management practices for maintenance of proper soil health. The basic concept underlying the IPNS is to provide an ideal nutrition for a crop through a proper combination of various nutrient resources and their optimum utilization along with maintenance of soil productivity.

Although sweet potato is one of the important tuber crops in Bangladesh, the actual yield of this crop is lower than the potential yield. Of the various factors responsible for low yield is the lack of proper management of soil (Elias *et al*., 1991). Soil fertility and productivity status of medium high land in Dhaka district where sweet potato is grown is not satisfactory. Therefore, the present study was undertaken to develop a fertilizer recommendation for sweet potato in medium high land under AEZ 28 at farmer’s field and to determine the profitability of different combinations of fertilizers.

Sher-e-Bangla Agricultural University authority has facilitated to conduct a research project entitled “Feasibility Survey for SDGs Business on Sweet Potato Production, Processing and Marketing for Improvement of Small-Scale Farmers’ Income and Reduction of Post-harvest Losses” with the financial help from JICA and supported by Maruhisa Co. Ltd, Japan. The research has been conducted at Sher-e-Bangla Agricultural University field in Bangladesh with the following objectives:

Objectives:

- To compare the yield performance among the local and exotic Sweet potato varieties
- To find out the suitable fertilizer dose for sweet potato cultivation

CHAPTER II
REVIEW OF LITERATURE

Growth and Yield of sweet potato varieties have been studied in various parts of the world. A very limited number of reports are available on yield performance of sweet potato varieties with different fertilizer doses. Fertilizers influence the physical, chemical and biological properties of soil though its quantity in soil is very small. The response of crops to the applied fertilizers is slow but the residual effect of these fertilizers last for long time. However, available information relevant to this study is reviewed in this chapter.

2.1 Yield Performance of Sweet Potato Varieties

Akther (2018) conducted a field study on Screening of Sweet Potato Varieties [*Ipomoea Batatas* (L.) Lam] for the characters of yield and quality. For screening of 13 BARI Sweet Potato varieties, an experiment was carried out in the Agronomic field of Sher-e-Bangla Agricultural University, Dhaka, during November, 2017 to March, 2018. A total number of 13 varieties were planted with 3 replications Randomized Complete Block Design (RCBD). Different varieties have shown different performance for yield and quality characters. The highest and lowest vine length was observed in BARI SP-12 and BARI SP- 4, respectively. The highest and the lowest leaf area index was observed in BARI SP-11 and BARI SP- 2 respectively. The highest and the lowest chlorophyll was observed in BARI SP-9 and BARI SP- 1 respectively. The highest and the lowest number of tuber/plants was observed in BARI SP-10 and BARI SP- 1 respectively. The highest and the lowest weight of tuber/plant was observed in BARI SP-10 and BARI SP- 2 respectively. The highest and the lowest marketable tuber/plant was observed in BARI SP-9 and BARI SP- 2 respectively. The highest and the lowest weight of tuber/plot and yield was observed in BARI SP-6 and BARI SP- 5 respectively. The highest and the lowest dry weight was observed in BARI SP-11 and BARI SP- 9 respectively. The highest and the lowest TSS was observed in BARI SP-1 and BARI SP- 13 respectively. Higher amount of sugar is present in BARI SP-6. BARI SP-1 contains higher amount of starch and BARI SP- 6 contains lower amount of starch. Among 13 varieties BSP-12 has shown highest amount of carotene content. Different sweet potato varieties show different result because of their different genetic makeup.

Ahmed (2019) conducted a study on Farmers' Performance on Sweet Potato Cultivation and found that variety KOKEI give the highest average yield tons per hectare compared to others. On the other hand, BARI Sweet Potato 12 variety gives lowest yield ton per hectare.

Ali *et al*. (2009) the field experiment was conducted during the rabi season of 2005-06 in the farmer's field of Multi-location Testing (MLT) site, Melandah, Jamalpur to evaluate the performance of sweet potato varieties as well as to determine the optimum dose of fertilizer of sweet potato. Two varieties of sweet potato viz., i) BARI Sweet Potato-5 and ii) BARI Sweet Potato-7 and five fertilizer doses viz., i) Estimated fertilizer dose for average yield goal (EDI for average yield goal), ii) Integrated Plant Nutrient System (IPNS) basis fertilizer dose, iii) Fertilizer Recommendation Guide' 97, iv) Farmer's practice, and v) Control. The highest sweet potato yield was obtained from BARI SP-7 with (IPNS) basis fertilizer doses (33.9 t/ha). The lowest sweet potato yield was obtained from BARI SP-7 with control treatment. The highest gross return (112700 Tk./ha) and gross margin (10756 Tk./ha) was recorded from IPNS basis fertilizer treatment. The lowest gross return (40950 Tk./ha) and gross margin (40951) Tk./ha) was recorded from control treatment. But the cost and return analysis showed that the highest benefit cost ratio (24.95) and marginal rate of return (1452) was found from FRG/97 treatment due to lower additional cost.

Uwah *et al*. (2013) a two-year field study was conducted during the growing seasons of 2007 and 2008 in Calabar, south eastern Nigeria to evaluate the response of two improved sweet potato varieties (TIS 8164 and Ex-Igbariam) to five rates (0, 40, 80, 120 and 160 kg K/ha) of potassium fertilizer. Factorial combinations of the treatments were arranged into a randomized complete block design with three replications. Results showed that Ex-Igbariam was more responsive to K application than TIS8164 as indicated by the production of longer vines, higher number of leaves and branches/plant and heavier vine dry weight at all the applied K rates. Averaged across the two years, revealed that Ex-Igbariam out-yielded TIS8164 by 12.5, 12.7 and 13.3% for number of tubers/plant, weight of tubers/plant and tuber yield/ha, respectively. Application of K at the highest rate (160 kg/ha) significantly ($P<0.05$) increased vine length, number of leaves and branches/plant, whereas dry weight of vine, diameter of tubers/plant and weight of tubers/plant were statistically similar at 120 and 160 kg K/ha rates. Number of tubers/plant and tuber yield/ha peaked at 120 kg K/ha and 160 kg K/ha, respectively. Aggregate tuber yield/ha obtained at 120 and 160 kg K/ha rates were more than 7 and 8 times, respectively higher than the control treatments. Potassium fertilizer application at 120 to 160 kg/ha appeared appropriate for optimum yield for Ex-Igbariam in the study area and is therefore recommended.

Rose and Vasanthakaalam (2011) the aim of the study was to compare the nutritional composition of selected yellow and white sweet potato varieties cultivated in Rwanda. Two yellow varieties (Kwizekumwe, 440170) and two white varieties (Mugande and Rutambira 4-160) were used for the study. Estimation of moisture, ash, protein, crude fibre was conducted using standard AOAC procedures. Total reducing sugars and β carotene was determined by UV Spectrophotometric method. The study revealed that the moisture content in the sweet potato varieties was quite high and ranged between 62.58 ± 0.42 to 64.34 ± 0.42. The crude protein (0.91 ± 0.05) and total reducing sugar (2.50 ± 0.12) content was high in Kwizekumwe and were the least in 440170 variety with 0.7 ± 0.03 and 1.74 ± 0.07 respectively. However, the 440170 variety recorded the highest in crude fibre (0.14 ± 0.00) and the least was observed in

Rutambira 4-160 variety (0.11 ± 0.00). Crude ash was high in Kwizekumwe (0.44±0.07) while Mugande had the least ash content (0.40±0.02). β carotene content was present only in the yellow varieties but was found to be high in Kwizekumwe (1.85±0.00). Thus, Kwizekumwe was found to be more nutritious when compared to the other varieties.

Dziedzoave *et al.* (2009)) in order to select a suitable Ghanaian variety of sweet potato as enzyme source for the production of glucose syrups, four varieties of sweet potatoes –Sauti, Santom pona, Faara and Okumkom– ultivated in two different agro-ecological zones of Ghana were evaluated for b-amylase activity. Faara and Okumkom varieties harvested at 5 months maturity from the forest zone showed the highest b-amylase activity and consequently the most suitable potential enzyme source for the hydrolysis of starchy materials in glucose syrup production. Enhancing b-amylase levels in sweet potatoes has potential cost efficiency advantages in glucose syrup production.

Kassali (2011) conducted a survey on Economics of Sweet Potato Production and found that economic efficiency needs to be ascertained for sustainability. Profitability, scale, and resource use efficiency in sweet potato production were analyzed using data from 90 producers. Cost and returns analysis indicates that labor accounted for 68% of total cost of production and that sweet potato production is profitable. Yield had a greater impact in improving profitability and capital inputs had the least impact in reducing profit. Experience, planting material, output transportation to market, adoption of new varieties, fertilizer level, and full-time farming positively influenced sweet potato output. There is scale inefficiency and no input was used efficiently. Fertilizers and transportation were underutilized; rent, farm implements, planting material, chemicals, and labor were overused. An increase in scale of sweet potato production, more capital inputs, and increase in yield can improve efficiency in sweet potato production.

2.2 Sweet potato

Sweet potato is considered as “poor’s food” in Bangladesh. It is the cheapest source of calories. It produces highest food calories among the tuber and root crops. The sweet potato contains between 16 –40 per cent dry mass, of which 75 – 90 per cent are carbohydrates made up of starch, sugar, cellulose, pectin and hemi-cellulose. Over 95 percent of the global sweet potato is produced in developing countries, where it is the fifth most important food crop in terms of fresh weight.

2.3 Global sweet potato scenario

According to FAO (2017), Sweet potato production from 115 countries was 106,569,572 tons. However, supply remains very concentrated, 82.3 per cent of global production being in Asia. China produces 84.4 % of global sweet potato production, Nigeria contributes 3.3%.USA contributes 1% of global sweet potato production but it has vast marketability. USA imports 49% of sweet potato on global market. Though China produces largest amount of sweet potato, it comprises only 13% of global market. In 2017, global sweet potato production was 112.84 million metric tons whereas it was 103.88 million metric tons in 2015. In global distribution of potato imports scenario Spain imports highest amount of potato 10.2% whereas 40.1% market is under many other countries (FAOSTAT, 2016). So, there is a lot of scope for widening global market of Bangladesh.

2.4 Growth of sweet potato

Sweet potato is the top source of calorie in human diet, containing higher calorie content than other root crops. Sweet potato is traditionally a root crop (Ruiz *et al.*, 1981); the top however is also valuable forage for ruminants and other livestock species (Backer *et al.*, 1980; Figueroa and Rodriguez 1994; Gonzalez *et al.*, 2003; Giang *et al*., 2004). Under improved cultivation, sweet potato is capable of very high dry matter yield per unit area of land (Moat and Dryden, 1993; Rashid *et al*., 2000). Sweet potato vine has a high crude protein content (18-30% in DM), which is comparable to leguminous forages (An *et al,*. 2003; Mupangwa *et al,*.1997; Farrell *et al,*. 2000).

