INFLUENCE OF POTASH ON MORPHOPHYSIOLOGICAL CHARACTERISTICS, GROWTH AND YIELD OF SWEET POTATO GERMPLASM

MIRANA AKHTER SUMI

DEPARTMENT OF HORTICULTURE

SHER-E-BANGLA AGRICULTURAL UNIVERSITY

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By

MIRANA AKHTER SUMI

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Approved by:

Prof. Dr. A. F. M. Jamal Uddin
Supervisor
Department of Horticulture
SAU, Dhaka

Prof. Dr. Md. Ismail Hossain
Co-supervisor
Department of Horticulture
SAU, Dhaka

Prof. Dr. Mohammad Humayun Kabir
Chairman
Examination Committee
Department of Horticulture
SAU, Dhaka

DEPARTMENT OF HORTICULTURE

Sher-e-Bangla Agricultural University

Sher-e-Bangla Nagar, Dhaka-1207

Phone: 9134789

CERTIFICATE

This is to certify that the thesis entitled ***"INFLUENCE OF POTASH ON MORPHOPHYSIOLOGICAL CHARACTERISTICS, GROWTH AND YIELD OF SWEET POTATO GERMPLASM"*** *submitted to the Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of* ***MASTER OF SCIENCE (M.S.)*** *in* ***HORTICULTURE,*** *embodies the results of a piece of bona fide research work carried out by* ***MIRANA AKHTER SUMI,*** *Registration. No.* ***10-03896*** *under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma.*

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

Dated: JUNE, 2017

Dhaka, Bangladesh

Prof. Dr. A. F. M. Jamal Uddin
Supervisor
Department of Horticulture
SAU, Dhaka

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The Author

INFLUENCE OF POTASH ON MORPHOPHYSIOLOGICAL CHARACTERISTICS, GROWTH AND YIELD OF SWEET POTATO GERMPLASM

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ABSTRACT

A field experiment was conducted to study the influence of potash on growth, yield and morphophysiological characteristics of sweet potato germplasmat horticulture farm, Sher-e-Bangla Agricultural University, Dhaka-1207, Bangladesh during October 2016 to March, 2017. Treatments consisted of seven different germplasm (G_L, Local; G_R, Vietnam red; G_W, White; G_Y, Yellow; $G_{O,}$ Orange; G_V, Violet and G_M, Magenta), four levels of potassium, (K_0,120 kg ha^{-1}; K_1,140 kg ha^{-1}; K_2, 160 kg ha^{-1} and K_3, 180kg ha^{-1}). Result revealed that vegetative performance was betterin Magenta germplasm (G_M)than the rest of the germplasm, whereas Orange germplasm (G_O) showed the highest yield (47.2 ton ha^{-1}) and yield contributing characters. For potassium application, the highestyield was 45.5 ton ha^{-1}in $K_3$where 180 kg murate of potash was applied. Therefore, it can be concluded that the application of potassiumhad a positive effect on yield of sweet potato where sevensweet potatogermplasmwas attributed for morphophysiological characteristics.

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ACRONYMS

AEZ	Agro-Ecological Zone
BARI	Bangladesh Agricultural Research Institute
BBS	Bangladesh Bureau of Statistics
Co	Cobalt
CV%	Percentage of coefficient of variance
DAE	Department of Agricultural Extension
DAS	Days after sowing
et al	And others
FAO	Food and Agriculture Organization
ha^{-1}	Per hectare
HI	Harvest Index
kg	Kilogram
Max	Maximum
Min	Minimum
MP	Muriateof Potash
N	Nitrogen
No.	Number
**Significantat	5% level of significance
SAU	Sher-e-Bangla Agricultural University
SRDI	Soil Resources and Development Institute
TSP	Triple Super Phosphate
UPOV	Union for the Protection of Plant Varieties

CHAPTER I

INTRODUCTION

The sweet potato (*Ipomoea batatas*) belongs to the Convolvulaceae family and recent results of molecular marker studies suggest Central America as the center of origin. It ranks as seventh most important food crop in the world and fourth in tropical countries with a 1.10 million metric ton annul production (FAOSTAT,2008). The morphophysiological characteristics of germplasm diversity is critical in crop improvement programs to satisfy the demand of an increasing human population (Ntare *et al.*, 2006). The evaluation of plant genetic resources is performed by using morphological descriptions of vegetative and reproductive organs in addition to classical agronomic assessment (Lowe *et al.*, 1996). The crop is highly adaptable and tolerates high temperatures, low fertility soil and drought which reliably provide food on marginal and degraded soils with little labor and with a few or no inputs from outside the farm. In recent years, several reports have indicated that the phytochemicals in sweet potatoes displayed antioxidative or radical-scavenging activity and exerted several health-promoting functions in humans (Konczak *et al.*, 2003). Depending on the flesh color, sweet potatoes are rich in beta-carotene, anthocyanins, total phenolics, dietary fiber, ascorbic acid, folic acid and minerals (Woolfe, 1992). The sweet potato is a symbol in the fight for a global nutrition plan that can save millions of children and help build a healthier and more productive future (Mbithe *et al.*, 2016). Orange-fleshed sweet potato, which contains high levels of pro-vitamin A, is of particular importance as vitamin A deficiency is a national public health problem (Labadarios *et al.*, 2007; Van Jaarsveld *et al.*, 2005). A red-fleshed sweet potato cultivar grown in the Andean region has been reported to have higher antioxidant activity and phenolic content than a cultivar of blueberry, a fruit with high levels of antioxidants (Cevallos-Casals and Cisneros-Zevallos, 2003). Purple-fleshed sweet potatoes developed in Japan contained about 0.4–0.6 mg anthocyanins (Furuta *et al.*, 1998). Sweet potato has been identified as a crop that has great potential for alleviating food security concerns (Scott *et al.*, 2000). The most important characters for distinction of the accessions are leaf outline, leaf lobe type, leaf lobe number, and shape of the central leaf lobe, and to get higher yield should provide special care of it (Laurie *et al*., 2013).

Sweet potato sugarcane, Irish potato and cassava are crops that have high demands for K because leaves, vines, stems and tubers usually remove substantial quantity of K from the soil. Potassium appears to be the most important nutrient in the production of sweet potato as its application increases yield by the formation of larger sized tubers. Potassium also affects the number, size, quality and the unit weight of tuberous roots produced, while the minimum levels of K suggested for healthy growth and yield are twice those recommended for N, although three times as much may be applied and occasionally even more (Degras, 2003). Application of potash fertilizer helped to increase yield dramatically and also increased the starch content of the tuber (Liang, 2013). Sweet potato yield is significantly depressed if K is deficient. Common recommendation in most countries is 35-65 kg N, 50-100 kg P_2O_5 and 80-170 kg K_2O per hectare (IFA, 1991). In the Hubei province of China, the optimum K rate for sweet potato varied from 150-300 kg K_2O/ha (Jian-wei *et al*., 2001). Whereas in India, the mean optimum requirement was put at 120 kg K_2O/ha, while the maximum was 160 kg K_2O/ha of potatoes with a yield response of 6.7 t/ha (Trehan *et al*., 2009). Sweet potato response to applied K is considerably influenced by the variety grown (Trehan, 2007). The varietal response to applied K is often related to its yield potential and the number of large sized tubers it can produce. Generally, rapid bulking varieties producing large sized tubers respond more to K than do the varieties with small tubers (Trehan and Grewal, 1990). Potassium nutrition influences in sweet potato tuber size, dry matter content, susceptibility to black spot bruise, after-cooking darkening, reducing sugar content, fry color and storage quality (Bansal and Trehan, 2011). In order to obtain good yield, studies must be conducted on improved varieties of crops which normally do require higher quantities of fertilizers with corresponding higher yield compared to the local varieties.

By considering the above circumstances, the present study was conducted with the following objectives

- To find out the suitable germplasm for adoption in Bangladesh; and
- To find out the optimum dose of potassium for higher yield of these germplasm

CHAPTER II

REVIEW OF LITERATURE

A field experiment was conducted at the Sher-e-Bangla Agricultural University to study influence of potash levels on morphophysiological characteristics, growth and yield of some exotic sweet potato germplasm. Some related research findings of different researchers of home and abroad have been cited below.

Studies suggested that the sweet potato *Ipomoea batatas* L. (Lam.) is a symbol in the fight for a global nutrition plan that can save millions of children and help build a healthier and more productive future. However, characterization of sweet potato varieties with optimal morphological features suitable for both food and feed has not been done. A population of 10,000 first filial generations (F1) sweet potato lines derived from seeds was generated through polycross crossing design in Uganda using 11 parents. Preliminary evaluation for the suitability of dual use of the F1's led to selection of 11 varieties which were the basis of this study. This study therefore sought to morphologically characterize selected Ugandan sweet potato varieties to identify those with superior characteristics suitable for food and feed purposes. Sweet potato plants were raised from seeds after scarification. A selection of seedlings possessing single leaf lobes was done, after which they entered observation yield trials (OT). This study enables the selection of sweet potato varieties with optimal characteristics for both food and feed use. The data generated from this study could help recommend to farmers on how dual-purpose sweet potato could be produced, in order to provide enough healthier food to millions of children in Uganda and in the world, and better feed for live-stock farmers (Mbithe *et al*., 2016).

A field experiment was carried out with the Irish potato (*Solanum tuberosum* L.) variety BP1 to determine the effect of inorganic fertilizer on the growth rate, yield and quality of potatoes grown in bags. The experiment was laid out in a randomized complete block design (RCBD) with five treatments replicated four times, giving a total of 20 plots. In each plot, 5 plants were planted to give a total plant population of 100.The treatments comprised of different inorganic Compound C fertilizer (6% nitrogen; 17% phosphorus; 15% potassium) application rates: Treatment 1- 1800 kg ha-1, Treatment 2- 1400 kg ha^{-1}, Treatment 3- 1000 kg ha^{-1}, Treatment 4- 600 kg ha^{-1} and Treatment 5 (control) with no fertilizer. All treatments were top dressed with ammonium nitrate (34.5% N) applied at a rate of 200 kg per hectare except the control. A significant difference ($P<0.05$) is noted on the average yields obtained per plant among different treatments. Treatment 2 had the highest yield (0.777 kg/plant) while the control treatment had the least yield (0.163 kg/plant). There are significant differences ($P<0.05$) in all the tuber sizes produced in different treatments. Treatment 1 had the highest number of very large tubers, while treatment 2 produced the highest number of large and small tubers (Rumhungwe *et al*., 2016).

Pulok *et al*. (2016) observed effect of potassium (K) and mulch materials on grading of different types of tuber were investigated at the Agronomy research field of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from November 2013 to March 2014. The experiment comprised of four different doses of K viz., 0 kg K ha^{-1}, 100 kg K ha^{-1}, 125 kg K ha^{-1}, 150 kg K ha^{-1} and four different types of mulch materials viz., soil mulch, rice straw, water hyacinth and saw dust. The experiment was laid out in a split plot design with 3 replications. Maximum large sized tubers were produced by 150 kg K ha^{-1} with rice straw mulch. Application of 125 kg K ha^{-1} with rice straw produced maximum seed potato and tuber for French fry.

A field experiment was conducted from November to March during the 2012/2013 planting season at Africa University Farm, Mutare, Zimbabwe to evaluate plant spacing and different potato varieties on growth, yield and quality of potato. Very close spacing produced highest number of small tuber leading to reduced market yield. Highest stem count was observed at high plant densities and lowest at low plant densities. An in–row spacing of 25 cm can be used by seed producers since the highest number of medium sized tuber was obtained in the study (Mangani *et al*., 2015).

Plant height increased rapidly at the early stages of growth; however, rate of progression in height was slow at the later stages except ‘Jam Alu’. the highest plant height (69.43 cm) was observed from the ‘BARI TPS-1’ with As0 treatment combination which was statistically similar (68.77 cm and 67.80 cm, respectively) the lowest plant (26.63 cm) was obtained from the ‘Lady Rosetta’. Number of leaves at harvest, the maximum leaves number $plant^{-1}$ (167.3) was obtained from the ‘Jam Alu’, the minimum (26.67) was recorded from the combination of ‘Courage’. Days to emergence Days to emergence was significantly influenced by the different potato varieties the variety ‘Jam Alu’ took the maximum duration (17.78 days) for emergence whereas, the minimum (10.22 days) was taken by ‘Quincy’ (Haque *et al*., 2015).

An investigation was carried out to study the genetic diversity and characterization using Mahalanobis's D^2– technique among thirty-five potatoes (*Solanum tuberosum* L.) The D^2 values were calculated and thirty-five potato germplasms were grouped into nine clusters for growth characters and ten clusters for quality traits respectively. The results broadly showed there was no parallelism between geographical and genetic divergence but had morphological variations (Datta *et al*., 2015).

Liao *et al*. (2015) conducted an experiment to reduce the error and faster classification and characterization by mechanizing in classifying the potato shape and size through machine vision using the extraction of characters procedure to identify the size and using the shape detection procedure to identify the shape. A wide range of variations were observed in terms of morphological characterization.

