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EVALUATION OF YIELD AND NUTRITIONAL COMPONENTS OF SOME HYBRIDS AND PARENTAL GENOTYPES OF SWEET POTATO (*Ipomoea batata* L.)

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ABSTRACT

The potential of sweet potatoes to address food insecurity, malnutrition and poverty in Africa has been acknowledged. The present study was therefore conducted to evaluate some parent genotypes, hybrids and local varieties for acceptable levels of provitamin A and other micronutrients root yield characteristics and assess the relationship among traits. Twenty sweet potato genotypes including eight parental varieties, ten hybrids and two local checks used as control. The experiments were arranged in a randomized complete block design with three replicates in each year. Data on root weight per plant, root yield, and number of roots per plant were recorded at harvest. The laboratory studies involved the determination of the approximate composition of parents, hybrids and the local sweet potato genotypes. Among the hybrids, beta carotene ranged from 0.54 mg/100g fresh root (SPU26) to 1.01 mg/100g fresh root for SPU14, while in parents, it ranged between 0.42 mg/100g fresh root for Blesbok and 0.57 mg/100g fresh root for Excel. The trend was comparable to that of iron content with a range of 1.7 mg/100g fresh root for SPU17 to 2.4 mg/100g fresh root for SPU14, 1.2 mg/100g fresh root for blesbok to 1.9 mg/100g fresh root for ex-oyunga and 1.15 mg/100g fresh root for Offa 1 to 1.24 mg/100g fresh root for ex-igbariam in the hybrids and parents, respectively. The highest root yield of 60.23t/ha was recorded for SPU02 among the hybrids, and resist recorded the highest yield (31.32 t/ha) among the parents and ex-igbariam among the checks. Therefore, breeders could find nutritional attributes useful for genetic manipulation and cultivar development for enhanced provitamin A, other micronutrients and yield parameters.

Keywords: ***compatibility, genetic gain, hidden hunger, hybridization, sweet potato***

INTRODUCTION

Sweet potato (*Ipomea batata* L.) is a valuable source of human food, animal feed and industrial raw material. The production, marketing and utilization of sweet potatoes have expanded in the last decade to almost all ecological zones of Nigeria ((FAOSTAT 2020). Nigeria is the single largest producer of sweet potato in Africa with 3.46 million metric tons and second only to China globally. Sweet potato varieties exist in many colours of skin and flesh, ranging from white to deep purple, although white and yellow and orange flesh are the most common (Fekadu, 2018). Sweet potatoes are usually consumed without special processing. The fresh root is boiled, roasted, baked, or fried as chips, which may be sold as snacks or salted and eaten as sweet potato crisps in most parts of Nigeria. Sweet potatoes are fed to livestock or processed industrially into alcohol, starch, noodles, candy, desserts and flour. The crop bears alternate heart-shaped or palmately-lobed leaves, which are not spared from being used as food. The young leaves are stir-fried as a leafy vegetable with chilli and minced dried shrimp (Kwarteng, 2020; Kagimbo*et al*., 2019).

Orange flesh sweet potatoes are rich in β – carotene (precursor of vitamin A). The strategy of increasing orange flesh sweet potato consumption helps to alleviate vitamin A deficiency (Ahmadizadeh and Felenji, 2011). Different sweet potato varieties have individual nutritional profiles, being excellent sources of different phytonutrients, including vitamins. Available daily intake of vitamin A is generally low in tropical Africa (5g in Nigeria) compared to 46-56g for an average person, and 96g for pregnant and lactating mothers as recommended by the Food and Nutrition Board of the Academy of Science (Abiodun *et al*., 2021). Millions of African children and nursing mothers suffered from vitamin A deficiency and other hidden hunger resulting from insufficient consumption of micronutrients. According to WHO, both young and old human beings need vitamins A, C, and B_2 (riboflavin) and other micronutrients which need to be supplied through foods and are readily available in sweet potato leaves and tuber. The absence or deficiency of any of these nutrients resulted in hidden hunger. From the human nutrition viewpoint, Vitamin A is the most important limiting vitamin in the cream-fleshed sweet potato. Orange flesh sweet potato was developed in order to fight night blindness and all other related health challenges.