Yield and quality of forage species vary with the age of the plant. Dry matter accumulation usually increases with increasing age while the nutritive value declines (Crowder and Chedda, 1982). Moat and Dryden (1993) reported an increase in dry matter yield of sweet potato, a decrease in protein content, and a fairly constant NDF content in sweet potato forage as the age of the plant increased. Removal of sweet potato vines during growth however reduces the supply of photosynthates during the remainder of the plant's growth with an eventual reduction in root yield (Nwinyi, 1992).

Sweet potato is a natural health food because of its high energy, dietary fiber, vitamins and mineral content (Padmaja, 2009).

Huang *et al.* (2004) reported that the sweet potato leaves contained high amounts of total phenolic and flavonoid compounds, which were responsible which were responsible for its DPPH radical scavenging activity. The nutritive value of sweet potato leaves has been attributed to the high content of antioxidants especially phenolic compounds in them (Islam *et al.,* 2002). Sweet potato is reported to have anti-diabetic property and the components contributing to this effect have been isolated and studied from white-skinned sweet potatoes (Kusano and Abe, 2000).The average storage root yield in Bangladesh is very low as compared to those of other tropical and subtropical countries (Verma *et al.*, 1994) due to cultivation of local and poor quality indigenous sweet potato varieties.

Acidic soils are one of the most important limitations to agricultural production worldwide (Kochian *et al.,* 2004). Acid-soil involves both nutrient deficiencies and toxicities, the tolerance of plants to soil acidity could take the form of efficient uptake and utilization of those nutrients that are deficient under acid soil conditions or outright tolerance to Al and Mn toxicities. Thus, it is important to select acid tolerant sweet potato genotypes with the intention of reducing the dependence of small farmers on lime and fertilizer inputs. Onunka *et al.* (2012) confirmed that yields of sweet potato is presently restricted by many factors among which are low soil fertility, varietal selection, planting date, weather condition, soil type, weed, insect and disease pressure and crop management practices among others. Soils may also become acidified rapidly as a consequence of intensive cultivation of cereals with application of ammonium-based N fertilizer (Mahler and Macdole, 1985) and heavy rain in the monsoon. For example, most of the top soils of the hills, terraces and other flood plains are acidified to variable extends (Sharfuddin and Ahmed, 2005; Sen *et al.*, 1988). Foy *et al.* (1992) stated that selection of genotypes with high adaptability to the acid soils is a promising alternative.

2.5 Sweet potato origin and distribution

Sweet potato originated in central or northwest South America (Yen, 1982; Huaman, 1997; Peet, 2000). At present, it is cultivated in tropical, subtropical, and temperate regions in latitudes between 400north and 400south, and from sea level to elevations of about 2000 m (Huaman, 1997; Peet, 2000). There are about 5000 cultivars present in New Guinea, therefore this area is considered as the secondary center for sweet potato diversity (Yen, 1974).

Sweet potato is a member of the Convolvulaceae family and is more commonly grown as an annual than a perennial crop (Onwueme and Charles, 1994; Norman *et al*, 1995). It is dicotyledonous, herbaceous plant (Duke, 1983; Hahn and Hozyo, 1984; Schultheis and Wilson, 2000) that can be propagated using tuber roots, stem cuttings and seeds;vine cuttings are most commonly used for sweet potato propagation (Onwueme and Charles, 1994; Norman et al, 1995). The plant habit is vine system, twining and cylindrical stems expand rapidly on the ground and increase under shading. The leaves may be rounded, reform (kidney shaped), cordite (heart shaped), triangular, hastate and lobed moderately or deeply (Huaman, 1992).

Leaves are usually horizontal, prostrate (Brown, 1992) and highly variable in their morphology. They are spirally and alternately arranged on the stem. Some cultivars show some variation in leaf shape on the same plant (Huaman, 1997). The root system in sweet potato consists of fibrous roots that absorb nutrients and water, and storage roots that hold photosynthetic products, predominately starches and sugars (Huaman, 1997).

As the plants mature, thick pencil roots with some lignification and other roots that have no lignification become fleshy and thicken and are called storage roots or tubers (Huaman, 1997). Tuber masses vary widely depending on cultivar and environmental conditions (Martin, 1988; Goswami *et al*., 1995; Anselmo *et al*. 1998). The development cycle of sweet potato from crop planting to harvesting of storage roots vary depending on the variety, soil type, and moisture and temperature conditions. Bertelson *et al*. (1994) reported the duration ranges from 70 to 150 days, while Ehisiannya *et al*. (2011) reported that sweet potato reaches maturity at three to eight months after planting.

2.6 Eco physiology

Sweet potato is grown over a broad range of environment and cultural practices and is commonly found in low input agriculture (Prakash, 1994). Genetic and environment factors determine crop growth and yield. Consequently, different crop genotypes may perform differently under diverse environmental conditions. Biophysical factors such as soils, pests and diseases, and other environmental variables, including temperature, light intensity and soil moisture affect physiological responses, growth and yield. Certain ecological ranges are required for sweet potato to produce maximum yield.

Sweet potato requires a moist sandy loam soil with good drainage and pH between 5.6 and 6.6 (Martin, 1988). Warm days and nights are the optimal conditions for sweet potato growth and development (McCraw, 2000). It is a warm weather crop and the best temperatures for growth and yield are above 240 C; growth is severely retarded at minimum temperatures below 100 C (Onwueme and Charles, 1994). Sweet potato grows best under relatively high light intensity, shading therefore should be avoided (Onwueme and Charles, 1994). It requires a short-day length of 11 hours or less to stimulate tuber formation, while long days tend to favor vine growth at the expense of the root tubers (Onwueme and Charles, 1994).

Sweet potato is highly sensitive to excessive rainfall and to deficit in soil moisture. The crop requires at least 500 mm of rainfall during growing season with optimum levels at 750-1000 mm (Onwueme and Charles, 1994).

Water supply has to be maintained during the first 40 days after planting, and during the tuber formation stage at 7 to 9 weeks after planting (Valenzuela *et al.*, 2000). Maintaining soil moisture above the wilting point during the whole season is essential for the growth and development of storage roots. The yield of storage roots is known to decrease under water deficit stress below 20% of soil water availability (Indira and Kabeerathumma, 1988). Due to its intolerance of a limited water supply, the production of sweet potato crops in drought prone semi-arid regions has not been reliable (Yen, 1982).

The photosynthetic pathway of sweet potato is similar to that of C3 plants (Kays, 1985). During the early growth period, the net photosynthesis rate (PN) is highest. It declines at the end of growth periods as the sink attains its maximum size (Bhagsari and Harmon, 1982). The rate of photosynthesis in individual leaves of sweet potato is affected by leaf age, and young fully expanded leaves tend to have higher photosynthetic rates. Common leaf chlorophyll concentrations lie between 7.6 and 10.6 mg/g leaf dry mass (Bhagsari and Harmon, 1982).

2.7 Morpho-physiology of sweet potato

Sweet potato seedling showed the tendency of producing primary branches in the terminal or apical part of the cuttings was more than those of the basal parts and the tip vine produced the maximum branches. Choudhury *et al.* (1986). Shen *et al.* (2015) reported that number of vine plant^{-1} ranges from 10.4-13.3 due to available nutrient present in soil. Delowar and Hakim (2014) stated that the fresh weight of leaves varied for soil characteristics and minimum growth of the plant occurred perhaps due to a variation in soil acidity. Dayal *et al*. (2006) stated that dry matter content of the sweet potato influenced the growth performance of the plant. Dayal *et al*. (2006) reported that the dry matter of fibrous root was 2.23-0.97%. Dry matter of non-storage root was higher in those genotypes whose poor plant growth but higher accumulation rate in non-storage roots. Farooque and Husain (1973) also showed that the storage roots number plant–1 varied from 4.70-11 and it depends on the genotypes of sweet potato.

Nitrogen (N) is an important factor in determining the yield and nutrient composition of root tubers (Constantin *et al*., 1984). Among the mineral nutrient elements, N most often limits plant growth and yield (Raymond *et al*., 1998). It is the most essential mineral nutrient for plant growth and development and its proper management is essential in an intensive agriculture for plant production. Nitrogen application was shown to linearly increase dry matter, carotenoid and protein content of sweet potato (Constantin *et al.,* 1984). Villagarcia found that the response of sweet potato to nitrogen fertilizer application depends highly on genotypic and environmental variations (Villargarcia, 1996).

Rashid *et al*. (2002) and Farooque and Husain (1973) showed that the length of the storage roots differed among the varieties. Rashid et al. (2002) and Farooque and Husain (1973) showed that the length of the storage roots differed among the varieties. Siddique et al. (1988) stated that the fresh weight of storage roots plant^{-1} varied widely the different genotypes. Delowar and Hakim (2014) reported that dry weight of storage roots depends on the varietal performance to the particular soil. The result showed that some genotypes failed to show the relationship of fresh weight to the dry weight of the storage roots. Naskar and Chowdhury (1994), Siddique *et al.* (1988) and Yooyongwech *et al*. (2014) found that yield potentiality of sweet potato depends on the genetic make-up plant. Sen *et al*. (1988) stated that significant variations among the genotypes were happened may be due to the adoption of proper cultural management techniques.

Tuber yield was determined from the actual area of each plot, which, according to Romani *et al.* (1993), provides a good estimate of true yield. This is also supported by Neppl *et al.* (2003) whose study indicated that interactions of centre row with border row were insignificant. Jahan *et al*. (2009) reported that harvest time had a significant effect on the weight of a tuber, with the maximum weight obtained at 150 days after planting. Monamodi *et al.* (2003) who reported that the dry weight of sweet potato increases linearly during the crop development stage. Jahan *et al*. (2009) also came to the conclusion that there is a significant effect of harvest time on the dry matter content of storage-roots.

CHAPTER III
MATERIALS AND METHODS

This chapter deals with the major information regarding materials and methods those were used and followed conducting the experiment. It consists of a short description of locations of the experimental site, characteristics of soil, climate, materials, layout and design of the experiment, land preparation, manuring and fertilizing, transplanting of seedlings, intercultural operations, harvesting, data recording procedures, economic and statistical analysis etc., which have been presented as follows;

3.1 Experimental site

The research work relating to determine the growth and yield performance of sweet potato varieties response to different fertilizer doses was conducted at the Sher-e-Bangla Agricultural University Farm, Dhaka-1207 during May 2018 to April 2019.