Shayanowako *et al.* (2014) studied that was carried out to determine the effect of stem density on growth, yield and quality of potato (*Solanum tuberosum* L.) variety 'amethyst' in Zimbabwe. They also recorded the morpho physiological characterization. Three stem density treatments were used and these were initially derived from the number of sprouts or eyes per tuber: 2 stems/hill, 4 stems/hill and +6 stems/hill. Emergence, haulm growth, yield and quality characteristics of tubers were the main parameters measured. A high marketable yield was obtained at 2 stems/hill compared to 6 stems/hill. An average of 21.08 small tubers per hill that is, those considered unsellable were obtained from treatments derived from 6 stems per hill compared to 3.75 small tubers /plant from plants with 2 stems per hill. The morpho physiological character showed significant levels of variations.

Ganga *et al*. (2014) conducted a study on ten varieties of potato tubers namely- Kufri Chipsona-2, Atlantic, Kufri Surya, Kufri Khayti, Kufri Jyoti, Kufri Pushkar, Kufri-Bahar, Kufri- Ashoka, J/99-24 with Kufri Pukhraj revealed that tubers mean length varied significantly ($p \leq 0.01$) between the cultivars ranging from 5.9 cm in J/99-242 to 7.6 cm in Kufri Ashoka. Mean breadth of tubers ranged between 4.4 cm to 5.6 cm with shortest in Kufri Pushkar and longest in Kufri Ashoka. Kufri Ashoka showed significantly ($p \leq 0.01$) large mass (113 g), highest volume (106.9 cc) and longest diameter (5.8 cm) while Kufri Pushkar had significantly smallest mass, lowest volume whereas Kufri Surya recorded significantly shortest diameter. Majority of the cultivars were oval shaped with brown coloured skin and cream flesh, number of eyes were less in most of the cultivars with shallow eye depth, without scars and green tint.

Highest number of natural depressions were found in Kufri Chipsona-2. Kufri Khayti produced highest slices (84.00%) as well as chips (22.83%) and thus ranked first.

Four CIP potato clones with 1 check variety 'Asterix' were grown during 2010-11 and 2011-12 at Horticulture Research Farm of Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur, Bangladesh to observe the effect of water stress on canopy structure, yield and growth rate of potato. The study validated that all the germplasms showed reduction in plant height, number of above ground shoots per plant, tuber number per plant and yield by different degrees of drought. Significant yield reduction was found among the germplasms due to drought treatments. Tuber number per plant ranged from 5.76 to 10.80 in 2010-11 & 7.23 to 10.42 in 2011-12 respectively found by (Mahmud *et al*., 2014).

Iheagwara (2013) conduced an experiment and reported that the sweet potato (Ipomoea batatas L (Lam)) starch was isolated and subjected to physical, chemical and enzymaticb modifications to generate hydrothermally modified (HMSPS), acid modified (AMSPS) and enzymatically modified (EMSPS) sweet potato starches. The proximate, physicochemical, pasting characteristics, light transmittance, freezethaw stability of the native and modified starches were characterized. Results obtained revealed that moisture, ash and protein contents were reduced following modifications. Hydrothermal modification (HMSPS) caused an increase in swelling power, solubility and water binding capacity while acid and enzymatic modifications reduced them. Also, there was significant reduction ($P \leq 0.05$) in sediment volume of all the modified starches with EMSPS (1.41 ml) having the least value. Breakdown (BD) and peak viscosity (PV) values declined for all modification with EMSPS having the least values of 519cP and 2027cP respectively for BD and PV. However, EMSPS and AMSPS exhibited improved pasting characteristics, freeze-thaw stability and paste clarity.

Study showed that the most important characters for distinction of the accessions were leaf outline, leaf lobe type, leaf lobe number, and shape of the central leaf lobe. The study provided comprehensive information concerning locally available sweet potato germplasm and is of vital importance for advancement in the sweet potato improvement program in South Africa. The information will also be useful to SASHA (a regional network for sweet potato breeding), ensuring wider utilization of these germplasms within Sub-Saharan Africa (Laurie *et al*., 2013).

Liang (2013) studied the effects of potassium fertilizing on yield of summer sweet potato variety Longshu24 and found that yield of sweet potato was increased dramatically and also increased the starch content of the tuber.

The classification of potato tubers through the separation of the product in plots with more homogeneous size characteristics, unite the market language of the different instances of the production chain. The results referring to this tubers classification, considering the greater diameter, fits completely in the classes II (29%) and III (71%), not having been verified tubers greater than 85mm and smaller than 33mm, represented by the classes I and IV, respectively. Among the classes the greater percentage was verified in the class III (Lopes *et al*., 2013).

Kaspar *et al*. (2013) studied carotenoid concentrations in white and purple potatoes were similar, while yellow potatoes had a 45-fold greater carotenoids concentration compared to white and purple potatoes. Consumers ranked the aroma and appearance of white and yellow potatoes higher than purple ($P < 0.05$). However, no significant differences were observed in overall acceptance between the potato cultivars. These results suggest that consumers may be willing to consume pigmented potatoes, which are beneficial to health due to their higher antioxidant content.

Khan *et al*. (2012) conducted another research on 11 potato cultivars to assess their genetic variability of different morphological parameters including emergence percentage (%), date of flowering, plant height (cm), number of leaves per plant, average leaf area, number of flowers per plant, number of stems per plant and number of fruits per plant. All of these characters showed a high level of variation among the varieties. Locally developed advanced line ‘SH-19’ showed maximum emergence percentage (92.33%). However, ‘Aziza’, ‘Leonardo’ and ‘Avalanche’ carried 2.67 and 1 stem per plant, respectively.

Ranjbar *et al*. (2012) observed phenotypic diversity in potato, *Solanum tuberosum* was assessed using morphological traits. To verify, how this diversity is distributed among the main potato varieties in the growing areas in Iran. A total of eleven potato varieties, ‘Ramose’, ‘Sante’, ‘Shepody’, ‘Marfona’, ‘Maradona’, ‘Milova’, ‘Santana’, ‘Boren’, ‘Cosima’, ‘Granola’ and ‘Agria’, were evaluated under vivo and situ experimental conditions. This study also studied number of tuber and average tuber weight.

Recent study reported that the traditional farmers play an important role in plant genetic resources conservation. Collecting the germplasm maintained by these farmers is a very important action to avoid genetic variability losses. The morphological characterization was efficient to detect genetic variability among accessions, revealing that traditional farmers from Campos dos Goytacazes and São João da Barra are responsible for sweet potato genotypes conservation with expressive genetic diversity in their properties. There was no relationship between genetic distance and collecting areas (Moulin *et al*., 2012).

Ten exotic potato varieties were used in an experiment during Nov. 2010 to Jan 2011 where the highest tuber number (57.52) per plant was found in Daisy germplasm and the lowest number of tubers (8.82) per plant was recorded in red varieties. Total tuber weight per plant was highest (344.6 g) in Diamont and lowest was (65.05 g). All blue varieties were showed the most potential yield in this experiment. (Karim *et al*., 2011).

Ahmad *et al*. (2011) conducted an experiment on five hybrid Potato cultivars namely ‘Amalia’, ‘Anjlique’, ‘Kardinal’, ‘Whisky Mac’ and ‘Rosy Cheeks’. Maximum plant height was found in Rosy Cheeks (83.0 cm) and minimum in ‘Kardinal’ (46.7 cm). Maximum numbers of leaves/plant were found in Rosy Cheeks (10.8) and minimum in Kardinal (8.8). Maximum leaf area was found in Whisky Mac (104.86 cm^2) and minimum in Anjlique (65.20 cm^2). Maximum leaf chlorophyll content was found in Whisky Mac (58.12mg g^{-1}) and minimum in Rosy cheeks (49.80 mg g^{-1}). Maximum bud diameter was found both in Amalia and Whisky Mac (3.1 cm) and minimum in Rosy Cheeks (2.6 cm). Maximum flower diameter was found in Amalia (5.8 cm) and minimum in Anjlique (4.8 cm).

Bansal and Trehan (2011) conducted an experiment on the application of potash fertilizers. In India a review of many field experiments conducted on response of potato to potassium application revealed a yield increase between 1.0 t ha^{-1} and 5.2 t ha^{-1} at different sites. Results of many experiments indicate that potassium nutrition influences tuber size, dry matter content, susceptibility to black spot bruise, after-cooking darkening, reducing sugar content, fry colour and storage quality. Considering the fact that tuber quality parameter is related to variety, to tuber maturity, growth and site conditions, water uptake and others, making of general recommendations on the optimal K fertilizer use is a complicated issue.

Khan *et al*. (2011) studied a field trial which was conducted to optimize the sowing date and crop growth period of potato at the Agricultural Research Institute, Dera Ismail Khan, NWFP during 2004-05. The tubers were planted on four dates with one-week interval starting from September 24 in 2004. Tubers planted at each sowing date were harvested on six different dates starting from week-10 and ending at week-15. Total number of stems increased with the delay in planting. Total numbers of tubers per unit area and percentage of large sized tubers (> 55 mm) were the highest at the earliest planting of September 24. Smaller tubers (< 35 mm) increased with delay in planting. Total number of tubers, percent larger and medium sized tubers, tuber yield and plant dry bio-mass increased with the delay in harvesting. However, dry matter in tuber was found higher at earlier harvestings.

Datta *et al.* (2011) undertaken a study on five mustard cultivars namely V_1- WBBN-1, V_2 –NC-1, V_3-YST-151, V_4-Ragini, V_5-$B_{9.}$ Among these varieties, maximum chlorophyll content was found in V_4 (1.550) and minimum in V_1 (1.311).

Field experiments were conducted during the two successive spring seasons of 2008 and 2009 in the International Potato Center (ICP), Agriculture Research Center (ARC), Kafr El-Zayat, El-Gharbia Governorate, Egypt to evaluate the effect of different levels of potassium fertilization and foliar application of different rates of zinc on sweet potato (*Ipomoea batatas* L) (cv. Abeese) 2 performance. Four rates of potassium fertilizer (60, 90, 120 and 150 kg K_2O/fed.) in the form of 2 potassium sulfate (48% K_2O) and four levels of foliar zinc fertilizer (0, 10, 20 and 30 ppm) in the form of zinc sulfate were applied. The individual effects showed that the highest sweet potato yield 2 was obtained from plants received 150 kg K_2O/fed., meanwhile the lowest root yield was obtained 2 from control treatment (60 Kg K_2O/fed.). On the other hand, the highest zinc dose recorded the highest production of root yield compared with other low doses. The interaction effect between potassium and zinc fertilizer showed the highest value of vegetative growth, yield and quality of roots when potassium and zinc were applied at the highest levels (El-Baky *et al*., 2010).

For a sweet potato plant to thrive, one of the key nutrients it needs is potassium (K). Potassium impacts the plant's ability to efficiently use nitrogen and aids water uptake. K is also essential for improving nutrient value, enhancing taste, color and texture, promoting disease resistance, optimizing yield and grade (Sweet Potato Research Station, 2007).

Jian-wei *et al*. (2001) conducted an experiment and found the yield and yield contributing characters of sweet potato increase due to the application potassium.

An experiment was carried out to study the morphological characteristics and yield potentialities of 23 potato varieties the varieties Ladyrosetta, Diamant, Provento, Granola and Dheera showed greater number of seed tuber emergence (>90%) while Terragold, Ladyolympic, Processor, Laura, Remarka and Almera showed poor performance (<40%) within 20 days after planting. Plant height ranged between 37 (Processor) to 76 cm (Quiney). Highest number of sprout per hill was produced in Diamant (8.53) followed by Innovator or Asterix while lowest in Ladyolympic (2.73). Largest canopy foliage expansion was noticed in Diamant (93%) followed by Quiney, Dheera and Innovator, and minimum (47%) in Ladyolympic (Awal *et al.*, 2007).

Host genetic resistance against pathogens and insects can be directly associated with leaf morpho-anathomical characteristics. The aim of the experiment was to study leaf morph-anatomical characteristics of five potato (*Solanum* spp.) clones differing in ploidy level and genetic background observed in that experiment (Bisognin *et al*., 2006).

A set of seventeen potato germplasm was evaluated for seven characters in sub-tropical plains (Modipuram and Jalandhar) and temperate hills ('Kufri') to estimate genetic parameters and character associations. Sufficient variation was present for all characters except for number of leaves and tuber dry matter. Heritability values were moderate to high for all characters except for number of leaves at all the locations and for plant height and number of shoots at 'Kufri'. Plant height was positively associated with number of leaves, and tuber yield with average tuber weight at all the locations. Tuber yield was not associated with any of the foliage characters (Joseph *et al*., 2005).

Lachman and Hamouz (2005) have studied red and purple potatoes are in addition contained acylated anthocyanins and pigmented potatoes display two to three times higher antioxidant potential in comparison with white-flesh potato.

Holtan *et al.* (2003) found in an experiment on tomato leaves variation and observed that leaves are one of the most conspicuous and important organs of all seed plants. A fundamental source of morphological diversity in leaves is the degree to which the leaf is dissected by lobes and leaflets and the experiment used publicly available segmental introgression lines to describe the quantitative trait loci (QTL) controlling the difference in leaf dissection seen between two tomato species, *Lycopersicon esculentum* and *Lycopersicon pennellii*. The study has defined eight morphological characteristics that comprise the mature tomato leaf and describe loci that affect each of these characters.

Recent evidence strongly suggests that Central America may be the actual center of origin of the sweet potato. According to a study carried out by Gichuki *et al*, (2003), the Central American/Caribbean genotypes showed a close relationship with sweet potato genotypes from all the regions outside the Americas.