Biofortified sweet potato cultivars and transgenic plants with high-value pharmaceutical and micronutrients such as β-carotene, anthocyanins, zinc, iron and other phenolicswere developed using molecular breeding and genetic engineering principles (Chandrasekara and Kumar, 2016). Crops biofortification can be considered the most powerful biotechnological approach to enhance the phytonutrient content of crops, thus increasing dietary intake of vitamins, and other nutrients as well, alleviating nutritional deficiencies (Ghosh,2016; Hasmawati and Husnaeni, 2016). Many crops have been bred for higher vitamins and other phytonutrient levels using either conventional or molecular engineering approaches, or many biofortified crops have been released, while others are still under trial cropping or are being tested (Ezekiel *et al*., 2013). The enhancement of sweet potato with provitamin A carotenoid has been part of Harvest Plus's research programme since the inception of the biofortification project (Peksa *et al*., 2013). Breeding for provitamin A has been successful for several crops including potatoes (Hosaka and Sanetomo, 2020) and sweet potatoes (Kwarteng*et al.* 2020). Agricultural perspective, the currently available information reveals a rapid growth in the development and introduction of provitamin A-enhanced sweet potatoes in developing countries around the world such as African Mozambique (Ghosh, 2016; Mori, 2008). In particular, orange-fleshed sweet potato (OFSP) production has evolved from home- to small-scale commercial production.

Against these backgrounds, the evaluation of OFSP yield potentials and micronutrient contents in the target environment is prerequisite for release to and adoption by farmers. The present study was therefore conducted to (i) evaluate some parent genotypes, hybrids and local genotypes for beta-carotene, iron, calcium, copper and zinc contents (ii) assess the genetic materials for tuber yield characteristics in the southern Guinea savanna agro-ecology, and (iii) determine the association among traits of the genotypes.

MATERIALS AND METHODS

Description of Genetic Materials

Twenty sweet potato genotypes including eight parental materials (four orange flesh and four yellow flesh varieties), ten hybrids and two local checks used as control were evaluated for nutritional qualities and tuber yield characteristics during three years (2012-2014) in cropping seasons at the Landmark University, Omu-Aran, Kwara State (Latitude: 8º 7’ 16” N Longitude:5° 4’ 50” E and Altitude 575m above sea level) located in the southern Guinea savanna of Nigeria. The vines of eight parental materials were obtained from National Root Crop Research Institute (NRCRI), Umudike, Abia State, ten hybrids were obtained from the germplasm of the University of Ibadan, while two local varieties were obtained from Offa, Kwara State.

Field Experimentation

The trials were established on 3rd May 2012, 20th July 2013, and 30th July 2014. The trials were laid out each cropping year in a randomized complete block design (RCBD) with three replications, with a spacing of 1m between the rows and 0.3m between plants within the rows to provide a uniform plant population of about 33,333 plants ha^{-1}. Each plot was three rows and the outer rows were used for destructive sampling, while observations were taken from the one in the middle row. No herbicides, fertilizers, or pesticides were applied. Weeding was carried out twice; at 3 and 6 weeks after planting (WAP) using traditional hoes.

Data Collection

Harvesting was done three and a half months after planting on the whole plot. Data related to root yield and yield characteristics were obtained at harvest, these included root weight per plant, root yield and number of roots per plant were recorded.