3.2 Location

3.2.1 Geographical Location

The experimental area was situated at 23°77'N latitude and 90°33'E longitude at an altitude of 8.6 meter above the sea level (Anon., 2004). The experimental field belongs to the Agro-ecological zone of "The Modhupur Tract", AEZ-28 (Anon., 1988a). This was a region of complex relief and soils developed over the Modhupur clay, where floodplain sediments buried the dissected edges of the Modhupur Tract leaving small hillocks of red soils as ‘islands' surrounded by floodplain (Anon., 1988b). The experimental site has been shown in the map of AEZ of Bangladesh in Appendix I.

3.2.2 Climate

Area has subtropical climate, characterized by high temperature, high relative humidity and heavy rainfall in Kharif season (April-September) and scanty rainfall associated with moderately low temperature during the Rabi season (October-March). Weather information regarding temperature, relative humidity, rainfall and sunshine hours prevailed at the experimental site during the study period has been presented in Appendix II.

3.3 Characteristics of soil

Soil of the experimental site belongs to the general soil type, Shallow Red Brown Terrace Soils under Tejgaon Series. Top soils were clay loam in texture, olive gray with common fine to medium distinct dark yellowish-brown mottles. Soil pH ranged from 6.1- 6.3 and had organic matter 0.84%. Experimental area was flat having available irrigation and drainage system and above flood level. Soil samples from 0-15 cm depths were collected from experimental field. The analyses were done by Soil Resource and Development Institute (SRDI), Dhaka. Physicochemical properties of the soil are presented in Appendix III.

3.4 Treatments of experiment

The research work was conducted with two sets of treatments (factors) consisting of 4 sweet potato varieties and 3 levels of fertilizers. The factors with their levels were as follows:

Factor A: sweet potato varieties (4)

V_1 = Annoh-Beni (Japan)
V_2 = Annoh-Kogane (Japan)
V_3 = Kokei (Japan)
V_4 = BARI Mistialu 12 (Bangladesh)

Factor B: Three (03) fertilizer doses

T_0 = Control (No chemical fertilizer and no compost),

T_1 = BARI fertilizer dose (Urea, 300 kg ha^{-1}; TSP, 250 kg ha^{-1}; MoP, 200 kg ha^{-1} and Cowdung, 10ton ha^{-1})

T_2 = Maruhisa (Chemical fertilizer + Improved compost) (Urea, 160 kg ha^{-1}; TSP, 440 kg ha^{-1}; MoP, 440 kg ha^{-1}; Mag, 22.5 kg ha^{-1} and Compost, 10 ton ha^{-1}).

Treatments

Thus there were 12 treatment combinations, which are given below:

i. V_1T_0
ii. V_1T_1
iii. V_1T_2
iv. V_2T_0
v. V_2T_1
vi. V_2T_2
vii. V_3T_0
viii. V_3T_1
ix. V_3T_2
x. V_4T_0
xi. V_4T_1
xii. V_4T_2

3.5 Design of the experiment

Two-factor experiment consisting of 12 treatment combinations was laid out in the Randomized Complete Block Design (RCBD) with three replications. At first the whole experimental area was marked with the measuring tape and rope. Total experimental area (309.1 m^2 x 200 m^2) was divided into three equal blocks, representing the replications. The total number of plots was 36. Size of each unit plot was 3 m x 1.8 m. There were 12 unit plots in each block. The row to row distance maintained was 60cm and plant to plant distance was 30cm.

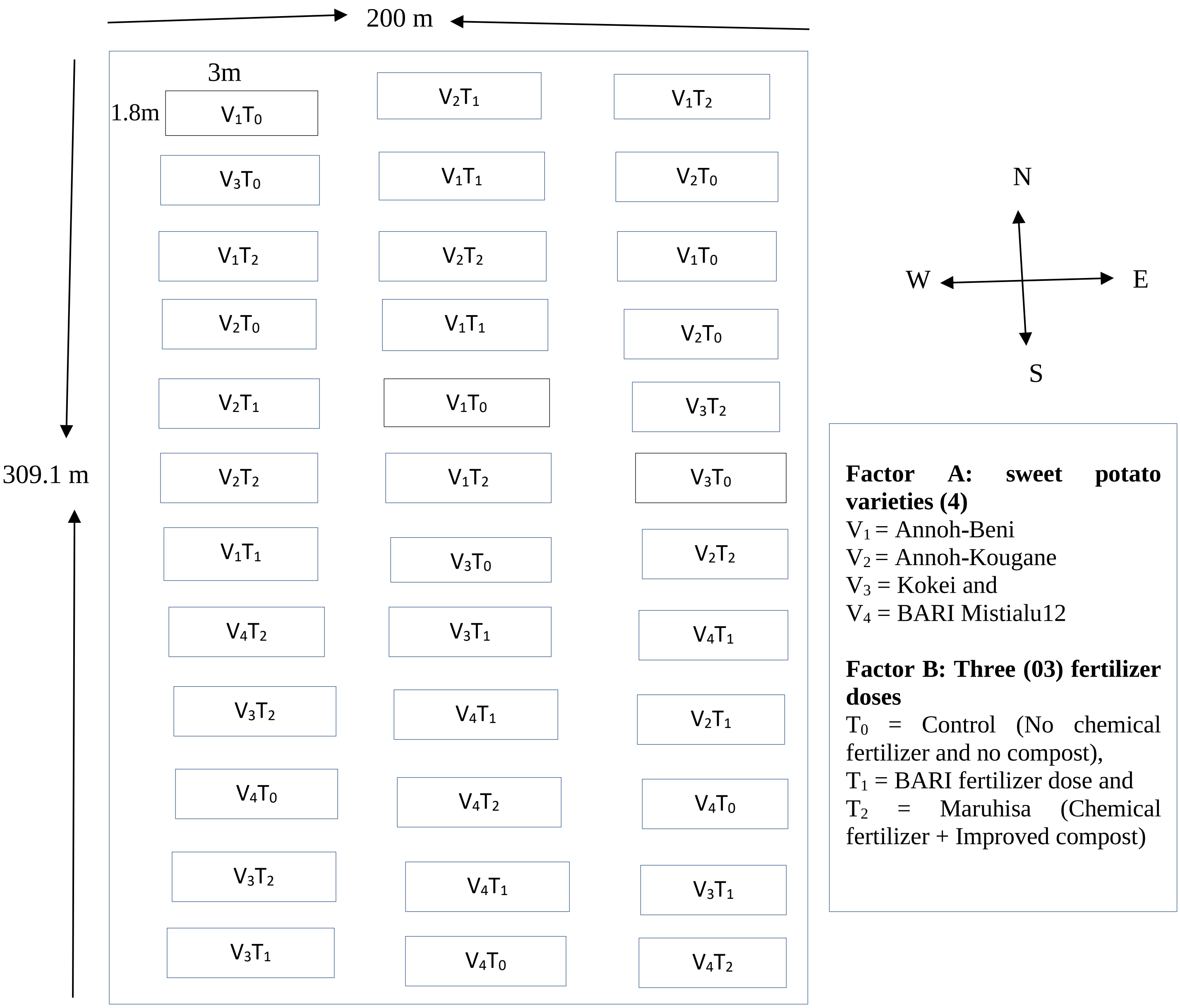

Figure 1. Experimental layout

3.6 Methods of sweet potato cultivation

3.6.1 Land preparation

Experimental plot was fallow during land preparation. The land was first opened on May 20, 2018 with a power tiller and it was exposed to the sun for few days prior to next ploughing followed by laddering to obtain good tilth. Weeds were uprooted and stubbles were removed from the field with the help of spades. Big clods were broken into fine soil particles and the surface was leveled until the desired tilth obtained. The soil was treated with insecticides (Cinocarb 3G @ 4kg/ha) at the time of final land preparation to protect young plants from the attack of insects such as cutworm and mole cricket. Experimental field was made plain and the plots were laid out according to plan.

3.6.2 Application of manures and fertilizers

The following doses of manures and fertilizers recommended by Rashid (1999) were applied to the experimental plots to grow the crop as below:

Manure/ fertilizers	Dose/ha	Dose/plot*
Well decomposed cowdung	14ton	6.80kg
Urea	260kg	122gm
Triple Super Phosphate (TSP)	395gm	72gm
Fertilizer	As per level of treatment	As per level of treatment

The entire amount of cowdung was applied at the time of initial land preparation and the total amount of urea and TSP was applied during final land preparation.

3.7 Vine transplanting

Vine of 4 sweet potato genotypes were transplanted on 5th October 2018 in rows of 60 cm apart, at the rate of 1080 pieces vine per ha.

3.8 Intercultural operations

Following intercultural operations were done during the period of field experiment:

i) Gap filling

Transplanted vines in the experimental plot were kept under careful observation. Very few vines were damaged after transplanting and such vines were replaced by new vines from the same stock planted earlier on the border of the experimental plots. Those vines were transplanted with a big mass of soil with roots to minimize transplanting shock. Replacement was done with healthy vines having a boll of earth which were also planted on the same date by the side of the unit plot. Transplants were provided with shade and irrigation for 7 days for their proper establishment.

ii) **Weeding**

Hand weeding was done at 15, 30 and 45 days after planting to keep the plots free from weeds.

iii) Mulching

Mulching was done as soon as the soil became workable after irrigation by breaking the crust of the soil for easy aeration and to conserve soil moisture as and when needed. This operation was done by khurpi or nirani.

iv**) Earthing up**

Earthing up was done at 20 and 40 days after transplanting on both sides of rows by taking the soil from the space between the rows by a small spade.

v) Irrigation

Light watering was given at every morning and afternoon according to its requirements and was continued for a week for well establishment of the transplanted vines.

vi) Pest and disease control

Insect infestation was a serious problem during the period of establishment of vines in the field. In spite of Cinocarb 3G applications during final land preparation few young plants were damaged due to the attack of mole cricket and cut worm. Cut worms were controlled both mechanically and spraying Darsban 29 EC @ 3%. Some of plants were infected by Alternaria leaf spot disease caused by Alternaria brassicae. To prevent the spread of the disease Rovral @ 2 g per liter of water was sprayed in the field. The diseased leaves were also collected from the infested plant and removed from the field. The nightingale visited the fields in the morning and afternoon. The birds were found to puncture the soft leaves and newly initiated curd and were controlled by striking kerosene tin frequently during day time.

3.9 Harvesting

Harvesting of the sweet potato crop was not possible on a certain or particular date because curd initiation as well as tuber maturation period in different plants were not uniform or similar probably due to different management practices and genetic or other factors. Only the compact mature tubers were harvested with 2-4 cm deep by using a sharp khurpi or nirani. After harvesting the main tuber, secondary shoots were developed from the main shoots, which also developed new roots and transformed into small secondary tubers and were harvested over a period of time. The crop under investigation was harvested for the first time on March 30, 2019 and the last harvesting was done on April 7, 2019.

