VARIABILITY, CHARACTER ASSOCIATION AND PATH ANALYSIS OF YIELD AND YIELD RELATED TRAITS IN SWEET POTATO (*Ipomoea batatas* (L.) LAM.)

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BY

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CERTIFICATE

*This is to certify that the thesis entitled, "Variability, character association and path analysis of yield and yield related traits in sweet potato (Ipomoea batatas (L.) Lam.)" was submitted to the faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE IN GENETICS AND PLANT BREEDING**, embodies the result of a piece of bona fide research work carried out by Fariha Naz Apon, Registration No.: 11-04422 under my supervision and guidance. No part of the 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 been duly been acknowledged by her.
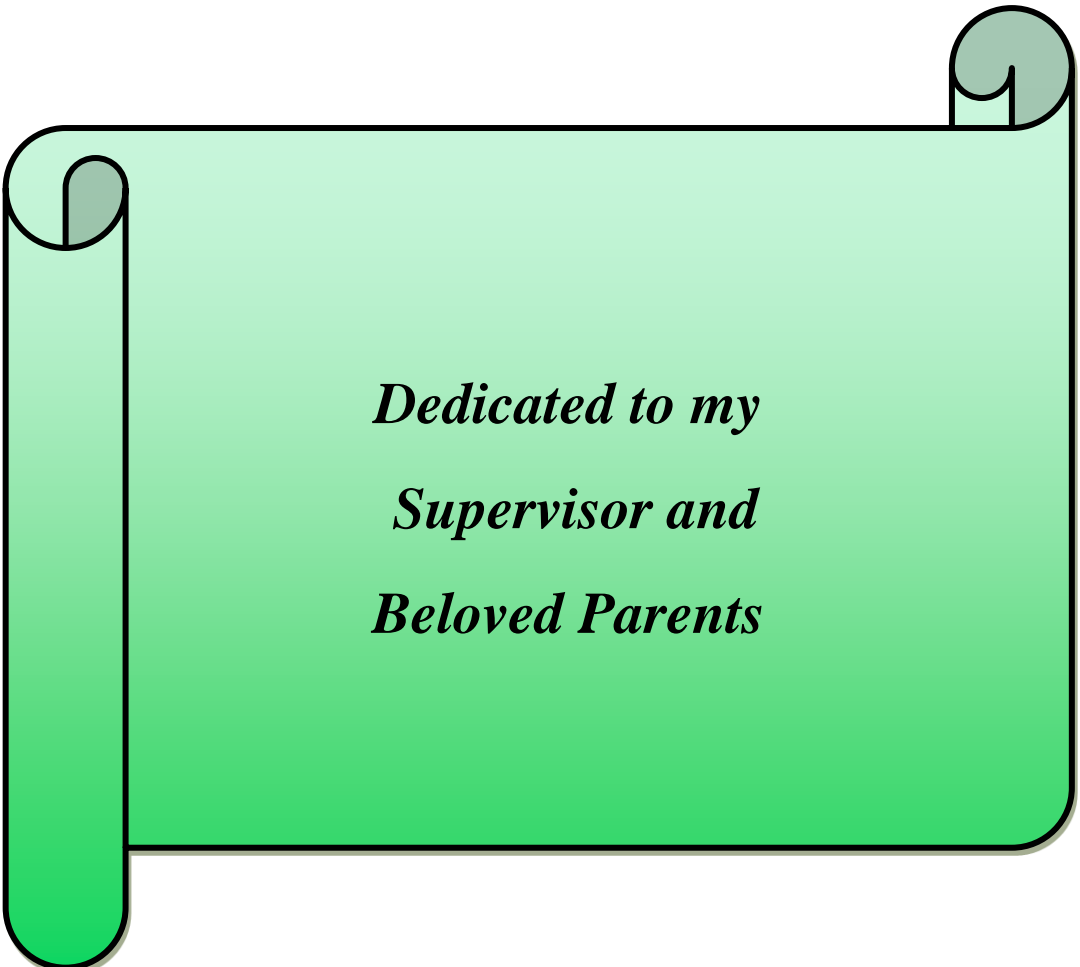
Dated: December, 2016
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(Dr. Naheed Zeba)
Professor
Supervisor

Dedicated to my

Supervisor and

Beloved Parents

Some commonly used abbreviations

Full word	Abbreviations	Full word	Abbreviations
Agricultural	*Agril.*	Horticulture	*Hort.*
Agriculture	*Agric.*	Horticulture	*Hort.*
And others	*et al.*	International	*Intl.*
Applied	*App.*	Journal	*J.*
Agronomy	*Agron.*	Kilogram	Kg
Applied	*Appl.*	Number	No.
Bangladesh Agricultural Research Council	BARC	Percentage	%
Bangladesh Agricultural Research Institute	BARI	Physiology	*Physiol.*
Bangladesh Bureau of Statistics	BBS	Research and Resource	*Res.*
Biology	*Biol.*	Review	*Rev.*
Breeding	*Breed.*	Science	*Sci.*
Botany	*Bot.*	Serial	Sl.
Centimeter	Cm	Society	*Soc.*
Environment	*Environ.*	Tropical	*Tropi.*
Etcetera	etc.	Technology	*Technol.*
Food and Agricultural Organization	FAO	That is	i.e.
Genetics	*Genet.*	Ton	T
Gram	G	Universal	*Univ.*
Hectare	ha.	Videlicet (namely)	viz.

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Variability, character association and path analysis of yield and yield related traits in sweet potato (*Ipomoea batatas* (L.) Lam.)

BY

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ABSTRACT

An experiment conducted to study the genetic variability and inheritance based on different yield contributing traits of sweet potato genotypes in Sher-E-Bangla Agricultural University, Dhaka-1207, and Bangladesh during Rabi season (2015). Among the analyzed genotypes, G1 (IB001) showed the best performance having variation in fourteen traits followed by G4 (IB004), G2 (IB002) and G3 (IB003). The Highest range of variation was observed in individual root weight (375.0- 614.50) g with the highest average mean of 459.92 g. Narrow gap between GCV and PCV was found in ten characters, leaf areal above-ground dry matter content, root number per plant, root length, individual root weight, root fresh yield per plant, root dry matter content, root dry yield per plant, root fresh yield per plot and root fresh yield per hectare suggesting minor environmental influence on gene expression controlling those traits. High heritability coupled with high genetic advance in percent of mean was observed in many traits, viz., vine length, leaf area, above ground fresh weight per plant, above ground dry weight per plant, root number per plant, root length, root diameter, individual root weight, root fresh weight per plant, root dry matter content, root dry yield per plant, root fresh yield per plot and root fresh yield per ha explaining high heritable nature. Heritability of these traits is most likely due to additive gene effects. This study serves wide opportunity for improvement through effective selection of these traits in early generation. The highly significant positive correlation with yield per hectare was observed with vine internode diameter, leaf area, above ground fresh weight per plant, root number per plant, root length, root diameter, individual root weight, root fresh yield per plant, root dry matter content, root dry yield per plant and root fresh yield per plot. Path co-efficient analysis indicated that all the characters except vine length, vine internode diameter, leaf area, above ground dry matter content, root diameter and root fresh yield per plant had the direct positive effect on yield. The positive significant indirect effect was also found by above-ground dry matter content on yield per plot.

Chapter I
Introduction

CHAPTER I
INTRODUCTION

Sweet potato (*Ipomoea batatas* (L.) Lam.) is a starchy crop which grows mostly in tropical and sub-tropical area of the world. It is a dicotyledonous plant belonging to Convolvulaceae family. This family includes almost 55 genera and more than 1000 species (Watson and Dallwitz, 2000). Sweet potato is originated in Central America. It is native to Central and South America and is one of the oldest vegetables known to man. Sweet potato is a cross pollinated, hexaploid plant (2n=6x=90) (Jones, 1965). It is a herbaceous perennial vine bearing alternate leaves of different shaped with or without lobes and medium shaped sympetalous flower usually light violet in color. Sweet potato is a tuberous root, sweet in taste, mostly used as root vegetable. The young leaves and stem are also used as green vegetable. Sweet potato is a year round crop which need low inputs and can be grown in varied agro-climatic zones. The edible tuberous root is long and tapered having smooth skin of different colors (yellow, orange, and red, purple, brown).

Sweet potato is the third most important root crop after potato and cassava due to its distinct advantages, such as adaptability to different environmental conditions and high nutritional value. In Bangladesh, the total production of sweet potato has been increased from 92,479 to 104,000 MT in 2000 to 2013, respectively (FAOSTAT, 2014). Sweet potato production has been increased in Bangladesh due to superior varieties and adaption of modern cultivation techniques by the farmers. This crop can be grown as single crop but also can be grown in relay cropping, intercropping and in rotation with other crops. Sweet potato has recently received greater research-related attention due to its many agricultural advantages such as its adaptability to wide range of environmental conditions and its nutritional value as being an excellent source of carbohydrates, dietary fiber, sugars, proteins, iron and calcium. In addition, it is also an important source of vitamin A and C, especially in the orange-fleshed varieties making sweet potato a key crop to solve

the vitamin A deficiencies around the world. The major carotenoid β-carotene is present in orange-fleshed sweet potato which is a precursor of vitamin A and essential micronutrient for immune functions in human being. Vitamin A deficiencies lead to the death of more than 600,000 people per year, especially of pregnant women and children in developing countries in Sub-Saharan Africa and South East Asia (Burri, 2011).

The importance of the nutritive value of the sweet potato as human food and animal feed has been well documented by Woolfe (1992). Rubatzky and Yamaguchi (1997) state that as a food, the roots may be roasted, baked, fried or prepared in various combination dishes, providing a rich source of carbohydrates and Pro-vitamin A. Pro-vitamin A or ß-carotene and sugar content have been found to be important consumer traits for various markets (Woolfe, 1992). In 200 g baked sweet potato, the amount of nutrition are as follows: protein- 4.02 g, carbohydrate- 41.42 g, Total Fat- 0.30 g, dietary fiber- 6.60 g, calories- 180.00 g, Total sugar- 12.96 g, Vitamin B1-0.21 mg, Vitamin B2- 0.21 mg, Vitamin B3- 2.97 mg, Vitamin C- 39.20 mg, Vitamin A- 3843.60 mcg (RE), Beta-Carotene- 23018.00 mcg, Carotenoid – 3843.60 mcg (RE) , Vitamin K-1.42 mg (Wingfield *et al.,* 2015). According to Picha (1987) carbohydrates constitute most of the dry matter in sweet potatoes and these carbohydrates exist in the form of starch and sugars. Sucrose, glucose and fructose are the main sugars in raw sweet potatoes and sweeter baked sweet potatoes are usually more acceptable to consumers.

Knowledge on genetic diversity helps the breeder to choose desirable parents to use in crop improvement breeding program. The diverse genotypes or accessions can be crossed to produce various biotic and abiotic stress resistant superior high yielding hybrids. Now a days, it became an urgent need to evaluate genetic accessions of sweet potato for the extent of genetic diversity. The amount of variability present in germplasm collections of a crop contributes toward breeding for better varieties. Genetic variability of sweet potato has not been exploited and

screened properly. Analysis of yield contributing characters from sweet potato genotypes offer a scope to future breeders. The genetic parameters such as heritability, genetic advance, genotypic and phenotypic coefficients of variability are effective tools for the breeders to select most desirable traits for yield. Thus selection process on different genotypes will allow breeders to choose the most suitable one in term of production and nutrition. With conceiving the above scheme in mind, the present research work has been undertaken in order to fulfill the following objectives:

- ➤ To find out the magnitude of genetic variability
- ➤ To estimate the phenotypic and genotypic correlations among yield and yield contributing characters
- ➤ To estimate the direct and indirect effects of different yield attributing characters by using path coefficient analysis

Chapter II
Review of literature

CHAPTER II
REVIEW OF LITERATURE

Sweet potato is the seventh most important food crop due to its adaptability to wide range environmental conditions and high nutritional values (Rodriguez-Bonilla et al., 2014; FAOSTAT 2011). Assessment of genetic variability became an important issue due to its high demand for food and conservation of agricultural and genetic resources. In Bangladesh, the purpose of genetic diversity of sweet potato was less understood. Sweet potato is one of the under-exploited of the developing countries major crops (Rees et al., 2003).The need to identify local germplasm with desirable traits has been pointed out by the breeders. The accessions of the local germplasm are better adapted in the local environment than that of the exotic one (Rees et al., 2003).

According to Jones (1986) many of sweet potato traits are quantitatively inherited. The phenotype of a quantitative trait occurs due to genotypic and environmental effect. Therefore, estimates of variability and its heritable components for the yield attributing characters available in the sweet potato germplasm are pre-requisite for high yield breeding program. Genetic-statistical methodologies are available that assists in selection of superior parents based on their combining ability and potentiality to produce promising segregating populations (Griffings, 1956).

It is necessary to find out the genetic makeup of important yield contributing characters and interrelations existing among them. In this investigation, attempt has been made to study genetic variability, heritability, genetic advance, correlation, path coefficient analysis and genetic divergence in sweet potato genotypes. A brief review of available literature pertaining to the present investigation in sweet potato has been presented in this chapter under the following headings.

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2.1 Sweet potato

Sweet potato (*Ipomoea batatas* (L.) Lam.) is an important staple crop of most tropic countries. It is mainly known for its drought resistance, vigorous growth and productivity with minimum inputs (Rahaman *et al.*, 2015). Globally sweet potato ranks seventh place after wheat, rice, maize, potato, barley and cassava (CIP, 2008). The largest sweet potato collection is maintained by CIP having about 4950 landraces, 21 wild varieties and six improved varieties (System-wide Information Network for Genetic Resources (SINGER, 2009). This genebank was developed by the contribution of sweet potato germplasm all over the world.

2.1.1. Taxonomy of sweet potato

Sweet potato is a dicotyledonous root tuber crop belonging to the Convolvulaceae family. Sweet potato is distantly related to the potato (*Solannum tuberosum*) belonging to the nightshade Solanaceae family, both having the same order Solanales. In some parts of North America, the soft orange sweet potato is known as 'Yam' although it is botanically different from original Yam (*Dioscorea*). *Dioscorea* is monocot belonging to Dioscoreaceae family and native to Africa and Asia. In Argentina, Venezuela, Puerto Rico and the Dominican Republic, sweet potato is known as '*batata*'. In Maxico, Peru, Chile, Cantral America and Phillipines, sweet potato is called *camote* (Annonymous, 2016a).

Sweet potato *(Ipomoea batatas (*L.) Lam.)* was botanically described in 1753 by Linnaeus as *Convolvulus batatas,* but Lamarck, in 1791, re-classified the crop into the genus *Ipomoea* on the basis of the stigma shape and the surface of the pollen grains (Thottappilly and Loebenstein, 2009). Hence, the crop belongs to the family of Convolvulaceae, tribe of *Ipomoeae*, genus *Ipomoea*, sub-genus *Eriospermum*, section Eriospermum and species *batatas*. Therefore, the botanical name of sweet potato was changed to *Ipomoea batatas (L.) Lam.*

2.1.2. Morphology of sweet potato

Due to presence of anthocyanine pigment, the color of leaves and stem varies from green to dark purple (Laurie and Niederwieser, 2004). The general leaf outline varies from round to almost divided with the margins having no lateral lobes to deeply lobes. The size and shape of the storage root varies from round and long irregular or curved depending on the variety and environmental factors (Woofle, 1992). The skin color of sweet potato varies from white to dark purple and flesh color varies from white to orange depending on distributions (Laurie and Niederwieser, 2004). Sweet potato has an extended storage root which accumulates more edible components compared to tuber potato.

2.1.3. Origin and diversity of sweet potato

The exact origin of sweet potato is still not well-known. According to historical evidences, it is assumed that sweet potato is originated from Central or South American lowlands. South American indigenous communities have probably cultivated this crop since 3000 BC (Woofle, 1992). Therefore, it is believed to be originated from Yucatan Peninsula of Maxico and Orinoco river in Venezuela. Later sweet potato was spread by the explorers (Zhang *et al.*, 2004). It was introduced to Europe, Asia and later in Africa by the 16th century (Allemann *et al.*, 2004). The wild cultivated progenitors has not yet been identified. It is believed that the current cultivated hexaploid sweet potato varieties are the result of cross between trtraploide primitive and diploid weedy sweet potatoes (Sauer, 1993). It is possible to find out existence of wild hexaploid but according to the history, cultivars were independently domesticated in various regions. However, the origin of sweet potato is still under investigation.

Christopher Columbus brought sweet potatoes to Europe and Portuguese after his first voyage to the new world in 1942. By the 16th century, they were brought to the Philippines by Spanish explorers and to Africa, India, Indonesia and Southern Asia by the Portuguese Around this same time, sweet potatoes began to be cultivated in

the southern Unites States, where they still remain a staple food in the traditional cuisine (Loebenstein and Thottappilly, 2009).

2.1.4. Economic aspect of sweet potato

Cultivation of sweet potato can play an important role in context of food security in Bangladesh (Hossain and Siddique, 1985). Sweet potato is a highly nutritious food crop which gives higher and faster production under diverse agro-ecological conditions with minimal input (CIP, 2008). It has potentiality to combat malnutrition and poverty. Moreover, it has been recognized as highly valuable crop due to its calorie value per cultivated area (Scott *et al.*, 1992). High yield ability, drought tolerance, palatability and crude protein content has made this crop remarkable. Orange-fleshed sweet potato contains more beta-carotene while the purple one contains more anthocyanine. This two elements act as anti-oxidant which throught to prevent chronic heart disease and cancer (Teow *et al.*, 2007). Increased beta-carotene content (pro-vitamin A) and crude protein content is good for nutrition and health (Ukom *et al.*, 2001).

2.1.5. Cultivation of sweet potato

Warm days and nights are better for optimum sweet potato yield. It is sensitive to low temperature and grows best in tropical and warm temperate regions having sufficient sunlight and water. Well aerated, moderate to slightly acidic, sandy to sandy loam soil having ability to tolerate harsh and climate are favorable conditions of sweet potato (Van den Berg and Laurie, 2004).

Gibson *et al* (2000) stated that landraces are adapted to their local areas and have developed resistance against local pests and diseases. However, in most cases. The landraces yield are low that reduces the overall sweet potato production (Allemann *et al.*, 2004). Similarly, Laurie *et al.* (2008) reported low yield and yield instability due to the use of old landraces addressed by the resource-poor farmers. In Bangladesh, sweet potato can give satisfactory yield under adverse climatic and

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soil condition and under low or no use of external inputs (Githunguri and Migwa, 2004; Ndolo *et al.*, 2001; Carey *et al.*, 1999).

Cultivation of sweet potato crop is increasing every year. According to FAO statistics, the world production of sweet potato was 110.75 million tons in 2013. Among it, about 77.38 million tons come from China and other Asian countries including Japan, Korea and Indonesia. In Bangladesh, 25000 ha area was under sweet potato cultivation in 2013 while it was 40874 ha in 2000.