Proximate Analysis

The laboratory studies involved the determination of the approximate composition of parents, hybrids and the local sweet potato genotypes. One large, one medium and one small storage root were randomly selected for determination of beta-carotene, iron, calcium, copper and zinc content. Storage roots selected were 3 cm or more in diameter and without cracks, insect damage or rotten parts (Dobson *et al*., 2004). The storage roots were washed, peeled and cut into four equal parts longitudinally. Two opposite quarters of the peeled storage roots were selected, sliced into pieces, and a 50g fresh sample was weighed into a polythene envelope, and this was taken to Redeemer University, Osun State, for laboratory analysis

Statistical Analyses

Data collected from the field experiments and laboratory samples were statistically analyzed using the PROC GLM model of SAS (SAS Institute, 2009) to compute mean squares for each parameter. Analysis of variance (ANOVA) on an individual year basis was first computed before combined ANOVA across years and pertinent means were separated by the use of least significant difference (Steel and Torrie, 1980). Genotypic correlation coefficients were estimated from the mean square and mean across products using Mode and Robinson's (1959) procedure.

RESULTS AND DISCUSSION

Proximate analysis of the sweet potato genotypes and the local checks varied significantly from one another with respect to β-carotene content, iron content, zinc content and storage yield (Table 1). This probably suggests that high variability exists in sweet potato genotypes with respect to these biochemical parameters. provitamin A and other micronutrients were very high among the hybrids followed by parents, and the controls, in that order (Table 1). Afolabi *et al*. (2020) reported a 1.01 (mg/100g fresh root) beta carotene content advantage over the normal sweet potato varieties. Hybrid SPU14 generally yielded the highest values of beta carotene, and other micronutrients compared with other genotypes. Mbusa *et al*. (2018) reported that while provitamin A content in OFSP is slightly improved, their beta carotene content improved compared to the normal sweet potato. Afolabi *et al.* (2022) observed that on the relative tuber yield basis, the OFSP hybrids have almost doubled their beta-carotene content. Among the hybrids, beta carotene ranged from 0.54 mg/100g fresh root (SPU26) to 1.01 mg/100g fresh root SPU14, while in parents, it ranged between 0.42 mg/100g fresh root (Blesbok) and 0.57 mg/100g fresh root. This was comparable to that of iron with a range of 1.7 mg/100g fresh root (SPU17) to 2.4 mg/100g fresh root (SPU14), 1.2 mg/100g fresh root (blesbok) to 1.9 mg/100g fresh root (ex-oyunga) and 1.15 mg/100g fresh root (Offa 1) to 1.24 mg/100g fresh root (ex-igbariam) in the hybrids and parents respectively. The percentage iron content of the two local checks, Offa 1 (1.15) and Ex-igbariam (1.24 mg/100g fresh root) were the lowest compared to the other genotypes. Hybrid SPU14 had a yield advantage of 55% for zinc content over SPU02. Similarly, SPU21 had the highest amount of crude protein (3.3 mg/100g fresh root) with crude protein content advantages of 2.76 mg/100g fresh root, and 2.24 mg/100g fresh root over the best parents and checks respectively. Also, the percentage zinc content of the two local checks, Offa 1 (0.15) and Ex-igbariam (0.24 mg/100g fresh root) were the lowest compared to the other genotypes especially hybrid 2PU14 (0.91 mg/100g), and parent Excel (0.47 mg/100g) (Table 1).

Root Yield and Related Attributes

The means for the interactive effect of genotype by year (G x Y) was significant for root yield among the sweet potato genotypes and the standard checks (Table 2). The eight parent materials, ten hybrids and two local checks had the lowest root yield in the year 2012 compared with 2013 and 2014. Generally, the range of root yield of hybrids is consistently higher (20.9t/ha, SPU27 to 14.15t/ha, SPU21) than the parent (13.5t/ha Blesbok to 11.45t/ha ex-oyunga) while local check gave the least range of root yield (9.72t/ha ex-igbariam to 8.9t/ha Offa 1)