3.10 Data collection

Ten plants were randomly selected from the middle rows of each unit plot for avoiding border effect except yields of tubers, which was recorded plot wise. Data were collected in respect of the following parameters to assess Vine length, number of branch, Number of leaf, tuber number, tuber length, tuber diameter, tuber weight and colour, total weight per plant, dry weight of tuber were recoded from collected root tuber at 40, 70 and 100 days after planting (DAP). All other parameters were recorded during harvest and after harvest. Data were recorded on the following parameters:

A. growth Parameter

1) Plant height (Vine length)
2) Number of branch plant^{-1}
3) Number of leaf plant^{-1}

B. Yield parameter:

1. Tuber length (cm)
2. Tuber diameter (cm)
3. Tuber weight plant^{-1} (kg)
4. Yield (t ha^{-1})

c. Quality parameter

1) Dry weight
2) TSS%

3.11 Sampling procedure for growth study during the crop growth period

3.11.1 Plant height (vine length)

Sweet potato plant height was recorded at 100 DAP. Height was measured by scale. Height of 5 plants from each plot was recorded.

3.11.2 No. of branches/plant

Number of branches of 5 randomly selected plants were recorded at 100 days after transplanting. The average number of branches of 5 plants were treated as number of branch/plants.

3.11.3 Leaves/plant

Leaves/plant of 5 randomly selected plants were recorded at 100 days after transplanting. The average leaves/plant of 5 plants were calculated and recorded as number of leaves/plants.

3.11.4 Diameter of tuber (cm)

Tuber diameter was recorded in several directions with a meter scale at matured stage from five randomly selected plants and each of plant was measured separately.

3.11.5 Number of leaves per plant

Number of leaves per plant of five randomly selected plants were counted at harvest. All the leaves of each plant were counted separately. Only the smallest young leaves at the growing point of the plant were excluded from counting.

3.11.6 Tuber length (cm)

A meter scale or tap (flexible) was used to measure the length of tubers. Tuber length of five randomly selected plants were measured in centimeter (cm) at harvest. It was measured from the base of the root tuber to the tip of the tuber. All the leaves of each plant were measured separately. Only the smallest young leaves at the growing point of the plant were excluded from measuring.

3.11.7 Number of tuber/plants

Number of tuber per plant was counted from the 5 replications. The average number of tuber/plant produce the number of tuber per plant.

3.11.8 Weight of tuber/plant

All tubers of selected plant were collected. Then these were placed on the digital balance for the calculation of weights.

3.11.9 Yield (t / ha)

The yield per hectare was calculated by converting the per plot yield data to per hectare and was expressed in ton (t).

3.11.10 Dry matter content

The dry sample content of sweet potatoes was determined by drying a representative 100g sweet potato sample at 80 °C for 72 h in a laboratory drying in oven. The dry matter content (%) was calculated by using the loss weight and the fresh sample weight according to the following formula.

Dry matter (%) = Dry weight of sample /Total fresh weight of sample x 100

3.12 Statistical analysis

The data obtained from the characters were statistically analyzed to find out the variation resulting from experimental treatments with R package. The difference between treatments was adjusted by Least Significant Different Test (LSD) (Gomez and Gomez, 1984).

CHAPTER 4

RESULTS AND DISCUSSION

Results obtained from the study on growth and yield performance of Sweet potato varieties in different fertilizer doses have been presented and discussed in this chapter.

4.1 Plant height (cm)

Plant height was significantly influenced by performance of varieties at different days after planting (DAP) (Figure 2 and Appendix IV). The tallest (62.26 cm) plant was recorded from V_4 (BARI Sweet potato12) variety which was followed by (60.93 cm) at V_3 and the shortest (53.35 cm) plant was recorded from V_1 at 40 DAP. The tallest (105.30 cm) plant was recorded from V_4 (BARI Sweet potato12) variety which was followed by (90.31 cm) variety V_3 and the shortest (87.76 cm) plant was recorded from V_1 at 70 DAP. The tallest (175.05cm) plant was recorded from V_4 (BARI Sweet potato12) variety which was followed by (133.95 cm) variety V_1 and the shortest (130.43 cm) plant was recorded from V_3 at 100 DAP.

The application of different levels of fertilizers markedly influenced the height (length) of plants (Figure 3 and Appendix IV). An increasing trend in plant height was observed due to increase of fertilizer levels. The maximum plant height (163.55 cm) was recorded from the treatment Maruhisa dose (Chemical fertilizer + Improved compost) (T_2) which was followed by (150.64 cm) T_1 treatment and minimum plant height (114.79 cm) was recorded from the control T_0 treatment plants at 100 DAP. The plant height increased with the progress of time. This might be due to the fact that fertilizer supplied adequate plant nutrients for better vegetative growth of sweet potato which ultimately increased plant height. Yang et al. (2006) also found the similar result in case of plant height.

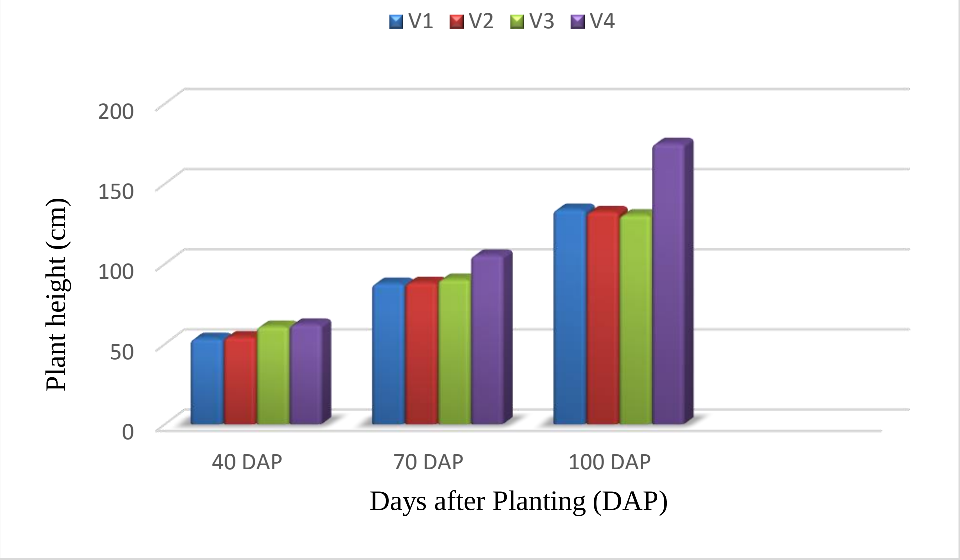

Figure 2. Effect of performance of different varieties on plant height at different days after planting of sweet potato varieties

V_1: Annoh-Beni, V_2: Annoh-Kougane, V_3: Kokei, V_4: BARI Sweet potato12

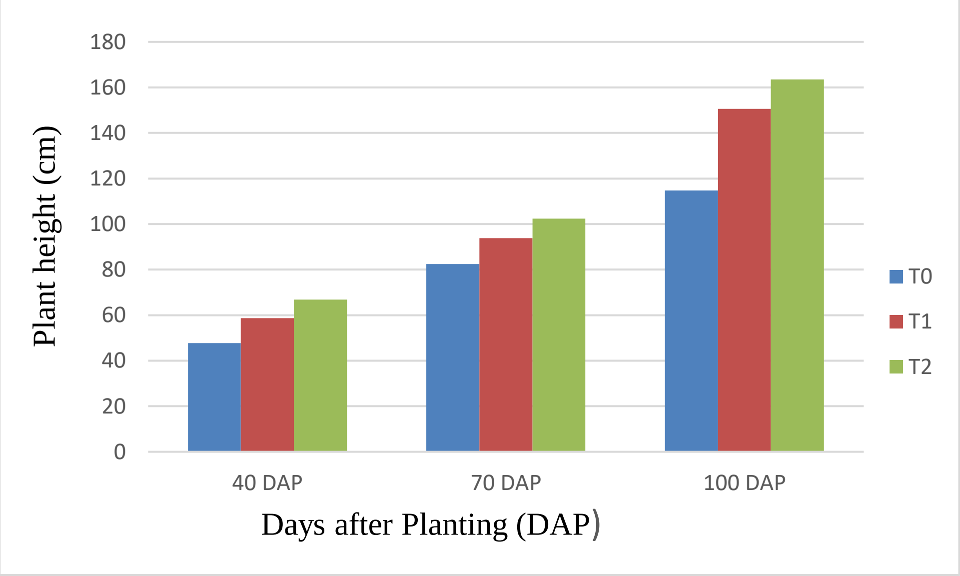

Figure 3. Effect different levels of fertilizers application on plant height at different days after planting of sweet potato varieties

T_0: Control (No chemical fertilizer and no compost), T_1: BARI fertilizer dose, T_2: Maruhisa dose (Chemical fertilizer + Improved compost)

Table 1. Interaction effect of sweet potato variety and different doses of fertilizer on plant height at different days after planting

Plant height (cm)			
Treatments	**40 DAP**	**70 DAP**	**100 DAP**
V_1T_0	44.25f	81.28g	107.05de
V_1T_1	55.37de	85.27f	141.74c
V_1T_2	60.44bc	96.74d	153.07bc
V_2T_0	46.73f	81.42g	107.18de
V_2T_1	56.94cd	86.55f	136.20cd
V_2T_2	59.41bc	96.86d	154.22bc
V_3T_0	47.22f	73.82h	88.79e
V_3T_1	60.72bc	96.28de	138.00c
V_3T_2	74.86a	100.82c	164.49ac
V_4T_0	52.49e	93.54e	156.14bc
V_4T_1	61.88b	107.33b	186.60a
V_4T_2	72.41a	115.04a	182.42ab
LSD Value	3.868	2.853	29.933
CV (%)	3.957	1.813	12.362

Mean followed by the same letters are not significantly different ($p<0.05$) according to LSD test.

V_1: Annoh-Beni, V_2: Annoh-Kougane, V_3: Kokei, V_4: BARI Sweet potato12
T_0: Control (No chemical fertilizer and no compost), T_1: BARI fertilizer dose, T_2: Maruhisa dose (Chemical fertilizer + Improved compost)

The effect of interaction between variety and different doses of fertilizer on plant height at 40, 70, 100 days after planting was significant. The tallest plant (186.60 cm) was recorded in the combination of BARI Sweet potato 12 and BARI fertilizer dose and the shortest one was recorded in the combination of variety Kokei and control condition (Table 1 and Appendix IV).

4.2 Number of branches per plant

Number of branches per plant was varied significantly by performance of different sweet potato varieties at different days after planting (DAP) (Figure 4 and Appendix IV). The maximum number of branches per plant (5.42) was recorded from V_4 (BARI Sweet potato12) variety which was followed by the variety V_3 (5.28) and the minimum number of branches per plant (3.82) was found from the closest spacing in V_1 at 100 DAP.