However morphological descriptors do not always allow the quantification of the genotypic difference or similarity between cultivars as do genetic distances based on DNA polymorphism (Lefebvre *et al*., 2001). In addition, they are unreliable due to their paucity and their vulnerability to environmental influence (Gepts, 1993; Vosman, 1998). Cultivars need to be grown to full maturity to carry out all necessary observations, which makes the process time consuming and expensive (Vosman, 1998). Despite the disadvantages associated with morphological characterization, a candidate variety by definition must differ from protected ones on the basis of phenotypic traits (morphological). Therefore, molecular markers will only provide complementary information in cases of phenotypic similarity or proximity (Lefebvre *et al*., 2001). The use of molecular markers to supplement and refine the morphological-based classification has been recommended by Russell et *al*, (1997). Soller and Beckman (1983) proposed using molecular markers as an additional tool for varietal description because they have the advantage of being independent of environmental effects and providing direct information of the genome of each individual.

Sweet potato (*Ipomoea batatas* L.) is a dicotyledonous plant that is classified in the taxonomic group *Ipomoea* section *batatas* in the Convolvulaceae family (Varadarajan and Prakash, 1992; Missah and Kissiedu, 1994). Amongst the approximately 50 genera and more than 1000 species of this family, only *Ipomoea batatas* is of major economic value owing to its edible tubers (Janssens, 2001; Woolfe, 1992).

Genetic diversity is the variation in the genetic constitution of individuals within or among species (Lanaud and Vincent, 1997). Assessment of genetic variability is important for conservation of genetic resources and broadening the genetic base of varieties (Lefebvre *et al.*, 2001). It is important to conserve the genetic diversity for availability and utilization by the community and users, (plant breeders, agronomists, and farmers) (Ayad *et al.*, 1997). The success of any genetic conservation program is dependent on understanding the amount and distribution of genetic diversity present in the gene pool (Zhang *et al.*, 2000) and it creates a basis for improvement of agricultural production. Data from genetic diversity studies may be used in establishing core collections. Maximum genetic diversity is the key to establishing a good core subset (Zhang *et al.*, 1998). Core collections are usually 10% of the total collection (Lanaud and Vincent, 1997). Cultivars are identified based either on morphological, biochemical or DNA profiling (Lefebvre *et al.*, 2001).

Sultana *et al.* (2001) studied with the treatments comprised of four sizes of seedling tubers viz. 5.0, 7.5, 12.5 and 17.5 g derived from the TPS progeny HPS II/67 and four depths of planting viz. surface level, 2.5, 5.0 and 7.5 cm with their all possible combinations. Seedling tuber size significantly influenced the growth and yield of potato. Yield was found to increase with the increase in seedling tuber size and the maximum yield (39.34 t/ha) was obtained from the large seeds (17.5g). Depth of planting had no significant effect on the growth and yield of potato.

Ayyub *et al.* (2011) conducted a study with the application of Potash fertilizers with organic matter like FYM and found FYM improves potassium uptake by potato plants. Results revealed that parameters like day to emergence, total emergence percentage and number of stems per plant was greatly affected by sulphate of Potash. Number of tubers per plant and number of compound leaves per plant was significantly affected by ½ MP and ½ of FYM. plant height was found highest with FYM.

Sweet potato is an important food crop particularly in developing countries where 98% of it is grown (Scott *et al.*, 2000; Woolfe, 1992) with China as the largest producer of sweet potato in the world. It is grown in 101 developing countries (Woolfe, 1992) as a valuable food resource and is adaptable to a wide range of agro-ecological conditions including tropical and sub-tropical climates. Sweet potato is widely grown in Eastern, Central, and Southern Africa, where it is a reliable, low input, food security crop for resource-poor farmers, with increasing commercial potential (Minde *et al.*, 1998).

Ahmed *et al*. (2000) carried an experiment by on the yield of potato in relation to variety (Cardinal and Desiree) and spacing (50, 75 and 100 cm) was conducted during the autumn in Peshawar conditions. Variety Desiree was significantly early (20 days) in 50% emergence as compared to 22 days of Cardinal. Plant Vigor in terms of height and spread was significantly more only after 60 days through 80 days while only plant spread was significantly more after 40 days. Highest number of stems were in Cardinal (3.88) as compared to 2.41 in Desiree. The total tuber yield was significantly higher in Cardinal (12.76 tons/ha) as compared to 9.80 tons/ha of Desiree. Maximum total yield of 14.31 and 13.52 tons/ha was produced in 50 cm spacing while it was minimum 9.95 and 6.37 tons/ha at 100 cm in Cardinal and Desiree accordingly.

The International Potato Centre (CIP) holds one of the largest sweet potato gene banks with more than 5,000 cultivated varieties from America, Africa, Asia and Oceania (Huaman *et al.*, 1999). This includes over 1671 accessions from over 30 countries of Asia and the Pacific transferred from the Asian Vegetable Research and Development Centre (AVRDC) after 1991 (AVRDC, 1992). Several national programs in the major sweet potato growing countries hold smaller germplasm collections.

Sweet potato has the potential for expanded production in stressful environments because of its ability to give reasonable root yield under adverse climatic conditions or poor soils (Kasele, 1998), with low pH and low fertility (UTA, 1982). Fast growing varieties have the capacity to produce ground cover that can be used to prevent soil erosion (Gregory, 1992). The failure of cassava and cereal crops, and the ability of sweet potato to withstand locust attack and drought has increased its importance among farmers and has consequently led to an increase in the production of sweet potato (Jeremiah, 1994; Scott *et al.*, 1998) and more so as a food security crop (Kasele, 1998).

Morphological characterization in sweet potato is achieved by checking variations in vine, leaf and storage root characters of collections. This is followed by data analysis and duplicate verification (CIP, AVRDC & IBPGR, 1991). Morphological descriptors for sweet potato are mostly applied to sort out duplicates, both in collections at the experimental and farmer fields (Ewell and Mutuura, 1991; Zosimo, 1992; Mok and Schmiediche, 1998). Morphological characters are also the principle descriptors in germplasm collections (Russell *et al*., 1997). Traditionally, morphological markers have been used to provide descriptors for identifying sweet potato cultivars (Huaman *et al*., 1991). Morphological characterization has also been used to assess genetic diversity and establish core collections, for example in Indian mung bean (Bisht *et al*., 1998) and sweet potato (Mok and Schmiediche, 1998).

Genet (1992) found an increasing proportion of the New Zealand potato crop is processed, the quality of the raw material has assumed increasing importance. The main quality characteristics of interest to both French fry and crisp producers are tuber size and shape, flesh colour, dormancy and storability, dry matter content and reducing sugar content. the dictates of processors' packaging and slicing equipment require round, medium size (100-200 g) tubers. Large crisps are more prone to damage, and are more difficult to fit in small packs. As tubers cannot be orientated at the slicing stage, long tubers are difficult to cut. Moreover, he observed Present attitudes favour white-fleshed french fries and yellow crisps.

Maity and Chatterjee (1977) reported that leaflet size, number of tubers per plant and plant height were closely related with tuber yield.

Taha (1961) studied the relationship between yields and shoot number and found that yield generally increased with an increase in shoot population and that small seed was inferior to large seed at the same number of shoots per acre. He attributed this to the greater vigor, earlier emergence and earlier tuber initiation in large seed, the effect of this on yield was apparently more than sufficient to offset any possible effects of the more shoot distribution in small seed.

CHAPTER IV

RESULTS AND DISSCUSSION

This chapter comprises presentation and discussion of the results obtained from the experiment.

4.1 General observation of germplasm

a. Local germplasm

Growth habit of this germplasm is semi upright. Leaf margin color and vine color absent here. Node color and petiole pigmentation is present in this germplasm. Number of lobe in leaf is three and anthocyanin coloration on leaf blade tip is absent. Mature and immature leaf color is green. (Plate 3)

Plate 3. Vine, flower and leaf of local germplasm

b. Vietnam red germplasm

Spreading type of growth habit and having large number of leaves. Node color, vine color and petiole pigmentation are present for this germplasm. Having cordate type leaf of this germplasm. Mature and immature leaf color is green. (Plate 4)

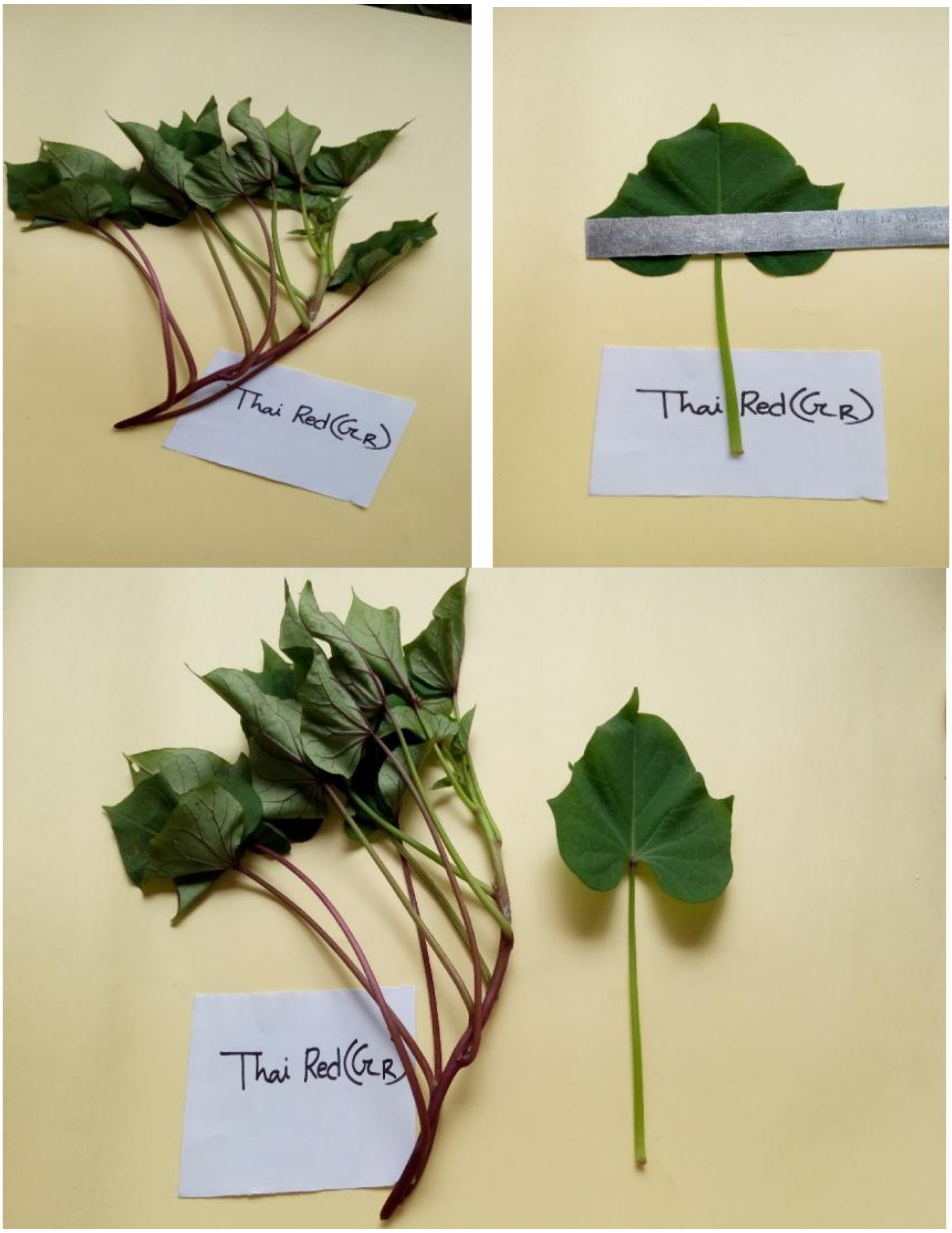


Plate 4. Leaf and vine of Vietnam red germplasm

c. White germplasm

Semi upright types of growth habit and having purple leaf margin color. Petiole pigmentation, anthocyanin coloration on lead blade tip, vine color is absent for this germplasm. Mature and immature leaf color is green. (Plate 5)