In this study, the hybrids were superior for root yield followed by parents and local varieties irrespective of the cropping years. Hybrids SPU02 and SPU21 had the highest root yield of 60.23 t ha^{-1} and 59.72 t ha^{-1} with yield advantages of 48 and 53% over the best parents and checks respectively. The two local checks (Ex-igbariam and Offa 1) demonstrated the stability of performance for root yield increase with ex-igbariam significantly yielding more than Offa 1 in the three years. Likewise, all the hybrid and parent sweet potato genotypes had stable root yields throughout the experimental periods. Gasura *et al*. (2010) and Ma *et al*. (2009) reported that the hybrids had better yield potential than the local checks. The authors, therefore, suggested that hybrids should be released to farmers for adoption not only for higher beta-carotene but also for superior micronutrient contents. The differences in performance among the genotypes for this character indicate variability, which could be heritable and this can be useful in the selection during breeding programs. Similar results were reported by Mwanga *et al.* (2007) and Thiyagu *et al.* (2012) who evaluated and identified high-yielding sweet potato varieties among different genotypes tested. The hybrids ranked best for root yield in this study followed by parents and standard checks. It was observed that most of the hybrids and some parents out-yielded the local varieties. The local varieties as the poorest yields may be due to the genetic composition of the genotypes. It has also been reported by many breeders of various crops that hybrids produced better and higher yields than local varieties (Jansky, 2009; Mwanga *et al*., 2010; Li *et al*. 2013; Manivannan *et al.,* 2017; Amudha and Ariharasutharsan, 2020). The highest root yield of 60.23 t/ha was recorded for SPU02 among the hybrids, 31.32 t/ha Resisto in the parents and ex-igbariam among the checks. The genotypes also differed significantly for yield component characteristics among all the genotypes with hybrids ranked the highest, while parents on average values and the local checks had the least values (Table 2). The number of roots per plant ranged from 6 to 15 in the hybrids and between 4 and 6 in the parents. The checks, Offa 1 had more roots per plant (9) than some parents and hybrids. Hybrids SPU02 had the highest root weight per plant (1699.6g). The root weight per plant of hybrids ranged between 616.75g and 1699.6g, while parent ranged between 551.0g and 678g while local checks ranged between 1074.55g and 574.5g.

Correlation Coefficients Analysis of Biochemical Parameters

Pearson correlation (r) among various quantitative parameters of the sweet potato genotypes in this trial revealed that beta carotene was highly significantly positively correlated with crude protein ($r = 0.92^{**}$), but correlated negatively with zinc and iron with coefficients of $r = -0.71^{**}$ and -0.61^{**} respectively (Table 3). Ravishanker *et al.* (2013) Shekhar *et al.* (2015) and Su *et al.* (2017) earlier reported the need for improvement in beta carotene by monitoring micronutrients while breeding or selecting orange flesh sweet potato genotypes. Iron content was positive and highly significantly associated with zinc (r= 0.90**) and crude protein ($r= 0.74^{**}$).

Correlation Coefficients Analysis of Tuber Characteristics

Genotypic correlation coefficients between root yield components showed that the number of roots per plant has the most positive correlation (r=0.71**) with fresh root yield. (Table 4). The correlation between fresh root yield and the number of roots per plant was positive and significant (r=0.88**). It seems that increasing the number of root weights per plant will translate to an increase in fresh root yield. This confirmed the findings of Gendy and Mohmed (2014) who also reported that an increase in the number of roots per plant will result in an increase in fresh root yield.

Zn had significant negative correlations with fresh root yield (r=-0.72), root weight per plant (r=-0.85) and a positive significant correlation with Fe (Table 4). This signifies that the higher the root yield, the lower the content of Zn and the higher the Fe content, the higher the Zn content. Fe content had a significant correlation with only the number of roots per plant. Beta-carotene was significantly correlated with all root parameters while crude protein had significant positive correlations with a number of roots (r=0.83**), beta-carotene (r=0.75**), Fe (r=0.68**) and Zn (r=0.72**) (Table 4). This implies that these traits with significant positive correlations could be simultaneously improved.