2.1.6. Constraints to Sweet potato Production

Despite the numerous potential uses and benefits of Sweet potato, the production of the crop is below the potential level in many parts of the world. Sweet potato has a yield potential of 20-50 t/ha of storage roots in the tropics (Çalifikan *et al.*, 2007). This yield potential is yet to be realized in Bangladesh. These low yields are as a result of several socioeconomic, biotic and abiotic constraints. Socio-economic constraints in the production of Sweet potato include, poor post-harvest handling and storage facilities, lack of processing skills, lack of clean seed and poor seed distribution system and poor agronomic varieties (Njeru *et al.*, 2004; Ames *et al.*, 1996).

Several biotic constraints of sweet potato production in the tropics are sweet potato weevil (Shonga *et al.,* 2013; Ehisianya et al., 2013), alternaria blight, sweet potato virus disease (SPVD) (McGregor *et al.,* 2009) and root-knot nematodes (*Meloidogyne sp*) mostly found in the temperate zones (Grüneberg *et al.*, 2009). Moisture stress due to drought is becoming a major abiotic constraint to crop production worsened by climate change (Nakashima and Yamaguchi-Shinozaki, 2013). Soil moisture availability determines the external water status at the boundaries of the plant (soil and air) and in the internal plant water status within the tissue of the plants. Drought stress reduces photosynthesis and translocation of assimilates thus reduce the yield (Anjum *et al.,* 2011). However breeding drought

tolerant varieties may ensure high yield production under conditions of limited water availability (Sorrells *et al.,* 2000).

2.2. Variability

Improvement of a crop mainly depends on the magnitude of genetic variability and the extent of heritable desirable characters. Sweet potato is a crop having wide range of variability in different agro-morphogenic characters like tuber skin, flesh colour, tuber shape, time of maturity, resistance to disease, leaf shape and several other characters which can be exploited for the development of a desirable genotype. Existence of genetic diversity in a crop population and proper knowledge on this divergence is of great importance to breeders. Breeders can manipulate this divergence for improvement breeding of a crop. Hence, an attempt has been made to collect the background information on the amount of genetic variability present in sweet potato genotypes. This attempt can assist as a guideline to select parents as a donor in breeding program for proper utilization of the quality trait and development of the desirable varieties for various agro-ecological zones (AEZ) in Bangladesh. The effect of environment in expression of desirable traits also need to be taken into account. Burton (1952) suggested that co-efficient of variability together with heritability estimation will provide a landscape of genetic advance that can be obtained by selection process. Several works already has been done to find out wide range of genetic variability for characters of vine and tubers of sweet potatoes (Rao *et al.*, 1992; Vimala and Lakshmi, 1990; Kamalam, 1990; Kamalam *et al.*, 1977; Lowe and Wilson, 1975; Hayneys and Wholey, 1971; Jones *et al*, 1969; Mc Lean, 1955).

2.2.1. Phenotypic and Genotypic Variability

Variation is the occurrence of differences among the individuals due to the differences in their genetic composition and the environmental effect (Allard, 1960). Sweet potato has wide adaptability to harsh growth condition but still sensitive to

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environmental variation. The study of magnitude of variability of a crop species is important as it provides the basis for effective selection (Singh, 1993). Information on the nature and magnitude of genetic variability of a crop helps in designing effective crop breeding program for producing hybrids (Poehlman and Sleper, 1995). In crop improvement, plant breeder selects crop based on their phenotype and the effectiveness of the selection would largely depend on the proportion of the phenotypic variation that is due to the genotype (Amsalu, 1993). The genetic component of variation is important in crop improvement, since only this component is transmitted to the next generation (Singh, 1993). Phenotypic variation is the observable variation present in a character in population. It includes both genotypic and environmental components of variation and as a result, its magnitude differs under different environmental conditions (Singh 1993). Genotypic variation, on the other hand, is the component of variation, which is due to the genotypic differences among individuals within a population.

2.2.2. Morphological variability

Wilckens *et al.* (1993) studied on 32 accessions of sweet potato and observed that 5 and 27 accessions showed variability for morphological characters like type of leaf lobbing, shape of the central leaves, petiole pigmentation and root flesh colour. Choudhary *et al.* (2001) studied 21 morphological traits in sweet potato like nature of twining, plant type, vine pigmentation, vine tip pubescence, vine inter node length and diameter, vine growth rate, petiole pigmentation, petiole length, foliage colour, abaxial leaf vein pigmentation, mature leaf shape, mature leaf size, flowering habit, flower colour, seed capsule setting, tuber neck length, tuber shape, tuber skin colour, tuber flesh colour, distribution of anthocyanin in tuber flesh and latex production in tuber and they observed wide range of variations in these traits. In a study by Kaledzi *et al.* (2010) on 40 accessions of sweet potato, they observed variations among the different accessions in terms of the vine, leaf, petiole, root skin and flesh characteristics.

Sreekanth *et al.* (2011) conducted a preliminary yield trial with 230 clones selected from 1600 orange fleshed clones for morphological observations like leaf shape, emerging leaf colour, skin colour, flesh colour, weight of vine and weight of storage roots. They also observed that selection of a number of superior hybrid clones based on yield and yield contributing attributes would provide a large gene pool for the recombinations. Wadud *et al.* (2011) conducted an experiment on sweet potato genotypes on the basis of leaf, vine and tuber characters and reported that leaf character varied from heart, tetralobbed to pentalobbed, the vine and vine tip colour ranged from green, pink, pinkish green, light purple, deep purple to light pink, and the shapes of tuber were globulose, elliptical and fusiform respectively. Vimala *et al.* (2011b) studied on 1600 orange fleshed sweet potato genotypes and observed wide range of genetic variation for skin colour of tuber (pink, purple and purple to light pink colour) and root flesh colour (orange, light orange, dark orange and creamy to yellow colour). Vimala *et al.* (2012) evaluated 1630 orange fleshed sweet potato genotypes and observed three types of leaf shapes like cordate (81.65%), slightly lobed (16.69%) and narrow lobed (1.66%) and emerging leaf colour ranged between green (92.5%) to purple (7.5%). In a study, Richardson (2012) evaluated six genotypes of sweet potato for tuber quality and found large variation in the leaf and tuber characteristics.

2.2.3. Quantitative variability

Kamalam (1990) conducted a trial with fifteen sweet potato cultivars and observed very high variability for some quantitative traits like vine length, vine thickness, number of branches, number of Tuber and tuber yield. Wilckens *et al.* (1993) studied 32 accessions of sweet potato and observed that 5 and 27 accessions showed variability for growth habit and internode length respectively. Velmurugan *et al.* (1999) conducted experiment on nine clones of sweet potato on based on variation existing in quantitative characters during 90, 105 and 120 days after planting and the result showed that, clones with high number of tubers per vine gave higher mean

value for tuber yield and highest variability was observed for weight of weevil free tubers, followed by weight of tubers per vine and number of weevil-free tubers per vine. Tsegaye *et al.* (2007) conducted a study on 30 sweet potato genotypes and revealed that there was significant variability among the genotypes for the characters like vine length, vine inter node length & diameter, leaf area, above ground fresh and dry weight per plant, storage root number per plant, storage root length and diameter, individual storage root weight, harvest index per plant, storage root dry matter content and storage root fresh yield per plot.

Cavalcante *et al.* (2010) conducted an experiment on 9 clones and 2 varieties of sweet potato and revealed that, clones 6 and 11 presented the highest marketable root yield and clones 8, 14 and the "Rainha Prata" variety presented the highest phytomass yield on the shoot. Binu *et al.* (2011) studied the changes in dry matter content during 35 days of storage in 10 orange fleshed sweet potato clones at Central Tuber Crop Research Institute Thiruvanthapuram, Kerala and observed that gradual decreases in dry matter content from 24.1 to 25.5 %. Vimala and Hariprakash (2011) evaluated 250 hybrid progenies on the basis of vine, fresh yield per plant, fresh yield per plot, storage root and dry matter content and observed that the selection of a number of superior F1 clones for yield and other attributes would provide a large gene pool for the recombination to generate the promising variety of considerable value. Vimala *et al.* (2011a) conducted an experiment on 230 clones of orange fleshed sweet potato genotypes. They observed the morphological characters like leaf shape, emerging leaf colour, skin colour, flesh colour, weight of vine and weight of storage root and reported that the selection of a number of superior hybrid clones for yield and other attributes would provide a large gene pool for the recombination from which the promising variety of considerable value could be generated. Vimala *et al.* (2011b) evaluated 42 orange fleshed sweet potato hybrids in upland and low land conditions for storage root yield and dry matter content (%) along with a control variety of Sree Kanaka and observed that root yield ranged from 3.0 - 20.0 t/ha in

upland, 3.0- 30.0 t/ha in lowland condition and dry matter content varied from 18.5 to 29.2 %.

Neiva *et al.* (2011) evaluated fifteen sweet potato genotypes on the basis of vegetative characters and root characters. The evaluation of the vegetative part were carried out three months after planting and the roots were harvested nine months after planting and observed that, the characteristics of vegetative part showed highest significant difference among the clones. Pushpalata *et al.*(2011) evaluated 15 genotypes of sweet potato and recorded observations on vine length, vine weight per plant, neck length of tuber, tuber diameter, dry yield per plant and revealed that genotypes like IGSP.C-18, 440038, 440036 and IGSP.C-16 were superior than Sree Rethna in respect of tuber yield. Richardson *et al.* (2012) evaluated six genotypes of sweet potato for tuber yield and reported that the variety 'Six Weeks' (early maturity) produced high dry matter content and high marketable yield (25.5t/ha) followed by 'Antigua' (25.2t/ha). Vimala *et al.* (2012) studied on 1600 orange fleshed sweet potato genotypes and concluded that vine weight, root weight and harvest index varied according to the clone and environmental conditions.

2.2.4. Qualitative variability

Miller (1958) observed high carbohydrate and starch content, in different genotypes which may be due to variation in the genetic makeup of the genotype. Akkamahadevi *et al.* (1996) recorded highest starch content of 84.7 per cent on dry weight basis in the clone Belgam local. Teshome *et al.* (2003) reported highest starch content in clone IGSP-9 (34.66%) and lowest in RNSP-1 (16.38%) under Coimbatore conditions. Sahu (2003) reported highest total soluble solids in genotypes IB-90-15-9 for Chhattisgarh plains. Vimala *et al.* (2009) evaluated 40 clones of orange fleshed sweet potato during different season like summer, kharif and rabi to find out the variability of carotenoids, β- carotene and observed that total carotenoid content ranged from 8.5-15.0 mg/100g fresh weight and β- carotene varied from 6.8-13.7 mg/100g fresh weight. Binu *et al.* (2011) studied the changes

in carotenoid content during 35 days of storage in 10 orange fleshed sweet potato clones at Central Tuber Crop Research Institute, Thiruvanthapuram, Kerala and observed that significant variation in total carotenoids content (10.32- 13.99 mg/100g fresh weight) and β-carotene (9.02-12.6 mg/100 g fresh weight) among the clones.

Pushpalata *et al.* (2011) evaluated 15 genotypes of sweet potato and recorded observations on starch percentage, total sugar percentage, carbohydrate percentage and TSS of Sweet potato and revealed that genotypes like IGSP.C-18, 440038, 440036 and IGSP.C-16 were superior than Sree Rethna in respect of quality parameters. Vimala *et al.* (2011b) evaluated 42 orange fleshed sweet potato hybrids in upland and low land conditions for storage root yield along with a control variety of Sree Kanaka and observed that variety 106427-10 and 106035-9 possessed high β- carotene content (14.37 mg/100 g fresh weight) and dry matter content varied from 18.5-29.2%. Out of 42 hybrids studied, 22 hybrids possessed high β-carotene content (10-15 mg/100 g fresh weight).

2.3. PCV, GCV, Heritability and Genetic advance

Phenotype of an individual plant is determined by genetic composition and environment conditions in which it grows. Success of a breeder in changing and improving the heredity of a trait depends upon the degree of correspondence between phenotypic and genotypic variations. Heritability is a measure that provides this information (Dabholkar, 1992). The principal uses of heritability estimates are: to determine the relative importance of genetic effects which could be transferred from parent to offspring, to determine which selection method would be most useful to improve the character, and to predict gain from selection (Poehlman and Sleper, 1995). Heritability characterizes not only the character itself but also the population and the environment in which the character is studied (Falconer and Mackay, 1996; Roy, 2000). Heritability in broad sense or degree of genetic determination is proportion of total hereditary variance to phenotypic variance. The more useful

estimate i.e. narrow sense heritability or degree of resemblance between relatives is ratio of additive genetic variance to phenotypic variance (Falconer, 1989). The most important function of heritability in the genetic studies of metric characteristics is its predictive role in expressing the reliability of phenotypic value as a guide to breeding value (Falconer, 1989). Genetic advance means improvement in the performance of selected lines over original population. Heritable variation can be determined with greater accuracy, when heritability is studied along with genetic advance (Swarup and Chaughale, 1962). High heritability with high genetic gain is associated with additive gene effects (Panse, 1957). On the contrary, non-additive gene effect (dominance or epistasis) is associated with characters exhibiting high heritability and low genetic advance. The phenotypic and genotypic coefficients of variation (PCV and GCV) for length of vine, length of petiole, number of branches, length of internode and length to girth ratio of tubers, showed very little differences indicating less influence of environment on these characters which suggested the presence of sufficient genetic variability and hence ample scope for effective selection (Singh *et al.*, 1998). Jones *et al.* (1969) observed high estimates of heritability for vine traits than root traits. Kasuhara *et al.* (1972) selected mother plants in breeding sweet potato based on high heritability, estimates direct lateral tubers were higher than the other tuber categories. Jong (1974) suggested that the additive genetic variance was more important than the non-additive genetic variance in determining tuberous root weight and top weight in contrast to the number of tuberous roots where the main genetic variance was non-additive type. Singh and Mishra (1975) reported high heritability and high genetic advance for vine length. Thamburaj and Muthukrishnan (1976) observed high genetic advance and high heritability estimates for girth of tubers and number of tubers. Kamalam *et al.* (1977) reported high genetic advance for length of vine and number of tubers per plant and high estimates of heritability for length of vine, number of tubers per plant, stem thickness, petiole length, skin colour, flesh colour and weight of tubers. They observed that the genotypic coefficient of variation was lower than the phenotypic

characters like length of vine, length of petiole, number of tubers per plant, weight of vines per plant, weight of individual tubers. Length of vine and number of tubers showed very high degree of phenotypic and genotypic coefficients of variation. Saladaga (1981) observed that heritability for both root skin and flesh colours were very low. The estimates of heritability for tuber yield indicated that selection could be practiced on an individual plant basis. Low heritability estimates were also observed for percentage weight loss and sprouting. Maluf *et al.* (1983) conducted an experiment on sweet potato to estimate the genetic variances and broad sense heritability of root and vine traits and revealed that the heritability estimates were high for vine length, number of inter nodes per vine and number of marketable roots. Negative estimates were observed for root yield, average weight per marketable root and mean inter nodal length. Lin (1983) evaluated fifteen cultivars of sweet potato and revealed that more than 65% of heritability observed in weight of dry matter, length of main stem, tuber weight, internodal length and yield. Tuber weight and number of large tubers showed very high genetic advance.

Dai *et al.* (1988) observed high heritability estimates for vine length and tuber weight. Chen *et al.* (1989) observed that tuber yield had high genotypic and phenotypic coefficient of variation. The broad sense heritability of tuber yield was relatively low and was non additive in sweet potato. Vimala and Lakshmi (1990) reported estimates of heritability high for tuber characters like tuber length, tuber weight and tuber girth and low for vine length. Chen Feng Xiang *et al.* (1995) conducted their studies on 30 sweet potato genotypes and observed that the genetic variation ranged from 20.03 to 37.65%. Studies conducted on 25 genotypes of sweet potato by Jain and Ganguli (1996) grown in Ranchi, during kharif revealed that vine length, number of branches, number of leaves and tuber yield showed high genotypic and phenotypic coefficients of variation whereas genotypic coefficient of variability ranged from 11.12 % (tuber length) to 39.07 % (number of branches). They also recorded high heritability estimates for vine length (96.05%), number of leaves (90.3%), number of branches (90.0%) and tuber yield (75.9%) and

comparatively low for number of tubers (45.5%). Number of tubers, tuber width and tuber weight showed high genetic association with yield. Alam *et al.* (1998) studied on 15 genotypes of sweet potato and observed that the higher genotypic and phenotypic coefficients of variation were recorded for number of branches, tubers per plant, yield per plant, number of leaves and vine length. They also said that high heritability along with high or moderate genetic advances were recorded for all the characters except tuber length. Choudhary *et al*. (1999) conducted a study on fifty genotypes of sweet potato and found that a wide difference of phenotypic and genotypic co-efficient of variation was observed for the vine length and root yield and high heritability coupled with high genetic advance. Vimala and Lakshmi (1999) obtained low heritability estimates for vine length and high heritability estimates for tuber length, tuber weight, number of branches, tuber girth and vine weight indicating genetic variance was relatively more important than non-additive genetic variance for these characters. Hossain *et al.* (2000) evaluated 30 genotypes of sweet potato and observed high phenotypic and genotypic coefficients of variation for number of tubers per plant, average tuber weight and tuber yield per plant. Estimates of heritability and genetic advance were highest for tuber yield per plant, average tuber weight and number of tubers per plant.

Sankari *et al.* (2001) evaluated fifteen genotypes of sweet potato and reported that the genotypic coefficient of variation was high for traits like yield of roots per vine, length of vine and girth of vine and observed high heritability coupled with high genetic advance for vine length, vine girth and yield of roots per vine. Teshome *et al.* (2004) studied 86 genotypes of sweet potato. They observed that characters *viz.*, number of branches per plant, weight of single tuber, girth of tuber, and vine traits like length of tuber, length of vine, weight of foliage per plant, number of tubers per plant and weight of single tuber showed higher phenotypic and genotypic coefficient of variation with high heritability estimates. Sharma (2004) reported that the highest estimate of genetic advance as per cent of mean was obtained from tuber yield per plant, vine weight per plant, marketable tuber yield

per plant, neck length of tuber, total soluble solids and vine length. Studies conducted on 30 genotypes of sweet potato by Tsegaye *et al.* (2007) revealed that the above ground fresh and dry weights, vine length, individual storage root weight, storage root fresh yield per plot, vine internodal length, storage root fresh yield per plant, leaf area and storage root number exhibited high genotypic coefficient of variation coupled with high heritability. Gin *et al.* (2008) conducted a study on 30 genotypes of sweet potatoes and observed that GCV was highest for vine growth rate (65.38%) followed by vine internodal length (61.64%), number of tubers per plant (44.87%), tuber weight per plant (43.72%), petiole length (35.85%), single tuber weight (28.73%), tuber length (26.69%) and tuber diameter (20.26%). Shashikanth *et al.* (2008) conducted a study on 15 sweet potato genotypes and observed that the phenotypic and genotypic coefficient of variations were found to be moderate to high for all the characters *viz.,* vine internodal length, fresh yield per plant, fresh yield per plot, number of branches per plant, number of leaves, total leaf area except length of vine. They also observed that high heritability with high genetic advance as percent over mean was for all the characters except leaf area. Choudhary and Mishra (2011) studied twelve genotypes of sweet potato and revealed that characters like vine length, number of tuber per plant and weight of tuber per plant exhibited high heritability coupled with high genetic advance. Thiyagu *et al.* (2013) conducted an experiment on 22 genotypes of sweet potato and revealed that high genotypic coefficients of variation along with high heritability were recorded for root length and leaf area.