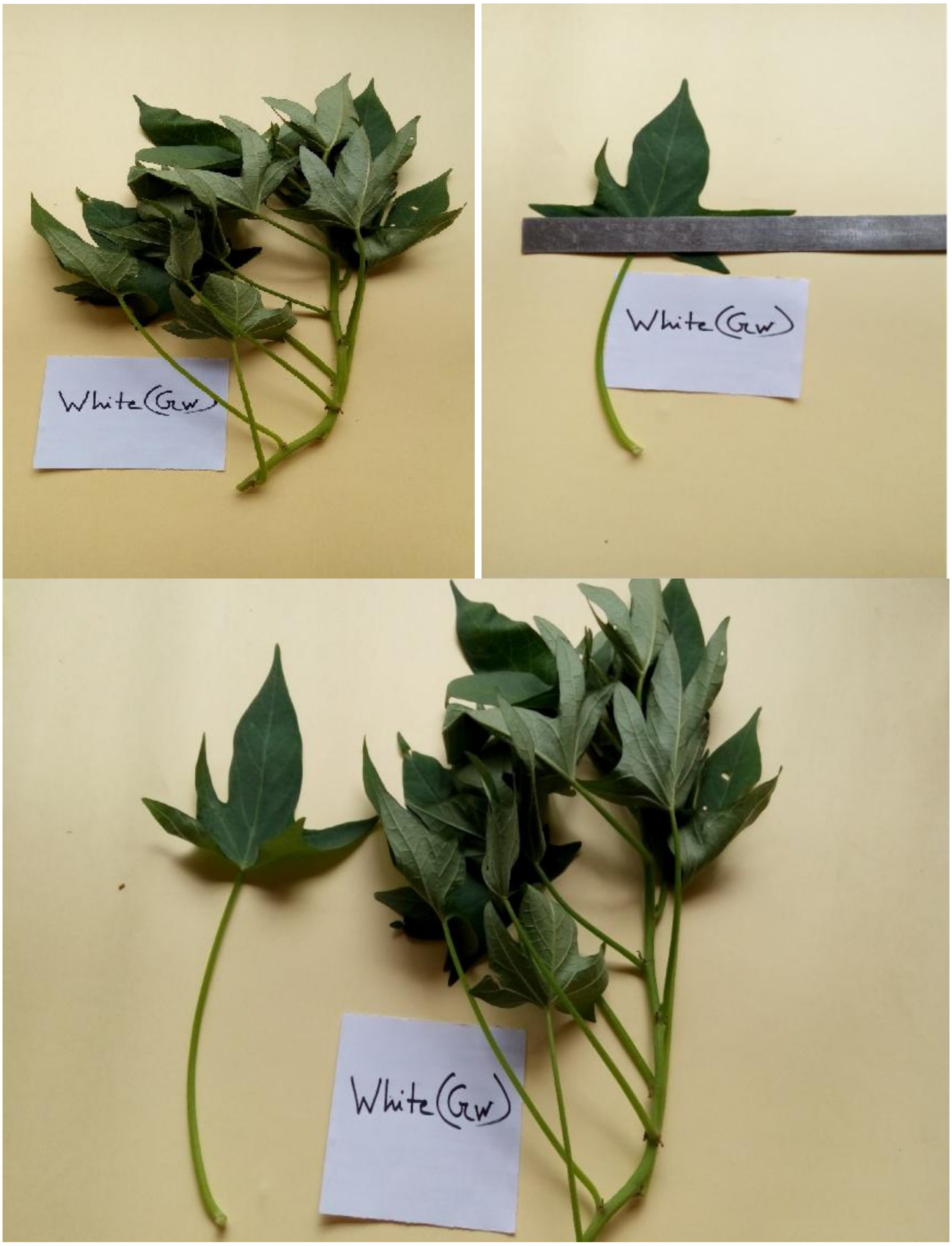
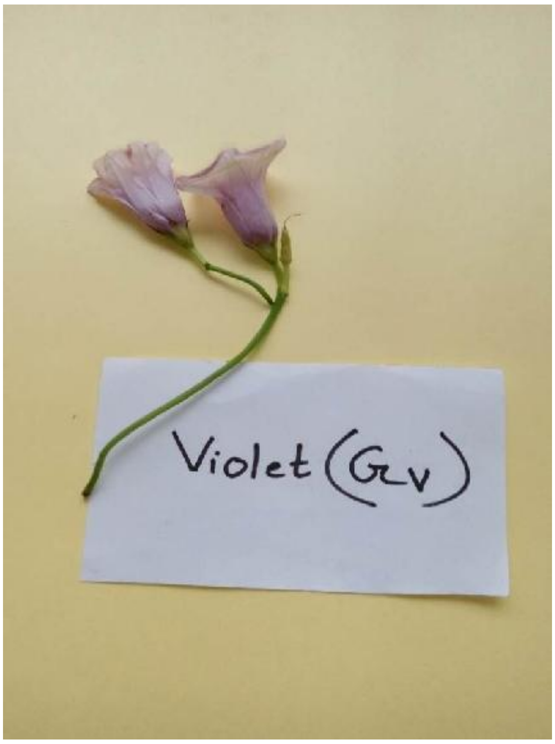


Plate 5. Leaf and vine of white germplasm

d. Violet germplasm

Violet germplasm showed a semi upright growth habit. Node color, vine color, petiole pigmentation is present here. Leaf margin color is purple and anthocyanin coloration on leaf blade tip is absent. (Plate 6)



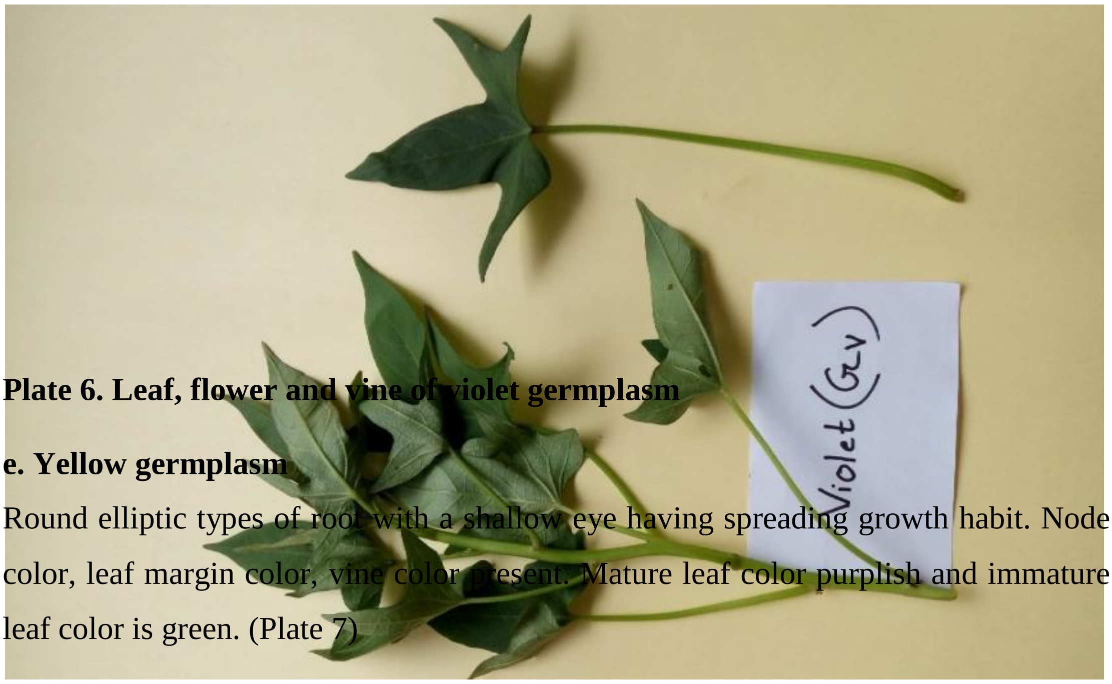


Plate 6. Leaf, flower and vine of violet germplasm

e. Yellow germplasm

Round elliptic types of root with a shallow eye having spreading growth habit. Node color, leaf margin color, vine color present. Mature leaf color purplish and immature leaf color is green. (Plate 7)

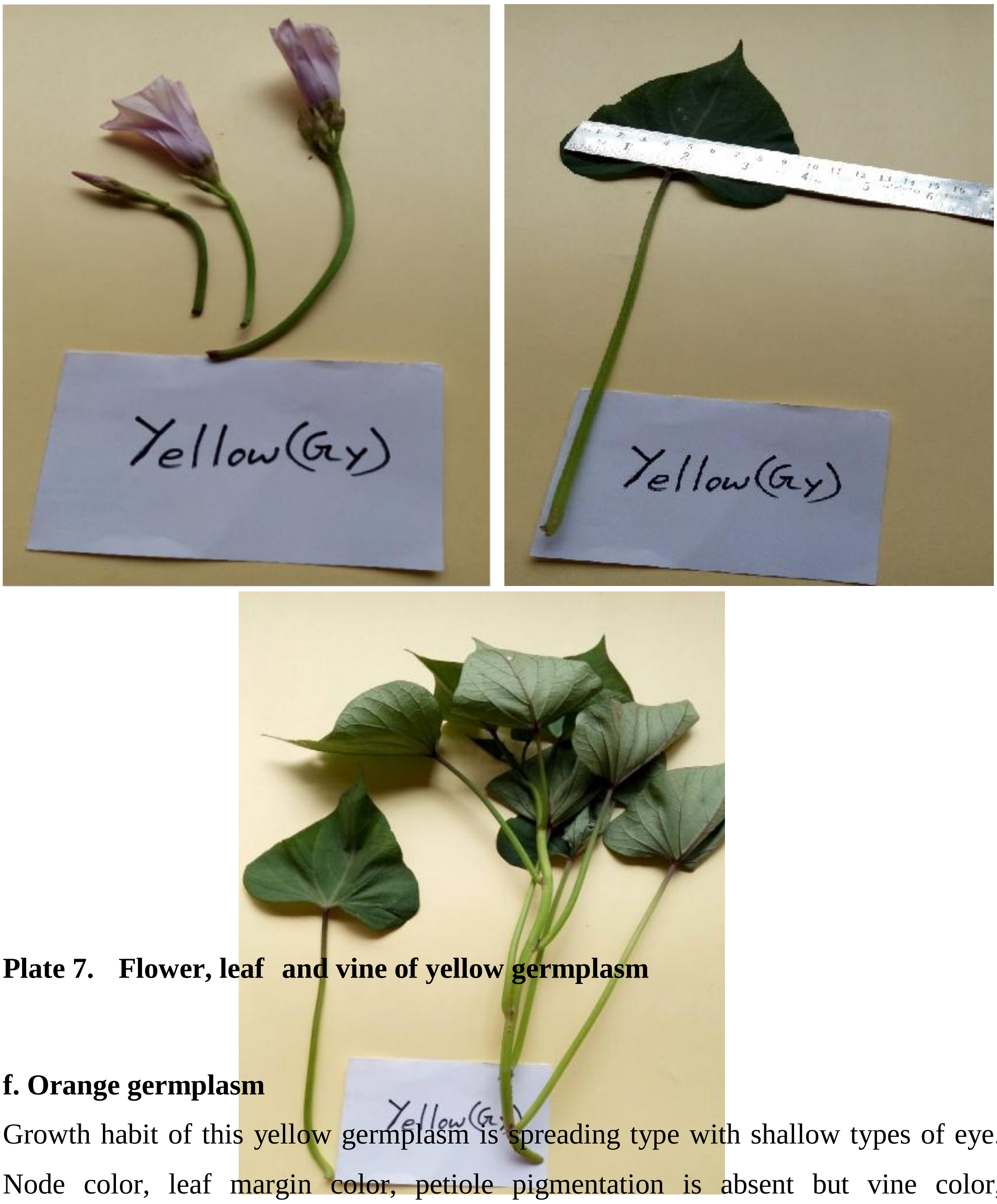


Plate 7. Flower, leaf and vine of yellow germplasm

f. Orange germplasm

Growth habit of this yellow germplasm is spreading type with shallow types of eye. Node color, leaf margin color, petiole pigmentation is absent but vine color, anthocyanin coloration on leaf blade tip is present. Immature color is purple and mature leaf color is green. (Plate 8)

Plate 8. Leaf and vine of orange germplasm

g. Magenta germplasm

Spreading types of growth habit with very shallow eyes are present. Immature and immature leaf color is green. Anthocyanin coloration on leaf blade tip, petiole pigmentation and node color are absent. Leaf margin color is purple. (Plate 9)

Plate 9. Leaf, flower and vine of magenta germplasm

4.2 Morphological character

The morphological characters were assessed by visual observations which were usually based on the guidelines published by the Union for the Protection of Plant Varieties (UPOV).

4.2.1 Root cracking

Root cracking was assesed by eye observation and it was found in local, Vietnam red and yellow germplasm. But in white, violet, orange and magenta germplasm root cracking was absent (Table 1).

4.2.2 Depth of eye

Eye observation of depth of eye showed the moderate types in local, Vietnam red, and white germplasm. Shallow eye was found in violet and orange germplasm. Yellow and magenta germplasm showed a very shallow kind of depth of eye (Table 1).

4.2.3 Types of root formation

Open cluster storage root formation was observed in Vietnam red and orange germplasm but close cluster types of storage root found in local germplasm. Disperse types of storage roots was recorded in violet and magenta germplasm but white and yellow germplasm showed a very disperse types of storage root (Table 1).

4.2.4 Types of root surface

In case of types of storage root surface all of the 7-germplasm showed a unique types of root surface and that is horizontal constriction (Table 1).

4.2.5 Types of root shape

Types of storage shape showed a long elliptic only for 2 germplasm namely local and magenta. Round elliptical root shape was observed in Vietnam red and yellow germplasm. Violet and orange germplasm represented ovate types root surface where white germplasm showed obovate (Table 1).

4.2.6 Number of roots

Different germplasm had different number of roots, i.e. local germplasm 5, Vietnam red 6, white 2-3, violet 4, yellow 4, orange and magenta had 6 for each (Table 1).

4.2.7 Immature leaf color

Immature leaf color did show a little range of variation. Only orange germplasm showed purple immature leaf color where rest of the germplasm showed green leaf color (Table 1).

4.2.8 Mature leaf color

In case of mature leaf color there also had no wide range of variation as like the immature leaf color (Table 1). Here yellow germplasm showed purplish leaf color and rest of the germplasm showed green leaf color for mature leaf.

