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Morphological analysis, vegetative growth and yield performance of fifteen sweet potato germplasm

S. Muntaha, I. Raisa, A. Dina, M. Rakibuzzaman and A. F. M. Jamal Uddin

Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh

For any information: jamal4@yahoo.com (Jamal Uddin AFM),
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ABSTRACT

A field experiment was performed to the study morphological analysis, growth and yield of fifteen sweet potato germplasm at the Horticulture Farm, Sher-e-Bangla Agricultural University, Bangladesh, during September 2018 to March 2019 following Randomized Complete Block Design (RCBD) with three replications. Fifteen sweet potato germplasm were collected from different countries based on skin and flesh colors of root tuber were used in this experiment. Based on the directions of the Union for the Protection of Plant Varieties (UPOV), they were classified according to their morphological differences. Different vegetative growth, reproductive growth and yield contributing parameters were studied and different germplasm showed different results from each other. Among them, maximum number of tuberous roots/plants (7.3) was observed from G_4. On the other, the utmost weight of a single root tuber (157.4 g), tuberous root yield/plant (1091.0 g) and tuberous root yield/ha (60.6 t/ha) were observed in G_7. In addition, statistically identical results were found in tuberous root yield/ha in G_3 (59.1 t/ha). The germplasm G_1, G_2, G_3, G_4, G_5, G_6, G_7, G_9, G_{12} and G_{14} can be utilized to have potential due to higher yield compared to our local variety. Furthermore, yield with color observation G_{11} may also have the prospects. This study would be effective for further research for researchers and breeders to adapt and recommend them in our country to pomp the agriculture sector.

***Key Words**: Sweet potato, Morpho-physiology, Germplasm and UPOV.*

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I. Introduction

Sweet potato (*Ipomoea batatas* L.) is an herbaceous and dicotyledonous perennial vine belonging to the Convolvulaceae family (Cuminging et al., 2009). In many countries of the world, it is treated as an essential root crop and cultivated in all the tropical, subtropical regions, particularly in Africa, Asia and the Pacific (De Moura et al., 2015). Central America is considered the place of origin of sweet potato crops (Huang and Sun, 2000 and Zhang et al., 2000). In the world, sweet potato occupied the 7th position after wheat (*Triticum aestivum*), rice (*Oryza sativa*), maize (*Zea mays*), Irish potato (*Solanum tuberosum*), barley (*Hordeum vulgare*) and cassava (*Manihot esculenta*) (Hironori et al., 2007). In

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Bangladesh, it is considered as fourth important crop after rice, wheat and potato (Delowar and Hakim, 2014). It is also considered as the 'Poor man's crop'. According to different studies, it plays a great role in saving the lives of millions of children and also helps to create a better future.

Compared to other crops, there are many advantages in the production of sweet potatoes, for example, production requires less input, but the yield and nutritional status do not get hampered, it can also grow against unfavorable conditions, such as this crop can adapt and tolerate low fertility of soil, high temperature and drought conditions (Mekonen et al., 2015). Sweet potato roots contain different sugars, proteins and minerals. The crop is widely differentiated through various morphological characteristics. It can be individualized based on its morphological features: shape, size, skin and flesh color of tuberous roots, yield, color and shape of leaves and so on (Zhang et al., 2000).

Comparing with other tropical and subtropical countries, the average yield of sweet potato root is meager in Bangladesh (Verma et al., 1994). Cultivating local and poor quality sweet potato varieties is one of the main reasons for less tuberous root production. Generally, sweet potato of white or pale yellow fleshed one is cultivated in Bangladesh. This variety did not get popular to be produced continuously due to yield contribution against the national demand touching the farmer's profit. So, it is necessary to evaluate the sweet potato germplasm to find out suitable variety and evaluate germplasm is needed for a suitable variety for continuous production with maximizing higher yield (Rahul et al., 2018, Hasan et al., 2019, Rakibuzzaman et al., 2021). Therefore, this study research work schemed to evaluate the potential sweet potato germplasm through studying morphological, vegetative growth and yield contributing characteristics. So that, it would be a valuable source for researchers and breeders for further research to recommend better cultivars and improve production technology.

II. Materials and Methods

This research work was carried out at Horticulture Farm, Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207. The duration of the experiment was from September 2018 to March 2019. The research was implemented to evaluate the morphological characteristics, vegetative growth and yield performance of 15 selected sweet potato germplasm. They were collected from different countries according to different skin and flesh colors of root tuber and were denoted for this study as G_1, G_2, G_3, G_4, G_5, G_6, G_7, G_8, G_9, G_{10}, G_{11}, G_{12}, G_{13}, G_{14} and G_{15}. Among them, G_8 collected from Bangladesh was used as a check in this study (Table 01).