Path Analysis of Tuber Characteristics

Since the significance of simple correlation among yield parameters cannot give enough reasons for cause/effect phenomena, path coefficient analysis for the determination of direct and indirect effects is essential (Gasura *et al.*, 2010). This is because the characteristics that are interrelated do not express in isolation, but are linked and connected to other yield attributes. The path coefficient analysis not only specifies the effective measure of direct and indirect causes of association but also depicts the relative importance of each factor involved in contributing to the final quality of yield. In the present study, the weight of root yield per plant has a maximum positive direct effect on root yield (12.52) followed by the number of tubers per plant (4.37) (Table 5). The positive and highly significant direct effects of quality traits on root yield were reported by other workers (Roulf, 2002; Tairo *et al.*, 2008; Veasey *et al.*, 2008).

CONCLUSION

Sweet potato genotypes evaluated in this study were generally of considerable beta carotene, zinc, iron and crude protein contents. The sweet potato hybrids seemed superior for the micronutrients followed by parents and with the local checks being most inferior for root yield. The best sweet potato hybrids for root yield (SPU02) had a percentage micronutrient advantage of 41% compared with the local checks. Similarly, these hybrids yielded more than other genotypes with a yield advantage of 15 and 27% over the best parents, and local checks respectively. Most of the sweet potato hybrids and parents evaluated have superior performance for root yield compared with local varieties. The sweet potato hybrids that combined high yield performance and micronutrients (especially hybrids SPU02 and SPU21) could be evaluated in different ecologies to identify those that could be released to farmers in each environment.

Table 1: Yield performance of the 20 sweet potatoes evaluated in Landmark University, Omu-Aran. Nigeria, in the 2012 to 2014 cropping seasons

Genotype	**Type of genetic material**	**Fresh root yield (t/ha)**		
		2012	**2013**	**2014**
SPU01	Hybrid	39.80	40.20	43.20
SPU02	Hybrid	56.55	58.55	60.23
SPU13	Hybrid	28.20	30.20	31.20
SPU14	Hybrid	39.05	40.73	42.52
SPU15	Hybrid	31.05	34.70	36.52
SPU17	Hybrid	39.70	41.70	42.70
SPU21	Hybrid	55.02	57.02	59.72
SPU22	Hybrid	27.08	30.20	31.20
SPU26	Hybrid	26.08	27.32	28.32
SPU27	Hybrid	22.85	23.83	25.35
Ex-oyunga	Parent	20.46	24.52	25.52
Resisto	Parent	20.91	22.91	31.32
Blsbok	Parent	21.64	25.35	26.35
Excel	Parent	23.93	25.93	26.93
440034	Parent	22.51	26.32	27.35
199062.1	Parent	19.25	21.25	25.51
199024.2	Parent	20.91	23.75	24.75
44141	Parent	18.26	22.75	25.70
Exigbariam	Check	27.38	30.32	28.52
Offa 1	Check	19.05	21.05	23.41
Mean		**28.98**	**31.43**	**33.32**
CV (%)		**48.24**	**50.24**	**51.24**
LSD (0.05)		**1.97**	**3.97**	**4.97**

Table 2: Performance of the eight parental materials, ten hybrids and two local checks of sweet potato for root yield characteristics evaluated in Landmark University, Omu-Aran Nigeria, in 20112 -2014 cropping seasons.