4.2.9 Depth of leaf lobing

Shallow types leaf lobbing was recorded in local germplasm where very shallow leaf lobbing was found in Vietnam red germplasm. But yellow and orange germplasm showed triangular types leaf lobing and violet and magenta showed moderate types of leaf lobing. A deep types of leaf lobing observed in white germplasm (Table 1).

4.2.10 Extent of coloration on abaxial leaf blade

Local and Vietnam red germplasm demonstrated the large extent of anthocyanin coloration on abaxial leaf blade where very large in yellow and small was found in violet germplasm. The extent of anthocyanin coloration on abaxial leaf blade was absent in three germplasm namely white, orange and magenta (Table 1).

Table 1. Morphological characteristics of sweet potato germplasm

Morphological traits	**Categories**	**Germplasm**
Root cracking	Present	Local, Vietnam red, yellow
	Absent	White, Violet, Orange, Magenta
Depth of eye	Moderate	Local, Vietnam red, White
	Shallow	Violet, Orange
	Very shallow	Yellow, Magenta
Types of root formation	Close cluster	Local, Orange
	Open cluster	Vietnam
	Very disperse	White, Yellow
	Disperse	Violet, Magenta
Types of root surface	Horizontal constriction	All germplasm
Types of root shape	Long elliptic	Local, Magenta
	Round elliptic	Vietnam red, Yellow
	Obovate	White
	Ovate	Violet, Orange
Number of root	2-3	White
	4	Violet, Yellow
	5	Local
	6	Vietnam red, Orange, Magenta
Immature leaf color	Green	Local, Vietnam red, White, Violet, Yellow, Magenta
	Purple	Orange
Mature leaf color	Green	Local, Vietnam red, White, Violet, Orange, Magenta
	Purplish	Yellow
Depth of leaf lobing	Shallow	Local
	Very shallow	Vietnam red
	Deep	White
	Moderate	Violet, Magenta
	Triangular	Yellow, Orange
Extent of coloration on abaxial leaf blade	Large	Local, Vietnam red
	Absent	White, Orange, Magenta
	Small	Violet
	Very large	Yellow

Table 1. Morphological characteristics of 7 sweet potato germplasm (Continued)

Morphological traits	Categories	Germplasm
Coloration on leaf blade tip	Absent	Local, Vietnam red, White, Violet, Magenta
	Present	Yellow, Orange
Number of lobe in leaf	3	Local
	5	White, Violet, Magenta
	Absent	Vietnam red, yellow, Orange
General outline	Lobed	Local, White, Violet
	Cordate	Vietnam red. Orange
	Triangular	Yellow
	Hastate	Magenta
Petiole coloration	Present	Local, Vietnam red
	Absent	White, Orange, Magenta
	Present on top	Violet
	Present in upper portion	Yellow
Vine color	Absent	Local, White
	Present	Vietnam red, Violet, Yellow, Orange, Magenta
Leaf margin color	Absent	Local, Vietnam red, Orange
	Purple	White, Violet, Yellow, Magenta
Node color	Present	Local, Vietnam red, White, Violet, Yellow
	Absent	Orange, Magenta
Growth habit	Semi Upright	Local, White, Violet
	Spreading	Vietnam red, Yellow, Orange, Magenta

4.2.11 Coloration on leaf blade tip

Anthocyanin coloration on leaf blade tip was present only in yellow and orange germplasm but in the rest of the germplasm it was totally absent (Table 1).

4.2.12 Number of lobe in leaf

The number of lobe in leaf was absent in Vietnam red, yellow and orange germplasm. But local variety had 3 lobes where white, violet and magenta had 5 lobes for each (Table 1).

4.2.13 General outline of the leaf

General outline of the leaf demonstrated that local, white and violet germplasm had lobed types leaf where Vietnam red and orange had cordate types. But yellow germplasm showed triangular types and magenta showed hastate types of leaf (Table 1).

4.2.14 Petiole coloration

Petiole pigmentation was found in local, Vietnam red, violet and yellow germplasm, but for the rest of the germplasm it was absent. Basically, for violet germplasm petiole pigmentation was observed on the tip and for yellow germplasm it was in the upper portion (Table 1).

4.2.15 Vine color

Some germplasm showed colorful vine and some had no color. Vine color was absent for local germplasm but rest of the germplasm showed colored vine (Table 1).

4.2.16 Leaf margin color

Leaf margin color was not found in a wide range of variations. Leaf margin color was absent for local, Vietnam red and orange germplasm, but rest of the germplasm i.e. white, violet, yellow and magenta showed purple color leaf margin (Table 1).

4.2.17 Node color

Node color was present for local, Vietnam red, white, violet and yellow germplasm but absent for orange and magenta (Table 1).

4.2.18 Growth habit

Two types of growth habit were found i.e. semi upright and spreading. Semi upright types of growth habit was found in local, white and violet germplasm. But spreading types of growth habit was observed in Vietnam red, yellow, orange and magenta germplasm (Table 1).

4.3 Vegetative growth

4.3.1 Vine length

Vine length showed significant effect for seven sweet potato germplasm (appendix III). The germplasm orange (G_O) showed the highest vine length (93.1 cm) where Vietnam red (G_R) showed the lowest value of vine length (36.3 cm) compared to other others germplasms (Table 2). The germplasms G_L, G_W, G_Y, G_V and G_M produced vine length 73.5, 63.9, 64.5, 68.5 and 62.3 cm, respectively. All of the germplasm showed a wide range of variation for the vine length growth. This might be due to genetic variation among the germplasms (Mbithe *et al*., 2016). Mahmun *et al*. (2016) reported the same finding. The finding agreed with the finding of Joseph *et al*. (2005), Lachman and Hamouz (2005), Holtan *et al.* (2003), Gichuki *et al*, (2003), Lefebvre *et al*. (2001).

Table 2. Vine length variation with different sweet potato germplasm

Treatments	Vine length (cm)
G_L	73.5 b
G_R	36.3 e
G_W	63.9 cd
G_Y	64.5 cd
G_O	93.1 a
G_V	68.5 bc
G_M	62.3 d
CV (%)	10.2
LSD (0.05)	5.1

G_L, Local; G_R, Vietnam red; G_W, White; G_Y, Yellow; G_O, Orange; G_V, Violet; G_M, Magenta.

Vine length showed significant effect for the application of different doses of potassium (appendix III). The variation of vine length was noticed for different germplasm of the sweet potato (Table 3). The highest vine length was found in K_2 (69.9 cm), and lowest in K_0 treatment. The finding is supported with the finding of Rumhungwe *et al*. (2016), Pulok *et al*. (2016), Liang (2013), Bansal and Trehan (2011), El-Baky *et al*. (2010).

Table 3. Effect of potassium on vine length of seven sweet potato germplasm

Treatments	Vine length (cm)
K_0	61.8 c
K_1	65.4 bc
K_2	69.9 a
K_3	67.0 ab
CV (%)	10.2
LSD (0.05)	4.2

K_0, 120 kg ha^{-1}; K_1, 140 kg ha^{-1}; K_2, 160 kg ha^{-1}; K_3, 180 kg ha^{-1}

There was significant effect among the interactions (appendix III). The interaction effect of germplasm and potassium showed a wide range of variation. The highest vine length was recorded from the G_OK_3 (95.0 cm) and lowest was found in G_RK_0 (32.3 cm) (Table 4).

Table 4. Interaction effect of germplasm and potassium on vine length, stalk length, leaf length and leaf width of seven sweet potato germplasm

Treatments	Vine length (cm)	Stalk length (cm)	Leaf length (cm)	Leaf width (cm)
G_LK_0	67.3 bcdef	4.5 fg	3.6 kl	10.0 i
G_LK_1	74.0 bcd	4.0 g	3.6 kl	9.3 j
G_LK_2	75.0 bc	3.8 g	3.5 l	9.5 j
G_LK_3	77.7 b	3.8 g	3.6 kl	9.6 j
G_RK_0	32.3 g	6.0 f	3.7 kl	10.6 gh
G_RK_1	33.3 g	5.8 f	3.7 kl	10.6 gh
G_RK_2	43.3 g	6.0 f	3.7 kl	10.7 gh
G_RK_3	36.3 g	6.0 f	3.8 kl	10.9 g
G_WK_0	56.3 f	5.3 fg	4.6 jkl	12.1 e
G_WK_1	64.3 cdef	5.4 fg	4.6 jkl	11.8 ef
G_WK_2	75.0 bc	5.2 fg	4.6 jkl	12.1 e
G_WK_3	60.0 ef	5.1 fg	4.7 jk	11.5 f
G_YK_0	61.7 def	5.3 fg	5.7 i	10.9 g
G_YK_1	65.9 bcdef	4.9 fg	5.5 ij	10.3 hi
G_YK_2	68.3 bcdef	4.9 fg	5.8 i	10.5 gh
G_YK_3	63.0 cdef	4.9 fg	5.7 i	10.6 gh
G_OK_0	89.0 a	16.7 c	11.3 def	10.3 hi
G_OK_1	93.7 a	11.5 e	12.2 cd	10.4 h
G_OK_2	94.7 a	12.5 e	11.1 ef	10.0 i
G_OK_3	95.0 a	11.3 e	12.0 cde	10.7 gh
G_VK_0	66.3 bcdef	14.2 d	10.1 gh	13.5 cd
G_VK_1	66.7 bcdef	11.4 e	10.9 fg	13.6 c
G_VK_2	68.3 bcdef	11.7 e	12.9 c	13.6 c
G_VK_3	72.7 bcde	12.7 e	9.9 h	13.2 d
G_MK_0	59.3 f	20.6 b	15.5 a	14.7 ab
G_MK_1	61.0 def	16.4 c	15.4 a	14.8 ab
G_MK_2	64.3 cdef	20.3 b	16.3 a	15.0 a

G_MK_3	64.3 cdef	24.3 a	13.9 b	14.5 b
CV %	10.2	9.4	7.1	1.9
LSD (0.05)	11.0	1.5	0.9	0.4

G_L= Local, G_R= Vietnam red, G_W= White, G_Y= Yellow, G_O= Orange, G_V= Violet, G_M= Magenta, K_0=120 kg ha^{-1}, K_1= 140 kg ha^{-1}, K_2= 160 kg ha^{-1}, K_3=180 kg ha^{-1}

4.1.2 Stalk length

In terms of stalk length there was significant difference among the germplasm (appendix III). The highest stalk length (20.4 cm) was found in G_M and lowest from G_L (4.1 cm) (Table 5). This might be due to the genetic variation among the germplasm (Mangani *et al*., 2015). The similar result reported by Haque *et al*. (2015). The present finding agreed with the finding of Datta *et al*., (2015), Liao *et al*. (2015), Shayanowako *et al.* (2014), Ganga *et al*. (2014), (Mahmud *et al*., 2014), Iheagwara (2013), Khan *et al*. (2012), Kaspar *et al*. (2013).

Table 5. **Stalk length variation with different sweet potato germplasms**

Treatments	Stalk length (cm)
G_L	4.1 e
G_R	6.0 c
G_W	5.3 d
G_Y	5.0 d
G_O	13.0 b
G_V	12.5 b
G_M	20.4 a
CV (%)	9.4
LSD (0.05) G	0.7

G_L, Local; G_R, Vietnam red; G_W, White; G_Y, Yellow; G_O, Orange; G_V, Violet; G_M, Magenta.

Stalk length variation was recorded due to different doses of potassium application and significant difference was found (appendix III). The maximum stalk length was recorded in the treatment K_0 (10.4 cm) and lowest value of this trait was in the treatment K_1 (9.2 cm) (Table 6). This result revealed that potassium had no effect on the stalk length of sweet potato. The finding is agreed with the finding of Sweet

Potato Research Station (2007), Jian-wei *et al*. (2001), Rumhungwe *et al*. (2016), Pulok *et al*. (2016), Liang (2013), Bansal and Trehan (2011), El-Baky *et al*. (2010).

Table 6. Effect of potassium on stalk length of 7 sweet potato germplasm

Treatments	Stalk length (cm)
K_0	10.4 a
K_1	8.5 c
K_2	9.2 b
K_3	9.7 b
CV (%)	9.4
LSD (0.05) K	0.6

K_0, 120 kg ha^{-1}; K_1, 140 kg ha^{-1}; K_2, 160 kg ha^{-1}; K_3, 180 kg ha^{-1}

There was significant effect among the interactions of germplasm and potassium (appendix III). The interaction effect of germplasm and potassium showed a wide range of variation. The highest stalk length was found from the G_MK_3 (24.3 cm) and lowest was found in G_LK_2 and G_LK_2 (3.8 cm) (Table 4).

4.3.3 Leaf length

The significant effect of germplasm on leaf length was recorded (appendix III). The germplasm G_M showed the highest value of leaf length (15.3 cm) where G_L showed the lowest value of leaf length (3.6 cm) (Table 7). The finding agreed with the finding of Joseph *et al*. (2005), Lachman and Hamouz (2005), Holtan *et al.* (2003), Gichuki *et al*, (2003), Lefebvre *et al*. (2001).

Table 7. **Leaf length variation with different sweet potato germplasm**

Treatments	Leaf length (cm)
G_L	3.6f
G_R	3.7f
G_W	4.6e
G_Y	5.7d
G_O	11.6b
G_V	11.0c
G_M	15.3a
CV (%)	7.1
LSD (0.05) G	0.4

G_L, Local; G_R, Vietnam red; G_W, White; G_Y, Yellow; G_O, Orange; G_V, Violet; G_M, Magenta.