The application of different levels of fertilizer markedly influenced the number of branches per plant (Figure 5 and Appendix IV). The maximum number of branches per plant (6.57) was recorded from the Maruhisa dose (Chemical fertilizer + Improved compost) which was followed by (5.17) obtained from T_1 treatment and minimum number of branches per plant (2.66) was recorded from the control T_0 treatment at 100 DAP.

The effect of interaction of variety and fertilizer management had significant influence on branch per plant (Table 2). It was found that interaction between BARI Sweet potato 12 and the dose of Maruhisa (chemical fertilizer + improved compost) dose produced the highest branch per plant (2.93, 6.26 at 40, 70 DAP respectively) and 7.40 at 100 DAP. The shortest branch per plant (.26) was recorded from the interaction between Annonh-Beni and control treatment followed by Annoh-Kogane and control at 70 DAP and 100 DAP respectively.

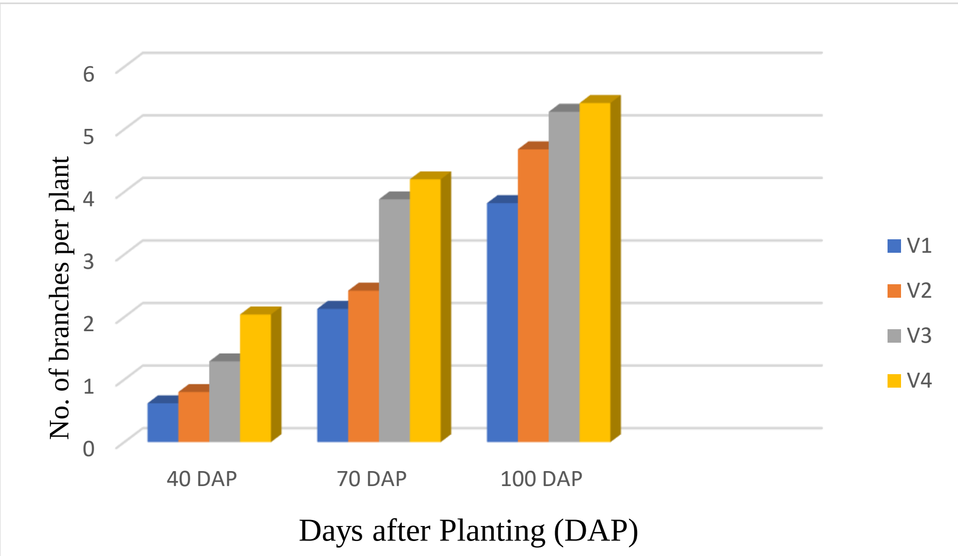

Figure 4. Effect performance of different sweet potato varieties on number of branches per plant at different days after planting

V_1: Annoh-Beni, V_2: Annoh-Kougane, V_3: Kokei, V_4: BARI Sweet potato12

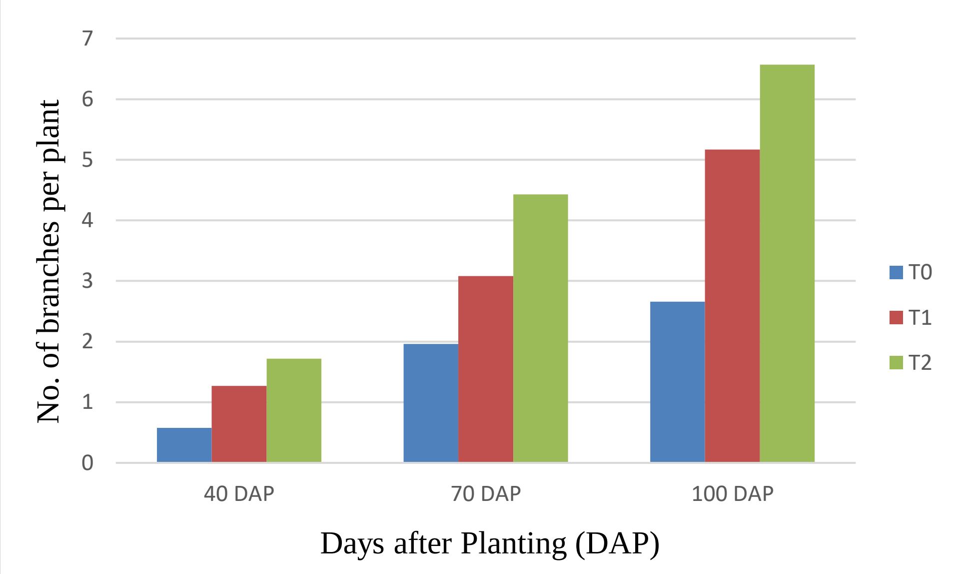

Figure 5. Effect of different levels of fertilizers application on number of branches per plant at different days after planting of sweet potato varieties

T_0: Control (No chemical fertilizer and no compost), T_1: BARI fertilizer dose, T_2: Maruhisa dose (Chemical fertilizer + Improved compost)

Table 2. Interaction effect of sweet potato variety and different doges of fertilizer on branch per plant at different days after planting

	Branch / plant		
Treatments	**40 DAP**	**70 DAP**	**100 DAP**
V_1T_0	0.26g	1.46fg	2.13d
V_1T_1	0.66ef	2.26de	4.20c
V_1T_2	0.93de	2.66ce	5.13b
V_2T_0	0.40fg	1.20g	2.26d
V_2T_1	0.93de	3.06bc	5.06b
V_2T_2	1.07cd	3.00b-d	6.73a
V_3T_0	0.60eg	3.20bc	2.73d
V_3T_1	1.33c	3.60b	5.73b
V_3T_2	1.93b	5.80a	7.03a
V_4T_0	1.07cd	2.00ef	3.53c
V_4T_1	2.13b	3.40bc	5.70b
V_4T_2	2.93a	6.26a	7.40a
LSD Value	0.3531679	0.791	0.767
CV (%)	17.54298	14.787	9.421

Mean followed by the same letters are not significantly different ($p<0.05$) according to LSD test.

V_1: Annoh-Beni, V_2: Annoh-Kougane, V_3: Kokei, V_4: BARI Sweet potato12

T_0: Control (No chemical fertilizer and no compost), T_1: BARI fertilizer dose, T_2: Maruhisa dose (Chemical fertilizer + Improved compost)

4.3 Number of leaves per plant

Number of leaves per plant was varied significantly by performance of different sweet potato varieties at different days after planting (DAP) (Figure 6 and Appendix V). The maximum number of leaves per plant (86.66) was recorded from V_4 (BARI Sweet potato12) variety which was followed by V_2 (60.33) and the minimum number of leaves per plant (52.77) was found from the V_1 at 100 DAP. It is probably due to inter plant competition having reduced access to nutrient and other resources. The result obtained from the experiment by Kunicki et al. (2005) supported this result under the present study.

The application of different levels of fertilizer application markedly influenced the number of leaves per plant (Figure 7 and Appendix V). The maximum number of leaves per plant (86.01) was recorded from the Maruhisa dose (Chemical fertilizer + Improved compost) which was followed by (69.20) obtained from T_1 treatment and minimum number of leaves per plant (37.38) was recorded from the control T_0 treatment at 100 DAP. The number of leaves per plant was increased mainly due to the increased vegetative growth of the plant. Yang et al. (2006) also found the similar result in case of number of leaves per plant

Number of leaf plant-1 was significantly influenced by the interaction of variety and fertilizer management (Table 3 and Appendix V). It was observed that BARI Sweet potato12 produced the highest number of leaf plant^{-1} (55.40, 118.60) with Maruhisa dose (chemical + improved compost) at 70 DAP and 100 DAP followed by the BARI Sweet potato 12 with the combination of BARI recommended fertilizer dose. The lowest number of leaf plant^{-1} 12.73 and 17.30 was recorded from the interaction Annoh-Kogane with control (no chemical fertilizer and no compost) at 40 and 70 DAP and at 100 DAP, 31.93 leaves was recorded from Annoh-Beni and control (No chemical fertilizer and no compost).

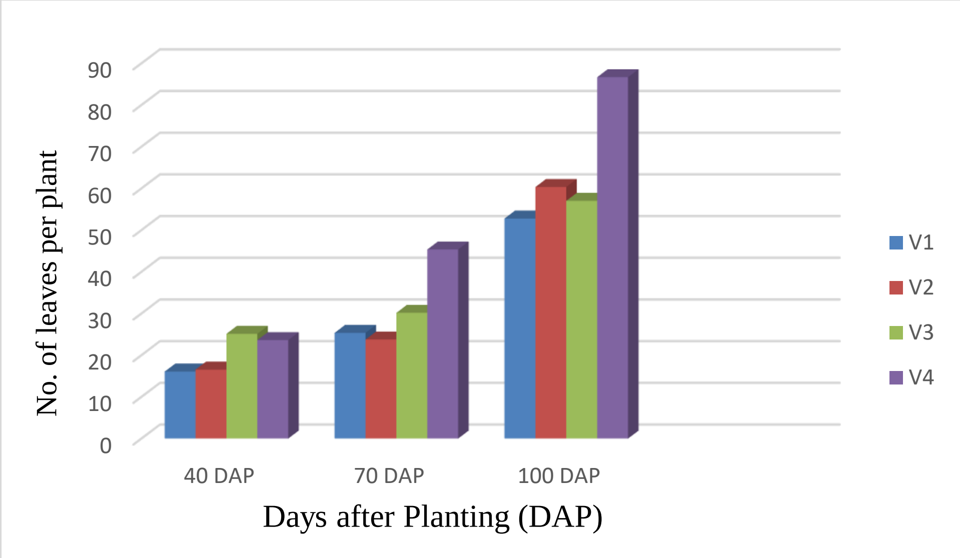

Figure 6. Number of leaves of 4 sweet potato varieties
V_1: Annoh-Beni, V_2: Annoh-Kougane, V_3: Kokei, V_4: BARI Sweet potato12