Genotype	Type of genetic material	No. of roots per plant			Root weight per plant (g)		
Year		**2012**	**2013**	**2014**	**2012**	**2013**	**2014**
SPU01	Hybrid	4.00	4.00	6.00	1187.54	1181.54	1190.54
SPU02	Hybrid	4.00	4.00	7.00	1696.60	1698.50	1699.60
SPU13	Hybrid	5.00	6.00	7.00	840.60	842.63	843.60
SPU14	Hybrid	2.00	3.00	5.00	955.20	967.25	958.20
SPU15	Hybrid	13.00	13.00	14.00	1179.82	1181.82	1182.82
SPU17	Hybrid	13.00	14.00	14.00	1170.83	1172.83	1173.83
SPU21	Hybrid	4.00	5.00	6.00	1650.00	1652.00	1653.00
SPU22	Hybrid	12.00	12.00	15.00	839.55	851.59	842.55
SPU26	Hybrid	3.00	4.00	6.00	782.60	784.60	785.60
SPU27	Hybrid	2.00	4.00	6.00	685.60	687.60	688.60
Ex-oyunga	Parent	4.00	5.00	6.00	613.75	615.75	616.75
Resisto	Parent	4.00	5.00	6.00	627.40	629.71	630.40
Blsbok	Parent	2.00	4.00	5.00	649.25	651.25	652.25
Excel	Parent	3.00	4.00	6.00	718.00	720.75	721.00
440034	Parent	2.00	4.00	4.00	675.29	677.73	678.29
199062.1	Parent	3.00	4.00	5.00	577.50	579.50	580.50
199024.2	Parent	4.00	5.00	6.00	627.40	630.40	630.40
44141	Parent	3.00	4.00	6.00	548.00	550.00	551.00
Exigbariam	Check	4.00	6.00	6.00	1071.55	1075.57	1074.55
Offa 1	Check	6.00	8.00	9.00	571.50	5813.35	574.50
Mean		**4.85**	**5.90**	**7.25**	**1633.40**	**1898.22**	**1636.40**
CV (%)		**48.13**	**49.23**	**51.13**	**53.97**	**55.97**	**56.97**
LSD (0.05)		**0.35**	**0.42**	**2.35**	**0.89**	**2.89**	**3.89**

Table 3: Correlation coefficient (r) of provitamin A and two micronutrients of the 20 sweet potato evaluated in Landmark University, Omu-Aran Nigeria

	Beta carotene	Fe	Zn
beta carotene		-	-
Fe	-0.71**		-
Zn	-0.61	0.90**	-
Cp	0.92**	0.74**	-0.72**

Table 4: Genotypic correlation coefficient between root yield and other yield characteristics of the 20 sweet potatoes evaluated in Landmark University, Omu-Aran Nigeria, in 2012-2014 cropping seasons.

	Fresh root yield (t/ha)	Root weight per plant (g)	No. of roots per plant	Beta carotene	Fe	Zn
Fresh tuber yield (t/ha)	-	-	-			
Root weight per plant (g)	0.13	-	-			
No. of root per plant	0. 71**	0.88**	-			
Beta carotene	-0.53	-0.56	0.53			
Fe	-0.15	-0.17	0.75**	0.03		
Zn	-0.72**	-0.85**	0.11	0.08	0.72**	
%Cp	-0.02	-0.32	0.83**	0.75**	0.68**	0.72**

*, ** significant at p<0.05 and 0.01 level of probability respectively

Table 5: Path coefficient showing the direct (values at the diagonal) and indirect (values above and below the diagonal) effects of beta carotene and other micronutrients on tuber yield of 20 sweet potato cultivars evaluated in Landmark University, Omu-Aran, Nigeria, in 2012-2014 cropping seasons

	No. of roots per plant	Root weight per plant (g)	Beta carotene	Fe	Zn	%Cp
No. of roots per plant	4.366	-1.23	0.76	0.17	0.87	0.07
Root weight per plant (g)	-4.63	12.52	0.26	0.08	0.53	0.17
Beta carotene	-0.53	-0.56	10.53	0.53	0.23	0.19
Fe	-0.15	-0.17	0.75	1.03	0.75	0.17
Zn	-0.72	-1.85	0.11	0.08	3.72	0.85
%Cp	-0.02	-0.32	0.83	0.75	0.68	6.72
Genotypic correlation	0.05	0.82	0.532	0.17	0.65	0.07

REFERENCES

Abiodun, A., Olayinka A., and Omotola, A. (2021). Production of complementary food for infants made from sweet potatoes, soybeans, maize and guinea corn. *European Journal of Nutrition & Food Safety*, 59-64. 10.9734/ejnfs/2021/v13i230375

Afolabi M.S., Agbowuro, G.O., Salami, A.E. and Akoroda, M.O. (2020). Combining Ability of Sweet Potato [*Ipomoea Batatas* (L.) Lam] Genotypes for beta carotene and dry matter content in southern Guinea savanna, Nigeria. *Journal of. Agricultural Research and Development*,19: 53-61.