Potassium had significant effect on leaf length of sweet potato (appendix III). Result revealed that K_2 produced the highest leaf length (8.3 cm) of sweet potato (Table 8). The treatment K_3 produced lowest leaf length (7.6 cm). The highest value of potassium in terms of leaf length indicated that it helped to cell elongation of leaf of sweet potato. The finding is supported with the finding of Rumhungwe *et al*. (2016), Pulok *et al*. (2016), Liang (2013), Bansal and Trehan (2011), El-Baky *et al*. (2010).

Table 8. **Effect of potassium on leaf length of seven sweet potato germplasm**

Treatments	Leaf length (cm)
K_0	7.8 b
K_1	8.0 ab
K_2	8.3 a
K_3	7.6 b
CV (%)	7.1
LSD (0.05) K	0.3

K_0, 120 kg ha^{-1}; K_1, 140 kg ha^{-1}; K_2, 160 kg ha^{-1}; K_3, 180 kg ha^{-1}

The interaction effect of germplasm and potassium had significant impact on leaf length of sweet potato (appendix III). The interaction G_MK_2 (16.3 cm) produced the highest value of leaf length and interaction G_LK_2 (5.3 cm) produced the lowest value of leaf length (Table 4).

4.3.4 Leaf width

As like the other vegetative characters the leaf width showed significant variation among the germplasm (appendix III). The germplasm showed significant impact and the germplasm G_M showed highest value of leaf width (14.8 cm) where germplasm G_L produced lowest leaf width (9.6 cm) (Table 9). This might be due to the genetic variation among the germplasm (Mangani *et al*., 2015). The similar result reported by Haque *et al*. (2015). The present finding agreed with the finding of Datta *et al*., (2015), Liao *et al*. (2015), Shayanowako *et al.* (2014), Ganga *et al*. (2014), (Mahmud *et al*., 2014), Iheagwara (2013), Khan *et al*. (2012), Kaspar *et al*. (2013).

Table 9. **Leaf width variation with different sweet potato germplasm**

Treatments	Leaf width (cm)
G_L	9.6 f
G_R	10.7 d
G_W	11.9 c
G_Y	10.6 d
G_O	10.3 e
G_V	13.5 b
G_M	14.8 a
CV (%)	1.9
LSD (0.05)	0.2

G_L, Local; G_R, Vietnam red; G_W, White; G_Y, Yellow; G_O, Orange; G_V, Violet; G_M, Magenta.

Result indicated that there had significant effect among the potassium doses (appendix III). The highest leaf width was recorded from K_3 (11.7 cm) where the lowest value of leaf width was found (11.3 cm) from K_0 (Table 10). This finding revealed that potassium had significant effect on leaf width of sweet potato. The finding is agreed with the finding of Sweet Potato Research Station (2007), Jian-wei *et al*. (2001), Rumhungwe *et al*. (2016), Pulok *et al*. (2016), Liang (2013), Bansal and Trehan (2011), El-Baky *et al*. (2010).

Table 10. **Effect of potassium on leaf width of seven sweet potato germplasm**

Treatments	Leaf width (cm)
K_0	11.3 d
K_1	11.5 c
K_2	11.6 b
K_3	11.7 a
CV (%)	1.9
LSD (0.05) K	0.1

K_0, 120 kg ha^{-1}; K_1, 140 kg ha^{-1}; K_2, 160 kg ha^{-1}; K_3, 180 kg ha^{-1}

The interaction effect of germplasm and potassium had significant impact on leaf width of sweet potato (appendix III). The interaction G_MK_2 (15 cm) produced the highest value of leaf width and interaction G_LK_1 (9.3 cm) produced the lowest value of leaf width (Table 4).

4.4 Reproductive growth

4.4.1 Number of tuberous root plant^{-1}

Number of tuberous root plant^{-1} showed statistically significant effect (appendix IV). The germplasm Orange (G_O) showed the highest number of tuberous root plant^{-1} (9.6) where local germplasm (G_L) showed the lowest value of number of tuberous root plant^{-1} (7.6) compared to other other germplasms (Table 11). The germplasms G_R, G_W, G_Y, G_V and G_M produced 8.0, 8.3, 8.1, 8.6 and 8.7 number of tuberous root plant^{-1} respectively. This might be due to the genetic variation among the germplasm (Mangani *et al*., 2015). The similar result reported by Haque *et al*. (2015). The present finding agreed with the finding of Datta *et al*., (2015), Liao *et al*. (2015), Shayanowako *et al.* (2014), Ganga *et al*. (2014), (Mahmud *et al*., 2014), Iheagwara (2013), Khan *et al*. (2012), Kaspar *et al*. (2013).

Table 11. **Number of tuberous root plant^{-1} variation with different sweet potato germplasm**

Treatments	Number of tuberous root plant^{-1}
G_L	7.6 f
G_R	8.0 e
G_W	8.3 c
G_Y	8.1 d
G_O	9.6 a
G_V	8.6 b
G_M	8.7 b
CV (%)	1.1
LSD (0.05)	0.1

G_L, Local; G_R, Vietnam red; G_W, White; G_Y, Yellow; G_O, Orange; G_V, Violet; G_M, Magenta.

Potassium doses showed significant difference in case of tuberous root yield plant^{-1} (appendix IV). The wide range of variation of number of tuberous root plant^{-1} was noticed for different doses of potassium for the sweet potato. The highest number of tuberous root plant^{-1} was found in K_2 and K_3 (69.9 cm), where the lowest was in K_0 germplasm (8.0) (Table 12). The finding is supported with the finding of Rumhungwe *et al*. (2016), Pulok *et al*. (2016), Liang (2013), Bansal and Trehan (2011), El-Baky *et al*. (2010).

Table 12. Effect of potassium on number of tuberous root plant^{-1} of seven sweet potato germplasm

Treatments	Number of tuberous root plant^{-1}
K_0	8.0 c
K_1	8.3 b
K_2	8.7 a
K_3	8.7 a
CV (%)	1.1
LSD (0.05)	0.1

K_0, 120 kg ha^{-1}; K_1, 140 kg ha^{-1}; K_2, 160 kg ha^{-1}; K_3, 180 kg ha^{-1}

Interaction effect of germplasm and potassium showed a little range of variation but there had significant effect among the interactions (appendix IV). The highest number of tuberous root plant^{-1} was recorded from the G_OK_3 (10.0) and lowest was found in G_LK_0 (6.7) (Table 13).

4.4.2 Number of tuberous root plot^{-1}

In terms of number tuberous root plot^{-1} there had significant difference among the germplasm (appendix IV). The highest number of tuberous root plot^{-1} (317.2) was found in G_O and lowest from G_L (249.9) (Table 14). This might be due to genetic variation among the germplasms (Mbithe *et al*., 2016). Mahmun *et al*. (2016) reported the same finding. The finding agreed with the finding of Joseph *et al*. (2005), Lachman and Hamouz (2005), Holtan *et al.* (2003), Gichuki *et al,* (2003), Lefebvre *et al*. (2001).

Table 13. Interaction effect of germplasm and potassium on number of tuberous root plant^{-1}, number of tuberous root plot^{-1}, tuberous root yield plant^{-1}, tuberous root yield plot^{-1} and tuberous root yield ha^{-1} of seven sweet potato germplasm

Treatments	Number of tuberous root plant^{-1}	No. tuberous root plot^{-1}	Tuberous root yield plant^{-1}	Tuberous root yield plot^{-1}	Tuberous root yield ha^{-1}
G_LK_0	6.7 r	220.3 r	747.8 r	24.7 r	41.0 jk
G_LK_1	7.2 q	236.0 q	801.0 q	26.4 q	42.8 ghi
G_LK_2	7.6 p	249.7 p	847.4 p	28.0 p	45.0 de
G_LK_3	8.9 e	293.7 e	996.7 e	32.9 e	45.5 cd

G_RK_0	7.7 o	254.7 o	864.3 o	28.5 o	30.1 o
G_RK_1	7.9 mn	261.7 mn	888.1 mn	29.3 mn	39.1 m
G_RK_2	8.1 jkl	268.7 jkl	911.8 jkl	30.1 jkl	39.6 lm
G_RK_3	8.4 hi	275.7 hi	935.6 hi	30.9 hi	47.8 b
G_WK_0	8.1 klm	266.7 klm	905.0 klm	29.9 klm	39.6 lm
G_WK_1	8.3 ij	273.7 ij	928.8 ij	30.7 ij	40.9 jk
G_WK_2	8.5 gh	280.7 gh	952.6 gh	31.4 gh	42.2 hi
G_WK_3	8.2 ijk	271.7 ijk	922.0 ijk	30.4 ijk	43.5 fg
G_YK_0	7.4 p	245.0 p	831.5 p	27.4 p	41.8 ij
G_YK_1	7.8 no	258.7 no	877.9 no	29.0 no	43.1 gh
G_YK_2	9.2 d	302.7 d	1027.0 d	33.9 d	44.4 ef
G_YK_3	8.0 lmn	263.7l mn	894.9 lmn	29.5 lmn	42.7 ghi
G_OK_0	9.2 d	303.7 d	1031.0 d	34.0 d	36.7 n
G_OK_1	9.5 c	312.7 c	1061.0 c	35.0 c	39.3 lm
G_OK_2	9.8 b	321.7 b	1092.0 b	36.0 b	47.5 b
G_OK_3	10.0 a	330.7 a	1122.0 a	37.0 a	49.7 a
G_VK_0	8.2 ijk	271.7 ijk	922.0 ijk	30.4 ijk	44.7 de
G_VK_1	8.5 gh	280.7 gh	952.6 gh	31.4 gh	46.4 c
G_VK_2	8.8 ef	289.7 ef	983.1 ef	32.4 ef	48.1 b
G_VK_3	9.1 d	298.7 d	1014.0 d	33.5 d	40.2 kl
G_MK_0	8.5 gh	279.7 gh	949.2 gh	31.3 gh	42.7 ghi
G_MK_1	8.7 f	286.7 f	972.9 f	32.1 f	44.4 ef
G_MK_2	8.9 e	293.7 e	996.7 e	32.9 e	46.1 c
G_MK_3	8.6 fg	284.7 fg	966.1 fg	31.9 fg	47.8 b
CV %	1.1	1.1	1.1	1.1	1.3
LSD (0.05)	0.1	4.9	16.7	0.6	0.9

G_L= Local, G_R= Vietnam red, G_W= White, G_Y= Yellow, G_O= Orange, G_V= Violet, G_M= Magenta, K_0=120 kg ha^{-1}, K_1= 140 kg ha^{-1}, K_2= 160 kg ha^{-1}, K_3=180 kg ha^{-1}

Table 14. Number of tuberous root plot^{-1} variation with different sweet potato germplasms

Treatments	No. tuberous root plot^{-1}
G_L	249.9 f
G_R	265.2 e
G_W	273.2 c
G_Y	267.5 d
G_O	317.2 a
G_V	285.2 b
G_M	286.2 b
CV (%)	1.1
LSD (0.05)	2.3

G_L, Local; G_R, Vietnam red; G_W, White; G_Y, Yellow; G_O, Orange; G_V, Violet; G_M, Magenta.

Significant difference was recorded in case of of number of tuberous root yield plot^{-1} (appendix III) which could be due to different doses of potassium application. The maximum number of tuberous root plot^{-1} was recorded in the treatment K_3 (288.4) and lowest value of this trait was in the treatment K_0 (263.1) (Table 15). This result revealed that potassium had an effect on the number of tuberous root plot^{-1} of sweet potato. The finding is agreed with the finding of Sweet Potato Research Station (2007), Jian-wei *et al*. (2001), Rumhungwe *et al*. (2016), Pulok *et al*. (2016), Liang (2013), Bansal and Trehan (2011), El-Baky *et al*. (2010). This might be due to change of location and weather condition.

Table 15. Effect of potassium on number of tuberous root plot^{-1} of seven sweet potato germplasms

Treatments	No. tuberous root plot^{-1}
K_0	263.1 c
K_1	272.9 b
K_2	286.7 a
K_3	288.4 a
CV (%)	1.1
LSD (0.05)	1.9

K_0, 120 kg ha^{-1}; K_1, 140 kg ha^{-1}; K_2, 160 kg ha^{-1}; K_3, 180 kg ha^{-1}

There was significant effect among the interactions of germplasm and potassium (appendix IV). Interaction effect of germplasm and potassium showed a wide range of variation. The highest number of tuberous root plot^{-1} was found from the G_OK_3 (330.7) and lowest was found in G_LK_0 (220) (Table 13).

4.4.3 Tuberous root yield plant^{-1}

The significant effect of germplasm on tuberous root yield plant^{-1} was recorded (appendix IV). The germplasm G_O showed the highest value of tuberous root yield plant^{-1} (1076.0 g) where G_L showed the lowest value of tuberous root yield plant^{-1} (848.2) (Table 16). This might be due to the genetic variation among the germplasm (Mangani *et al*., 2015). The similar result reported by Haque *et al*. (2015). The present finding also agreed with the finding of Datta *et al*., (2015), Liao *et al*. (2015), Shayanowako *et al.* (2014), Ganga *et al*. (2014), (Mahmud *et al*., 2014), Iheagwara (2013), Khan *et al*. (2012), Kaspar *et al*. (2013).