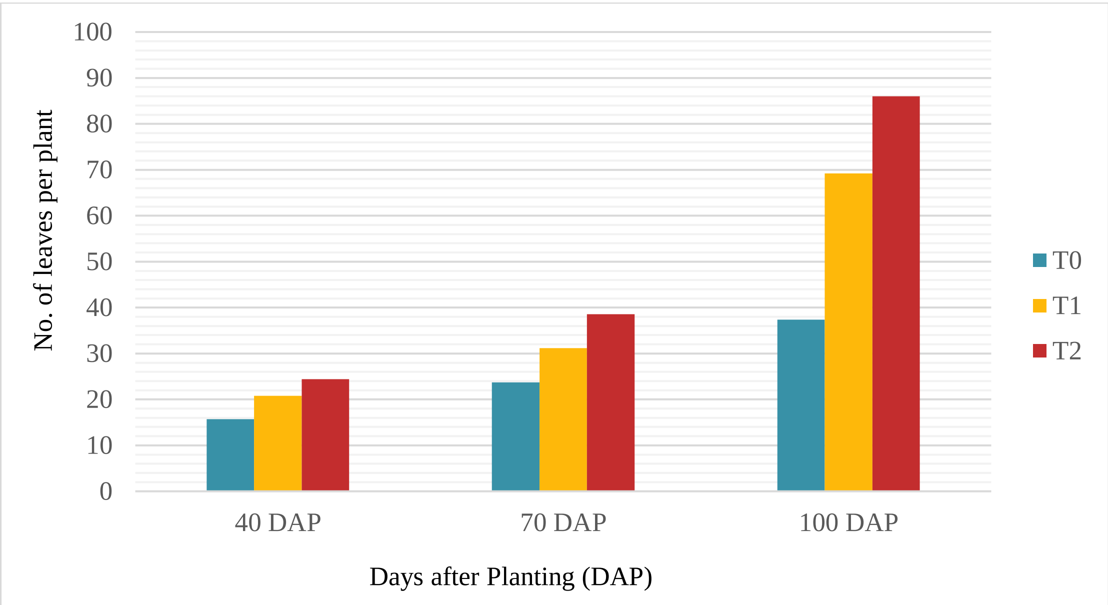

Figure 7. Effect of different levels of fertilizers application on number of leaves per plant at different days after planting of sweet potato varieties

T_0: Control (No chemical fertilizer and no compost), T_1: BARI fertilizer dose, T_2: Maruhisa dose (Chemical fertilizer + Improved compost)

Table 3. Interaction effect of sweet potato variety and different doges of fertilizer on number of leaves plant^{-1} at different days after planting

Number of leaf /plant			
Treatments	**40 DAP**	**70 DAP**	**100 DAP**
V_1T_0	13.20g	20.66f	31.93g
V_1T_1	16.13f	24.06e	52.13f
V_1T_2	18.86de	31.26d	74.26cd
V_2T_0	12.73g	17.30g	31.06g
V_2T_1	16.80ef	22.66ef	70.13de
V_2T_2	20.06d	31.26d	79.80c
V_3T_0	17.20ef	23.20ef	33.80g
V_3T_1	26.00bc	30.86d	65.86e
V_3T_2	32.13a	36.40c	71.40de
V_4T_0	19.73d	33.60cd	52.73f
V_4T_1	24.33c	47.03b	88.66b
V_4T_2	26.73b	55.40a	118.60a
LSD Value	2.360	3.199	6.940
CV (%)	6.858	6.066	6.384

Mean followed by the same letters are not significantly different ($p<0.05$) according to LSD test.

V_1: Annoh-Beni, V_2: Annoh-Kougane, V_3: Kokei, V_4: BARI Sweet potato12

T_0: Control (No chemical fertilizer and no compost), T_1: BARI fertilizer dose, T_2: Maruhisa dose (Chemical fertilizer + Improved compost)

4.4 Tuber Length (cm)

Tuber length was significantly influenced by performance of different sweet potato varieties during the cropping season (Table 4 and Appendix VI). Highest tuber length (16.85 cm) was recorded from V_3 which was followed by V_4 (16.40) and the lowest tuber length (11.78 cm) was recorded from V_1.

There were no significantly influenced by different levels of fertilizer application during the cropping season on tuber length (Table 4 and Appendix VI). Highest tuber length (13.49 cm) was recorded from T_1 and the lowest tuber diameter (13.38 cm) was recorded from T_0.

The interaction effect of tuber length of different sweet potato varieties and different doses of fertilizer showed significant differences (Table 5 and

Appendix VI). The longest length of tuber (20.61) was observed in the combination Kokei with maruhisa (Chemical fertilizer and improved Compost) which was followed by BARI Sweet potato 12 and maruhisa (chemical fertilizer + improved Compost). On the other hand, the lowest tuber length 9.48 was observed in annoh-Beni in control condition which was statistically similar to Annoh-Kogane with control condition. Tuber length differs significantly from genotype to genotype. The present results are in agreement with the findings of Siddique *et al*. (1988) who stated that the tuber length plant^{-1} varied widely the different genotypes.

4.5 Tuber diameter

Tuber diameter was significantly influenced by performance of different sweet potato varieties during the cropping season (Table 4 and Appendix VI). Highest tuber diameter (18.68 cm) was recorded from V_4 and the lowest tuber diameter (12.82 cm) was recorded from V_1.

Tuber diameter was significantly influenced by different levels of fertilizer application during the cropping season (Table 4 and Appendix VI). Highest tuber diameter (17.16 cm) was recorded from T_2 and the lowest tuber diameter (12.45 cm) was recorded from T_0.

Tuber diameter is one of the most significant yield contributing characters in sweet potato. The more diameter in produce, the yield increase in great extent. The interaction of tuber diameter of variety and fertilizer doges on sweet potato had significant effect. The highest tuber diameter was found on the BARI Sweet potato 12 when applied BARI recommended fertilizer doges and the lowest one recorded in the combination of Annoh-Beni and control condition (Table 5 and Appendix VI). Similar results was also found (Ali *et al.,* 2009 and Siddiky *et al*., 2019).

4.6 Tuber weight/plant

Tuber weight/plant was significantly influenced by performance of different sweet potato varieties during the cropping season (Table 4 and Appendix VI). Highest tuber weight/plant (0.73 kg) was recorded from V_3 and the lowest tuber weight/plant (0.26 kg) was recorded from V_2.

Tuber weight/plant was significantly influenced by different levels of fertilizer application during the cropping season (Table 4 and Appendix VI). Highest tuber weight/plant (0.67 kg) was recorded from T_2 and the lowest tuber weight/plant (0.39 kg) was recorded from T_0.

The interaction effect of tuber weight/plant of different sweet potato varieties with fertilizer doses showed significant differences (Table 5 and Appendix VI). The highest tuber weight/plant was observed in 0.97 kg in the combination of Kokei and Maruhisa dose (Chemical fertilizer+ improved compost) which was similar to BARI Sweet potato12 (0.90 kg). On the other hand, the lowest tuber weight was observed in the combination Annoh-kogane with control (no Chemical fertilizer and no compost). This might be due to the variation of genetic makeup of the different sweet potato genotypes. The results obtained from the present study are consistent with the results of Rashid *et al*. (2002) and Uwah *et al*. (2013) who stated that the tuber weight plant^{-1} were found considerable variation.

4.7 Yield per hectare

Yield/ha was significantly influenced by performance of different sweet potato varieties during the cropping season (Table 4 and Appendix VI). Highest yield/ha (24.39 t/ha) was recorded from V_3 and the lowest yield/ha (8.75 t/ha) was recorded from V_2.

Yield/ha was significantly influenced by different levels of fertilizer application during the cropping season (Table 4 and Appendix VI). Highest yield/ha (22.42

t/ha) was recorded from T_2 and the lowest yield/ha (13.15 t/ha) was recorded from T_0.

The highest tuber yield from Kokei was due to the highest number of tuber length, tuber diameter, tuber plant^{-1} (Table 5 and Appendix VI). Tuber yield differences might be due to genetic characteristics of the varieties. Tuber yield differed due to varietal differences was also reported by Ali *et al* 2009, Siddiky *et al* 2019. Intercation effect of variety and fertilizer dose for yield of different sweet potato varieties with fertilizer doges showed significant differences. The highest yield was observed in Kokei (32.55 t ha^{-1}) in Maruhisa (chemical fertilizer + Improved Compost) which followed by BARI Sweet potato 12 (30.06 t ha^{-1}). On the other hand, the lowest yield was observed in Annoh-Kogane in control condition (6.86 t ha^{-1}) which was statistically similar to Annoh-Kougane (8.19 t ha^{-1}).These results are corroborated with the findings of Naskar and Chowdhury (1994), Siddique *et al*. (1988) and Yooyongwech *et al*. (2014) Ali *et al* 2009, Siddiky *et al* 2019 found that yield potentiality o sweet potato depends on the genetic make-up plant (Sen *et al*., 1988) stated that significant variations among the genotypes were happened may be due to the adoption of proper cultural management techniques.

Table 4. Performance of different sweet potato varieties and effect of different levels of fertilizers application on tuber length, tuber diameter, tuber weight/plant and yield (t/ha)

Treatments	**Tuber length (cm)**	**Tuber diameter (cm)**	**Tuber weight / plant (kg)**	**Yield (t/h)**
V_1	11.78 b	12.82 c	0.40 b	13.38 b
V_2	11.55 b	13.13 c	0.26 c	8.75 c
V_3	16.85 a	16.30 b	0.73 a	24.39 a
V_4	16.40 a	18.68 a	0.71 a	23.78 a
$LSD_{0.05}$	0.96	1.308	0.02	1.03
CV (%)	6.95	8.77	4.43	4.43
Fertilizer				
T_1	13.49 a	12.45 b	0.39 c	13.15 c
T_2	13.38 a	16.10 a	0.51 b	17.16 b
T_3	13.45 a	17.16 a	0.67 a	22.42 a
$LSD_{0.05}$	0.96	1.13	0.01	0.66
CV (%)	8.44	8.77	4.43	4.43

V_1: Annoh-Beni, V_2: Annoh-Kougane, V_3: Kokei, V_4: BARI Sweet potato12

T_0: Control (No chemical fertilizer and no compost), T_1: BARI fertilizer dose, T_2: Maruhisa dose (Chemical fertilizer + Improved compost)

Table 5. Interaction effect of variety and different doges of fertilizer on yield of sweet potato

Treatments	Tuber length (cm)	Tuber diameter (cm)	Tuber weight / plant (kg)	Yield (t/h)
V_1T_0	9.48g	10.0h	0.31g	10.51g
V_1T_1	10.63fg	12.24gh	0.41f	13.76f
V_1T_2	15.23cd	16.20ce	0.47e	15.86e
V_2T_0	9.52g	10.70h	0.20i	6.86i
V_2T_1	11.59f	13.50fg	0.24h	8.19h
V_2T_2	13.54e	15.22df	0.33g	11.22g
V_3T_0	13.71de	14.17eg	0.52d	17.46d
V_3T_1	16.24bc	16.48cd	0.69c	23.17c
V_3T_2	20.61a	18.26bc	0.97a	32.55a
V_4T_0	14.12de	14.90df	0.53d	17.76d
V_4T_1	17.31b	22.18a	0.70c	23.53c
V_4T_2	17.75b	18.96b	0.90b	30.06b
LSD Value	1.665	2.264	0.039	1.322
CV (%)	6.953	8.776	4.448	4.442

Mean followed by the same letters are not significantly different ($p<0.05$) according to LSD test.