Afolabi, M. S, Abdul Waheed J. A and Akoroda M. O. (2022). Assessment of sweet potato hybrids for forage yield and quality. *Journal of Global Affairs and Sustainable Development Institute*, 1:.147-157

Ahmadizadeh M and Felenji, M (2011). Evaluating diversity among potato cultivars using agro-morphological and yield components in fall cultivation of Jiroft Area. *AmericanEurasian Journal of Agriculture and Environmental Sciences,* 11 (5): 655- 662.

Chandrasekara, A., and Kumar, T.J., (2016). Roots and tuber crops as functional foods: A review on phytochemical constituents and their potential health benefits, *International Journal of Food Science,* 6: 1-16.

Dewey, D. R. and Lu, K. H. (1959) A correlation and path coefficient analysis of components of crested wheatgrass seed production. *Agronomy Journal*, 51:515-518

Dobson G, Griiths D.W., Davies H.V. and McNicol J.W. (2004). Comparison of fatty acid and polar lipid contents of tubers from two potato species, *Solanum tuberosum* and *Solanum* *phureja*. *Journal of Agricultural and Food Chemistry*, 52: 6306-6314

Ezekiel, R., Singh N., Sharma, S., and Kaur, A. (2013). Beneficial phytochemicals in potato – A review. *Food Research International*. 50 (2):487-496

FAOSTAT. (2020). FAOSTAT. Available at http://faostat.fao.org/ site/612/default.aspxancor [accessed 23 June 2022]

Fekadu, G., Hussein, S. and Mark, L., (2018). Combining ability, heterosis and heritability of storage root dry matter, beta-carotene and yield-related traits in Sweet potato. *HortScience* 53: 167-175.

Gasura E, Mashingaidze, A. and Mukasa, S. (2010). Genetic variability for tuber yield, quality, and virus disease complex traits in Uganda sweet potato germplasm. *African Crop Science Journal*, 16: 147-160

Gendy, A. S. and Mohmed, A.G. (2014). Heterosis and yield components of some F_1 hybrids of sweet potato. *Journal of Plant Production*,5 (10):1717 -1728

Ghosh, D., (2016). Process of Fortification of Cow Milk Curd with Beta (ß) Carotene Producing Sweet Potato. *Journal of Nutritional Health and Food Engineering*. 53: 167-175

Hasmawati, H., and Husnaeni H., (2016). Dry matter digestibility and natural organic matter mulberry feed gamal leaves on male goat crossbreed Ettawa. *Chalaza Journal of Animal Husbandry*,2(1):42-46

Hosaka, K., and Sanetomo R., (2020).Broadening genetic diversity of the Japanese potato gene pool. *American Journal of Potato Research*, 2(97):127-142.

Jansky S. (2009) Breeding, genetics, and cultivar development. In: Singh J, Kaur L, editors. *Advances in Potato Chemistry and Technology*. San Diego: Academic Press; 2009. p. 27-62

Kagimbo, F., Shimelis H., and Sibiya J.(2019). Combining ability, gene action and heritability of weevil resistance, storage root yield and yield related-traits in Sweet potato. *Euphytica*.2:215-

Kwarteng, E., Oduro I., Ellis W., and Agbenorhevi J., (2020**).** Rapid assessment of compositional stability in improved sweet potato varieties: relevance in breeding and utilization. *International Journal of Innovative Research and Development*. 7:9-