2.4. Correlation and path-coefficient analysis in sweet potato

Correlation and path-coefficient are among the important analysis in crop improvement programs. The purpose of correlation and path-coefficient analysis are to describe the pattern of interrelationship among the various traits. It is useful to identify the degree of interrelationship of traits for direct and indirect selection for improve breeding program.

2.4.1. Correlation analysis

Correlation analysis is useful for selection of more complex and less heritable traits, such as yield, through selecting for traits that are highly correlated with yield, given that their heritability is high (De Araujo *et al*., 2002). Larger genotypic correlation coefficients indicate greater contribution of genetic factors and reduced effects of the environment (Iqbal *et al*., 2003). According to Martin and Rhodes (1983) significant correlations have direct implication on the progress of a selection program. Knowledge of the frequency of desired traits, and correlations among these, is helpful for direct/indirect selection and to develop selection index (in mass or recurrent selection) to emphasize and develop the traits most desired.

Tsegaye *et al*. (2006) reported that in sweet potato clones, the genotypic correlation coefficients were lower than the phenotypic correlation coefficients among different sweet potato traits, 27 indicating the significant effects of the environment. The authors indicated the presence of high positive correlations between storage root yield, and root diameter, harvest index (HI) and individual root weight per plant. On the other hand, storage root number had a significant negative correlation with storage root diameter and individual root weight implying that an increase in the number of roots per plant will result in competition between storage roots within a plant. This will result in many small sized roots (Tsegaye *et al*., 2006). In a study by Lin *et al*. (2007), significant positive correlations were found between above ground biomass, fresh root weight, and storage root number; between storage root shape and above ground biomass and storage root weight; between skin colour and flesh colour of storage root, and between starch content and amylase content. This suggests that above ground biomass can be used as an indicator for storage root yield (fresh weight and number). Gasura *et al*. (2008) also found a positive correlation between yield and tuber number, while sugar content was negatively

correlated with starch content. Protein content was positively correlated with dry matter content (Gasura *et al*., 2008). There exists a slight negative correlation between root dry matter and β-carotene contents of sweet potato (Cervantes-Flores *et al*., 2010; Chiona, 2009; Simonne *et al*., 1993), implying that the simultaneous improvement of the two traits is a challenge in sweet potato breeding for quality traits. Several studies indicated the existence of strong positive correlation between flesh colour and β-carotene content in sweet potato (Vimala and Hariprakash, 2011; Cervantes-Flores *et al*., 2010; Burgos *et al*., 2009; Mcharo and LaBonte, 2007). Therefore, root flesh colour ranging from pale orange to dark orange may be used as an indicator of β-carotene content especially at the beginning of screening work where many progeny have to be evaluated. A colour chart developed by Burgos *et al*. (2009) can serve as a useful indicator to facilitate selection for high β-carotene content.

Gupta (1969) observed positive association of vine weight and vine length with tuber yield. Garica *et al*. (1970) reported that increase in orange colour of edible protein in sweet potato was positively correlated with carotene content Wilson (1975) reported positive correlation between tuber weight and tuber shape. Huett *et al*. (1976) reported that tuber yield is positively associated with the harvest index and also said that high yielding genotypes generally had high harvest index. Pushkaran *et al.* (1976) observed that the root characters as a whole were more strongly correlated with the tuber yield than shoot characters. Thamburaj and Muthukrishnan (1976) resulted that tuber yield of sweet potato was highly and positively correlated with tuber width, length of tuber, petiole length and number of branches and negatively correlated with length of vine and inter node length. Warid *et al.* (1976) reported that vine length was negatively correlated with yield, while root number and yield were positively correlated in all test cases. Kamalam (1977) reported that genotypic correlations were higher than the phenotypic correlations. She reported that the number of tubers had positive significant correlations with yield. However the length as well as weight of vine

showed significant negative correlations with yield. Enyi (1977) stated that the highest yields were associated with earlier tuber initiation. Shikata (1980) conducted population studies on sweet potato and observed lack of correlation between root yield and starch content from his study. Saladaga *et al.* (1981a) worked out correlations among yields and its components and observed that total yield was positively correlated with skin colour, leaf shape, stem length and diameter, internodal length and number of branches per stem. Bacusmo *et al*. (1982) reported that leaf area index, crop growth rate, leaf angle of younger leaves, vine length, number of tuber per plant and mean root weight were positively correlated with root yield. Janssens (1982) claimed that tuber yield was positively correlated with average tuber weight and number of tubers per unit of ground area. Bhagsari and Harman (1982) revealed that yield is positively associated with the harvest index in sweet potato. Maluf *et al.* (1983) reported that the genotypic correlation between root and vine traits was low. Lin (1983) found that yield per plant was positively correlated with the yield per unit area, tuber dry weight, number of branches, number of large to intermediate tubers and the length of petiole and negatively correlated with stems per tuber value and drying percentage of the tubers. Bourke (1984) observed that tuber yield at the final sampling was very closely correlated with total dry weight per plant and number of tubers per plant. Yoshida (1985) in a study of correlation between successive yield tests for agronomic characters in sweet potato showed that correlation coefficients were generally higher at more advanced stages of selection. Naskar *et al.* (1986) revealed that in general genotypic correlations were higher than phenotypic correlations. The characters like number of branches, girth of tubers and length of tubers were found to have high positive correlations with yield, where as the length of vine and intermodal length were negatively correlated with yield. Ibrahim *et al.* (1987) observed that the root characters as a whole were more strongly correlated to the tuber yield than shoot characters. Tiwari *et al*. (1987) reported a positive correlation of root yield with number of root per plant and average weight of root per plant. Gerpacio (1994)

revealed that tuber yield of sweet potato was highly and positively correlated with root size and dry matter percentage of tuber. Nanda (1994) reported that the marketable tuber yield was positively correlated with number of tuber per plant while, it had non significant association with neck length. Kumar *et al.* (1996) observed that tuber yield of sweet potato was highly and positively correlated with number of tubers, tuber width and weight of tuber. Rajesh Kumar Jain and Ganguli (1996) conducted their studies on 25 genotypes and reported that number of tubers, tuber width and tuber weight had high genetic association with yield. Amarchandra (1997) reported that various sink parameters i.e. number of tuber per plant, tuber length and fresh weight per tuber were positively correlated with tuber yield. Alam *et al.* (1998) studied on fifteen genotypes of sweet potato and revealed that characters *viz*., tubers per plant, tuber width and weight of individual tuber were positively correlated with yield while vine length had a negative significant association with yield at both genotypic and phenotypic levels. Parida *et al.* (1999) resulted that marketable tuber yield and numbers of tubers per plant were significantly positively correlated with tuber yield. Choudhary *et al.* (2000) evaluated fifty genotypes and revealed that the total tuber yield had highly significant and positive phenotypic correlation with petiole length and tuber girth. Hossain et al. (2000) evaluated 30 sweet potato genotypes and revealed that root yield was positively and significantly correlated with root diameter ($r = 0.756$), average tuber weight ($r = 0.729$) and number of tubers per plant ($r = 0.635$). Perez *et al.* (2001) studied on eight sweet potato clones and resulted that tuber weight and total plant weight were significantly and positively correlated with yield. Sahu *et al.* (2005) studied on 24 genotypes of sweet potato and concluded that tuber yield was positively and significantly correlated with biological yield per plant, tuber diameter and harvest index whereas Vine weight per plant had a positive correlation with vine length. Engida Tsegaye *et al.* (2006) conducted an experiment on 30 sweet potato genotypes and resulted storage root yield had positive and significant correlation with individual storage root weight, harvest index and storage

root girth whereas number of storage roots per plant was negatively and significantly correlated with individual storage root weight and storage root girth. Shashikanth *et al.* (2008) reported that characters like tuber diameter, tuber dry matter, starch and sugar content and fresh weight of vine are significantly and positively correlated with tuber yield. Li Yun Song *et al.* (2010) studied on 10 sweet potato genotypes and reported that the number of tuber per plant, number of branches per plant and number of green leaves per plant were significantly correlated with tuber yield. Choudhary and Mishra (2011) conducted their studies on 25 genotypes and revealed number of tubers per plant exhibited significant and positive correlation with marketable tuber yield. Tirkey *et al.* (2011) revealed that tuber yield showed significant positive correlation with vine weight at both genotypic and phenotypic level.

2.4.2. Path-coefficient analysis

Path-coefficient analysis was developed by Wright (1921a), cited by Lynch and Walsh (1998), with the aim of interpreting the correlation between two variables in terms of hypothetical path of causality between the variables. The purpose of path-coefficient analysis is the quantification of the relative contributions of casual sources of variance and covariance once it is known that there is a certain degree of interrelatedness between the variables (Lynch and Walsh, 1998). It is a standard partial regression coefficient that measures the direct influence of one variable up on others, and permits the separation of the correlation coefficient into components of direct and indirect effects (Shimelis and Hugo, 2011; Diz. *et al*., 1994).

Each correlation coefficient between a causal or independent variable and the response or dependent variable is partitioned. This provides components with a direct effect or path coefficient for the predictor variable and indirect effects, which involve the product of a correlation coefficient between two predictor variables with the appropriate path-coefficient in the path diagram (Shimelis, 2006; Diz. *et al*., 1994). Therefore, knowledge about both the direct and indirect effects of selecting

for specific components can be attained by determining the inter-relationships among yield components and breeders can get a comprehensive understanding of the relationship among a set of traits and how each trait affects or contribute to yield (Board *et al*., 1997; Akheter and Sneller, 1996; Diz. *et al*., 1994). Tsegaye *et al*. (2006) conducted correlation and path analysis of various traits in sweet potato and reported that individual storage root weight had a maximum positive direct effect of 0.7576 and 0.8497, using phenotypic and genotypic correlations, respectively. Storage root number also had a high positive direct effect of 0.5325 and 0.6487 on storage root yield per plant based on phenotypic and genotypic correlations, in that order. However, the negative indirect effect through individual storage root weight, i.e., -0.3856 and -0.4512 at phenotypic and genotypic levels, respectively, resulted in a low correlation coefficient among the two traits at both phenotypic and genotypic levels (Tsegaye *et al*., 2006). From this study it could be deduced that that although a character seems to have a positive direct contribution to yield, it may have an indirect negative influence on yield via another character that has a direct contribution to yield. Path-coefficient analysis therefore helps to understand those relationships and to identify the trait that best correlate with and influence root yield. Lowe and Wilson (1974) observed that the tuber width was related to the mean tuber weight and yield. Tuber width appeared to be the most important determinant of yield in their investigation. Thamburaj and Muthukrishnan (1976) indicated that weight of the foliage contributed maximum direct effect on tuber yield and also reported that tuber yield of sweet potato had maximum positive direct effect on girth of tuber and number of tuber per vine. Kamalam *et al.* (1977) reported that tuber yield in sweet potato had direct influenced on number of tubers. They also suggested that the number of tubers per plant, length of petiole and to a lesser extent weight of vine should be the criteria for selection of a high yielding plant type in sweet potato. Lin (1983) revealed that number of branches had the direct effect on root yield per plant. Naskar *et al.* (1986) revealed that length of tubers showed maximum positive direct effect on yield. They also stated that selection based on characters like length

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of tubers, length of petiole and girth of tubers appeared to be most desirable for improving the yield in sweet potato. Ibrahim (1987) reported that root characters viz. tuber girth, number of tubers and tuber length showed higher path values than shoot characters and finally concluded that in a breeding programme for yield, less importance may be given for shoot characters. Nanda (1994) reported that the direct effect on tuber yield was positive due to the characters *viz.*, tuber girth, tuber length, neck length of tuber and number of tuber per plant. Chen Feng Xiang (1995) studied on 30 sweet potato genotypes and observed that the high yielding genotypes having more roots, vigorous growth, heavy leaves and short vines. Kumar *et al.* (1996) indicated that tuber yield of sweet potato is influenced by the maximum positive direct effect on girth of tuber and weight of tuber. They noticed moderately high positive direct effect of number of branches on tuber yield. Rajesh Kumar Jain and Ganguli (1996) studied on 25 genotypes of sweet potato and revealed that the maximum direct effect (0.74) on tuber yield was through tuber weight. Tuber width, number of branches and number of tubers also had direct effects on tuber yield. Alam *et al.* (1998) studied on fifteen genotypes of sweet potato and resulted that tubers per plant and tuber width had maximum positive direct effect and the vine length had maximum negative direct effect on yield. Parida *et al.* (1999) observed that marketable tuber yield and number of tubers per plant had direct influence on tuber yield. Choudhary *et al.* (2000) evaluated fifty genotypes of sweet potato and revealed that total tuber yield had direct effect on total tuber yield per plant and marketable tuber yield. Hossain *et al.* (2000) evaluated thirty sweet potato genotypes and concluded that average tuber weight and number of tubers per plant had positive direct effect on yield. Sahu *et al.* (2005) studied on 24 sweet potato genotypes and revealed that the number of marketable tubers had a direct positive effect on tuber yield whereas vine weight had positive indirect effects on tuber yield via tuber yield per plant and marketable tuber yield. Neck length of tuber, tuber length, tuber diameter, biological yield, harvest index, total soluble solids, dry matter content of foliage, and dry matter content of tuber also exhibited positive

indirect effects on tuber yield. Engida Tsegaye *et al.* (2006) conducted study on thirty sweet potato genotypes and revealed that storage root yield had direct effect on individual storage root weight, number of storage roots per plant and harvest index. Shashikanth *et al.* (2008) revealed that number of tubers had direct association with tuber yield. Li Yun Song *et al.* (2010) studied on 10 sweet potato genotypes and resulted that the characters of number of tubers per plant and number of green leaves per plant had important direct effect on sweet potato yield. Tirkey *et al.* (2011) revealed that marketable tuber yield, biological yield, tuber diameter and dry matter per cent of tuber, neck length of tuber, tuber length and vine had positive direct effect on tuber yield. Choudhary and Mishra (2011) studied on twelve sweet potato genotypes and concluded that number of tubers per plant exhibited had high significant direct effect on tuber yield.

Chapter III
Materials and Methods

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MATERIALS AND METHODS

This chapter illustrates information concerning methodology that was used in the performance of the experimentation. It contains a brief description about locations of experimental site, setting materials (sweet potato vines), climatic and soil conditions, layout and design of the experiment, land preparation, manuring and fertilizing, intercultural operations, harvesting, data collection procedure, statistical procedure etc., which are represented as follows:

3.1 Experimental site

The experiment was accomplished at experimental field, Sher-e-Bangla Agricultural University, Dhaka-1207, Bangladesh during the period from November- March, 2015. Location of the site is 23°74' N latitude and 90°35' E longitude with an elevation of 8 meters from sea level (Anon., 2004) in Agro-ecological zone of "Madhupur Tract" (AEZ-28) (Anon.1988). The experimental site is shown in the map of AEZ of Bangladesh in (Appendix I).

3.2 Experimental materials

The experimental materials consist of six sweet potato genotypes. Four of them were collected from GEPB department of Sher-E-Bangla Agricultural University and the other two were collected from Horticulture Research Centre (HRC) at Bangladesh Agricultural Research Institute (BARI), Gazipur. The name and source of collection of these genotypes are presented in Table 1.

3.3 Climate and soil

The experimental site was located in the subtropical climatic zone, having plenty of sunshine and moderately low temperature prevailing during October to March (Rabi season) which is suitable for sweet potato growing in Bangladesh. The soil was sandy loam in texture having pH 5.46-5.62. Weather information and

physicochemical properties of the soil are presented in (Appendix II and Appendix III respectively).

Table 1. Name and origin of six sweet potato genotypes used in the present study

Sl. No.	Genotypes No.	Name/Acc No. (BD)	Source of collection
1	G1	IB001	
2	G2	IB002	GEPB, SAU
3	G3	IB003	
4	G4	IB004	
5	G5	BARI sweet potato-8	HRC, BARI
6	G6	BARI sweet potato-12	HRC, BARI

HRC= Horticulture Research Centre, BARI=Bangladesh Agricultural Research Institute

3.4 Plot and vine preparation

Plots were prepared by tillering 5 days before sowing. Fertilizing and watering were also done before sowing vines. Vine sowing of sweet potato was carried out on November 12, 2015 in the plots. The vines were collected from different sources and raised in pots. Sweet potato vines were cut into pieces (each vine approx. 20-25 cm long, having 3-4 nodes). Vine cuttings collected from the apical and middle portions are considered to have large number of sprouts and high yield of tubers in comparison with the cuttings from basal portion (Nedunchezhiyan *et al*. 2008). Vines were sown in rows spaced at 50 cm apart, plots were watered regularly. Recommended cultural practices (i.e. weeding, earthing up) were taken up before and after sowing the vines.

3.5 Design and layout of the experiment

The experiment was laid out with six genotypes and evaluated under field condition during Rabi 2015-16 in a Randomized Complete Block Design (RCBD). The experiment was conducted with 4 replications. Plant to plant distances in each plot

was 50 cm $\times$ 60 cm with plot size of 25×14 m. The total plot number was 24. The whole experiment was conducted during Robi season, 2015-16. All the collected vines were sown in 12th November 2015. The experimental site was in Sher-e-Bangla Agricultural University, Dhaka-1207, Bangladesh.

3.6 Land preparation

The experimental plots were ploughed at 15-20 cm depth and brought into a fine tilth. Application of the recommended dose of fertilizers and farm yard manures (FYM) were done. Weeds and other stubbles were removed carefully from the experimental plot and leveled properly. The final land preparation was done on November 11, 2015.

3.7 Vine sowing

The vines were collected from different sources and raised in pots. After preparing plots, the vines were cut into small pieces of 20-25 cm with 3-4 nodes. The vines were planted in 5-7 cm depth in 12 November, 2015. Vines were irrigated in the next day after sowing and later flood irrigation was provided via irrigation channels.

3.8 Manure and fertilizers application

Total cow dung and Triple Super Phosphate (TSP) were applied in the field during final land preparation. Half Urea and half Muriate of Potash (MOP) were applied in the main field preparation. Remaining Urea and Muriate of Potash (MOP) were applied after five weeks of sowing with second earthing up. Doses of manure and fertilizers used in the study are presented in Table 2.

Table 2. Doses of manures and fertilizers used in the study

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Sl. No.	Fertilizers/ Manures	Dose	
		Applied in the plot	Quantity/ha
1.	Urea	10.5 kg	182 kg
2.	TSP	08 kg	100 kg
3.	MOP	4.5 kg	235 kg
4.	Cow dung	200 kg	10 ton
5.	Furadan	250 gm	400 gm

3.9 Intercultural operations

Gap filling was done after one week in the plots to ensure optimum plant density per plot. When the vines were well established, first weeding was done uniformly in all the plots. Second and third weeding were done after 20 days and 50 days of the first one respectively. Earthing up was done after 20 days of sowing. Second earthing up was done 15 days after the first one. Spilt portion of fertilizers was provided during second earthing up. Sevin dust and Furadan were given as protection of the vines.