Table 01. Coding as treatment of fifteen sweet potato germplasm collected from different countries based on skin and flesh color of sweet potato root tuber

Skin color	Flesh color	Source	Used in this study as
Purple red	Light Yellow	Japan	G_1
Creamy white	Pinkish purple	Japan	G_2
Creamy orange	Light orange	Japan	G_3
Creamy white	white	Japan	G_4
Creamy orange	Orange	Japan	G_5
Light purple	Light orange	Japan	G_6
White	White	Japan	G_7
White	White	Bangladesh	G_8
Purple red	Purple	Malaysia	G_9
Light purple	Light orange	Malaysia	G_{10}
Purple red	Deep purple	Malaysia	G_{11}
White	White	Malaysia	G_{12}
Purple red	Light orange	Malaysia	G_{13}
Dark purple	Deep purple	Malaysia	G_{14}
Dark purple	Deep purple	Malaysia	G_{15}

The study was laid out in the Randomized Complete Block Design (RCBD) with three replications. In the experimental area, a total of 45 plots was created. Vines of sweet potato with 4-5 nodes were planted on the plots. Plant to plant distance 30 cm and row to row distance 60 cm were maintained in

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planting vines. In each plot, there were ten plants and each block contained a total of 150 plants. Fertilizers and manures were applied following BARI recommended doses. Irrigation was applied twice at the vegetative stages and earthing up, weeding operation was also done manually. When the crops became fully matured, harvesting all the germplasm was done on the 2nd week of March, 2019 and the entire field was harvested.

Data on different morphological characteristics were recorded following Union of Protection of Plant Varieties (UPOV) guidelines based on visual observation and represented into appropriate categories. Data have also been collected based on vegetative growth and yield attributing parameters. Three plants were randomly selected from each unit of plot for the collection of data. The plants in the outer rows and the extreme end of the middle rows were excluded from the random selection to avoid the border effect. Data on leaf length (cm), leaf width (cm), length of internode (cm), petiole length (cm), flower stalk/peduncle length (cm), tuberous root length (cm), tuberous root diameter (cm), number of tuberous roots/plants, weight of a single tuberous root (g), tuberous root yield/plant (g), tuberous root yield/ha (t) were measured. The data recorded for different vegetative and yield contributing parameters were statistically analyzed using MSTAT-C computer package program to determine the significance of variation among the treatments. Differences between germplasm were evaluated by the Least Significance Difference test (LSD) at 5% level of significance.

III. Results and Discussion

Morphological characteristics observation

Classification of sweet potato germplasm according to skin, flesh and flesh after baking

Color of skin

i. Purple red: G_1, G_9, G_{11} and G_{13} were observed purple red color while G_6 and G_{10}were found to have light purple color and G_{14} and G_{15} recorded as dark purple.
ii. White: Five germplasm such as G_2, G4, G_7, G_8 and G_{12} were showed white skin color.
iii. Orange: Two germplasm like G_3 and G_5 were creamy orange in color.

Color of flesh

i. Yellow: $G_1$was found to have yellow flesh color.
ii. Purple: G_9 was found purple flesh, G_2 found as pinkish purple and G_{11}, G_{14} and G_{15} deep purple.
iii. Orange: Five germplasms such as G_3, G_5, G_6, G_{10} and G_{13} were found to have orange flesh color.
iv. White: G_4, G_7, G_8 and G_{12} were white in color.

Color of flesh after baking

i. Yellow: G_1 was observed to have yellow flesh color.
ii. Purple: Five germplasm like G_2, G_9, G_{11}, G_{14} and G_{15} were observed purple color.
iii. Orange: G_3, G_5, G_6, G_{10} and G_{13} were found orange in color.
iv. Gray: Four germplasm such as G_4, G_7, G_8 and G_{12} were gray in color.

Classification of sweet potato germplasm according to leaf, different plant parts and root tuber

The studied sweet potato germplasm was classified into different categories by visual observations following Union of Protection of Plant Varieties (UPOV) guidelines. Furthermore, the whole observation expressed below as tabular form for this classification of tuberous root of sweet potato germplasm into different categories (Table 02), classification of sweet potato leaf (Table 03) and classification of different parts of sweet potato germplasm (Table 04).