V_1: Annoh-Beni, V_2: Annoh-Kougane, V_3: Kokei, V_4: BARI Sweet potato12

T_0: Control (No chemical fertilizer and no compost), T_1: BARI fertilizer dose, T_2: Maruhisa dose (Chemical fertilizer + Improved compost)

4.8 Dry weight

Dry weight of different sweet potato varieties showed significant differences (Figure 8 and Appendix VII). The highest dry weight was observed in Annoh-Beni (38.00 g/100g). On the other hand, the lowest dry weight of tuber was observed in BARI Sweet potato12 (34.33 g/100g). Delowar and Hakim (2014) reported that dry weight of storage roots depends on the varietal performance to the particular soil. The result showed that some genotypes failed to show the relationship of fresh weight to the dry weight of the roots.

Dry weight of different sweet potato varieties showed significant differences at different levels of fertilizer application (Figure 9 and Appendix VII). The highest dry weight was observed in Maruhisa dose (Chemical fertilizer + Improved compost) (37.75 g/100g). On the other hand, the lowest dry weight of tuber was observed in Control (T_0) (35.00 g/100g).

Interaction effect on dry weight of different sweet potato varieties and fertilizer doses showed significant differences (Table 6 and Appendix VII). The highest dry weight (39.33 g/100g) was observed in the combination of Annoh-Kogane with maruhisa dose (Chemical fertilizer + improved compost). Followed by variety Annoh-Beni when applied no fertilizer. On the other hand, the lowest dry weight of tuber was observed in BARI Sweet potato 12 in control condition (33.66 g/100g). Delowar and Hakim (2014) reported that dry weight of storage roots depends on the varietal performance to the particular soil. The result showed that some genotypes failed to show the relationship of fresh weight to the dry weight of the roots.

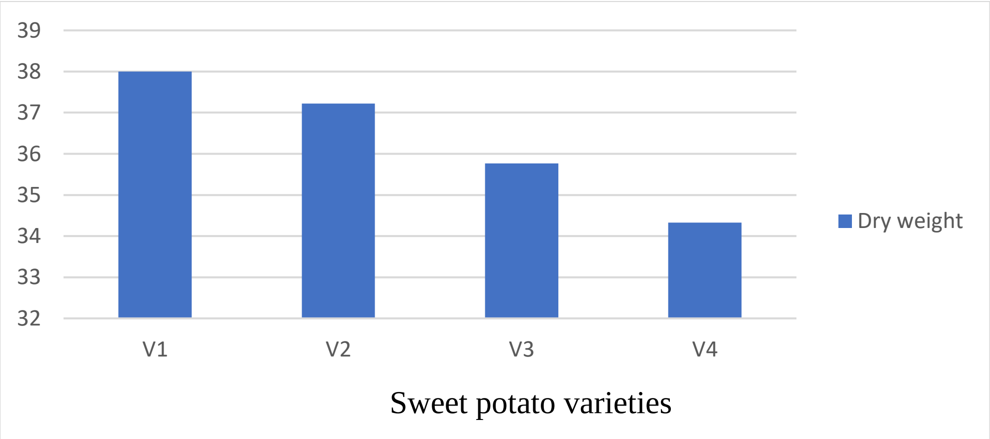

Figure 8. Dry weight of 4 sweet potato varieties
V_1: Annoh-Beni, V_2: Annoh-Kougane, V_3: Kokei, V_4: BARI Sweet potato12

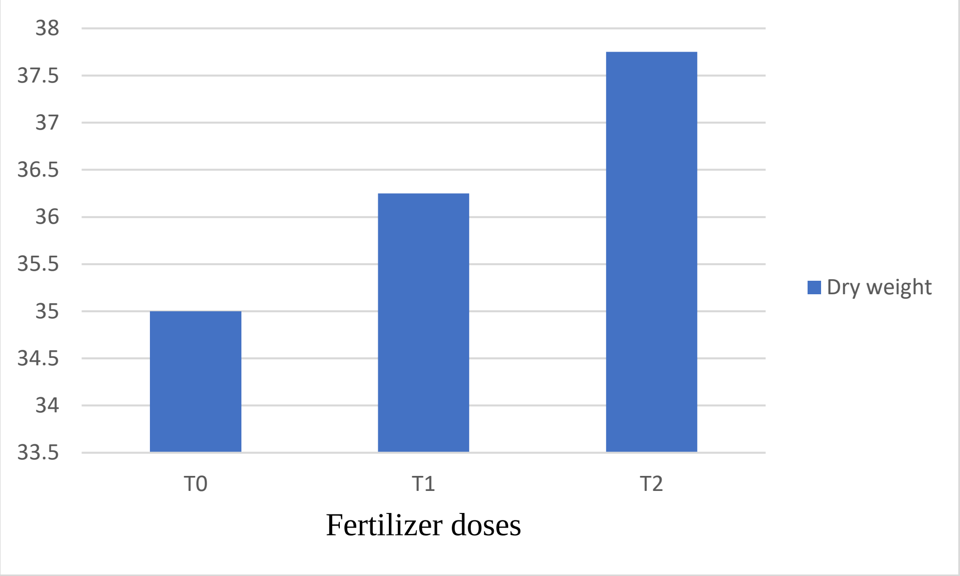

Figure 9. Dry weight of different levels of fertilizer application on sweet potato varieties

T_0: Control (No chemical fertilizer and no compost), T_1: BARI fertilizer dose, T_2: Maruhisa dose (Chemical fertilizer + Improved compost)

4.9 Total soluble solid (TSS)

TSS of different sweet potato varieties showed significant differences (Figure 10 and Appendix VII). The highest TSS was observed in Kokei (14.21 %). On the other hand, the lowest TSS of tuber was observed in V_2 (11.84 %). It has been reported that sucrose is the most abundant sugar in raw sweet potatoes with smaller amount of glucose and fructose (Bouwkamp, 1985). These results correlate with the findings by Chattopadhyay *et al.* (2006).

TSS of different sweet potato varieties showed significant differences at different levels of fertilizer application (Figure 11 and Appendix VII). The highest TSS was observed in Maruhisa dose (Chemical fertilizer + Improved compost) (13.49 %). On the other hand, the lowest TSS of tuber was observed in Control (T_0) (13.45 %).

Interaction effect of TSS of different sweet potato varieties and fertilizer dose showed significant differences (Table 6 and Appendix VII). The highest TSS was observed in the combination of Naruto-kintoki (14.26 %) in control treatment which was followed by Naruto-kintoki when applied in BARI recommended dose (14.23 %). Statistically similar results also found in fewer combination. On the other hand, the lowest TSS was observed in Annoh-Kogane when applied BARI recommended doge (11.56 %).

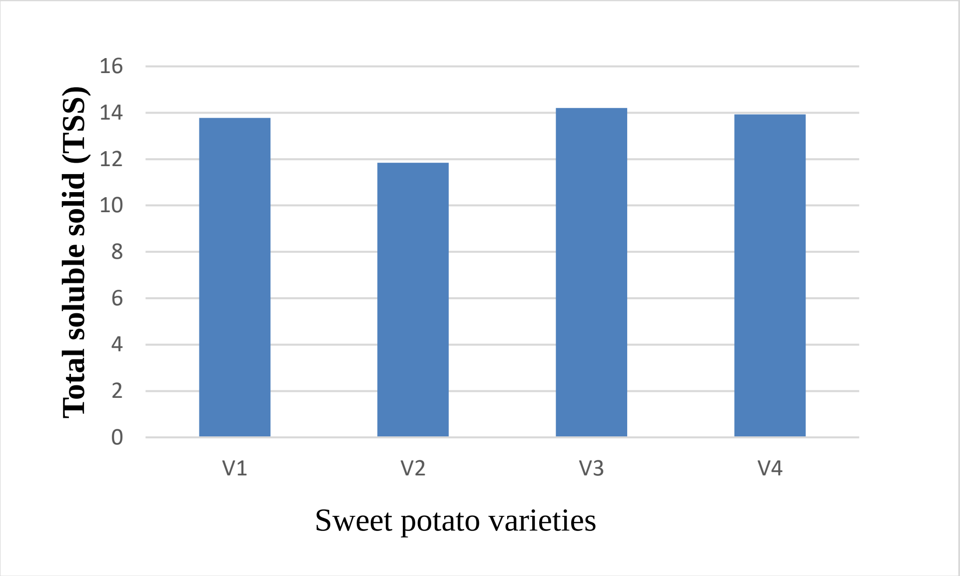

Figure 10. Total soluble solid of 4 sweet potato varieties
V_1: Annoh-Beni, V_2: Annoh-Kougane, V_3: Kokei, V_4: BARI Sweet potato12

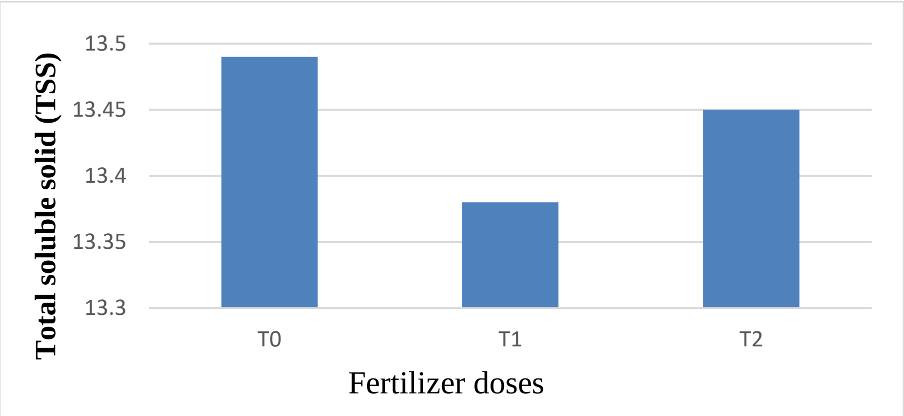

Figure 11. Total soluble solid of different levels of fertilizer application on sweet potato varieties

T_0: Control (No chemical fertilizer and no compost), T_1: BARI fertilizer dose, T_2: Maruhisa dose (Chemical fertilizer + Improved compost)

Table 6. Interaction effect of variety and different dozes of fertilizer on dry weight and TSS of sweet potato

Quality parameters of sweet potato			
Treatments	**Dry weight**		**TSS (%)**
V_1T_0	37.66ab		13.96a
V_1T_1	38.66ab		13.73ab
V_1T_2	37.66ab		13.66ab
V_2T_0	36.33ab		11.93bc
V_2T_1	36.00ab		11.56c
V_2T_2	39.33a		12.03bc
V_3T_0	33.33ab		14.26a
V_3T_1	36.66ab		14.23a
V_3T_2	37.33ab		14.13a
V_4T_0	32.66b		13.80ab
V_4T_1	33.66ab		14.00a
V_4T_2	36.66ab		14.00a
LSD Value	6.176		1.923
CV (%)	10.038		8.449

Mean followed by the same letters are not significantly different ($p<0.05$) according to LSD test.