3.10 Harvesting and processing:

All sweet potato verities were harvested in 3rd March, 2016 (approx. after four months). Harvesting from each plot was done by digging out carefully with spades or forks.

3.11 Observations recorded

Data from the following characters were collected from each genotypes and each replications during the course of experimentation.

3.11.1 Morphological characters:The following morphological characters were observed.

Plate 1: Different stages of sweet potato plants in the experiment
      A. Vine sowing
      B. Raising of the vines in each plots
      C. Harvesting of sweet potato

3.11.1.1 Plant types

Growth habit (erect, semi compact, spreading and extremely spreading) of the plants under different accessions were observed at 90 days after planting.

3.11.1.2 Vine pigmentation

Based on the distribution of pigmentation shown in the veins and recorded the most frequent colour.

3.11.1.3 Abaxial leaf vein pigmentation

Based on the distribution of pigmentation shown in the veins of the lower surface of leaves and recorded the most frequent colour.

3.11.1.4 Type of leaf lobes

The leaf lobing pattern of genotypes was noted as slight, moderate, deep and very deep.

3.11.1.5 Number of leaf lobes

Number of leaf lobes were counted from the leaf selected from the middle part of plant and recorded the predominant number as number of leaf lobes.

3.11.1.6 Mature leaf colour

The colour of fully expand mature leaf was observed at 2 months after planting (MAP) and recorded the predominant colour.

3.11.1.7 Petiole pigmentation

For the petiole pigmentation, leaf taken from the mid height portion of stems from selected plants and recorded the most frequent occurrence.

3.11.1.8 Root shape

Observed the outer shape of the tuber and recorded the most frequent shape as external shape of storage roots.

Plate 2: Different intercultural operations of sweet potato in the experimental plots
    A. Sweet potato plot at the time of maturity
    B. Flood irrigation in the plots
    C. Earthing up

3.11.1.9 Root skin colour

Observed the outer skin colour of the tuber and recorded the most frequent colour as external colour of storage roots.

3.11.1.10 Root flesh colour

Observed the flesh colour of root and recorded the most frequent occurrence.

3.11.2 Quantitative parameters

The following quantitative characters were observed.

3.11.2.1 Vine length (cm)

Length of the vine was measured for five plants from cotyledonary node to the tip of the plant at the time of final harvest and the average was taken and expressed in centimetres.

3.11.2.2 Vine inter node length (cm)

The ratio of total vine length to the number of nodes per vine gave the internodal length.

3.11.2.3 Petiole length (cm)

Measured the length of petiole from the base of the petiole to the intersection point of all leaf lobes of a selected leaf from middle third of plant and expressed in centimetres.

3.11.2.4 Length of leaf lobe (cm)

Length of the middle leaf lobe was measured with a scale from the intersection point of all lobes to tip of the middle leaf lobe and expressed in centimetres.

3.11.2.5 Width of leaf lobe (cm)

The widest part of the middle lobe of the leaf selected from the middle of the plant measured with a scale and expressed in centimetres.

3.11.2.6 Number of leaves per plant

The total number of leaves present on a plant were counted at the time of harvest and recorded.

3.11.2.7 Total Leaf area index (cm^2)

The length and width of middle leaves in the plant were recorded at its widest point along with the number of lobes per leaf at 2MAP. The leaf area per plant was computed adopting the linear measurement procedure and expressed in cm^2.

3.11.2.8 Number of roots per plant

The number of storage tubers of five plants was counted and the mean expressed as number of tubers per plant.

3.11.2.9 Root length (cm)

The length of the storage roots was measured with the scale and the mean was expressed in centimetres.

3.11.2.10 Root girth (cm)

The maximum diameter of the tuber was measured at middle part of the tuber for 5 tubers per plant with the measuring tape and expressed in centimetres.

3.11.2.11 Root yield per plant (g)

The total weight of all marketable roots obtained per vine was recorded for five plants and the average was expressed in grams.

3.11.2.12 Dry matter content per plant (%)

Three plants at random from outside of the net plot area were carefully dugout with roots at 3 MAP and the leaves, stems and tuberous roots were separated, fresh weights were recorded and air dried. Their weights were recorded after drying in oven at 55ºC for 72 hours and the mean dry weight of samples was recorded and expressed in percentage.

Dry matter of plant (%) = Dry weight of vine/ Fresh weight of vine X 100

Dry matter of tuber (%) = Dry weight of tuber/Fresh weight of tuber X 100

3.11.2.13 Total root yield (t/ha)

The mean weight of fresh roots from each plot was recorded and calculated the root yield per hectare and expressed in tonnes.

3.11.2.14. Days to flowering

The days of first flowering of each varities were recorded.

3.11.2.15. Days to maturity

The number of days was counted from the date of sowing to first harvesting.

3.12 Statistical analysis

Mean data of the characters were subjected to multivariate analysis. Univariate analysis of the individual character was done for all characters under study using the mean values (Singh and Chaudhury, 1985) and was estimated using MSTAT-C computer programme. Duncan's Multiple Range Test (DMRT) was performed for all the characters to test the differences between the means of the genotypes. Mean, range and co-efficient of variation (CV %) were also estimated using MSTAT-C.

3.12.1 Estimation of genotypic and phenotypic variances

Genotypic and phenotypic variances were estimated according to the formula given by Johnson et al. (1992).

Genotypic variance, $\sigma^2 = \dfrac{GMS - EMS}{r}$

Where,

GMS = Genotypic mean sum of squares

EMS = Error mean sum of square

r = number of replications

Phenotypic variance, $\sigma^2_{ph} = \sigma^2_g + EMS$

Where,

σ^2_g = Genotypic variance

EMS = Error mean sum of square

Environmental variance ($\sigma^2 e$) = EMS
        Where,
EMS = Mean Square Error

3.12.2 Estimation of genotypic and phenotypic co-efficient of variation

Genotypic and phenotypic co-efficient of variation were calculated by the formula suggested by Burton (1971).

Genotypic co-efficient of variation, GCV % = $\dfrac{\sqrt{\sigma^2 g}}{\bar{x}} \times 100$

Where,

σ^2_g = Genotypic variance

$\bar{x}$ = Population mean

Similarly,

The phenotypic co-efficient of variation was calculated from the following formula.

Phenotypic co-efficient variation, PCV = $\dfrac{\sqrt{\sigma^2 ph}}{\bar{x}} \times 100$

Where,

σ^2_{ph}= Phenotypic variance

$\bar{x}$ = Population mean

3.12.3 Estimation of heritability

Broad sense heritability was estimated (Lush, 1943) by the following formula, suggested by Johnson *et al.* (1992).

Heritability, $h^2_b\% = \dfrac{\sigma^2_g}{\sigma^2_{ph}} \times 100$

Where,

h^2_b = Heritability in broad sense

σ^2_g = Genotypic variance

σ^2_{ph} = Phenotypic variance

3.12.4 Estimation of genetic advance

The expected genetic advance for different characters under selection was estimated using the formula suggested by Lush (1943) and Johnson *et al.* (1992).

Genetic advance, GA = K. h^2. σ_p

Or Genetic advance, GA = K. $\dfrac{\sigma^2_g}{\sigma^2_{ph}}.\sigma_{ph}$

Where,

K = Selection intensity, the value which is 2.06 at 5% selection intensity

σ_{ph} = Phenotypic standard deviation

h^2_b = Heritability in broad sense

σ^2_g = Genotypic variance

σ^2_{ph} = Phenotypic variance

3.12.5 Estimation of genetic advance mean's percentage

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Genetic advance as percentage of mean was calculated from the following formula as proposed by Comstock and Robinson (1952):

$$\text{Genetic advance (\% of mean)} = \frac{\text{Genetic Advance (GA)}}{\text{Population mean } (\bar{x})} \times 100$$

3.12.6 Estimation of simple correlation co-efficient:

Simple correlation co-efficients (r) was estimated with the following formula (Clarke, 1983; Singh and Chaudhary, 1985).

$$r = \frac{\sum xy - \frac{\sum x . \sum y}{N}}{\sqrt{[\{\sum x2 - \frac{(\sum x)2}{N}\}\{\sum y2 - \frac{(\sum y)2}{N}\}]}}$$

Where,

$\sum$ = Summation

x and y are the two variables correlated

N = Number of observation

3.12.7 Estimation of genotypic and phenotypic correlation co-efficient

For calculating the genotypic and phenotypic correlation co-efficient for all possible combinations the formula suggested by Miller *et al.* (1990), Johnson *et al.* (1992) and Hanson *et al.* (1956) were adopted. The genotypic co-variance component between two traits and have the phenotypic co-variance component were derived in the same way as for the corresponding variance components. The co-variance components were used to compute genotypic and phenotypic correlation between the pairs of characters as follows:

Genotypic correlation, $r_{gxy} = \dfrac{GCOVxy}{\sqrt{GVx.GVy}} = \dfrac{\sigma_{gxy}}{\sqrt{(\sigma^2_{gx}.\sigma^2_{gy})}}$

Where,

$\sigma_{gxy} =$ Genotypic co-variance between the traits x and y

$\sigma^2_{gx} =$ Genotypic variance of the trait x

$\sigma^2_{gy} =$ Genotypic variance of the trait y

Phenotypic correlation $(r_{pxy}) = \dfrac{PCOVxy}{\sqrt{PVx.PVy}} = \dfrac{\sigma_{pxy}}{\sqrt{(\sigma^2_{px}.\sigma^2_{py})}}$

Where,

$\sigma_{pxy} =$ Phenotypic covariance between the trait x and y

$\sigma^2_{px} =$ Phenotypic variance of the trait x

$\sigma^2_{py} =$ Phenotypic variance of the trait y

3.12.8 Estimation of path co-efficient

It was done according to the procedure employed by Dewey and Lu (1959) also quoted in Singh and Chaudhary (1985), using phenotypic correlation coefficient values. In path analysis, correlation coefficients between yield and yield contributing characters were partitioned into direct and indirect effects on yield per hectare. In order to estimate direct and indirect effects of the correlated characters, i. e. 1, 2, 3….and 12 on yield y, a set of simultaneous equations (twelve equations in this example) is required to be formulated as shown below:

$r_{1.y} = P_{1.y} + r_{1.2}\,P_{2.y} + r_{1.3}\,P_{3.y} + r_{1.4}\,P_{4.y} + r_{1.5}\,P_{5.y} + r_{1.6}\,P_{6.y} + r_{1.7}\,P_{7.y} + r_{1.8}\,P_{8.y} + r_{1.9}\,P_{9.y} + r_{1.1}P_{10.y} + r_{1.11}\,P_{11.y} + r_{1.12}\,P_{12.y}$

$$r_{2.y} = r_{1.2} P_{1.y} + P_{2.y} + r_{2.3} P_{3.y} + r_{2.4} P_{4.y} + r_{2.5} P_{5.y} + r_{2.6} P_{6.y} + r_{2.7} P_{7.y} + r_{2.8} P_{8.y} + r_{2.9} P_{9.y}$$
$$+ r_{2.10} P_{10.y} + r_{2.11} P_{11.y} + r_{2.12} P_{12.y}$$

$$r_{3.y} = r_{1.3} P_{1.y} + r_{2.3} P_{2.y} + P_{3.y} + r_{3.4} P_{4.y} + r_{3.5} P_{5.y} + r_{3.6} P_{6.y} + r_{3.7} P_{7.y} + r_{3.8} P_{8.y} + r_{3.9} P_{9.y}$$
$$+ r_{3.10} P_{10.y} + r_{3.11} P_{11.y} + r_{3.12} P_{12.y}$$

$$r_{4.y} = r_{1.4} P_{1.y} + r_{2.4} P_{2.y} + r_{3.4} P_{3.y} + P_{4.y} + r4_{1.5} P_{5.y} + r_{4.6} P_{6.y} + r_{4.7} P_{7.y} + r_{4.8} P_{8.y} + r_{4.9}$$
$$P_{9.y} + r_{4.10} P_{10.y} + r_{4.11} P_{11.y} + r_{4.12} P_{12.y}$$

$$r_{5.y} = r_{1.5} P_{1.y} + r_{2.5} P_{2.y} + r_{3.5} P_{3.y} + r_{4.5} P_{4.y} + P_{5.y} + r_{5.6} P_{6.y} + r_{5.7} P_{7.y} + r_{5.8} P_{8.y} + r_{5.9} P_{9.y}$$
$$+ r_{5.10} P_{10.y} + r_{5.11} P_{11.y} + r_{5.12} P_{12.y}$$

$$r_{6.y} = r_{1.6} P_{1.y} + r_{2.6} P_{2.y} + r_{3.6} P_{3.y} + r_{4.6} P_{4.y} + r_{5.6} P_{5.y} + P_{6.y} + r_{6.7} P_{7.y} + r_{6.8} P_{8.y} + r_{6.9} P_{9.y}$$
$$+ r_{6.10} P_{10.y} + r_{6.11} P_{11.y} + r_{6.12} P_{12.y}$$

$$r_{7.y} = r_{1.7} P1.y + r_{2.7} P_{2.y} + r_{3.7} P_{3.y} + r_{4.7} P_{4.y} + r_{5.7} P_{5.y} + r_{6.7} P_{6.y} + P_{7.y} + r_{7.8} P_{8.y} + r_{7.9}$$
$$P_{9.y} + r_{7.10} P_{10.y} + r_{7.11} P_{11.y} + r_{7.12} P_{12.y}$$

$$r_{8.y} = r_{1.8} P_{1.y} + r_{2.8} P_{2.y} + r_{3.8} P_{3.y} + r_{4.8} P_{4.y} + r_{5.8} P_{5.y} + r_{6.8} P_{6.y} + r_{7.8} P_{7.y} + P_{8.y} + r_{8.9} P_{9.y}$$
$$+ r_{8.10} P_{10.y} + r_{8.11} P_{11.y} + r_{8.12} P_{12.y} +$$

$$r_{9.y} = r_{1.9} P_{1.y} + r_{2.9} P_{2.y} + r_{3.9} P_{3.y} + r_{4.9} P_{4.y} + r_{5.9} P_{5.y} + r_{6.9} P_{6.y} + r_{7.9} P_{7.y} + r_{8.9} P_{8.y} +$$
$$P_{9.y} + r_{9.10} P_{10.y} + r_{9.11} P_{11.y} + r_{9.12} P_{12.y} +$$

$$r_{10.y} = r_{1.10} P_{1.y} + r_{2.10} P_{2.y} + r_{3.10} P_{3.y} + r_{4.10} P_{4.y} + r_{5.10} P_{5.y} + r_{6.10} P_{6.y} + r_{7.10} P_{7.y} + r_{8.10}$$
$$P_{8.y} + r_{9.10} P_{9.y} + P_{10.y} + r_{10.11} P_{11.y} + r_{10.12} P_{12.y}$$

$$r_{11.y} = r_{1.11} P_{1.y} + r_{2.11} P_{2.y} + r_{3.11} P_{3.y} + r_{4.11} P_{4.y} + r_{5.11} P_{5.y} + r_{6.11} P_{6.y} + r_{7.11} P_{7.y} + r_{8.11}$$
$$P_{8.y} + r_{9.11} P_{9.y} + r_{10.11} P_{10.y} + P_{11.y} + r_{11.12} P_{12.y} + r_{11.13} P_{13.y}$$

$$r_{12.y} = r_{1.12} P_{1.y} + r_{2.12} P_{2.y} + r_{3.12} P_{3.y} + r_{4.12} P_{4.y} + r_{5.12} P_{5.y} + r_{6.12} P_{6.y} + r_{7.12} P_{7.y} + r_{8.12}$$
$$P_{8.y} + r_{9.12} P_{9.y} + r_{10.12} P_{10.y} + r_{11.12} P_{11.y} + P_{12.y}$$

$$r_{13.y} = r_{1.12} P_{1.y} + r_{2.12} P_{2.y} + r_{3.12} P_{3.y} + r_{4.12} P_{4.y} + r_{5.12} P_{5.y} + r_{6.12} P_{6.y} + r_{7.12} P_{7.y} + r_{8.12}$$
$$P_{8.y} + r_{9.12} P_{9.y} + r_{10.12} P_{10.y} + r_{11.12} P_{11.y} + P_{12.y}$$

$$r_{14.y} = r_{1.12} P_{1.y} + r_{2.12} P_{2.y} + r_{3.12} P_{3.y} + r_{4.12} P_{4.y} + r_{5.12} P_{5.y} + r_{6.12} P_{6.y} + r_{7.12} P_{7.y} + r_{8.12}$$
$$P_{8.y} + r_{9.12} P_{9.y} + r_{10.12} P_{10.y} + r_{11.12} P_{11.y} + P_{12.y}$$

$$r_{15.y} = r_{1.12} P_{1.y} + r_{2.12} P_{2.y} + r_{3.12} P_{3.y} + r_{4.12} P_{4.y} + r_{5.12} P_{5.y} + r_{6.12} P_{6.y} + r_{7.12} P_{7.y} + r_{8.12}$$
$$P_{8.y} + r_{9.12} P_{9.y} + r_{10.12} P_{10.y} + r_{11.12} P_{11.y} + P_{12.y}$$

Where,

r_{1y} = Genotypic correlation coefficients between y and I th character (y = Fruit yield)

P_{iy} = Path coefficient due to ith character (i= 1, 2, 3….12)

1 = Vine length (inch)

2 = Vine Internode length (cm)

3 = Vine internode diameter (mm)

4 = Leaf area (cm^2)

5 = Above ground fresh weight per plant (kg)

6 = Above ground dry matter content (%)

7 = Above ground dry weight per plant (kg)

8 = Storage root number per plant

9 = Storage root length (cm)

10 = Storage root diameter (mm)

11 = Individual storage root weight (g)

12 = Storage root fresh yield per plant (kg)

13 = Storage root dry matter content (%)

14 = Storage root dry yield per plant (kg)

15 = Harvest index per plant (%)

16 = Storage root fresh yield per plot (kg)

Total correlation, say between 1 and y i. e., r_{1y} is thus partitioned as follows:

$P_{1.y}$ = the direct effect of 1 on y

$r_{1.2} P_{2.y}$ = indirect effect of 1 via 2 on y

$r_{1.3} P_{3.y}$ = indirect effect of 1 via 3 on y

$r_{1.4} P_{4.y}$ = indirect effect of 1 via 4 on y

$r_{1.5} P_{5.y}$ = indirect effect of 1 via 5 on y

$r_{1.6} P_{6.y}$ = indirect effect of 1 via 6 on y

$r_{1.7} P_{7.y}$ = indirect effect of 1 via 7 on y

$r_{1.8} P_{8.y}$ = indirect effect of 1 via 8 on y

$r_{1.9} P_{9.y}$ = indirect effect of 1 via 9 on y

$r_{1.10} P_{10.y}$ = indirect effect of 1 via 10 on y

$r_{1.11} P_{11.y}$ = indirect effect of 1 via 11 on y

$r_{1.12} P_{12.y}$ = indirect effect of 1 via 12 on y

$r_{1.13} P_{12.y}$ = indirect effect of 1 via 13 on y

$r_{1.14} P_{12.y}$ = indirect effect of 1 via 14 on y

$r_{1.15} P_{12.y}$ = indirect effect of 1 via 15 on y

$r_{1.16} P_{12.y}$ = indirect effect of 1 via 16 on y

Where,

$P_{1.y}, P_{2.y}, P_{3.y.} \ldots\ldots\ldots P_{15.y}$ = Path coefficient of the independent variables 1, 2, 3… 15 on the dependent variable y, respectively.