Table 02. Morphological characterization of sweet potato root tuber following UPOV Standard

Morphological characteristics	Categories	Germplasm
Types of root tuber shape	Irregular	G_1, G_7, G_8, G_{12}, G_{13}
	Oblong	G_9
	Long oblong	G_3
	Ovate	G_{11}
	Obovate	G_{15}
	Long elliptic	G_2,G_4, G_5, G_6, G_{10}, G_{14}

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Morphological characteristics	Categories	Germplasm
Depth of eye on root tubers	Shallow Deep	G_9, G_{11}, G_{14}, G_{15} G_1, G_2, G_3, G_4, G_5, G_6, G_7, G_8, G_{10}, G_{12}, G_{13}
Types of storage root tuber surface	Horizontal constriction	All germplasm
Distribution of anthocyanin pigmentation in the root tuber flesh	Covers most of the flesh Covering whole flesh No anthocyanin color	G_2 G_1, G_3, G_5, G_6, G_9, G_{10}, G_{11}, G_{13}, G_{14}, G_{15} G_4, G_7, G_8, G_{12}
Root cracking	Found Not found	G_1, G_{10}, G_{13}, G_{14} G_2, G_3, G_4, G_5, G_6, G_7, G_8, G_9, G_{11}, G_{12}, G_{15}
General outline	Lobed Cordate	G_1, G_2, G_3, G_4, G_5, G_7, G_8,G_9, G_{11}, G_{12}, G_{13}, G_{14}, G_{15} G_6, G_{10}

Table 03. Morphological characterization of sweet potato leaf of fifteen sweet potato germplasm following UPOV Standard

Morphological characteristics	Categories	Germplasm
Young leaf blade color	Purplish brown Light green	G_6 G_1, G_2, G_3, G_4, G_5, G_7, G_8, G_9, G_{10}, G_{11}, G_{12}, G_{13}, G_{14}, G_{15}
Color of mature leaf blade	Green	All germplasm
Depth of leaf lobing	Deep Moderate Shallow Very shallow	G_2, G_9, G_{11}, G_{14}, G_{15} G_3, G_5, G_8, G_{12} G_4, G_{13} G_1, G_7
Number of leaf lobe	Absent 3 5	G_6, G_{10} G_8, G_{12} G_1, G_2, G_3, G_4, G_5, G_7, G_9, G_{11},G_{13}, G_{14}, G_{15}
Anthocyanin coloration of upper side of leaf	Weak Did not show	G_5, G_{10}, G_{11}, G_{13} G_1, G_2, G_3, G_4, G_6, G_7, G_8, G_9, G_{12}, G_{14}, G_{15}

Table 04. Anthocyanin coloration observation of sweet potato petiole, abaxial vein, node and internodes of fifteen sweet potato germplasm following UPOV Standard.

Morphological characteristics	Categories	Germplasm
Anthocyanin coloration of petiole	Found Not found	G_1, G_2, G_3, G_5, G_7, G_8, G_{12} G_4, G_6, G_9, G_{10}, G_{11}, G_{13}, G_{14}, G_{15}
Extent of anthocyanin coloration on abaxial veins	Absent Very small Medium Large Very large	G_4, G_9, G_{11}, G_{14}, G_{15} G_6 G_1 G_8, G_{13} G_2, G_3, G_5, G_7, G_{10}, G_{12}
Anthocyanin coloration of node	Strong Medium Weak Not found	G_1, G_2, G_3, G_{10}, G_{12}, G_{13} G_5, G_7, G_8 G_4, G_6, G_{11}, G_{15} G_9, G_{14}
Anthocyanin coloration of internode	Strong Weak No coloration	G_1, G_2, G_{13} G_4, G_{10}, G_{12} G_3, G_5, G_6, G_7, G_8, G_9, G_{11}, G_{14}, G_{15}
Anthocyanin coloration of tip	Found Not found	G_1, G_2, G_6 G_3, G_4, G_5, G_7, G_8, G_9, G_{10}, G_{11}, G_{12}, G_{13}, G_{14}, G_{15}

Vegetative growth attributes

Length of leaf: The length of leaves varied significantly among fifteen sweet potato germplasm. The germplasm (G_{14}) showed the highest leaf length (11.2 cm) while the lowest (5.9 cm) was found from (G_4) compared to another germplasm (Figure 01). Length of leaf must vary from cultivar to cultivar due to their gene characteristics (Holtan et al., 2003).