V_1: Annoh-Beni, V_2: Annoh-Kougane, V_3: Kokei, V_4: BARI Sweet potato12

T_0: Control (No chemical fertilizer and no compost), T_1: BARI fertilizer dose, T_2: Maruhisa dose (Chemical fertilizer + Improved compost)

CHAPTER V

SUMMARY AND CONCLUSION AND RECOMMENDATIONS

The present study was conducted in the Agronomic field of Sher-e-Bangla Agricultural University, Dhaka, to optimize the fertilizer dose for sweet potato cultivation. The experiments were arranged in a Randomized Complete Block Design (RCBD) with three replications. Sweet potato vines were grown in the field and the Data were taken by sampling the vine. Different data of growth, physiology and biochemical parameters were measured. Plant height, tuber weight and dry weight were measured.

Yield parameters includes tuber length (cm), number branch/ plant, total weight of tubers/plant (kg), and yield**.** Quality parameters include dry weight, and TSS. In the present study 4 sweet potato varieties has shown their yield and quality performance. Different varieties have shown different performance in yield and quality analysis. Some varieties have shown better performance in plant height but not good at yield performance. At vegetative stages, the highest and lowest plant height was observed in (74.86cm), (44.25cm), (115.04cm), (7.82cm), (186.60cm), (88.79cm), at 40, 70 and 100 DAP respectively in V_3T_2, V_1T_0, V_4T_2, V_3T_0 and V_4T_1, V_3T_0 respectively. The number of branch plant^{-1} at all growth stages differed significantly due to variety, different vine parts and their interactions. The highest branch plant^{-1} (2.93), (6.26) and (7.40) was observed in BARI sweet potato 12 applied maruhisa treatment. The highest and the lowest leaves plant^{-1}was observed BARI sweet potato 12 applied maruhisa treatment and Annoh-Kogane in control condition respectively. The highest tuber length /plant, tuber/plant (kg), yield was observed in Kokei with maruhisa (chemical fertilizer + improved compost). This might be due to the variation of genetic makeup of the different sweet potato genotypes. The highest and the lowest tuber diameter were observed in BARI sweet potato 12 with maruhisa (chemical fertilizer + improved compost) and Annouh-Beni in control condition respectively. Dry weight of storage roots plant^{-1} differs significantly from genotype to genotype. Best quality of tuber gives best market value. The highest (24.40 t ha^{-1}) and the lowest yield (8.76 t ha^{-1}) was observed in Kokei and Annoh-Kogane variety respectively. The highest and the lowest dry weight were found in Annoh-Kougane with maruhisa (chemical fertilizer + improved compost) and BARI sweet potato 12 in control treatment. The highest (14.26%) and the lowest (11.56%) TSS was observed in Kokei 14 T_0 in control treatment and Annoh-Kogane with BARI recommended fertilizer, respectively.

Finally, it may be concluded that application of maruhisa (chemical fertilizer + improved compost) fertilizer Kokei appeared as the promising practice in sweet potato cultivation in terms of yield.

Considering the situation of the present experiment, further studies in the following areas may be suggested:

1. Another experiment may be carried out with various sweet potato varieties.
2. Other levels of fertilizer and other fertilizer dose also may be used for further studies.
3. Such study is needed in different agro-ecological zones (AEZ) of Bangladesh for regional compliance and other performance.

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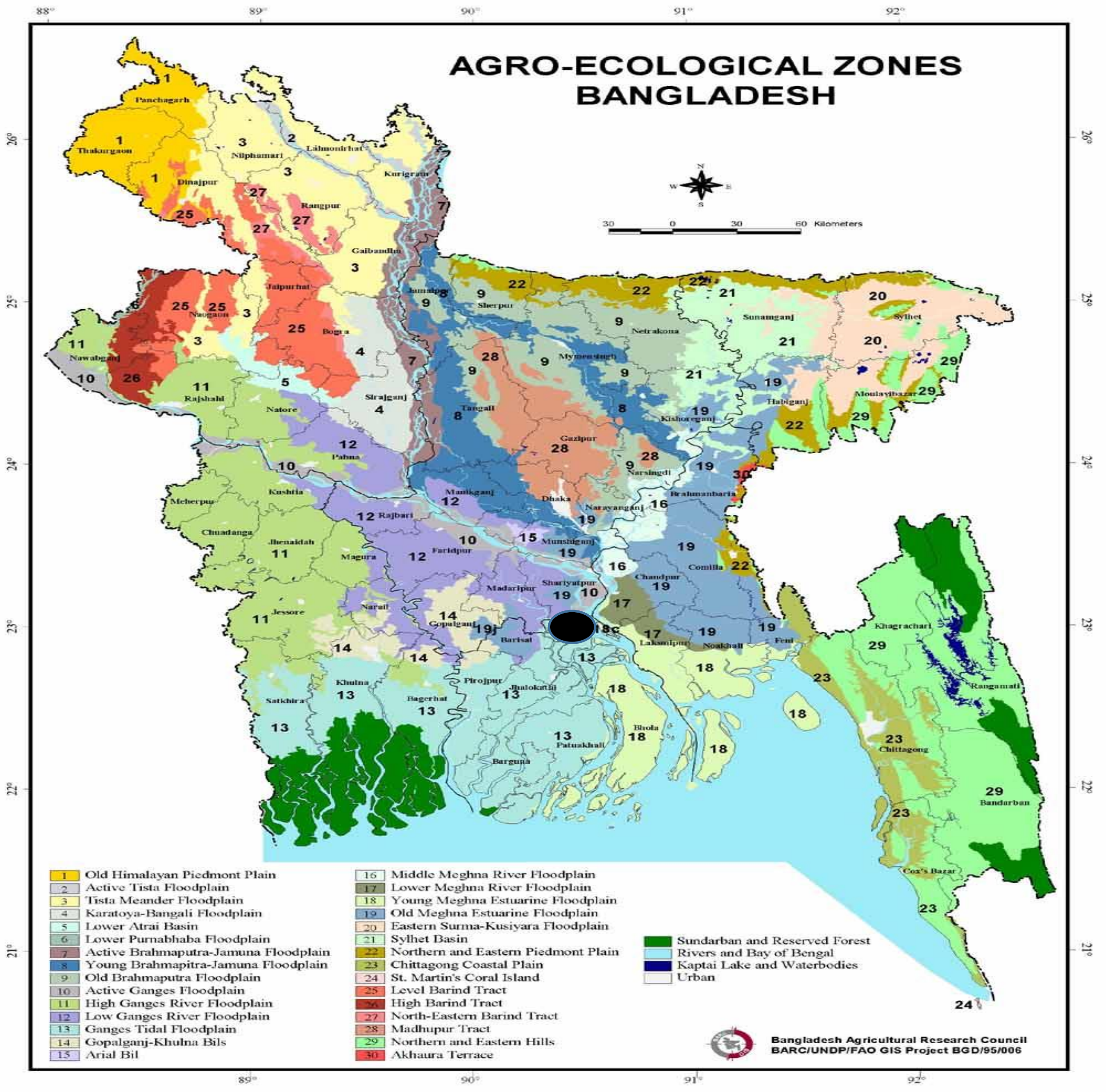
APPENDICES

Appendix I. Map showing the experimental site under the study



Appendix II. Monthly average temperature, relative humidity and total rainfall of the experimental site during the period from October 2018 to February 2019

Year	Month	Air temperature (°c)			Relative humidity (%)	Rainfall (mm)
		Maximum	Minimum	Average		
2018	October	30.97	23.31	27.14	75.25	208
	November	29.45	18.63	24.04	69.52	00
	December	26.85	16.23	21.54	70.61	00
2019	January	24.52	13.86	19.19	68.46	04
	February	28.88	17.98	23.43	61.04	06

Source: Bangladesh Meteorological Department (Climate division), Agargaon, Dhaka-1207

Appendix III. Characteristics of (SAU) Farm soil as analyzed by Soil Resources Development Institute (SRDI), Khamar Bari, Farmgate, Dhaka.

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Horticulture Garden ,SAU, Dhaka
AEZ	Madhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land t}pe	High land
Soil scries	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained
Cropping pattern	Fallow - Broccoli

Appendix III (contd.)

B. Physical and chemical properties of the initial soil

Characteristics	Value
Particle size analysis	
% 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 (mc/100 g soil)	0.10
Available S (ppm)	45

Source: Soil Resource and Development Institute (SRDI), Dhaka

Appendix IV. Mean square values of plant height and no. of branch/plant of sweet potato varieties

Mean square of							
Source of variation	df	Plant height at			No. of branch/plant at		
		40 DAT	70 DAT	100 DAT	40 DAT	70 DAT	100 DAT
Replication	2	15.39	33.76	484.7	0.0144	0.1336	0.909
Variety	3	183.86	625.00	4130.8	3.6430	9.6337	4.783
Error-I	2	0.008	6.85	5.30	0.90	1.0452	0.0012
Fertilizer	2	1104.34	1190.10	7658.7	3.9078	18.3078	47.054
Variety x Fertilizer	6	36.00	57.24	333.7	0.2574	2.0826	0.480
Error-II	22	5.22	2.84	312.5	0.0435	0.2185	0.205

Appendix V. Mean square of number of leaves of sweet potato varieties

df: degree of freedom

Mean square of				
Source of variation	df	No. of leaves/plant at		
		40 DAT	70 DAT	100 DAT
Replication	2	11.441	0.88	94.1
Variety	3	198.428	873.44	2105.1
Error-I	2	0.001	0.002	0.005
Fertilizer	2	230.964	665.29	7320.6
Variety x Fertilizer	6	13.538	22.06	173.6
Error-II	22	1.944	3.57	16.8

Appendix VI. Mean square values of tuber length, tuber diameter, weight of tuber/plant, and yield (t/ha) of sweet potato varieties

Mean of square					
Source of variation	df	Tuber length	Tuber diameter	Weight of tuber/plant	Yield (t/ha)
Replication	2	0.669	1.456	0.00138	1.44
Variety	3	74.195	69.839	0.48606	541.23
Error-I	2	0.01	0.30	0.05	0.18
Fertilizer	2	77.554	73.426	0.23375	259.53
Variety x Fertilizer	6	3.527	8.068	0.01910	21.64
Error-II	22	0.968	1.788	0.00055	0.61

Appendix VII. Mean square of dry weight and tss of sweet potato varieties

Mean square of			
Source of variation	df	Dry weight	TSS
Replication	2	1.456	6.0553
Variety	3	69.839	10.5163
Error-I	2	0.20	0.35
Fertilizer	2	73.426	0.0369
Variety x Fertilizer	6	8.068	0.0910
Error-II	22	1.788	1.2904