$r_{1.y}, r_{2.y}, r_{3.y}\ldots r_{15.y}$ = Correlation coefficient of 1, 2, 3… 15 with y, respectively.

After calculating the direct and indirect effect of the characters, residual effect (R) was calculated by using the formula (Singh and Chaudhary, 1985) given below

$P^2_{RY} = 1 - (r_{1.y}P_{1.y} + r_{2.y}P_{2.y} + \ldots\ldots\ldots\ldots.. + r_{15.y}P_{15.y})$

Where,

$P^2_{RY} = R^2$

and hence residual effect, $R = (P^2_{RY})^{1/2}$

$P_{1.y}$ = Direct effect of the i th character on yield y.

$r_{1.y}$ = Correlation of the i th character with yield y.

Chapter IV
Results and Discussion

CHAPTER IV

RESULTS AND DISCUSSION

The experimental work was accomplished for the diversity analysis of six sweet potato (*Ipomoea batatas* (L.) Lam.) genotypes based on their yield and yield contributing traits. This chapter represents the results, discussions and possible interpretations. The roots were harvested when they began to change in shape and size and almost after four months of sowing. Leaves and roots of the genotypes are presented in plate 3,4 and 5. The data pertaining to seventeen characters have been presented and statistically analyzed with the possible interpretations given under the following headings:

4.1 Morphological variability

Different morphology has been observed in all the sweet potato genotypes under study. In G1, compact plant type with green vine was found with green leaves having no lateral lobes. Root of G1 was yellow elliptic with deep orange fresh colour. G2 was semi spreading type with 5-6 deep lobes. The roots in G2 was irregular red with deep violet colour. G3 was semi spreading type with purple vein colour and roots was long elliptic with light orange flesh. G4 was compact type, leaves were deeply lobed and roots were long elliptic with light purple flesh. G5 was spreading type, leaves were very slightly lobed, roots were round having creamy flesh colour. G6 was spreading type having slightly lobed leaves and ovate roots with yellowish flesh. The morphological variability is presented in Table 1.
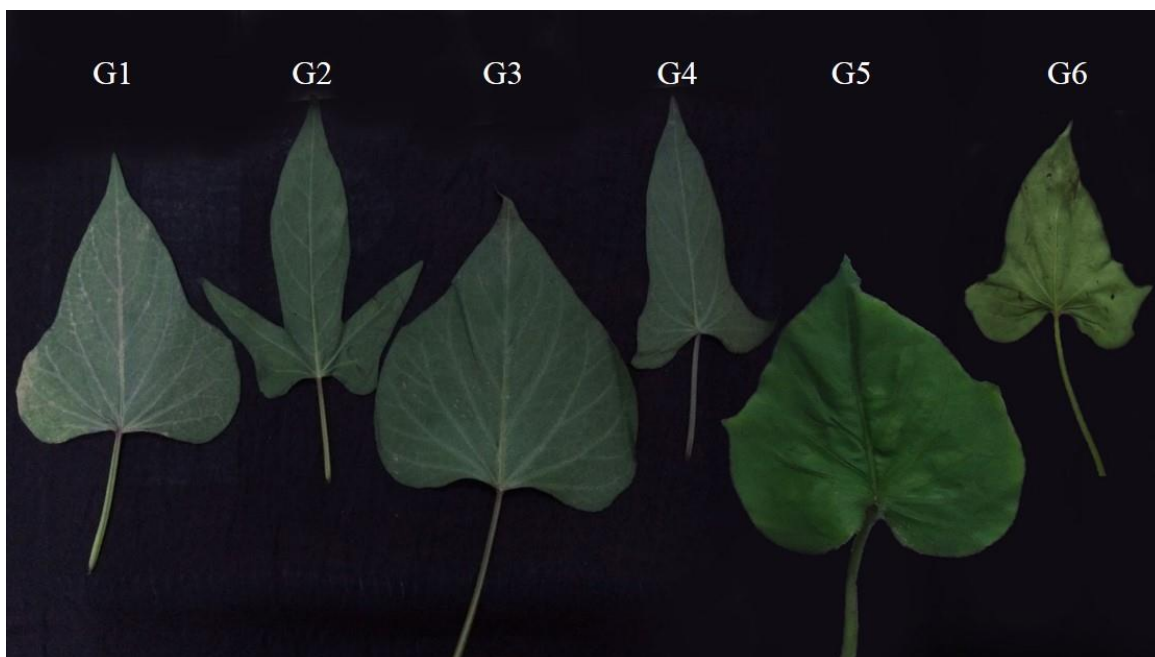
Plate 3: Leaves of sweet potato genotypes showing variation in size, shape color, no. of lobes etc.
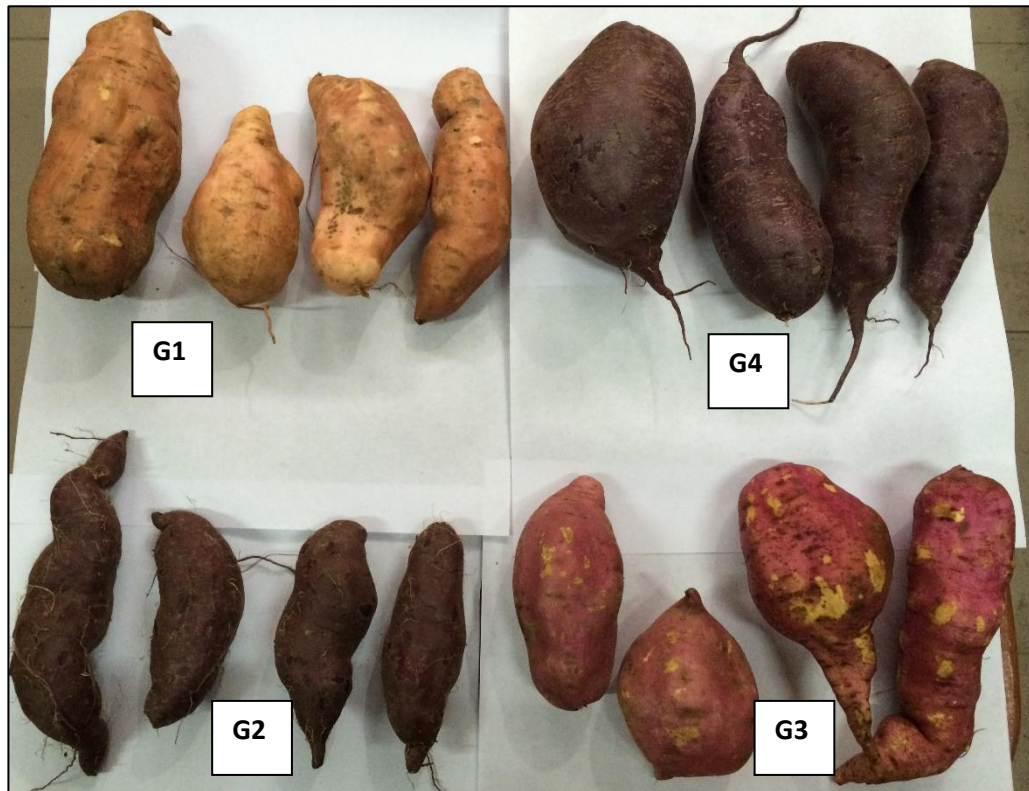
Plate 4. Variation in roots of exotic sweet potato genotypes in size, shape and color of the skin

Plate 5. Variation in roots of sweet potato genotypes in size, shape and color of the flesh

Table 1: Different morphological variations observed in sweet potato genotypes

	Plant Type	Vine pigmentation	Abaxial leaf vein pigmentation	Type of leaf lobes	No. of leaf lobes	Mature leaf color	Petiole pigmentation	Root shape	Root skin color	Root flesh color
IB001	Compact	Green	Light green	No lateral lobes	2	Green	Green	elliptic	Yellow	Deep orange
IB002	Semi spreading	Green	Light green	Deeply lobed	5-6	Green	Green	Irregular	Red	Deep violet
IB003	Semi spreading	Green with few purple spots	Purple	No lateral lobes	2	Purplish green	Purple at both ends	Long elliptic	Orange purplish	Light orange
IB004	Compact	Green with few purple spots	Deep purple	Deeply lobed	6	Green with purple mid rib	Purple at both ends	Long elliptic	Deep violet	Light purple
IB005	Spreading	Green	Purple	Very slightly lobed	5-6	Green with purple vein at lower surface	Green with purple at both ends	Round	Cream	Cream
IB006	Spreading	Green	Light green	Slightly lobed	5-6	Green	Light green	ovate	Purple red	yellowish

4.2 Genetic variability, heritability and genetic advance

The mean values for each character of all the genotypes are shown in Table 3. Performance of the genotypes is described below for each character. The extent of variation among the genotypes in respect of seventeen characters was studied and mean sum of square, phenotypic variance ($\sigma^2 p$), genotypic variance ($\sigma^2 g$), phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability ($h^2 b$), genetic advance (GA) genetic advance in percent of mean and coefficient of variation (CV) presented in Table 4.

The data were analyzed and possible interpretations are given here based on established scales. According to Deshmukh *et al.* (1986) phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) can be categorized as low (<10%), moderate (10-20%) and high (>20%). Wide difference between PCV and GCV for the traits implies their susceptibility to environmental fluctuation, whereas narrow difference suggested their relative resistant to environmental alteration. Heritability is the percentage of phenotypic variance that is attributed to genetic variance. According to Singh (2009), heritability of a trait is considered as vary high or high when the values is 80% or more and moderate when it ranged from 40-80% and when it is less than 40%, it is low. The estimates of heritability alone fail to indicate the response to selection (Johnson *et al.*, 1955). Therefore, the heritability estimates appears to be more meaningful when accompanied by estimates of genetic advance and the genetic advance as percentage of mean. Deshmukh *et al.* (1986) classified genetic advance as percentage of mean as low (<10%), moderate (10-20%) and high (>20%).

4.2.1 Vine length

The variance due to vine length showed that the genotypes differed higher significantly and ranged from 66.50 inch in G1 to 98.75 inch in G6 (Table 3). The genotypic variance and phenotypic variance for this trait were 187.37 and 215.53 respectively (Table 3). The PCV appeared to be higher than the GCV suggested influence of environment on the expression of genes

Table 3: Mean analysis of yield and yield contributing parameters

Genotypes	Vine length (inch)	Vine internode length (cm)	Vine internode diameter (mm)	Leaf area (cm^2)	Above ground fresh weight per plant (kg)	Above ground dry matter content (%)	Above ground dry weigh (kg)	Storage root number per plant	Storage root length (cm)	Storage root diameter (mm)	Individual storage root weight (g)	Storage root fresh yield per plant (kg)	Storage root dry matter content (%)	Storage root dry yield per plant (kg)	Harvest index per plant (%)	Storage root fresh yield per plot (kg)	Storage root fresh yield (ton/ha)
IB001	66.50	5.63	6.11	91.70	3.10	48.50	1.70	8.00	24.38	103.00	614.50	3.37	51.75	2.02	52.08	80.76	44.87
IB002	92.25	5.25	5.88	81.88	2.16	48.36	1.68	6.73	21.68	84.75	451.25	2.57	40.50	1.52	54.41	61.74	34.30
IB003	73.75	7.25	5.74	76.75	1.04	47.12	1.55	6.21	19.80	74.25	395.00	2.29	43.01	1.34	69.05	54.84	30.47
IB004	81.75	5.75	5.89	87.13	2.53	40.60	1.10	7.40	21.80	91.75	542.50	3.05	47.01	1.78	54.72	73.14	40.63
IB005	90.00	7.88	5.10	71.50	1.29	47.92	1.46	5.71	16.88	72.00	375.00	2.10	36.75	1.22	62.89	50.40	28.00
IB006	98.75	7.63	5.60	74.75	1.34	44.67	1.11	5.56	16.88	69.25	381.25	1.95	38.00	1.08	59.54	46.80	26.00
Min	**66.50**	**5.25**	**5.10**	**71.50**	**1.04**	**40.60**	**1.10**	**5.56**	**16.88**	**69.25**	**375.00**	**1.95**	**36.75**	**1.08**	**52.08**	**46.80**	**26.00**
Max	**98.75**	**7.88**	**6.11**	**91.70**	**3.10**	**48.50**	**1.70**	**8.00**	**24.38**	**103.00**	**614.50**	**3.37**	**51.75**	**2.02**	**69.05**	**80.76**	**44.87**
Average	**83.83**	**6.56**	**5.72**	**80.62**	**1.91**	**46.19**	**1.43**	**6.60**	**20.23**	**82.50**	**459.92**	**2.55**	**42.84**	**1.49**	**58.78**	**61.28**	**34.04**

Table 4: Estimation of genetic parameters in seventeen characters of six genotypes in sweet potato

Traits	MS	Min	Max	Mean	CV (%)	o^2_g	o^2_e	o^2_P	GCV	ECV	PCV	h^2_b	GA (5%)	GA (% mean)
Vine length (inch)	590.27**	66.50	98.75	83.83	6.33	187.37	28.16	215.53	16.33	6.33	17.51	86.94	26.29	31.36
Vine internode length (cm)	5.27**	5.25	7.88	6.56	12.77	1.52	0.70	2.22	18.81	12.77	22.73	68.44	2.10	32.05
Vine internode diameter (mm)	0.49 NS	5.10	6.11	5.72	3.86	0.15	0.05	0.19	6.67	3.86	7.71	74.92	0.68	11.90
Leaf area (cm2)	239.42**	71.50	91.70	80.62	1.55	79.29	1.56	80.85	11.04	1.55	11.15	98.07	18.16	22.53
Above ground fresh weight/plant (kg)	2.66 NS	1.04	3.10	1.91	14.84	0.86	0.08	0.94	48.56	14.82	50.77	91.48	1.83	95.69
Above ground dry matter content (%)	37.98**	40.60	48.50	46.19	2.95	12.04	1.85	13.90	7.51	2.95	8.07	86.67	6.66	14.41
Above ground dry weight/plant (kg)	0.29 NS	1.10	1.70	1.43	9.93	0.09	0.02	0.11	21.06	9.96	23.30	81.71	0.56	39.22
Storage root number/plant	3.71*	5.56	8.00	6.60	6.83	1.17	0.20	1.37	16.38	6.83	17.74	85.18	2.06	31.14
Storage root length (cm)	35.54**	16.88	24.38	20.23	4.33	11.59	0.77	12.36	16.83	4.33	17.38	93.80	6.79	33.58
Storage root diameter (mm)	691.80**	69.25	103.00	82.50	8.08	215.79	44.44	260.23	17.81	8.08	19.55	82.92	27.56	33.40
Individual storage root weight (g)	3873.67**	375.00	614.50	459.92	4.43	127.22	41.00	131.22	24.57	4.43	24.97	96.84	229.08	49.81
Storage root fresh yield/plant (kg)	1.24 NS	1.95	3.37	2.55	4.67	0.41	0.01	0.42	25.03	4.67	25.46	96.63	1.29	50.68
Storage root dry matter content (%)	130.25**	36.75	51.75	42.84	5.15	41.79	4.87	46.67	15.09	5.15	15.95	89.56	12.60	29.42
Storage root dry yield /plant (kg)	0.50 NS	1.08	2.02	1.49	4.38	0.17	0.00	0.17	27.41	4.40	27.76	97.49	0.83	55.75
Harvest index/plant (%)	162.72**	52.08	69.05	58.78	8.98	44.96	27.85	72.80	11.41	8.98	14.52	61.75	10.85	18.47
Storage root fresh yield/plot (kg)	711.89**	46.80	80.76	61.28	4.67	234.57	8.17	242.74	24.99	4.67	25.42	96.63	31.01	50.61
Storage root fresh yield (ton/ha)	219.70**	26.00	44.87	34.04	4.67	72.39	2.52	74.91	24.99	4.67	25.42	96.63	17.23	50.60

**= significant   NS= None-significant

controlling this trait. Moderate PCV and GCV were estimated for vine length (Table 4), implying equal importance of additive and non-additive gene action. The wider PCV (17.51) and GCV (16.33) values were observed for vine length (Table 4), indicating dominant role played by the environment in the expression of this trait and was not desirable for the improvement of this crop. Jain and Ganguli (1996) reported high GCV and PCV for vine lrngth. Similar findings were reported by Tsegaye *et al.* (2007) and Kamalam (1990). Pushpalata *et al.* (2011) also found similar results in sweet potato. The heritability estimates for vine length was high (86.94%) (Table 4). High heritability indicates that the environmental influence is minimal on this character. This result suggested that selection could be fairly easy and improvement is possible using selection breeding for this trait improvement. Dai *et al*. (1988), Maluf *et al.* (1983) and Singh and Mishra (1975) found high heritability and high genetic advance for vine length. Vimala and Lakshmi (1990) estimated low heritability for this trait. Based on the established scale, vine length had high genetic advance at percentage of mean (31.36%) (Table 4). High heritability coupled with high genetic advance at percent of mean for vine length suggesting that this trait was highly heritable and there is a wide scope for improvement through selection of this trait. Most likely the heritability of this trait is due to additive gene effects and selection maybe effective in early generations for this trait. Genetic advances in per cent of mean were high which is in accordance with the findings of Singh and Mishra (1975), Dai *et al*. (1988). Maluf *et al.* (1983) also reported high heritability for vine length. Vimala and Lakshmi (1990) found low heritability in vine length.

4.2.2 Vine Internode length

Significant variation was found for vine internode length and it ranged from 5.25 cm in G2 to 7.88 cm in G5 (Table 3). The phenotypic variance (2.22) was higher than genotypic variance (1.52) for this trait which advise significant influence of environment on the expression of genes. GCV and PCV were found moderate (18.81 and 22.73 respectively) (Table 4), implying similar additive and non-additive gene action. Wider gap between GCV and PCV implies that

selection based upon phenotypic expression of this character wouldn't be productive for the improvement of sweet potato. Many author also found higher PCV than GCV (Wilckens *et al.* 1993 and Singh *et al.*, 1998). The heritability estimates for this trait was moderate (68.44) suggesting that selection should be delayed to more advance generations for this trait. Low genetic advance (2.10) and high genetic advance in per cent of mean (32.05) were found. Moderate heritability and high genetic advance in percent of mean was obtained in this observation.