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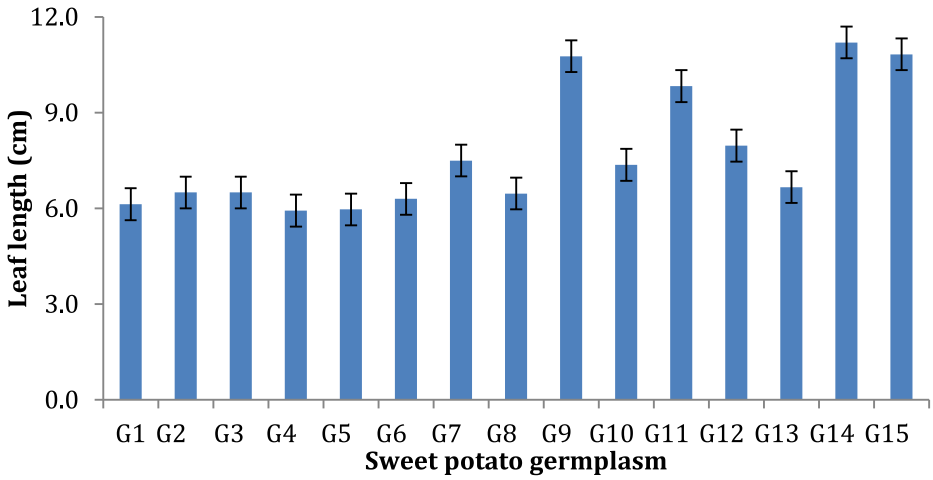

Figure 01. Performance of sweet potato germplasm on the length of leaf

Leaf width: There was a significant difference in leaf width of different sweet potato germplasm. The highest result (11.5 cm) of leaf width was found in germplasm (G_{11}) and the minimum result (9.7 cm) was observed in germplasm (G_{12}) compared to others (Figure 02.). According to Khan et al. (2012), variation in leaf width happens because of genetic differences among sweet potato germplasm.

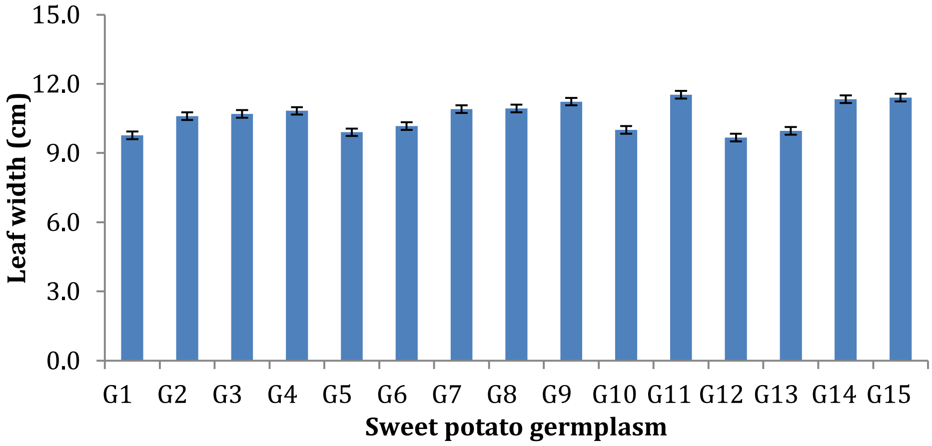

Figure 02. Performance of sweet potato germplasm on the leaf width

Length of internode: In case of length of internode, fifteen different germplasm showed a significant difference. Germplasm (G_{11}) showed the highest value (7.2 cm) of length of internode, which was statistically similar with G_{10} (6.4 cm), while germplasm (G_{13}) showed the lowest value (0.9 cm) (Figure 03). According to Egbe et al. (2012), length of internode depends on cultivars and time. The finding also agreed with Fongod et al. (2012) and Yada et al. (2010).

