

Evaluation of F₁ Population of Elite Sweet Potato (*Ipomoea batatas* (L.) Lam) For Yield and Yield Related Traits in Humid Rainforest of Umudike, Southeastern Nigeria

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ABSTRACT

Sixty-eight sweet potato progenies developed from one common parent (Ligri PC), were evaluated alongside with national and local checks varieties (Umuspo 3 and TIS 87/0087) in a two-year replicated field trial under rainfed conditions to identify superior genotypes with high fresh storage root yield, dry matter, starch and vulnerability to *Cylas puncticollis* at the National Root Crops Research Institute, Umudike, Southeastern Nigeria during the 2015 and 2016 cropping seasons. Yield and yield related data collected at harvest were subjected to analysis of variance, correlation analysis and principal component analysis. During the first-year trial, LPC/13 produced the highest yield of 22.50 tons/ha while LPC/14 produced the highest yield of 22.56 tons/ha in the second-year trial. LPC/45 had the highest starch content, 68.79 mg100g⁻¹. Total storage root yield was highly significant ($P \leq 0.01$) and positively correlated with marketable root number ($r=0.571$), unmarketable root number ($r=0.301$), marketable root weight ($r=0.793$) and unmarketable root weight ($r=0.481$), respectively. Results from this study showed that fourteen (14) genotypes had no observable sweet potato weevil damage, whereas sixteen (16) genotypes had minimal sweet potato weevil damage. Fifteen (15) genotypes recorded moderate damage caused by sweet potato weevil attack. Superior genotypes are recommended to be mass produced for cultivation in the humid rain forest zone of Nigeria and incorporated into sweet potato breeding program for the development of high-yielding and resistant genotypes.

Keywords: *Cylas puncticollis*, dry matter, progenies, storage root yield, sweet potato

INTRODUCTION

Sweet potato (*Ipomoea batatas* (L.) Lam) is a dicotyledonous plant of the *Convolvulaceae* family that originated in Northern South America and the southern part of Central America. It is a cross-pollinated, hexaploidy ($2n=6x$) crop with 90 chromosomes. Sweet potato is an important

stable crop that is grown and consumed in temperate and tropical regions around the world (Thottappilly and Loebenstein, 2009; Afuape *et al.*, 2011). According to FAOSTAT (2012), sweet potato is the world's sixth most important food crop, following wheat, rice, maize, potatoes, barley, and cassava. Sweet potatoes have a high carbohydrate content and a low glycemic index (Burri 2011). Vitamin A, micronutrients (Zn, Fe, Ca, and K), and anti-oxidants are also found in sweet potatoes (Aywa *et al.* 2013; Pradhan *et al.*, 2015). Sweet potatoes are grown on an estimated 9 million hectares with a yield of 13.7 t/ha (FAOSTAT, 2009), with Africa accounting for approximately 15% of global production (Loebenstein, 2009). Sweet potato yields are high per unit of time (Nedunchezhiyan *et al.*, 2012) and per area (Nwankwo *et al.*, 2012). Fresh Sweet potato roots have a low glycemic index due to the slow rate of digestion of its complex carbohydrate and the slower rate of sugar absorption into the bloodstream. Hence, diabetic patients can consume it safely (Willcox *et al.*, 2009). Sweet potato is also suitable for use as a raw material in the food industry due to its starch content (Zhao *et al.* 2015; Trancoso-Reyes *et al.* 2016). Sweet potatoes' starch content accounts for 70% of their dry weight, and a high dry matter content is a desirable trait that is usually taken into account during selection (Mwanga *et al.*, 2007).

In Nigeria, sweet potato production is faced with several constraints including sweet potato weevil infestation caused by *Cylas spp.* Sweet potato weevil (*Cylas puncticollis*) is primarily reported to be a major insect pest damaging sweet potato fresh storage roots in the field. Sweet potato weevil has been reported to cause severe damage to all harvestable parts of the plant, resulting in yield losses of up to 80% (Smit *et al.*, 2001; Rees *et al.*, 2003). Sweet potato weevil could cause a significant decline in quality and lower market value owing to the unappealing terpenoids released by the crop in response to weevil infestation (Stathers *et al.*, 2003). Sweet potato is a highly heterozygous plant, allowing for extensive variability within the species that plant breeders can exploit (Afuape *et al.*, 2011). Identification of superior genotypes with important agronomic traits is critical for breeding purposes considering the nature and extent of variability among sweet potato genotypes. Therefore, the objective of this study was to evaluate sweet potato 68 genotypes obtained through a poly cross system and determine the extent of variation of quantitative and qualitative traits.