4.2.3 Vine internode diameter

The studied genotypes showed non-significant difference for vine internode diameter. The maximum mean was found 6.11 mm in G1 and the minimum mean was recorded 5.1 mm in G5 with mean value 5.72 mm (Table 3). The genotypic variance (0.15) was lower than phenotypic (0.19) variance. GCV (6.67) and PCV (7.71) were found lower indicating low variability among the genotypes (Table 4). GCV and PCV values were found close to each other (Table 4), suggesting environmental influence was minor on the expression of the genes controlling this trait. So, selection based upon phenotypic expression of this character would be effective for the improvement of this crop. The results of Singh *et al.*, (1998) support the findings. The heritability estimates (74.92) for this trait was moderate suggesting delay selection of this trait to more advance generation. In contrast genetic advance (0.68) and genetic advance at per cent of mean (11.90) were found low and moderate respectively. High heritability and high genetic advance for this trait was found by Vimala and Lakshmi (1990) and Thamburaj and Muthukrishnan (1976).

4.2.4 Leaf area

High Significant differences were observed among the genotypes for leaf area which ranged from 91.70 cm^2 (G1) to 71.50 cm^2 (G5) with mean value 80.62 cm^2 (Table 3). Tsegaye *et al.* (2007) found similar significant variation for leaf area. The phenotypic and genotypic variance was observed 80.85 and 79.29, respectively (Table 4) with large environmental influence. PCV (11.15) and

GCV (11.04) were moderate for leaf area. Shashikanth *et al.* (2008) found moderate to high value for PCV and GCV for leaf area. Very narrow difference between GCV and PCV explained low environmental effect and ensured heritable nature of this trait. The heritability estimates for this trait was high (98.07) with moderate genetic advance (18.16%) and high genetic advance in percent of mean (22.53%) (Table 4) revealed that this trait is highly heritable in next generations. Thiyagu *et al.* (2013) found high heritability but Shashikanth *et al.* (2008) found low heritability and genetic advance for this trait.

4.2.5 Above ground fresh weight per plant

Above ground fresh weight per plant in sweet potato showed non-significant difference where the maximum value for the trait was found 3.1 kg in G1 and the minimum was recorded 1.04 kg in G3 with mean value 1.91 kg (Table 3). The phenotypic variance (0.94) was higher than the genotypic variance (0.86) revealing low environmental influence. The GCV and PCV were 48.56 and 50.77, respectively (Table 4) indicating existence of higher variability among the genotypes. Wider difference between GCV and PCV illustrate the trait as not viable as this trait was highly controlled by the environmental effect. Sreekanth *et al.* (2011) also showed that the PCV was higher than GCV for above ground fresh weight per plant. Tsegaye *et al.* (2007) also found significant variability for this trait. The heritability estimates for this trait was high (91.48), genetic advance was low (1.83) and genetic advance in per cent of mean (95.69) (Table 4) were found high, revealed that this trait can contribute to crop improvement due to its heritable nature. High heritability and high genetic advance for this character was also observed by Velmurugan *et al.* (1999).

4.2.6 Above ground dry matter content

Above ground dry matter content was significantly different ranging from 48.50% in G1 and 40.60% in G4 with mean value of 46.19% (Table 3). The genotypic variance and phenotypic variance for this trait were 12.04 and 13.90, respectively (Table 4). The phenotypic variance appeared higher than the genotypic variance suggested influence of environment on the expression of the

genes controlling this character. The GCV (7.51) was lower than PCV (8.07) which was desirable for the improvement of this crop. Similar PCV and GCV were also observed by Vimala and Hariprakash (2011). Study conducted by Binu *et al.* (2011) does not support the observation. The heritability estimates (86.67) for this trait was high with low genetic advance (6.66) and moderate genetic advance at percent of mean (14.41) indicated that this trait was controlled by non-additive gene and selection for this character would take long time. In contrast, high heritability coupled with high genetic advance was obtained by Richardson *et al.* (2012) and Lin (1983).

4.2.7 Above ground dry weight per plant

Non-significant differences were observed among the genotypes for above ground dry weight per plant which ranged from 1.10 kg (G4) and 1.70 kg (G1) with mean value 1.43 kg (Table 3). The genotypic variance and phenotypic variance for this trait were 0.09 and 0.11, respectively. The phenotypic variance appeared higher than the genotypic variance (Table 4). PCV and GCV were high (23.30 and 21.06 respectively) indicating that the trait is desirable due to high magnitude of variability. High PCV and GCV were found by Tsegaye *et al.* (2007) also. The heritability estimates for this trait was very high (81.71), genetic advance was low (0.56) and genetic advance in percent of mean was found high (39.22), revealed that the environmental control is lower and this character is highly heritable in nature to assist selection process for crop improvement. High heritability and high genetic gain for this character were also observed by Akkamahadevi *et al*. (1996).

4.2.8 Storage root number per plant

From the current study we observed that the maximum range for storage root number per plant was found 8.00 in G1 and the minimum was recorded 5.56 in G6 with average number of 6.60 with moderately significant difference (Table 3). The difference between genotypic (1.17) and phenotypic (1.37) variances indicate high environmental influence (Table 4). PCV (17.74) and GCV (16.38) was moderate, which indicated equal importance of additive and non-additive

gene action (Table 4). Tsegaye *et al.* (2007) found high PCV and GCV value which did not support the findings. The heritability estimates for this trait was high (85.18), low genetic advance (2.06) and genetic advance at percent of mean (31.14) were found high, revealed that this character is less controlled by the environment, highly heritable and desirable for crop improvement. This character showed high heritability coupled with high genetic gain which is supported by Lin *et al.* (2007) and Velmurugan *et al.* (1999).

4.2.9 Storage root length

The storage root length was highly significant having the maximum mean recorded 24.38 cm in G1 and the minimum was recorded 16.88 cm in both G5 and G6 with mean value 20.23 (Table 3). The genotypic variance (11.59) found smaller than phenotypic variance (12.36) for storage root length (Table-4). GCV and PCV were moderate (16.38 and 17.83, respectively) and close to each other, proved that environment had little influence of the expression of this character and ensured presence of variation among the genotypes. Therefore selection based upon phenotypic expression of this character would be effective for the improvement of this crop. High GCV and PCV for average fruit weight were also noticed by Tsegaye *et al.* (2007). High heritability (93.80) associated with high genetic advance at percent of mean (33.58) and low Genetic advance (6.79) (Table 4) was observed indicating scope for crop improvement and use of this highly heritable trait for selecting during crop improvement. Thiyagu *et al.* (2013) found high PCV and GCV for this trait.

4.2.10 Storage root diameter

The storage root diameter was highly significant. The trait mean was noticed as 82.50 mm with a range of 69.25mm in G6 to 103.00 mm in G1. The genotypic and phenotypic variance were 215.79 and 260.23, respectively and GCV (17.81) and PCV (19.55) were not close to each other (Table 4), indicating existence of strong environmental influence on this character that would not be effective for the improvement of this crop. Tsegaye *et al.* (2006) showed that the PCV was the greatest for this character which supportd the present study. High heritability

estimates (82.92) with high genetic advance (27.56) and genetic advance at percent mean (33.40) (Table 4) indicate that effective selection might be made for storage root diameter. High heritability and high genetic advance for this character was observed by Pushpalata *et al.* (2011).

4.2.11 Individual storage root weight

Individual storage root weight was found to be highly significant. The mean of this trait was 459.92 g with a range of 375.00 g (in G5) to 614.50 g (in G1) (Table 3). The phenotypic and genotypic variance were 127.22 and 131.22 respectively indicating environmental control of the trait. Whereever, GCV (24.57) and PCV (24.97) (Table 4) were very close to each other, indicating minor environmental influence on this character that would be effective for the improvement of sweet potato. Tsegaye *et al.* (2007) showed that the PCV was greatest for this character which support the present study. High heritability estimate (96.84) with high genetic advance (229.08) and genetic advance at percent of mean (49.81) (Table 4) indicate that effective selection may be made for individual storage root weight. High heritability coupled with high genetic gain for this character was observed by Kamalam *et al.* (1977).

4.2.12 Storage root fresh yield per plant

Storage root fresh yield per plant was found to be non-significant with 3.37 kg in G1 which was the highest and the lowest was recorded 1.95 kg in G6 with mean value 2.55 kg (Table 3). The phenotypic variance (0.42) found higher than genotypic variance (0.41) (Table 4), suggested considerable influence of environment on the expression of the genes controlling this character. GCV and PCV were 25.03 and 25.46, respectively for storage root fresh yield per plant, which indicating that significant variation exists among different genotypes which made the trait effective for selection. Similar findings supported by Shashikanth *et al.* (2008) and Tsegaye *et al.* (2007). Vimala *et al.* (2012) observed environmental effect on this trait. Estimation of high heritability (96.63) for storage root fresh yield per plant with low genetic advance (1.29) and high Genetic advance at percent mean (50.68) (Table 4) revealed that this

character provides opportunity for selecting high valued genotypes for breeding programme. High heritability and high genetic advance was also observed by Vimala and Hariprakash (2011).

4.2.13 Storage root dry matter content

Storage root dry matter content was found to be highly significant. The mean values of this trait was 42.84% ranging from the minimum 36.75% in G5 to the maximum 51.75% in G1. Phenotypic and genotypic variance were recorded 46.67 and 41.79 respectively. GCV (15.09) and PCV (15.95) (Table 4) were moderate and very close to each other, indicating minor environmental influence on this character that would be effective for the improvement of sweet potato. High heritability estimates (89.56) with moderate genetic advance (12.60) and high genetic advance at percent of mean (29.42) indicate that effective selection may be made for this trait.

4.2.14 Storage root dry yield per plant

The trait was found to be non-significant. From the current study we observed that the maximum range of storage root dry yield per plant was found 2.02 kg in G1 and the minimum was recorded 1.08 in G6 with mean average of 1.49 kg (Table 3). There is no difference between genotypic and phenotypic variances (both have value of 0.17) (Table 4). PCV (27.76) and GCV (27.41) was high, which indicated presence of higher variability among the genotypes. Observations done by Pushpalata *et al.* (2011) also supported the findings. The very narrow difference of GCV and PCV revealed resistant to environmental alteration. The heritability estimates for this trait was high (97.49), low genetic advance (0.83) and genetic advance at percent of mean (55.75) (Table 4) were found high, revealed that this character has minimum environmental control and improvement breeding is possible by selection of this trait.

4.2.15 Harvest index per plant

The studied genotypes showed significant difference in case of harvest index (Table 3). The Maximum was found 69.05% in G3 and the minimum was

recorded 52.08% in G1 with mean value 58.78% (Table 3). The genotypic variance (44.96) was lower than phenotypic (72.80) variance explained presence of environmental effect. GCV (11.41) and PCV (14.52) were moderate and not so close to each other (Table 4) suggesting equal additive and non-additive gene function and environmental influence has control upon the expression of the genes controlling this trait. So, selection based upon phenotypic expression of this character would be non-effective for the improvement of this crop. Findings by Vimala *et al.* (2012) and Tsegaye *et al.* (2007) did not support the observation as they found higher PCV and GCV for harvest index per plant. The heritability estimates (61.75) for this trait was moderate suggesting delay in selection process to more advanced generations for this trait. In contrast genetic advance (10.85) and genetic advance at percent of mean (18.47) were found moderate.

4.2.16 Storage root fresh yield per plot

Significant variation was found for storage root fresh yield per plot and it is ranged from 46.80 kg in G6 to 80.76 kg in G1 with mean value of 61.28 kg (Table 3). Present study observed phenotypic variance (242.74) higher than genotypic variance (234.57) advised significant influence of environment on the expression of genes governing the trait. Similar findings for storage root fresh yield per plot were also observed by Tsegaye *et al.* (2007) and Vimala and Hariprakash (2011). GCV and PCV were found moderate (24.99 and 25.42 respectively) implying similar importance of additive and non-additive gene action (Table 4). Shashikanth *et al.* (2008) found similar result with moderate to high variability for this trait. Narrow gap between GCV and PCV shows that selection based upon phenotypic expression of this character can be productive for the improvement of sweet potato. The heritability estimates for this trait was high (96.63) with high genetic advance (31.03) and genetic advance at per cent of mean (50.61), indicating this trait serves wide scope for crop improvement.

4.2.17 Storage root fresh yield

Significant differences were observed among the genotypes for storage root fresh yield which ranged from 26.00 ton/ha in G6 and 44.87 ton/ha in G1 with mean

value of 34.04 ton/ha (Table 3). The genotypic variance and phenotypic variance for this trait were 72.39 and 74.91 respectively. GCV and PCV were moderate (24.99 and 25.42 respectively) but the phenotypic variance appeared higher than the genotypic variance (Table 4). The observations found by Tsegaye *et al.* (2007) and Vimala and Hariprakash (2011) were not similar. The narrow difference between GCV and PCV indicated less environmental control over the trait. The heritability estimates for this trait was very high (96.63), genetic advance was moderate (17.23) and genetic advance at percent of mean (50.60) was found high, revealed that this character had minimal environmental influence and selection for this character would be effective.

4.3 Correlation Co-efficient

Correlation studies along with path analysis provide a better understanding for the association of different characters with fruit yield. Simple correlation was partitioned into phenotypic (that can be directly observed), genotypic (inherent association between characters) components as suggested by (Singh and Chaudhary, 1985). As we know yield is a complex product being influence by several inter-dependable quantitative characters. So selection may not be effective unless the other contributing components influence the yield directly or indirectly. When selection pressure is applied for improvement of any character highly associated with yield, it simultaneously affects a number of other correlated characters. Hence knowledge regarding association of character with yield and among themselves provides guideline to the plant breeders for making improvement through selection with a clear understanding about the contribution in respect of establishing the association by genetic and non-genetic factors (Dewey and Lu, 1959). Phenotypic and genotypic correlation coefficients among different pairs of yield and yield contributing characters for different genotype are given in Table 5 and Table 6.

4.3.1 Vine length

Vine length had significant positive correlation with vine internode length at genotypic level (0.377) (Table 5). This character showed no highly significant

positive association at both genotypic and phenotypic levels with any other traits. It had highly negative significant correlation at genotypic and phenotypic level with vine internode diameter (-0.602 and -0.544), leaf area (-0.668 and -0.638), above ground fresh weight per plant (-0.499 and -0.473), above ground dry weight per plant (-0.515 and -0.472), storage root number per plant (-0.75 and -0.718), storage root length (-0.732 and -0.714), storage root diameter (-0.696 and -0.670), individual storage root weight (-0.684 and -0.664), storage root fresh yield per plant (-0.743 and -0.712), storage root dry matter content (-0.872 and -0.849), storage root dry yield per plant (-0.759 and -0.73), storage root fresh yield per plot (-0.744 and -0.712) and storage root fresh yield (-0.744 and -0.712) (Table 5 and 6). Warid *et al.* (1976) and Bacusmo *et al.* (1982) found the similar findings for this trait. Gupta (1969) and Alam *et al.* (1998) observed positive correlation of this trait with storage root fresh yield which does not support the present findings. Vine length had positive but non-significant correlation with vine internode length at phenotypic level (0.343) and with harvest index per plant at both genotypic and phenotypic level (0.056 and 0.054) (Table 5 and 6). This trait had non-significant negative correlation at both levels for above ground dry matter content (0.129 and 0.168).

4.3.2 Vine Internode length

Vine internode length showed non-significant negative association at phenotypic level with above ground dry weight per plant (0.346) indicated that the association between these traits is largely influenced by environmental factors (Table 5 and Table 6). Saladaga *et al.* (1981) observed positive correlation for this trait. It showed highly significant positive association with harvest index per plant (0.933 and 0.781) at genotypic and phenotypic level.

Table 5. Genotypic correlation coefficients among different pairs of yield and yield contributing characters for different genotype of sweet potato

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17
C1		0.377*	-0.602**	-0.668**	-0.499**	-0.149	-0.515**	-0.750**	-0.732**	-0.696**	-0.684**	-0.743**	-0.872**	-0.759**	0.056	-0.744**	-0.744**
C2			-0.909**	-0.929**	-0.933**	0.087	-0.389*	-0.923**	-0.959**	-0.922**	-0.846**	-0.881**	-0.716**	-0.873**	0.933**	-0.881**	-0.881**
C3				0.936**	0.791**	-0.132	0.256	0.880**	0.962**	0.801**	0.829**	0.833**	0.896**	0.795**	-0.686**	0.835**	0.835**
C4					0.963**	-0.154	0.228	1.000**	0.967**	1.000**	0.985**	0.981**	0.955**	0.972**	-0.832**	0.981**	0.981**
C5						-0.095	0.218	0.964**	0.893**	0.995**	0.977**	0.959**	0.837**	0.948**	-0.929**	0.959**	0.959**
C6							0.954**	-0.096	0.062	-0.047	-0.144	-0.106	-0.136	-0.056	0.146	-0.105	-0.106
C7								0.333	0.486**	0.366	0.215	0.290	0.230	0.347	-0.029	0.290	0.290
C8									0.982**	1.000**	1.000**	1.000**	0.993**	1.000**	-0.767**	1.000**	1.000**
C9										0.993**	0.926**	0.955**	0.922**	0.966**	-0.702**	0.955**	0.955**
C10											1.000**	1.000**	0.948**	1.000**	-0.801**	1.000**	1.000**
C11												0.997**	0.952**	0.986**	-0.826**	0.997**	0.997**
C12													0.960**	1.000**	-0.788**	1.000**	1.000**
C13														0.953**	-0.550**	0.960**	0.960**
C14															-0.755**	1.000**	1.000**
C15																-0.788**	-0.788**
C16																	1.000**

C1- Vine length (inch), **C2**- Vine internode length (cm), **C3**- Vine internode diameter (mm), **C4**- Leaf area (cm^2), **C5**- Above ground fresh weight per plant (kg), **C6**- Above ground dry matter content (%), **C7**- Above ground dry weight per plant (kg), **C8**- Storage root number per plant, **C9**- Storage root length (cm), **C10**- Storage root diameter (mm), **C11**- Individual storage root weight (g), **C12**- Storage root fresh yield per plant (kg), **C13**- Storage root dry matter content (%), **C14**- Storage root dry yield per plant (kg), **C15**- Harvest index per plant (%), **C16-** Storage root fresh yield per plot (kg), **C17-** Storage root fresh yield (ton/ha)

Table 6. Phenotypic correlation coefficients among different pairs of yield and yield contributing characters for different genotypes of sweet potato

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17
C1		0.343	0.544**	-0.638**	0.473**	-0.168	0.472**	0.718**	0.714**	0.670**	-0.664**	0.712**	-0.849**	0.730**	0.054	-0.712**	-0.712**
C2			0.819**	-0.860**	0.846**	0.047	-0.346	0.844**	0.896**	0.838**	-0.780**	0.818**	-0.662**	0.819**	0.781**	-0.818**	-0.818**
C3				0.882**	0.733**	-0.115	0.228	0.814**	0.881**	0.776**	0.778**	0.774**	0.820**	0.762**	-0.578**	0.774**	0.774**
C4					0.948**	-0.155	0.222	0.982**	0.953**	0.974**	0.979**	0.974**	0.934**	0.965**	-0.761**	0.974**	0.974**
C5						-0.093	0.219	0.936**	0.875**	0.968**	0.964**	0.942**	0.817**	0.935**	-0.902**	0.942**	0.942**
C6							0.880**	-0.086	0.062	-0.025	-0.139	-0.112	-0.123	-0.053	0.134**	-0.112	-0.112
C7								0.314	0.471**	0.339	0.206	0.280	0.239	0.340	-0.051	0.280	0.280
C8									0.967**	0.990**	0.979**	0.997**	0.943**	0.996**	-0.703**	0.997**	0.997**
C9										0.949**	0.910**	0.945**	0.902**	0.953**	-0.644**	0.945**	0.945**
C10											0.987**	0.991**	0.913**	0.992**	-0.769**	0.991**	0.991**
C11												0.986**	0.937**	0.977**	-0.768**	0.986**	0.986**
C12													0.939**	0.998**	-0.711**	1.000**	1.000**
C13														0.933**	-0.513**	0.939**	0.939**
C14															-0.695**	0.998**	0.998**
C15																-0.711**	-0.711**
C16																	1.000**

C1- Vine length (inch), **C2**- Vine internode length (cm), **C3**- Vine internode diameter (mm), **C4**- Leaf area (cm^2), **C5**- Above ground fresh weight per plant (kg), **C6**- Above ground dry matter content (%), **C7**- Above ground dry weight per plant (kg), **C8**- Storage root number per plant, **C9**- Storage root length (cm), **C10**- Storage root diameter (mm), **C11**- Individual storage root weight (g), **C12**- Storage root fresh yield per plant (kg), **C13**- Storage root dry matter content (%), **C14**- Storage root dry yield per plant (kg), **C15**- Harvest index per plant (%), **C16-** Storage root fresh yield per plot (kg), **C17-** Storage root fresh yield (ton/ha)

Vine internode length exhibited strongly significant negative relationship with vine internode diameter (-0.909 and -0.819), leaf area (-0.929 and -0.86), above ground fresh weight per plant (-0.933 and -0.846), storage root number per plant (-0.923 and -0.844), storage root length (-0.9959 and -0.896), storage root diameter (-0.922 and -0.838), individual storage root weight (-0.846 and -0.78), storage root fresh yield per plant (-0.881 and -0.818), storage root dry matter content (-0.716 and -0.662), storage root dry yield per plant (-0.873 and -0.819), storage root fresh yield per plot (-0.881 and -0.818) and storage root fresh yield (-0.881 and -0.818) (Table 5 and 6). The character revealed non-significant positive relation with above ground dry matter content (0.087 and 0.047) at genotypic and phenotypic level and with vine length (0.343) at phenotypic level. Non-significant negative association with above ground dry weight per plant in phenotypic level (Table 5 and 6). Non- significant association of this trait with above ground dry matter content indicated that the association was largely influenced by environment.