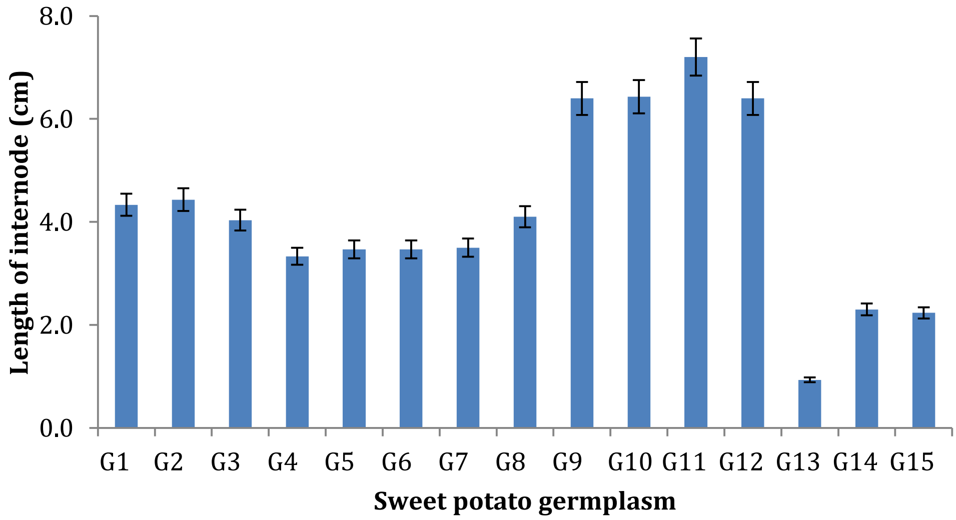

Figure 03. Performance of sweet potato germplasm on the length of internode

Petiole length: Like the other vegetative growth traits, the petiole length showed significant variation among different germplasm. G_2 showed the highest value (15.4 cm), whereas the lowest value (7.1 cm) was observed from G_8, which was statistically similar with G_{14} (7.1 cm), G_{11} (7.3 cm), G_9 (7.6 cm) and G_{13} (7.6 cm) (Figure 04.). According to Haque et al. (2015), variation occurs in petiole length due to genetic variation in different cultivars.

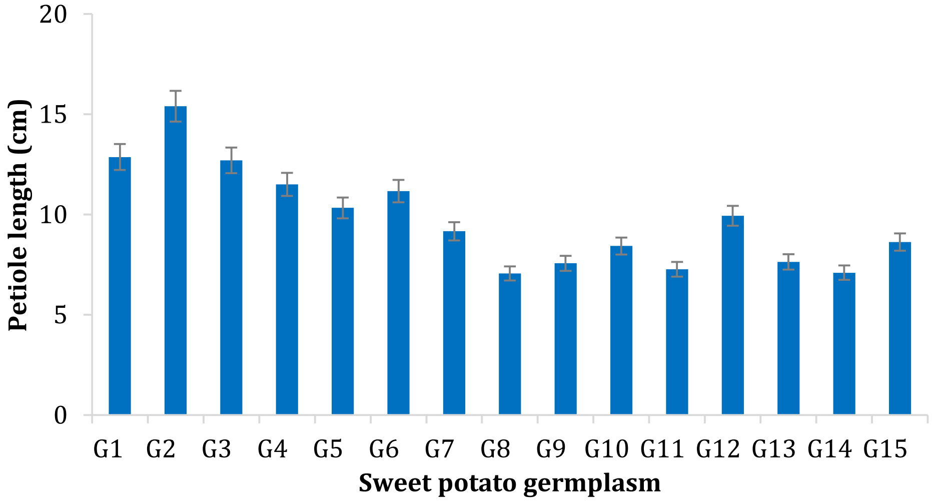

Figure 04. Performance of sweet potato germplasm on the petiole length

Flower stalk length: Flower stalk length showed significant differences among different sweet potato germplasm. The maximum flower stalk length (14.1 cm) was recorded from G_5 while G_{12} showed the lowest (6.4 cm) compared to others and G_{12} is statistically identical with G_{13} (6.5 cm), G_{15} (6.6 cm) and G_{10} (6.6 cm) (Figure 05). Differences occur in stalk length due to genetic variation among genotypes. This finding was also supported by Fongod et al. (2012) and Yada et al. (2010).