Table 16. Tuberous root yield plant^{-1} variation with different sweet potato germplasms

Treatments	Tuberous root yield plant^{-1}
G_L	848.2 f
G_R	900.0 e
G_W	927.1 c
G_Y	907.9 d
G_O	1076.0 a
G_V	967.8 b
G_M	971.2 b
CV (%)	1.1
LSD (0.05)	7.7

G_L, Local; G_R, Vietnam red; G_W, White; G_Y, Yellow; G_O, Orange; G_V, Violet; G_M, Magenta.

Potassium had significant effect on tuberous root yield plant^{-1} of sweet potato (appendix IV). Result revealed that K_3 produced the highest tuberous root yield plant^{-1} (978.7 g) of sweet potato (Table 17) and the treatment K_0 produced lowest tuberous root yield plant^{-1} (892.9 g). But the treatment K_2 and K_3 showed statistically similar performances. The highest value of potassium in terms of tuberous root yield plant^{-1} indicated that it helped to reproductive development of sweet potato. The finding is supported with the finding of Rumhungwe *et al*. (2016), Pulok *et al*. (2016), Liang (2013), Bansal and Trehan (2011), El-Baky *et al*. (2010).

Table 17. Effect of potassium on number of tuberous root yield plant^{-1} of 7 sweet potato germplasms

Treatments	Tuberous root yield plant^{-1}
K_0	892.9 c
K_1	926.1 b
K_2	972.9 a
K_3	978.7 a
CV (%)	1.1

LSD (0.05)	6.3

K_0, 120 kg ha^{-1}; K_1, 140 kg ha^{-1}; K_2, 160 kg ha^{-1}; K_3, 180 kg ha^{-1}

The interaction effect of germplasm and potassium had significant impact on tuberous root yield plant^{-1} of sweet potato (appendix III). The interaction G_OK_3 produced the highest value of tuberous root yield plant^{-1} (1122.0 g) and interaction G_LK_0 produced the lowest value of tuberous root yield plant^{-1} (747.8 g) (Table 13).

4.4.4 Tuberous root yield plot^{-1}

As like the other vegetative characters, the tuberous root yield plot^{-1} showed a significant effect among the germplasm (appendix IV). Among them germplasm G_O showed highest value of tuberous root yield plot^{-1} (35.5 kg) where germplasm G_L produced lowest tuberous root yield plot^{-1} (28.0 kg) (Table 18). The reason behind the finding is that the genetic variations among the germplasm. This might be due to genetic variation among the germplasms (Mbithe *et al*., 2016). Mahmun *et al*. (2016) reported the same finding. The finding agreed with the finding of Joseph *et al*. (2005), Lachman and Hamouz (2005), Holtan *et al.* (2003), Gichuki *et al,* (2003), Lefebvre *et al*. (2001).

Table 18. Tuberous root yield plot^{-1} variation with different sweet potato germplasms

Treatments	Tuberous root yield plot^{-1}
G_L	28.0 f
G_R	29.7 e
G_W	30.6 c
G_Y	30.0 d
G_O	35.5 a
G_V	31.9 b
G_M	32.1 b
CV (%)	1.1
LSD (0.05)	0.3

G_L, Local; G_R, Vietnam red; G_W, White; G_Y, Yellow; G_O, Orange; G_V, Violet; G_M, Magenta.

Result indicated that there had significant effect among the potassium doses (appendix IV). The highest tuberous root yield plot^{-1} was recorded from K_3 (32.3kg) where lowest (29.5 kg) from K_0 (Table 19). This finding revealed that potassium is responsible for reproductive development of sweet potato. The finding is agreed with the finding of Sweet Potato Research Station (2007), Jian-wei *et al.* (2001), Rumhungwe *et al*. (2016), Pulok *et al*. (2016), Liang (2013), Bansal and Trehan (2011), El-Baky *et al*. (2010).

Table 19. **Effect of potassium on tuberous root yield plot^{-1} of seven sweet potato germplasms**

Treatments	Tuberous root yield plot^{-1}
K_0	29.5 c
K_1	30.6 b
K_2	32.1 a
K_3	32.3 a
CV (%)	1.1
LSD (0.05)	0.2

K_0, 120 kg ha^{-1}; K_1, 140 kg ha^{-1}; K_2, 160 kg ha^{-1}; K_3, 180 kg ha^{-1}

The interaction effect of germplasm and potassium had significant impact on tuberous root yield plot^{-1} of sweet potato (appendix IV). The interaction G_OK_3 (37.0 kg) produced the highest value of tuberous root yield plot^{-1} and interaction G_LK_0 (24.7 kg) produced the lowest value of tuberous root yield plot^{-1} (Table 13).

4.4.5 Tuberous root yield ha^{-1}

The significant effect of germplasm on tuberous root yield ha^{-1} was recorded (appendix IV). The germplasm G_O showed the highest value of tuberous root yield ha^{-1} (47.2 t ha^{-1}) where G_L showed the lowest value of tuberous root yield ha^{-1} (40.7 t ha^{-1}) (Table 20). This might be due to the genetic variation among the germplasm (Mangani *et al*., 2015). The similar result reported by Haque *et al*. (2015). The present finding agreed with the finding of Datta *et al*., (2015), Liao *et al*. (2015), Shayanowako *et al.* (2014), Ganga *et al*. (2014), (Mahmud *et al*., 2014), Iheagwara (2013), Khan *et al*. (2012), Kaspar *et al*. (2013).

Table 20. **Tuberous root yield ha^{-1} variation with different sweet potato germplasm**

Treatments	Tuberous root yield ha^{-1}
G_L	40.7 f
G_R	41.5 e
G_W	43.0 d
G_Y	40.9 f
G_O	47.2 a
G_V	45.2 c
G_M	46.4 b
CV (%)	1.3
LSD (0.05)	0.4

G_L, Local; G_R, Vietnam red; G_W, White; G_Y, Yellow; G_O, Orange; G_V, Violet; G_M, Magenta.

Potassium had significant effect on tuberous root yield ha^{-1} of sweet potato (appendix IV). Result revealed that K_3 produced the highest tuberous root yield ha^{-1} (45.5 t ha^{-1}) of sweet potato (Table 21) and the treatment K_0 produced lowest tuberous root yield ha^{-1} (40.7 t ha^{-1}). But the treatment K_2 and K_3 showed statistically similar performances. The highest value of potassium in terms of tuberous root yield ha^{-1} indicated that it helped in reproductive development of sweet potato. The finding is agreed with the finding of Sweet Potato Research Station (2007), Jian-wei *et al*. (2001), Rumhungwe *et al*. (2016), Pulok *et al*. (2016), Liang (2013), Bansal and Trehan (2011), El-Baky *et al*. (2010).

Table 21. Effect of potassium on number of tuberous root yield ha^{-1} of seven sweet potato germplasms

Treatments	Tuberous root yield ha^{-1}
K_0	41.0 d
K_1	42.8 c
K_2	45.2 a
K_3	45.5 a
CV (%)	1.3
LSD (0.05)	0.3

K_0, 120 kg ha^{-1}; K_1, 140 kg ha^{-1}; K_2, 160 kg ha^{-1}; K_3, 180 kg ha^{-1}

The interaction effect of germplasm and potassium had significant impact on tuberous root yield ha^{-1} of sweet potato (appendix IV). The interaction G_OK_3 produced the highest value of tuberous root yield ha^{-1} (49.7 t ha^{-1}) and interaction G_LK_0 produced the lowest value of tuberous root yield ha^{-1} (41.0 t ha^{-1}) (Table 13).

4.5 Color attributes of 7 sweet potato germplasm

4.5.1 Skin color

Local germplasm

The L*, a*, b* C* and *h* values for skin color of local germplasm (G_L) was 78.23, 6.17, 21.34, 22.22 and 73.87, respectively (Plate 10 and Table 22).

Vietnam red germplasm

The values of L*, a*, b* C* and *h* was recorded of skin for G_R 48.5, 36.09, 13.99, 38.71 and 21.18, respectively (Plate 10 and Table 22).

White germplasm

The L*, a*, b* C* and *h* values for skin of white germplasm (G_W) was 71.63, 8.16, 20.72, 22.27 and 68.50, respectively (Plate 10 and Table 22).

Yellow germplasm

The L*, a*, b* C* and *h* values for skin of G_Y germplasm was 45.75, 28.60, 3.79, 28.85 and 7.50, respectively (Plate 10 and Table 22).

Orange germplasm

The values of L*, a*, b* C* and *h* was recorded for skin of G_O germplasm 58.34, 24.51, 29.63, 38.45 and 50.51, respectively (Plate 10 and Table 22).

Violet germplasm

The L*, a*, b* C* and *h* values for skin of G_V germplasm was 35.34, 13.85, 7.51, 15.76 and 28.48, respectively (Plate 10 and Table 22).

Magenta germplasm

The L*, a*, b* C* and *h* values for skin of G_M germplasm was 41.63, 21.31, 26.2, 38.77 and 50.88, respectively (Plate 10 and Table 22).

Table 22. Skin color traits of 7 sweet potato germplasm

Treatments	Skin color				
	L*	a*	b*	C*	*h*
G_L	78.23	6.17	21.34	22.22	73.87
G_R	48.5	36.09	13.99	38.71	21.18
G_W	71.63	8.16	20.72	22.27	68.50
G_Y	45.75	28.60	3.79	28.85	7.50
G_O	58.34	24.51	29.63	38.45	50.51
G_V	35.66	13.85	7.51	15.76	28.48
G_M	41.63	21.31	26.2	38.77	50.88

G_L= Local, G_R= Vietnam red, G_W= White, G_Y= Yellow, G_O= Orange, G_V= Violet, G_M= Magenta

Plate 10. Skin color of 7 sweet potato germplasm

4.5.2 Flesh color

Local germplasm

The L*, a*, b* C* and *h* values for flesh color of local germplasm (G_L) are 85.73, 1.83, 12.39, 12.52 and 81.61, respectively (Table 23 and Plate 11).

Vietnam red germplasm

The values of L*, a*, b* C* and *h* was recorded of flesh for G_R 76.41, 17.02, 39.37, 42.90 and 66.62, respectively (Table 23 and Plate 11).

White germplasm

The L*, a*, b* C* and *h* values for flesh of white germplasm (G_W) were 51.01, 25.01, -12.32, 27.88 and 333.77, respectively (Table 23 and Plate 11).

Yellow germplasm

The L*, a*, b* C* and *h* values for flesh of G_Y germplasm were 74.10, 25.21, 41.51, 48.57 and 58.73, respectively (Table 23 and Plate 11).

Orange germplasm

The values of L*, a*, b* C* and *h* was recorded for flesh of G_O germplasm 61.61, 29.81, 46.44, 55.18 and 57.30, respectively (Table 23 and Plate 11).

Violet germplasm

The L*, a*, b* C* and *h* values for flesh of G_V germplasm were 39.67, 32.41, -6.36, 33.02 and 348.90, respectively (Table 23 and Plate 11).

Magenta germplasm

The L*, a*, b* C* and *h* values for flesh of G_M germplasm was 28.57, 29.50, -11.28, 31.58 and 339.07, respectively (Table 23 and Plate 11).

Plate 11. Flesh color of 7 sweet potato germplasms

Table 23. Flesh color traits of 7 sweet potato germplasm

Treatments	Flesh color				
	L*	a*	b*	C*	*h*
G_L	85.73	1.83	12.39	12.52	81.61
G_R	76.41	17.02	39.37	42.90	66.62
G_W	51.01	25.01	-12.32	27.88	333.77
G_Y	74.10	25.21	41.51	48.57	58.73
G_O	61.61	29.81	46.44	55.18	57.30
G_V	39.67	32.41	-6.36	33.02	348.90
G_M	28.57	29.50	-11.28	31.58	339.07

G_L= Local, G_R= Vietnam red, G_W= White, G_Y= Yellow, G_O= Orange, G_V= Violet, G_M= Magenta

4.5.3 Flesh color (after baking)

Local germplasm

The L*, a*, b* C* and *h* values for flesh after baking color of local germplasm (G_L) was 64.71, 2.01, 6.23, 6.55 and 72.12, respectively (Table 24 and Plate 12).

Vietnam red germplasm

The values of L*, a*, b* C* and *h* was recorded of flesh after baking for G_R 61.07, 16.44, 39.95, 43.20 and 67.63, respectively (Table 24 and Plate 12).

White germplasm

The L*, a*, b* C* and *h* values for flesh after baking of white germplasm (G_W) were 44.65, 9.79, -12.17, 15.62 and 308.80, respectively (Table 24 and Plate 12).

Yellow germplasm

The L*, a*, b* C* and *h* values for flesh after baking of G_Y germplasm was 64.80, 8.61, 27.76, 29.07 and 51.16, respectively (Table 24 and Plate 12).

Orange germplasm

The values of L*, a*, b* C* and *h* was recorded for flesh after baking of G_O germplasm 57.79, 19.81, 24.59, 31.58 and 51.16, respectively (Table 24 and Plate 12).

Violet germplasm

The L*, a*, b* C* and *h* values for flesh after baking of G_V germplasm were 39.16, 9.41, -4.83, 10.65 and 333.01, respectively (Table 24 and Plate 12).

Magenta germplasm

The L*, a*, b* C* and *h* values for flesh after baking of G_M germplasm was 33.59, 30.73, -4.97, 40.6 and 340.08, respectively (Table 24 and Plate 12).