4.3.3 Vine internode diameter

Vine internode diameter had highly significant negative correlation with harvest index per plant (-0.686 and -0.578), vine length (-0.602 and -0.544) and vine internode length (-0.909 and 0.819) at genotypic and phenotypic levels (Table 5 and Table 6). It had non-significant negative association with above ground dry matter content (-0.132 and -0.115) and nom-significant positive association with above ground dry weight per plant (0.256 and 0.228) at both levels. Vine internode diameter had highly positive association with leaf area,above ground fresh weight per plant,storage root number per plant,storage root length, storage root diameter,individual storage root weight,storage root fresh yield per plant,storage root dry matter content, storage root dry yield per plant, storage root fresh yield per plant and storage root fresh yield. A significant and positive correlation was observed by Saladaga *et al.* (1981a) for this trait.

4.3.4 Leaf area

Plant height had non-significant negative correlation with above ground dry matter content (-0.154 and -0.155) at genotypic and phenotypic levels (Table 5 and Table 6). Leaf area had non-significant positive correlation with above ground dry weight per plant (0.228 and 0.222) which was supported by Bacusmo *et al*. (1982). It had high significant positive correlation with all other traits except with harvest index per plant (-0.832 and -0.761), vine length (-0.668 and -0.638) and vine internode length (-0.929 and -0/86) at both levels (Table 5 and Table 6).

4.3.5 Above ground fresh weight per plant

Above ground fresh weight per plant had non-significant negative and positive correlation with above ground dry matter content (-0.095 and -0.093) and above ground dry weight per plant (0.218 and 0.219) respectively at both levels (Table 5 and 6). This trait showed highly significant positive correlation with vine internode diameter, leaf area, storage root number per plant, storage root length, storage root diameter, individual storage root weight, storage root fresh yield per plant, storage root dry matter content, storage root dry yield per plant, storage root fresh yield per plot and storage root fresh yield. Tiwari *et al*. (1987) and Sahu *et al*. (2005) found high correlation of this trait with storage root fresh yield and vine length respectively. Highly significant negative correlation was found with vine length, vine internode length and harvest index per plant.

4.3.6 Above ground dry matter content

Above ground dry matter content had highly significant and positive association with above ground dry weight per plant (0.954 and 0.88) at both level and with harvest index per plant (0.134) at phenotypic level (Table 5 and 6). Positive non-significant correlation was found with vine internode length (0.087 and 0.047), storage root length (0.062 and 0.062) at both level and with harvest index per plant (0.146) at genetic level (Table 5 and 6). All other traits (vine length, vine internode diameter, leaf area, storage root number per plant, storage root diameter, individual storage root weight, storage root fresh yield per plant,

storage root dry matter content, storage root dry yield per plant, storage root fresh yield per plot and storage root fresh yield) had non-significant negative correlation with this trait. A positive correlation between above ground dry matter content and storage root yield per plant was also observed by Shashikanth *et al.* (2008) and Gerpacio (1994). Cervantes-Flores *et al.* (2010), Chiona (2009) and Simonne *et al.* (1993) found slight negative correlation for this trait.

4.3.7 Above ground dry weight per plant

Above ground dry weight per plant showed highly significant positive correlation with storage root length (0.486 and 0.471) and above ground dry matter content (0.954 and 0.88) at both genotypic and phenotypic levels (Table 5 and 6). The findings also supported by Lin (1983) and Bourke (1984). All other trait except harvest index (-0.029 and -0.051) were found to have positive but non-significant correlation with the trait at genotypic and phenotypic levels.

4.3.8 Storage root number per plant

Storage root number per plant had highly significant and positive association with vine internode diameter (0.88 and 0.814), leaf area (1.0 and 0.982), above ground dry matter content (0.964 and 0.936), storage root length (0.982 and 0.967), storage root diameter (1.0 and 0.990), individual storage root weight (1.0 and 0.979), storage root fresh yield per plant (1.0 and 0.997), storage root dry matter content (0.993 and 0.943), storage root dry yield per plant (1.0 and 0.996), storage root fresh yield per plot (1.0 and 0.997) and storage root fresh yield (1.0 and 0.997) at both levels (Table 5 and 6). Lin *et al.* (2007) showed that storage root number per plant was positively correlated. On the other hand, Tsegaye *et al.* (2006) and Warid *et al.* (1976) reported that the storage root number per plant was negatively associated with storage root diameter, vine length and individual root weight. It had also significant negative correlation with harvest index per plant (-0.767 and -0.703) at both level (Table 5 and 6).

4.3.9 Storage root length

Storage root length showed highly significant and positive correlation with vine internode diameter (0.962 and 0.881), leaf area (0.967 and 0.953), above ground fresh weight per plant (0.893 and 0.875), above ground dry weight per plant (0.486 and 0.471), storage root number per plant (1.0 and 0.99), storage root diameter (0.993 and 0.949), individual storage root weight (0.926 and 0.910), storage root fresh yield per plant (0.955 and 0.945), storage root dry matter content (0.922 and 0.902), storage root dry yield per plant (0.966 and 0.953), storage root fresh yield per plot (0.955 and 0.945) and storage root fresh yield (0.955 and 0.945) for both levels (Table 5 and Table 6). Amarchandra (1997), Naskar *et al.* (1986) and Thamburaj and Muthukrishnan (1976) found that Storage root length had significant positive correlations with storage root yield. Kamalam (1977) found negative correlation of this trait with yield. It had highly significant negative effect with vine length (-0.732 and -0.714) and vine internode length (-0.959 and -0.896) at both levels. High significant positive effect were found for harvest index per plant (0.644) at genetic level and significant negative effect for harvest index per plant (-0.702) at phenotypic level. Non-significant correlation was found with above ground dry matter content (0.062 and 0.062) at both levels.

4.3.10 Storage root diameter

This trait was found to be highly significant and positively correlated with most of the traits vine internode diameter (0.801 and 0.776), leaf area (1.0 and 0.974), above ground fresh weight per plant (0.995 and 0.968), storage root number per plant (1.0 and 0.979), storage root length (0.993 and 0.949), individual storage root weight (1.0 and 0.987), storage root fresh yield per plant (1.0 and 0.991), storage root dry matter content (0.948 and 0.913), storage root dry yield per plant (1.0 and 0.992), storage root fresh yield per plot (1.0 and 0.991), storage root fresh yield (1.0 and 0.991) at genotypic and phenotypic levels. Hossain et al. (2000) found high correlation of storage root diameter with storage root yield. Tsegaye *et al.* (2006) found negative correlation of this trait. Some of the traits (vine length, vine internode length and harvest index per plant) were found to be

highly significant and negatively correlated in both levels. Above ground dry matter content and above ground dry weight per plant were found to be non-significant but positive and negatively correlated respectively (Table 5 and 6).

4.3.11 Individual storage root weight

High significance and positive correlation were found with vine internode diameter (0.829 and 0.778), leaf area (0.985 and 0.979), above ground fresh weight per plant (0.977 and 0.964), storage root number per plant (1.0 and 0.997), storage root length (1.0 and 0.991), storage root diameter (1.0 and 0.987), individual storage root weight (0.997 and 0.986), storage root dry matter content (0.952 and 0.937), storage root dry yield per plant (0.986 and 0.977), storage root fresh yield per plant (0.997 and 0.986) and storage root fresh yield (0.997 and 0.986) at both levels (Table 5 and 6). Alam *et al.* (1998) supported this findings. Highly significant and negatively correlated traits were vine length (-0.684 and -0.846), vine internode length (-0.846 and -0.780) and harvest index per plant (-0.826 and -0.768) at both levels. Non-significant positive and negative correlation was found in above ground dry weight per plant (0.215 and 0.206) and above ground dry matter content (-0.144 and -0.139) respectively. Tsegaye *et al.* (2006) found negative significant correlation for this trait.

4.3.12 Storage root fresh yield per plant

Most of the traits were found to be highly significant and positively correlated vine internode diameter (0.833 and 0.774), leaf area (0.981 and 0.974), above ground fresh weight per plant (0.959 and 0.942), storage root number per plant (0.993 and 0.943), storage root length (0.948 and 0.913), storage root diameter (0.952 and 0.937), individual storage root weight (0.997 and 0.986), storage root dry matter content (0.960 and 0.939), storage root dry yield per plant (1.0 and 0.998), storage root fresh yield per plot (1.0 and 1.0) and storage root fresh yield (1.0 and 1.0) in genotypic and phenotypic levels. Sahu *et al.* (2005) and Lin (1983) also found the similar result. Negative correlated and high significant were also observed with vine length (-0.743 and 0.712), vine internode length (-0.881 and -0.818) and harvest index per plant (-0.788 and -0.711) at both levels.

Non-significant negative and positive correlation were found in above ground dry matter content (-0.106 and -0.112) and above ground dry weight per plant (0.290 and 0.28) respectively.

4.3.13 Storage root dry matter content

Strong and positive correlation of this trait were observed with vine internode diameter (0.896 and 0.820), leaf area (0.955 and 0.934), above ground fresh weight per plant (0.837 and 0.817), storage root number per plant (1.0 and 0.996), storage root length (1.0 and 0.992), storage root diameter (0.986 and 0.977), individual storage root weight (1.0 and 0.998), storage root fresh yield per plant (0.960 and 0.939), storage root dry yield per plant (0.943 and 0.933), 16(0.960 and 0.939) and storage root fresh yield (0.960 and 0.939) in both levels. Shashikanth *et al.* (2008) supported this observation. Strong negative correlation in genotypic and phenotypic levels were also observed in vine length, vine internode length and harvest index per plant. Cervantes-Flores *et al.* (2010) and Chiona (2009) also found slightly negative correlation for this trait. Non-significant negative and positive correlation were found with above ground dry matter content and above ground dry weight per plant.

4.3.14 Storage root dry yield per plant

Storage root dry yield per plant was found to be highly and positively correlated at both levels with vine internode diameter (0.795 and 0.762), leaf area (0.972 and 0.965), above ground fresh weight per plant (0.948 and 0.935), storage root dry matter content (0.953 and 0.933), storage root fresh yield per plant (1.0 and 0.998) and storage root fresh yield (1.0 and 0.998) at both levels. Bourke (1984) supports this findings. Strong negative correlation was found in vine length, vine internode length, storage root number per plant, storage root length, storage root diameter, individual storage root weight, storage root fresh yield per plant and harvest index per plant in both genotypic and phenotypic levels. Non-significant negative and positive correlations were observed in

above ground dry matter content and above ground dry weight per plant.

4.3.15 Harvest index per plant

Strong and positive correlation were found in vine internode length (0.933 and 0.781), storage root number per plant (1.0 and 0.997), storage root length (1.0 and 0.991), storage root diameter (0.997 and 0.986), individual storage root weight (1.0 and 1.0), storage root fresh yield per plant (0.960 and 0.939) and storage root dry matter content (1.0 and 0.998) at both levels. Tsegaye *et al.* (2006), Sahu *et al.* (2005) and Huett *et al.* (1976) also found similar observations. High and negative correlations were found in vine internode diameter, leaf area, above ground fresh weight per plant, storage root dry yield per plant, storage root fresh yield per plot and storage root fresh yield. Non-significant correlation were observed in vine length (0.056 and 0.054) at both levels and in above ground dry matter content (0.146) at genotypic level.

4.3.16 Storage root fresh yield per plot

The observation states positive and high correlation vine internode diameter (0.835 and 0.774), leaf area (0.981 and 0.974), above ground fresh weight per plant (0.959 and 0.942), storage root number per plant (1.0 and 0.997), storage root length (1.0 and 0.991), storage root diameter (0.997 and 0.986), individual storage root weight (1.0 and 1.0), storage root fresh yield per plant (0.96 and 0.939), storage root dry matter content (1.0 and 0.998) and storage root fresh yield (1.0 and 1.0) at both levels (Table 5 and 6). Thamburaj and Muthukrishnan (1976), Bhagsari and Harman (1982), Maluf *et al.* (1983), Gerpacio (1994) and Kumar *et al.* (1996) also supports this findings. Highly negative correlation were found in vine length (-0.744 and -0.712), vine internode length (-0.881 and -0.818), storage root dry yield per plant (-0.788 and -0.711) and harvest index per plant (-0.788 and -0.711) (Table 5 and 6). Non-significant positive and negative correlation was found in above ground dry weight per plant and above ground dry matter content respectively.

4.3.17 Storage root fresh yield

Storage root fresh yield was positively and strongly correlated with vine internode diameter (0.835 and 0.774), leaf area (0.981 and 0.974), above ground

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fresh weight per plant (0.959 and 0.942), storage root number per plant (1.0 and 0.997), storage root length (0.955 and 0.945), storage root diameter (1.0 and 0.991), individual storage root weight (0.997and 0.986), storage root fresh yield per plant (1.0 and 1.0), storage root dry matter content (0.96 and 0.99), storage root dry yield per plant (1.0 and 0.998) and storage root fresh yield per plot (1.0 and 1.0) at both genotypic and phenotypic levels. Huett *et al.* (1976), Bourke (1984) and Jain and Ganguli (1996) also found similar results. Negative high correlation was observed in vine length, vine internode length and harvest index per plant (Table 5 and 6). Non-significant positive and negative correlation was found in above ground dry weight per plant and above ground dry matter content respectively at both levels.

4.4 Path coefficient analysis

The direct and indirect effects of yield contributing characters on yield were worked out by using path analysis. Here yield (ton/ha) was considered as effect (dependent variable) and vine length (inch), Vine Internode length (cm), Vine internode diameter (mm), Leaf area (cm^2), Above ground fresh weight per plant (kg), Above ground dry matter content (%), Above ground dry weight per plant (kg), Storage root number per plant, Storage root length (cm), Storage root diameter (mm), Individual storage root weight (g), Storage root fresh yield per plant (kg), Storage root dry matter content (%), Storage root dry yield per plant (kg), Harvest index per plant (%) and Storage root fresh yield per plot (kg) were treated as independent variables. The residual effect was found 0.111. Path coefficient analysis was showed direct and indirect effects of different characters on yield of sweet potato in Table 7.