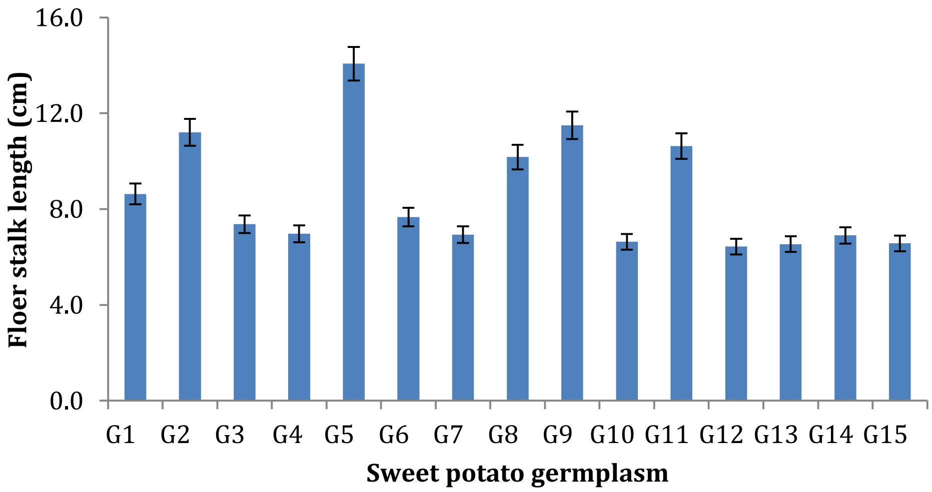

Figure 05. Performance of sweet potato germplasm on the flower stalk length

Yield contributing parameters

Tuberous root length: Fifteen germplasm showed a significant variation in terms of tuberous root length. The highest tuberous root length (19.6 cm) was found in germplasm 12 (G_{12}), statistically similar with G_1 (19.4 cm), G_2 (19.1 cm), G_5 (18.8 cm), G_3 (18.5 cm), G_{13} (18.3 cm) and G_7 (17.4 cm). On the other hand, the lowest value (9.5 cm) recorded in germplasm 11 (G_{11}), statistically similar to G_{15} (11.5 cm) and showed the lowest value (Table 05). According to Egbe et al. (2012), length of tuberous root depends on sweet potato varieties. Tuberous roots length greatly affected by genotypes of sweet potato and environmental conditions.

Tuberous root diameter: There was a significant difference among different sweet potato germplasm in tuberous root diameter. G_{15} showed the highest value (6.4 cm) for tuberous root diameter, while

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germplasm G_{13} showed the lowest value (1.3 cm) compared to another germplasm (Table 05). Hasan et al. (2019) reported that different okra varieties had a significant effect on pod breadth.

No. of tuberous roots/plant: Number of tuberous roots/plant differed positively among sweet potato germplasm. The maximum number of root tuber/plant (7.3) was found in G_4, which was statistically identical with G_9 (7.2), G_5 (7.2) and G_3 (7.1) and the minimum number (5.2) was recorded in G_{10} (Table 05). Tuberous root number per plant extensively varies due to genetic variation in different genotypes (Mau et al., 2019).

Weight of single tuberous root: A significant difference was recorded in fifteen sweet potato germplasm in case of a single tuberous root weight. G_7 showed the highest value (157.4 g) for weight of a single tuberous root, while G_{10} showed the lowest value (65.5 g) compared to another germplasm (Table 05). Weight of a single tuberous root greatly depends on the sweet potato varieties (Egbe et al., 2012). This finding was similar to Awal et al. (2007) and Datta et al. (2015).

Root yield/plant: Tuberous root yield/plant showed significant differences among different sweet potato germplasm. G_7 showed the highest value (1091.0 g) for tuberous root yield/plant and germplasm 10 (G_{10}) showed the lowest result (340.8 g) compared to another germplasm (Table 05). Variation in the yield of storage roots per plant occurs due to cultivar, location and time (Caliskan et al., 2007).

Root tuber yield/ha: Significant variation was observed among different sweet potato germplasm in tuberous root yield/ha. The highest result (60.6 t/ha) was found for tuberous root yield/ha in G_7, statistically identical with G_3 (59.1 t/ha), while the minimum yield (18.9 t/ha) was found in germplasm 10 (G_{10}) compared to another germplasm (Table 05). Again, G_{13} (25.6 t/ha) statistically similar to G_{15} (24.2 t/ha). However, the germplasm G_1 (44.8 t), G_2 (55.2 t), G_3 (59.3 t), G_4 (47.1 t), G_5 (55.1 t), G_6 (48.7 t), G_7 (60.6 t), G_9 (46.6 t), G_{12} (43.7 t) and G_{14} (50.6 t) showed higher yield than G_8 (40.3 t) statistically identical with G_{11} (39.4 t). So, they may be the potential variety for our country. Due to genetic variation in the cultivars of sweet potato, there were differences in tuberous root yield/ha (Mamun et al., 2016). Mbithe et al. (2016) also agreed with the findings.