Table 24. Flesh color traits of 7 sweet potato germplasm (after baking)

Treatments	Flesh color (after baking)				
	L*	a*	b*	C*	*h*
G_L	64.71	2.01	6.23	6.55	72.12
G_R	61.07	16.44	39.95	43.20	67.63
G_W	44.65	9.79	-12.17	15.62	308.80
G_Y	64.80	8.61	27.76	29.07	51.16
G_O	57.79	19.81	24.59	31.58	51.16
G_V	39.16	9.41	-4.83	10.65	333.01
G_M	33.59	30.73	-4.97	40.6	340.08

G_L= Local, G_R= Vietnam red, G_W= White, G_Y= Yellow, G_O= Orange, G_V= Violet, G_M= Magenta

Plate 12: Flesh color of 7 sweet potato germplasms (after baking)

CHAPTER V

SUMMARY AND CONCLUSION

The investigation was conducted at the Horticulture Farm, Sher-e-Bangla Agricultural University to assess influence of potash on morphophysiological characteristics, growth and yield of sweet potato germplasm during the period from October to March, 2017. For this purpose, 7 selected sweet potato germplasm namely Local, Vietnam red, White, Yellow, Orange, Violet and Magenta were used as a test crop.

Result showed that vine length, stalk length, leaf length and leaf width for Local germplasm was 75.5 cm, 4.1 cm, 3.6 cm and 9.6 cm, respectively. The number of tubers plant^{-1}, number of tubers plot^{-1}, tuber yield plant^{-1}, tuber yield ha^{-1} were 7.6, 249.9, 848.2 g, 28.0 g and 40.7 ton, respectively. The L*, a*, b* C* and *h* values for skin color of local germplasm (G_L) was 78.23, 6.17, 21.34, 22.22 and 73.87, respectively. The L*, a*, b* C* and *h* values for flesh color of local germplasm (G_L) are 85.73, 1.83, 12.39, 12.52 and 81.61, respectively. The L*, a*, b* C* and *h* values for flesh after baking color of local germplasm (G_L) was 64.71, 2.01, 6.23, 6.55 and 72.12, respectively. Growth habit of this germplasm was semi upright. Leaf margin color and vine color absent here. Node color and petiole pigmentation was present in this germplasm. Number of lobe in leaf was three and anthocyanin coloration on leaf blade tip was absent. Mature and immature leaf color is green where close cluster types of root was present with moderate type of eye.

Vine length, stalk length, leaf length and leaf width were recorded 36.3 cm, 6.0 cm, 3.7 cm and 10.7 cm, respectively for Vietnam red germplasm. The number of tubers plant^{-1}, number of tubers plot^{-1}, tuber yield plant^{-1}, tuber yield ha^{-1} were 8.0, 265.2, 900.0 g, 29.7 kg and 41.5 ton, respectively. The values of L*, a*, b* C* and *h* was recorded of skin for G_R 48.5, 36.09, 13.99, 38.71 and 21.18, respectively. The values of L*, a*, b* C* and *h* was recorded of flesh for G_R 76.41, 17.02, 39.37, 42.90 and 66.62, respectively. The values of L*, a*, b* C* and *h* was recorded of flesh after baking for G_R 61.07, 16.44, 39.95, 43.20

and 67.63, respectively. Spreading type of growth habit was observed with having the large number of leaves. Node color, vine color and petiole pigmentation were present for this germplasm. Cordate type leaf was found for this germplasm. Depth of eye was moderate and open cluster types of root. Mature and immature leaf color was green.

Vine length, stalk length, leaf length and leaf width were recorded 63.9 cm, 5.3 cm, 4.6 cm and 11.9 cm, respectively for White germplasm. The number of tubers plant^{-1}, number of tubers plot^{-1}, tuber yield plant^{-1}, tuber yield ha^{-1} were 8.3, 273.2, 927.1 g, 30.6 kg and 43.0 ton, respectively. The L*, a*, b* C* and *h* values for skin of white germplasm (G_W) was 71.63, 8.16, 20.72, 22.27 and 68.50, respectively. The L*, a*, b* C* and *h* values for flesh of white germplasm (G_W) were 51.01, 25.01, -12.32, 27.88 and 333.77, respectively. The L*, a*, b* C* and *h* values for flesh after baking of white germplasm (G_W) were 44.65, 9.79, -12.17, 15.62 and 308.80, respectively. Semi upright type of growth habit was observed and had purple lead margin color. Petiole pigmentation, anthocyanin coloration on lead blade tip, vine color was absent for this germplasm. Mature and immature leaf color was green.

Vine length, stalk length, leaf length and leaf width were recorded 64.5 cm, 5.0 cm, 5.7 cm and 10.6 cm, respectively for Yellow germplasm. The number of tubers plant^{-1}, number of tubers plot^{-1}, tuber yield plant^{-1}, tuber yield ha^{-1} were 8.1, 267.5, 907.9 g, 30.0 kg and 40.9 ton, respectively. The L*, a*, b* C* and *h* values for skin of G_Y germplasm was 45.75, 28.60, 3.79, 28.85 and 7.50, respectively. The L*, a*, b* C* and *h* values for flesh of G_Y germplasm were 74.10, 25.21, 41.51, 48.57 and 58.73, respectively. The L*, a*, b* C* and *h* values for flesh after baking of G_Y germplasm was 64.80, 8.61, 27.76, 29.07 and 51.16, respectively. Round elliptic types of root with a shallow eye having spreading growth habit was noticed. Node color, leaf margin color, vine color was present. Mature leaf color purplish and immature leaf color was green.

Vine length, stalk length, leaf length and leaf width were recorded 93.1 cm, 13.0 cm, 11.6 cm and 10.3 cm, respectively for Orange germplasm. The number of tubers $plant^{-1}$, number of tubers $plot^{-1}$, tuber yield $plant^{-1}$, tuber yield ha^{-1} were 9.6, 317.2, 1076.0 g, 35.5 kg and 47.2 ton, respectively. The values of L*, a*, b* C* and *h* was recorded for skin of G_O germplasm 58.34, 24.51, 29.63, 38.45 and 50.51, respectively. The values of L*, a*, b* C* and *h* was recorded for flesh of G_O germplasm 61.61, 29.81, 46.44, 55.18 and 57.30, respectively. The values of L*, a*, b* C* and *h* was recorded for flesh after baking of G_O germplasm 57.79, 19.81, 24.59, 31.58 and 51.16, respectively. Growth habit of this yellow germplasm was spreading type with shallow types of eye. Node color, leaf margin color, petiole pigmentation was absent but vine color, anthocyanin coloration on leaf blade tip was present. Immature color is purple and mature leaf color was green.

Vine length, stalk length, leaf length and leaf width were recorded 68.5 cm, 12.5 cm, 11.0 cm and 13.5 cm, respectively for Violet germplasm. The number of tubers $plant^{-1}$, number of tubers $plot^{-1}$, tuber yield $plant^{-1}$, tuber yield ha^{-1} were 8.6, 285.2 967.8 g, 31.9 kg and 45.2 ton, respectively. The L*, a*, b* C* and *h* values for skin of G_V germplasm was 35.34, 13.85, 7.51, 15.76 and 28.48, respectively. The L*, a*, b* C* and *h* values for flesh of G_V germplasm were 39.67, 32.41, -6.36, 33.02 and 348.90, respectively. The L*, a*, b* C* and *h* values for flesh after baking of G_V germplasm were 39.16, 9.41, -4.83, 10.65 and 333.01, respectively. Shallow type of eye with a semi upright growth habit was found. Node color, vine color, petiole pigmentation was present. Leaf margin color was purple and anthocyanin coloration on leaf blade tip was absent.

Vine length, stalk length, leaf length and leaf width were recorded 62.3 cm, 20.4 cm, 15.3 cm and 14.8 cm, respectively for Magenta germplasm. The number of tubers $plant^{-1}$, number of tubers $plot^{-1}$, tuber yield $plant^{-1}$, tuber yield ha^{-1} were 8.7, 286.2, 971.2 g, 32.1 kg, 46.4 ton, respectively. The L*, a*, b* C* and *h* values for skin of G_M germplasm was 41.63, 21.31, 26.2, 38.77 and 50.88, respectively. The L*, a*, b* C* and *h* values for flesh of G_M germplasm was 28.57, 29.50, -11.28, 31.58 and 339.07, respectively. The L*, a*, b* C* and *h* values for flesh after baking of G_M germplasm was 33.59, 30.73, -4.97, 40.6 and 340.08, respectively. Spreading type of growth habit with very shallow eyes was present. Immature and immature leaf color was green. Anthocyanin coloration on leaf blade tip, petiole pigmentation and node color were absent. Leaf margin color was purple.

Data revealed that vine length (93.1cm) was highest in G_O, lowest in G_R (36.3 cm). Stalk length, leaf length and leaf width the highest value was obtained from the magenta (20.4, 15.3, 14.8 cm) but lowest was recorded from the local germplasm (4.1, 3.6, 9.6 cm).

For potassium application the highest vine length was found in K_2 (69.9 cm), but stalk length in K_0 (10.4 cm), leaf length in K_2 (8.3 cm) and leaf width in K_0 (11.7 cm).

For combination the highest vine length was recorded from the G_OK_3 (95.0 cm) and lowest was found in G_RK_0 (32.3 cm). The highest stalk length was found in G_MK_3 (24.3 cm), leaf length and leaf width in G_MK_2 (16.3, 15.0 cm, respectively) but lowest stalk length in G_LK_2, G_LK_3 (3.8 cm), leaf length in G_LK_2 (3.5 cm) and leaf width in G_LK_1 (9.3 cm).

The germplasm orange showed the highest value of number of tuber plant^{-1}, number of tuber plot^{-1}, tuber yield plant^{-1}, tuber yield plot^{-1} and tuber yield ha^{-1}.

The highest number of tuber plant^{-1} was found in K_2 and K_3 (8.7), but number of tuber plot^{-1}, tuber yield plant^{-1}, tuber yield plot^{-1} and tuber yield ha^{-1} was highest in K_3 (288.4, 978.7 g plant^{-1}, 32.3 kg plot^{-1} and 45.5 t ha^{-1}, respectively).

For combination effect the number of tuber plant^{-1}, number of tuber plot^{-1}, tuber yield plant^{-1}, tuber yield plot^{-1} and tuber yield ha^{-1} was highest in G_OK_3 (10.0, 330.7, 1122.0 g plant^{-1}, 37.0 kg plot^{-1} and 49.7 t ha^{-1}, respectively).

For germplasm, magenta showed the best result for vegetative traits and for reproductive traits the orange germplasm showed best performance.

For potassium application, vegetative characters was not consistent. In case of reproductive traits, the treatment K_2 and K_3 showed the best performance.

The present experiment was carried out only one season. So, it can be concluded that the further study should be carried out to evaluate and verify the present finding.

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APPENDICES

Appendix I. Monthly recorded the average air temperature, rainfall, relative humidity and sunshine of the experimental site during the period from October 1, 2016 to April 2017.

Month	Air temperature (^0C)		Relative humidity (%)	Total rainfall(mm)	Sunshine (hr)
	Maximum	Minimum			
October, 2016	32.6	23.8	78	172.3	5.2
November, 2016	29.6	19.2	77	34.4	5.7
December, 2016	26.4	14.1	69	12.8	5.5
January, 2017	25.4	12.7	68	7.7	5.6
February, 2017	28.1	15.5	68	28.9	5.5
March, 2017	32.5	20.4	64	65.8	5.2
April, 2017	33.7	23.6	69	165.3	5.9

Source: Sher-e-Bangla Agricultural University Weather Station

Appendix II. Physical characteristics & chemical composition of soil of the experimental plot

Soil characteristics	Analytical results
Agrological Zone	Madhupur Tract
pH	6.00-6.63
Organic mater	0.84
Total N (%)	0.46
Available phosphorous	21 ppm
Exchangeable K	0.41meq / 100 g soil

Source: Soil resource and development institute (SRDI), Dhaka

Appendix III. Analysis of variance of the data of vegetative growth of seven sweet potato germplasm influenced by potassium

Sources of variation	Degree of Freedom	Means square			
		Vine length (cm)	Stalk length (cm)	Leaf length (cm)	Leaf width (cm)
Replication	2	1.440	1.518	0.165	1.147
Germplasm	6	3393.540**	440.851**	259.209**	42.030**

(G)					
Potassium (K)	3	239.155**	13.532 **	1.472 **	0.150 **
G×K	18	30.201**	7.060 **	1.328 **	0.184 **
Error	54	45.440	0.796	0.312	0.049

**:Significant at 1% level of significance

Appendix IV. Analysis of variance of the data of yield and yield attributing character of seven sweet potato germplasm influenced by potassium

Sources of variation	Degree of Freedom	Means square				
		Number of tuber plant^{-1}	No. tuber plot^{-1}	Tuber yield plant^{-1}	Tuber yield plot^{-1}	Tuber yield ha^{-1}
Replication	2	0.235	256.000	2948.334	3.213	10.803
Germplasm (G)	6	5.035**	5477.25**	63091.045**	68.69**	88.374**
Potassium (K)	3	2.776**	3018.583**	34770.570**	37.856**	91.597**
G×K	18	0.467**	509.509**	5868.908**	6.390 **	15.059**
Error	54	0.008	8.988	103.516	0.113	0.314

**:Significant at 1% level of significance