4.4.1 Vine length

Vine length had negative direct effect on yield (-0.627) which is contributed to result non-significant negative genotypic correlation with yield per plant (-

Table 7. Path coefficient analysis showing direct and indirect effects of different characters on yield of sweet potato

Characters	Direct effect	Indirect effect																Genotypic correlation with yield
		C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	
C1	-0.627		0.182	0.319	0.813**	-0.496**	0.371	-0.063	-0.804**	-0.051	0.211	-0.061	-0.528	-0.476**	-0.313	0.500***	0.279	-0.744**
C2	0.443	0.157		0.444**	0.976**	-0.903**	0.804**	-0.911**	-0.896**	-0.131	0.152	-0.130	-0.662	-0.382*	-0.413*	0.341	0.222	-0.881**
C3	-0.893	0.097	-0.400*		-0.239	0.650**	0.534**	0.469**	0.702**	-0.025	-0.322	-0.007	0.453	0.293	0.262	-0.385*	-0.347	0.835**
C4	-0.212	0.294	-0.378*	-0.615**		0.057	0.144	0.686**	0.051	0.088	-0.287	0.130	0.879	0.553**	0.498**	-0.509**	-0.404*	0.981**
C5	0.089	0.214	-0.335	-0.469**	-0.181		0.080	0.779**	0.063	0.089	-0.277	0.139	0.836	0.484**	0.485**	-0.675**	-0.362	0.959**
C6	-0.074	0.218	-0.207	0.438**	0.287	-0.083		0.317	-0.765**	0.165	-0.711	-0.191	-0.070	-0.585**	-0.182	0.864**	0.481**	-0.106
C7	0.442	0.291	-0.043	-0.057	-0.219	0.378*	-0.849**		0.421**	0.817**	-0.604**	0.441**	0.314	0.257	0.257	-0.667**	-0.883**	0.290
C8	0.009	0.305	-0.417**	-0.589**	-0.254	-0.007	0.678**	0.856**		0.033	-0.344	0.056	0.792	0.438**	0.435**	-0.537**	-0.454**	1.000**
C9	0.194	0.466**	-0.311	-0.464**	-0.110	0.166	-0.787**	0.181	0.145		-0.186	0.199	0.929	0.621**	0.570**	-0.354	-0.304	0.955**
C10	-0.288	0.368	-0.298	-0.575**	-0.150	0.093	-0.434**	0.953**	0.084	0.109		0.153	0.789	0.535**	0.501**	-0.521**	-0.318	1.000**
C11	0.139	0.336	-0.342	-0.538**	-0.206	0.061	0.091	0.611**	0.051	0.080	-0.296		0.880	0.568**	0.505**	-0.538**	-0.400*	0.997**
C12	0.060	0.366	-0.334	-0.486**	-0.174	0.087	0.134	0.907**	0.086	0.119	-0.250	0.159		0.584**	0.553**	-0.427**	-0.387**	1.000**
C13	0.667	0.466**	-0.286	-0.503**	-0.173	0.057	0.070	0.052	0.058	0.097	-0.253	0.136	0.820		0.476**	-0.364	-0.355	0.960**
C14	0.543	0.365	-0.365	-0.561**	-0.195	0.065	0.475**	0.059	0.066	0.097	-0.288	0.137	0.918	0.562**		-0.471**	-0.402*	1.000**
C15	0.784	-0.360	0.262	0.310	0.904**	-0.068	-0.094	-0.325	-0.717**	-0.840**	0.225	-0.081	-0.477	-0.255	-0.286		0.233	-0.788**
C16	-0.394	0.384*	-0.328	-0.496**	-0.177	0.083	0.118	0.059	0.085	0.118	-0.253	0.154	0.947**	0.581**	0.544**	-0.423**		1.000**

C1- Vine length (inch), **C2**- Vine internode length (cm), **C3**- Vine internode diameter (mm), **C4**- Leaf area (cm^2), **C5**- Above ground fresh weight per plant (kg), **C6**- Above ground dry matter content (%), **C7**- Above ground dry weight per plant (kg), **C8**- Storage root number per plant, **C9**- Storage root length (cm), **C10**- Storage root diameter (mm), **C11**- Individual storage root weight (g), **C12**- Storage root fresh yield per plant (kg), **C13**- Storage root dry matter content (%), **C14**- Storage root dry yield per plant (kg), **C15**- Harvest index per plant (%), **C16-** Storage root fresh yield per plot (kg), **C17-** Storage root fresh yield (ton/ha)

0.744.). It had positive significant indirect effect on C4 (0.813) and C15 (0.500) positive non-significant effect on C2 (0.182), C3 (0.319), C6 (0.371), C10 (0.211) and C16 (0.279). Negative significant indirect effect were found on C5 (-0.496), C8 (-0.804) and C13 (-0.476). Negative non-significant effect noted on C7 (-0.063), C9 (-0.051), C11 (-0.061), C12 (-0.528) and C14 (-0.313). (Table 7). Kamalam *et al.* (1977) and Naskar *et al.* (1986) suggested vine length as criteria for selection of a high yielding plant type in sweet potato as this trait has direct influence on tuber number and tuber yield. Alam *et al.* (1998) reported dissimilar result with the present study and they stated that this trait had negative direct effect on tuber yield.

4.4.2 Vine Internode length

Vine internode length had positive direct effect (0.443) and negative correlation (-0.881) on yield. Vine internode length had positive indirect effect on C3 (0.444), C4 (0.976), C6 (0.804) which were significant and non-significant positive effect were found in C1 (0.157), C10 (0.152), C15 (0.341), C16 (0.222). But it had negative significant indirect effect on C5 (-0.903), C7 (-0.911), C8 (-0.896), C13 (-0.382), C14 (-0.413) and non-significant negative effect on C9 (0.131), C11 (-0.130), C12 (-0.662) (Table 7). Sahu *et al.* (2005) and Nanda (1994) found positive direct effect of vine internode length on tuber yield.

4.4.3 Vine internode diameter

Vine internode diameter had negative direct effect on yield (-0.893) and it had also significant positive correlation with yield (0.835) at genotypic level. Vine internode diameter had positive indirect effect on C1 (0.097), C5 (0.650), C6 (0.534), C7 (0.469), C8 (0.702), C12 (0.453), C13 (0.293) and C14 (0.262). This trait had also negative indirect effect on C2 (-0.400), C4 (-0.239), C9 (-0.025), C10 (-0.322), C11 (-0.007), C15 (-0.385) and C16 (-0.347). (Table 7).

4.4.4 Leaf area

Leaf area had negative direct effect (-0.212) on yield (Table 7). It had positive indirect effect through C1 (0.294), C5 (0.057), C6 (0.144), C8 (0.051), C9 (0.088), C11 (0.130), C12 (0.879), C13 (0.553) and C14 (0.498). On the other

hand, leaf area showed negative indirect effect on yield through C2 (-0.378), C13 (-0.615), C10 (-0.287), C15 (-0.509) and C16 (-0.404).

4.4.5 Above ground fresh weight per plant

Above ground fresh weight per plant had positive direct effect on yield per (0.089) and it had also positive significant correlation with yield (0.959). This trait had positive indirect effect on C1 (0.214), C6 (0.080), C7 (0.779), C8 (0.063), C9 (0.089), C11 (0.139), C12 (0.836), C13 (0.484) and C14 (0.485). On the other hand negative indirect effect was found on C2 (-0.335), C3 (-0.469), C4 (-0.181), C10 (-0.277), C15 (-0.675) and C16 (-0.362). Hossain *et al.* (2000) also reported that above ground fresh weight per plant had direct positive effects on yield which was supported by present findings.

4.4.6 Above ground dry matter content

Above ground dry matter content had negative direct effect (-0.074) on yield and non-significant negative correlation with yield (-0.106). It had positive indirect effect on C1 (0.218), C4 (0.287), C7 (0.317), C9 (0.165), C15 (0.864) and C16 (0.481). This trait showed negative indirect effect on C2 (-0.207), C5 (-0.083), C8 (-0.765), C10 (-0.11), C11 (-0.191), C12 (-0.070), C13 (-0.585) and C14 (-0.182). Sahu *et al.* (2005) found positive direct effect of this trait on yield which did not support the findings.

4.4.7 Above ground dry weight per plant

Above ground dry weight per plant showed positive direct effect (0.442) on yield and positive non-significant correlation (0.290) at genotypic level. It also showed positive indirect effects through C1 (0.291), C5 (0.378), C8 (0.421), C9 (0.817), C11 (0.441), C12 (0.314), C13 (0.257) and C14 (0.257) (Table 7). It also showed negative indirect effects on C2 (-0.043), C3 (-0.057), C4 (-0.219), C6 (-0.849), C10 (-0.604), C15 (-0.667) and C16 (-0.883).

4.4.8 Storage root number per plant

Storage root number per plant showed positive direct effect (0.009) on yield. It had also significant positive correlation with yield (1.0). Storage root number per

plant had positive indirect effects on C1 (0.305), C6 (0.678), C7 (0.856), C9 (0.033), C11 (0.056), C12 (0.792), C13 (0.438) and C14 (0.435). It had negative indirect effect on C2 (-0.417), C3 (-0.589), C4 (-0.254), C5 (-0.007), C10 (-0.344), C15 (-0.537) and C16 (-0.454). Nanda (1994), Lin (1983), Kamalam *et al.* (1977) and Thamburaj and Muthukrishnan (1976) also observed Storage root number per plant had direct positive effects on tuber yield at the genotypic and phenotypic levels.

4.4.9 Storage root length

Path analysis revealed that storage root length had direct positive effect (0.194) on and significant positive correlation with yield (0.955). This trait had also indirect positive effect on C1 (0.466), C5 (0.166), C7 (0.181), C8 (0.145), C11 (0.199) and C12 (0.929). Further, fruit weight showed indirect negative effect on C2 (-0.311), C3 (-0.464), C4 (-0.110), C6 (-0.787), C10 (-0.186), C15 (-0.354) and C16 (-0.304). Significant genotypic correlation between storage root length and yield further strengthened their reliability in the process of selection for higher yield. Sahu *et al.* (2005) and Nanda (1994) also reported positive direct effects on tuber yield.

4.4.10 Storage root diameter

Storage root diameter had negative direct effect (**-**0.288) on yield. It had also significant positive correlation with yield (1.0). This trait had also indirect positive effect on C1 (0.368), C5 (0.093), C7 (0.953), C8 (0.084), C9 (0.109), C11 (0.153), C12 (0.789), C13 (0.535) and C14 (0.501). Storage root diameter showed indirect negative effect on C2 (-0.298), C3 (-0.5785), C4 (-0.150), C6 (-0.434), C15 (-0.521) and C16 (-0.318) (Table 7). Ibrahim (1987), Naskar *et al.* (1986) and Thamburaj and Muthukrishnan (1976) revealed that Storage root diameter exhibited positive effect on tuber yield at the genotypic and phenotypic levels.

4.4.11 Individual storage root weight

Individual storage root weight showed highly positive direct effect (0.139) on yield. It had also significant positive correlation with yield (0.997). It had

positive indirect effect on C1 (0.336), C5 (0.061), C6 (0.091), C8 (0.051), C9 (0.080), C12 (0.880), C13 (0.568) and C14 (0.50). This trait had negative indirect effects on C2 (-0.348), C3 (-0.538), C4 (-0.206), C10 (-0.296), C15 (-0.538) and C16 (-0.4) (Table 7). Tsegaye *et al.* (2006) and Tsegaye *et al.* (2006) found that this trait had high positive direct effect on tuber yield at the genotypic and phenotypic levels. This was supported by present findings.

4.4.12 Storage root fresh yield per plant

Storage root fresh yield per plant had positive direct effect (0.060) on yield. It had also significant positive correlation with yield (1.0). This trait had also indirect positive effect on C1 (0.366), C5 (0.087), C6 (0.134), C7 (0.907), C8 (0.086), C9 (0.119), C11 (0.159), C13 (0.584) and C14 (0.553). Storage root fresh yield per plant showed indirect negative effect on C2 (-0.334), C3 (-0.486), C14 (-0.174), C10 (-0.25), C15 (-0.427) and C16 (-0.387) (Table 7). Similar findings were also observed by Tsegaye *et al.*, (2006).

4.4.13 Storage root dry matter content

Storage root dry matter content had positive direct effect (0.667) on yield. It had also significant positive correlation with yield (0.960). This trait had also indirect positive effect on C1 (0.466), C5 (0.057), C6 (0.07), C7 (0.052), C8 (0.058), C9 (0.097), C11 (0.136), C12 (0.820) and C14 (0.476). Tirkey *et al.* (2011) and Sahu *et al.* (2005) also found positive direct effect on tuber yield for this trait. Storage root dry matter content showed indirect negative effect on C2 (-0.286), C3 (-0.503), C4 (-0.173), C10 (-0.253), C15 (-0.364) and C16 (-0.355) (Table 7).

4.4.14 Storage root dry yield per plant

Storage root dry yield per plant had positive direct effect (0.543) on yield. It had also significant positive correlation with yield (1.0). This trait had also indirect positive effect on C1 (0.365), C5 (0.065), C6 (0.475), C7 (0.059), C8 (0.066), C9 (0.097), C11 (0.137), C12 (0.918) and C13 (0.562). Storage root dry yield per plant showed indirect negative effect on C2 (-0.365), C3 (-0.561), C4 (-0.195), C10 (-0.188), C15 (-0.471) and C16 (-0.402) (Table 7).

4.4.15 Harvest index per plant

Harvest index per plant had positive direct effect (0.784) on yield. Tsegaye *et al.* (2006) and Sahu *et al.* (2005) also made similar observations. But it had significant negative correlation with yield per plant (-0.788). This trait had also indirect positive effect on C2 (0.262), C3 (0.310), C4 (0.904), C10 (0.225) and C16 (0.233). Harvest index per plant showed indirect negative effect on C1 (-0.360), C5 (-0.068), C6 (-0.094), C7 (-0.325), C8 (-0.717), C9 (-0.840), C11 (-0.081), C12 (-0.477), C13 (-0.255) and C14 (-0.286) (Table 7).

4.4.16 Storage root fresh yield per plot

Storage root fresh yield per plot had negative direct effect (-0.394) on yield. It had also significant positive correlation with yield (1.0). This trait had also indirect positive effect on C1 (0.384), C5 (0.083), C6 (0.118), C7 (0.059), C8 (0.085), C9 (0.118), C11 (0.154), C12 (0.947), C13 (0.581) and C14 (0.544). Storage root fresh yield per plot showed indirect negative effect on C2 (-0.329), C3 (-0.496), C14 (-0.177), C10 (-0.253) and C15 (-0.423) (Table 7).

Chapter V
Summary and Conclusion

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SUMMARY AND CONCLUSION

The present study was undertaken at Sher-e-Bangla Agricultural University Farm, Dhaka-1207, Bangladesh with six sweet potato genotypes during November 2015 to March 2016. Vine was prepared and sown to the main field in Randomized Complete Block Design (RCBD) with four replications. Data on various yield attributing characters such as vine length (inch), vine Internode length (cm), vine internode diameter (mm), leaf area (cm^2), above ground fresh weight per plant (kg), above ground dry matter content (%), above ground dry weight per plant (kg), storage root number per plant, storage root length (cm), storage root diameter (mm), individual storage root weight (g), storage root fresh yield per plant (kg), storage root dry matter content (%), storage root dry yield per plant (kg), harvest index per plant (%), storage root fresh yield per plot (kg), storage root fresh yield (ton/ha) were recorded. Analysis of variance revealed significant differences among all the genotypes for all the characters under study except vine node diameter, above ground fresh weigh per plant, above ground dry weight per plant, storage root fresh yield per plant and storage root dry yield per plant.

The analysis of variances showed significant mean squares for different characters indicated the presence of sufficient variation among the genotypes for vine length (inch), vine internode length (cm), leaf area (cm^2), above ground dry matter content (%), storage root number per plant, storage root length (cm), storage root diameter (mm), individual storage root weight (g), storage root dry matter content (%), harvest index per plant (%), storage root fresh yield per plot (kg) and storage root fresh yield (ton/ha). The individual storage root weight showed highest range of variation (375.0- 614.50) g that means wide range of variation present for this character.

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In case of leaf area (cm^2), above ground dry matter content (%), storage root number per plant, storage root length (cm), individual storage root weight (g), storage root fresh yield per plant (kg), storage root dry matter content (%), storage root dry yield per plant (kg), storage root dry yield per plot (kg) and storage root fresh yield (ton/ha) showed minor influence of environment for the expression of these characters. On the other hand, vine internode diameter (mm), above ground fresh weight per plant (kg), above ground dry weight per plant (kg), storage root fresh yield per plant (kg) and storage root dry yield per plant (kg) showed least difference in phenotypic and genotypic variance suggesting additive gene action for the expression of the characters. All the characters under the present study exhibit the highest value of heritability except vine internode length (cm), vine internode diameter (mm) and harvest index per plant (%).

Correlation coefficients among the characters were studied to define the association between yield and yield contributing components. In general, most of the characters showed the genotypic correlation co-efficient were higher than the corresponding phenotypic correlation co-efficient suggesting a strong inherent association between the characters under study. The significant positive correlation with yield (ton/ha) was found in vine internode diameter, leaf area, above ground fresh weight per plant, storage root number per plant, storage root length, storage root diameter, individual storage root weight, storage root fresh yield per plant, storage root dry matter content, storage root dry yield per plant and storage root fresh yield per plant at genotypic and phenotypic level. In addition, there were non-significant positive correlation with yield per ha was also found in above ground dry weight per plant at genotypic and phenotypic level, respectively. On the other hand, the non-significant negative correlation with yield was also found in above ground dry matter content while the high significant negative correlation was found in vine length, vine internode length and harvest index per plant at genotypic and phenotypic level, respectively.

Path coefficient analysis showed that above ground fresh weight had the positive correlation with yield. Coherently, this trait contributed to the yield through direct effect (0.089) indicating selection would be judicious and more effective for these characters in future breeding program. It also showed that storage root number per plant, storage root length, individual storage root weight, storage root fresh yield per plant, storage root dry matter content and storage root dry yield per plant had the positive correlation (1.0, 0.955, 0.997, 1.0, 0.96 and 1.0 respectively) with yield and this trait contributed to the yield through positive direct effect (0.009, 0.194, 0.139, 0.06, 0.667 and 0.543, respectively) indicating selection would be more effective for these characters in crop improvement. Vine length, vine internode diameter, leaf area, above ground dry matter content, storage root diameter and storage root fresh yield per plot had negative direct effect with yield. Vine length, vine internode length and harvest index per plant had a high negative correlation to yield where above ground dry matter content had negatively non-significant correlation effect. Vine internode length, above ground fresh weight per plant, above ground dry weight per plant, storage root number per plant, storage root length, individual storage root weight, storage root fresh yield per plant, storage root dry matter content, storage root dry yield per plant and harvest index per plant had positive direct effect on yield (0.443, 0.089, 0.442, 0.009, 0.194, 0.139, 0.06, 0.667, 0.53 and 0.784, respectively). Vine internode diameter, leaf area, storage root diameter and storage root fresh yield per plot also had a positive correlation to yield. Significant positive (in leaf area and harvest index per plant) and negative indirect effect (in above ground fresh weight per plant, storage root number per plant and storage root dry matter content) was also found.

From the findings of the present study, the following conclusions could be drawn:

i. Technique of selection would be applied for desired characters such as vine length, leaf area, storage root number, storage root length to develop high yielding varieties.

ii. Wide Genetic diversity existed at wide range among the sweet potato genotypes. That variability could be used for future breeding program of sweet potato in Bangladesh.

iii. Comparatively higher value and lower differences between genotypic co-efficient of variation and phenotypic coefficient of variation of different yield contributing characters were observed which indicated high potentiality to select these traits in future which were less affected by environmental influence.

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Appendices

APPENDICES

Appendix I. Map showing the experimental site under the study

The experimental site under study

Appendix II. Monthly average Temperature, relative humidity and total rainfall and sunshine of the experimental site during the period from November, 2015 to March, 2016.

Month	Air temperature (ºC)		Relative humidity (%)	Rainfall (mm) (total)	Sunshine (h)
	Maximum	Minimum			
November, 2015	34.8	18.0	77	227	5.8
December, 2015	32.3	16.3	69	0	7.9
January, 2016	29.0	13.0	79	0	3.9
February, 2016	28.1	11.1	72	1	5.7

Source: Bangladesh Meteorological Department (Climate and Weather Division), Agargoan, Dhaka - 1212

Appendix III: Morphological, physical and chemical characteristics of initial soil (0-15 cm depth) of the experimental site

A. Physical composition of the soil

Soil separates	%
Sand	36.90
Silt	26.40
Clay	36.66
Texture class	Clay loam

B. Chemical composition of the soil

Sl. No.	Soil characteristics	Analytical data
1	Organic carbon (%)	0.82
2	Total N (kg/ha)	1790.00
3	Total S (ppm)	225.00
4	Total P (ppm)	840.00
5	Available N (kg/ha)	54.00
6	Available P (kg/ha)	69.00
7	Exchangeable K (kg/ha)	89.50
8	Available S (ppm)	16.00
9	pH (1:2.5 soil to water)	5.55
10	CEC	11.23

Source: Central library, Sher-e-Bangla Agricultural University, Dhaka.

Experiment in the farm of Sher-e-Bangla Agricultural University

Intercultural operations in the Experimental plots