Li, L., Tacke, E., Hoferbert, H.R., Lübeck, J., Strahwald, J., Drafehn, A.M., and Walkemeier, B., and Gebhardt, C. (2013) Validation of candidate gene markers for marker-assisted selection of potato cultivars with improved tuber quality. *Theoretical and Applied* Genetics, 126: 1039-1052

Ma, D.F. Q, Li; X. Y Li; H. M. Li; Z. H Tang; L. Hu; Q. H. Cao; Y. Y. Xie and X. Wang (2009). Selection of parents for breeding edible varieties of sweet potato with high carotene content. *AgriculturalScience China*, 8: 1166-1173

Mbusa, H., Ngugi K., Olubayo F., Kivuva B., Muthomi J., and Nzuve F., (2018). Agronomic Performance of Kenyan Orange Fleshed Sweet potato Varieties. *Journal of Plant Studies*. 2(7):11.

Mode, C. J. and Robinson, H. F. (1959) Pleiotropism and the genetic variance and covariance. *Biometrics*, 15: 518-537.

Mori, M. (2008). Breeding new potato cultivars to meet processing needs and increase the contents of functional ingredients. *Gamma Field Symposia*. 47: 49-57

Mwanga, Z., Mataa, M. and Msabaha, M. (2007). Quality and yield stability of orange-fleshed sweet potato (*Ipomoea batatas*) varieties grown in different agro-ecologies. *African Crop Science Journal*,8: 339-345

Mwanga, R. Odongo, B. Niringiye, C. Kapinga, R., Tumwegamire, S Abidin, P., Carey, E. Lemaga, B., Nsumba, J. and Zhang, D. (2010). Sweet potato selection releases: Lessons learnt from Uganda. *African Crop Science Journal*15: 11-23.

Peksa, A., Kita, A., Kułakowska, K., Aniołowska, M., Hamouz, K. and Nemś, A. (2013). The quality of protein of coloured flesh potatoes. *Food Chemistry*, 141:2960-2966

Ravishanker, A., Kumar, S., Baranwal, D. K, Chatterjee, A. and Solankey, S S. (2013). Genetic diversity based on cluster and principal component analyses for yield and quality attributes in Ginger (*Zingiber officinale* Roscoe). *International Journal of Plant Breeding and Genetics, 6(6): 444-457*

SAS Institute (2009). SAS STAT 9.2 user's guide, vol 5 SAS Institute, Cary, NC, USA

Shekhar, S., Mishra, D., Buragohain, A. K., Chakraborty, S. and Chakraborty, N., (2015). Comparative analysis of phytochemicals and nutrient availability in two contrasting cultivars of sweet potato (*Ipomoea batatas* L.). *Food Chemistry*, 173: 957–965.

Su, X., Griffin J., Xu J., Ouyang P., Zhao Z., and Wang W. (2017). Identification and quantification of anthocyanins in purple-fleshed sweet potato leaves. *Heliyon*. 6(5): 19-20

Steel, R. G. D. and Trrie, J. H. (1980) Principle and procedures of statistics. A biometrical approach, 2nd Edition, *Mcgraw-Hill Book Company New York*

Tairo F, Mneney E and Kullaya A (2008). Morphological and agronomical characterization of sweet potato [*Ipomoea batatas (*L.) Lam.] germplasm collection from Tanzania. *African Journal of Plant Science*, 2 (8): 77-85.

Thiyagu, D., Rafii, M.Y., Mahmud, T.M.M. and Latif, M. A. (2012). Stability Analysis of Sweet Potato*Food Chemistry*, 170: 900–917.

Veasey, E A, Borges A, Rosa M S, Queiroz Silva J R, Bressan E de A and Peroni N (2008). Genetic diversity in Brazilian sweet potato (Ipomoea batatas (L.) Lam., Solanales Convolvulaceae) landraces assessed with microsatellite markers. *Genetics and Molecular Biology*, 31 (3): 725- 733