Table 05. Performance of different sweet potato germplasm on yield attributes

Treatments	Root tuber length (cm)	Root tuber dia. (cm)	No. of root tuber/plant	Single root tuber wt. (g)	Yield per plant (g)	Cumulative yield/ha.(t)
G_1	19.4 a	44.2 cd	6.1 f	132.8 e	805.6 f	44.8 f
G_2	19.1 a	45.0 cd	7.0 bc	142.0 c	993.7 b	55.2 b
G_3	18.5 ab	59.6 a	7.1 a-c	149.1 b	1064.0 a	59.1 a
G_4	14.6 de	41.3 de	7.3 a	116.2 g	847.9 e	47.1 e
G_5	18.8 ab	51.2 b	7.2 ab	137.6 d	990.6 b	55.0 b
G_6	15.5 cd	25.3 g	6.4 e	136.2 de	876.6 d	48.7 d
G_7	17.4 a-c	44.4 cd	6.9 c	157.4 a	1091.0 a	60.6 a
G_8	16.5 b-d	37.1 e	7.0 bc	103.6 i	725.2 g	40.3 g
G_9	12.2 ef	31.3 f	7.2 ab	116.6 g	839.3 e	46.6 e
G_{10}	15.4 cd	16.4 h	5.2 h	65.5 k	340.8 i	18.9 i
G_{11}	9.5 g	30.2 fg	6.4 e	110.8 h	709.0 g	39.4 g
G_{12}	19.6 a	40.1 de	6.3 e	124.1 f	785.9 f	43.7 f
G_{13}	18.3 ab	13.1 h	5.9 f	78.0 j	460.1 h	25.6 h
G_{14}	15.6 cd	47.2 bc	6.7 d	136.1 de	911.8 c	50.6 c
G_{15}	11.5 fg	6.4 i	5.4 g	80.3 j	436.6 h	24.23 h
LSD	2.55	5.56	0.22	3.61	28.01	1.55
CV	9.54	9.36	1.99	1.8	2.11	2.10

IV. Conclusion

After observing and analyzing all the data, it can be concluded that there were significant differences among fifteen sweet potato germplasm studied in terms of different growth and yield related parameters. Though the present study categorized the sweet potato germplasm based on the different

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morphological parameters and evaluated their growth and yield performances, this information is surely an informative source for the researchers and breeders to recommend better cultivars and improve production technology.

V. References

[1]. Awal, M. A., Das, S. K. and Dhar, M. (2007). Morphological characteristics and yield attributes of twenty-three potato varieties. Journal of Agroforestry and Environment, 1(2), 15-19.

[2]. Caliskan, M. E., Sogut, T., Boydak, E., Ertuerk, E. and Arioglu, H. (2007). Growth, yield, and quality of sweet potato (*Ipomoea batatas* L.) cultivars in the southeastern anatolian and east mediterranean regions of Turkey. Turkish Journal of Agriculture and Forestry, 31(4), 213-227.

[3]. Cuminging, J. H., Beatty, E. R. and Englyst, H. N. (2009). Physiological properties of improved sweet potato varieties. The Journal of Nutrition, 7, 733-737.

[4]. Datta, S., Das, R. and Dhirendra, S. (2015). Evaluation of genetic diversity for yield and quality parameters of different potato (*Solanum tuberosum* L.) germplasm. Journal of Applied and Natural Science, 7(1), 235-241. https://doi.org/10.31018/jans.v7i1.596

[5]. De Moura, F. F., Millof, A. and Boy, E. (2015). Retention of pro-vitamin A carotenoids in sample crops targeted for biofication in Africa; cassava, maize and sweet potato. Critical Reviews in Food Science and Nutrition, 55, 1246-1269. https://doi.org/10.1080/10408398.2012.724477

[6]. Delowar, H. K. M. and Hakim, M. A. (2014). Effect of salinity levels on the morpho-physiological characteristics and yield attributes of sweet potato genotypes. International Journal of Scientific Research, 10, 929-934.

[7]. Egbe, O. M., Afuape, S. O. and Idoko, J. A. (2012). Performance of improved sweet potato (*Ipomea batatas* L.) varieties in Makurdi, Southern Guinea Savanna of Nigeria. American Journal of Experimental Agriculture, 2(4), 573-586.

[8]. Fongod, A. G. N., Mih, A. M. and Nkwatoh, T. N. (2012). Morphological and agronomic characterization of different accessions of sweet potatoes (*Ipomoea batatas* L.) in Cameroon. International Research Journal of Agricultural Science and Soil Science, 2(6), 234-245.

[9]. Haque, N., Hazrat, A., Muhammad, M. S. and Nousad, H. (2015). Growth performance of fourteen potato varieties as affected by arsenic contamination. Journal of Plant Science, 3(1), 31-44.

[10]. Hasan, M. K., Rahul, S. k., Rakibuzzaman, M., Mahato, A. K. and Jamal Uddin, A. F. M. (2019). Study on Morpho-physiological and yield Characteristics of Sixteen Okra Varieties. International Journal of Business, Social and Scientific, 7(3), 01-05.

[11]. Hironori, M., Ogasawara, F., Sato, K., Higo, H. and Minobe, Y. (2007). Isolation of a regulatory gene of anthocyanin biosynthesis in tuberous roots of purple-fleshed sweet potato. Plant Physiology, 143, 1252-1268.

[12]. Holtan, H. E. and Hake, S. (2003). Quantitative trait locus analysis of leaf dissection in tomato using *Lycopersicon pennellii* segmental introgression lines. Genetics, 165(3), 1541-1550. https://doi.org/10.1093/genetics/165.3.1541

[13]. Huang, J. C. and Sun, M. (2000). Genetic diversity and relationships of sweet potato and its wild relatives in *Ipomoea* series *batatas* (Convolvulaceae) as revealed by inter-simple sequence repeat (ISSR) and restriction analysis of chloroplast DNA. Theoretical and Applied Genetics, 100, 1050-1060. https://doi.org/10.1007/s001220051386

[14]. Khan, F., Tabassum, N., Ltif, A., Khaliq, A. and Malik, M. (2012). Morphological characterization of potato (*Solanum tuberosum* L.) germplasm under rainfed environment. African Journal of Biotechnology, 12(21), 3214-3223.

[15]. Mamun, A., Abdullah, M., Mahmud, A., Al., Zakaria, M., Hossain, M. M. and Hossain, M. T. (2016). Effects of planting times and plant densities of top-shoot cuttings on multiplication of breeder seed potato. Agriculture and Natural Resources, 50(1), 26-31. https://doi.org/10.1016/j.anres.2014.08.001

[16]. Mau, Y. S., Ndiwa, A. S., Markus, J. E. and Arsa, I. G. A. (2019). Agronomic performance and drought tolerance level of sweet potato hybrids grown in Kupang, East Nusa Tenggara, Indonesia. Biodiversitas Journal of Biological Diversity, 20(8), 2187-2196. https://doi.org/10.13057/biodiv/d200812

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[17]. Mbithe, M. J., Steven, R., Agili, S., Kivuva, M. B., Kioko, W. F. and Kuria, E. (2016). Morphological characterisation of selected Ugandan sweet potato (*Ipomoea batatas* L.) varieties for food and feed. Journal of Phylogenetics and Evolutionary Biology, 4(2),163

[18]. Mekonen, B., Tulu, S. and Nego, J. (2015). Orange fleshed sweet potato (*Ipomoea batatas* L.) varieties evaluated with respect to growth parameters at Jimma in southwestern Ethiopia. Journal of Agronomy, 14, 164-169.

[19]. Rahul, S., Rahman, M. M., Rakibuzzaman, M., Islam, M. N. and Jamal Uddin, A. F. M. (2018). Study on growth and yield characteristics of twelve cherry tomato lines. Journal of Bioscience and Agricultural Research, 17(01), 1403-1409. https://doi.org/10.18801/jbar.170118.173

[20]. Rakibuzzaman, M., Tusi, R. R., Maliha, M., Husna, A. and Jamal Uddin, A. F. M. (2021). Response of Potato Germplasm to Trichoderma viride as Bio-stimulator. International Journal of Business, Social and Scientific Research, 9(2), 17-21.

[21]. Verma, V. S., Singh, K. P., Singh, N. K., Singh, J. R. P. and Verma, S. P. (1994). Rajendra Shakarkand 35 and Rajendra Shakarkand 43: Two high yielding selections of sweet potato. Journal of root crops, 20, 15-19.

[22]. Yada, B., Tukamuhabwa, P., Alajo, A. and Mwanga, R. O. M. (2010). Morphological characterization of Ugandan sweet potato germplasm. Crop Science, 50(6), 2364-2371. https://doi.org/10.2135/cropsci2009.04.0199

[23]. Zhang, D., Cervantes, J., Huaman, E., Carey, E. and Ghislain, M. (2000). Assessing genetic diversity of sweet potato (*Ipomoea batatas* L.) cultivars from tropical America using AFLP. Genetic Resources and Crop Evolution, 47, 659-665. https://doi.org/10.1023/A:1026520507223

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Harvard
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Vancouver
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