MATERIALS AND METHOD

Experimental Site

The experimental site was located at the National Root Crops Research Institute in Umudike, Southeastern Nigeria. This experiment was a two-year replicated trial that was conducted during the 2015 and 2016 cropping seasons.

Umudike is located at latitude 05° 29' N, longitude 07° 33' E, and elevation 122m above sea level. Umudike is located in the humid tropics and has an annual rainfall of approximately 2,177 mm, an average annual temperature of approximately 26 °C, and sandy-loamy ultisol soil (NRCRI, 2012).

Table 1: List of sweet potato progenies evaluated in this study and their sources.

S/No.	Progenies	Sources	S/No.	Progenies	Sources
1.	LPC/1	CIP, Ghana	36.	LPC/36	CIP, Ghana
2.	LPC/2	CIP, Ghana	37.	LPC/37	CIP, Ghana
3.	LPC/3	CIP, Ghana	38.	LPC/38	CIP, Ghana
4.	LPC/4	CIP, Ghana	39.	LPC/39	CIP, Ghana
5.	LPC/5	CIP, Ghana	40.	LPC/40	CIP, Ghana
6.	LPC/6	CIP, Ghana	41.	LPC/41	CIP, Ghana
7.	LPC/7	CIP, Ghana	42.	LPC/42	CIP, Ghana
8.	LPC/8	CIP, Ghana	43.	LPC/43	CIP, Ghana
9.	LPC/9	CIP, Ghana	44.	LPC/44	CIP, Ghana
10.	LPC/10	CIP, Ghana	45.	LPC/45	CIP, Ghana
11.	LPC/11	CIP, Ghana	46.	LPC/46	CIP, Ghana
12.	LPC/12	CIP, Ghana	47.	LPC/47	CIP, Ghana
13.	LPC/13	CIP, Ghana	48.	LPC/48	CIP, Ghana
14.	LPC/14	CIP, Ghana	49.	LPC/49	CIP, Ghana
15.	LPC/15	CIP, Ghana	50.	LPC/50	CIP, Ghana
16.	LPC/16	CIP, Ghana	51.	LPC/51	CIP, Ghana
17.	LPC/17	CIP, Ghana	52.	LPC/52	CIP, Ghana
18.	LPC/18	CIP, Ghana	53.	LPC/53	CIP, Ghana
19.	LPC/19	CIP, Ghana	54.	LPC/54	CIP, Ghana
20.	LPC/20	CIP, Ghana	55.	LPC/55	CIP, Ghana
21.	LPC/21	CIP, Ghana	56.	LPC/56	CIP, Ghana
22.	LPC/22	CIP, Ghana	57.	LPC/57	CIP, Ghana
23.	LPC/23	CIP, Ghana	58.	LPC/58	CIP, Ghana
24.	LPC/24	CIP, Ghana	59.	LPC/59	CIP, Ghana
25.	LPC/25	CIP, Ghana	60.	LPC/60	CIP, Ghana
26.	LPC/26	CIP, Ghana	61.	LPC/61	CIP, Ghana
27.	LPC/27	CIP, Ghana	62.	LPC/62	CIP, Ghana
28.	LPC/28	CIP, Ghana	63.	LPC/63	CIP, Ghana
29.	LPC/29	CIP, Ghana	64.	LPC/64	CIP, Ghana
30.	LPC/30	CIP, Ghana	65.	LPC/65	CIP, Ghana
31.	LPC/31	CIP, Ghana	66.	LPC/66	CIP, Ghana
32.	LPC/32	CIP, Ghana	67.	LPC/67	CIP, Ghana
33.	LPC/33	CIP, Ghana	68.	LPC/68	CIP, Ghana
34.	LPC/34	CIP, Ghana	69.	Umuspo 3	Local check variety
35.	LPC/35	CIP, Ghana	70.	TIS 87/0087	National check variety

Nursery Management

A nursery was established for the propagation of sweet potato seeds. The nursery soil was a 3: 2: 1 mix of topsoil, organic material, and river sand. The nursery was established in the greenhouse of the National Root Crops Research Institute in Umudike, Southeastern, Nigeria. After immersing the seeds in cold water for about twenty-four hours to break dormancy, some of the seeds sprouted and were carefully isolated from the container with cold water and sown separately in well-watered soil in polyethylene bags containing 1 kg of soil.

Cultural Practices

The trial's field was cleared, ploughed, harrowed and divided into 1.5 m² (1 m x 1.5 m) plots. The field was laid out in a complete block randomized design, with two control varieties planted in each block. The planting area was 1m x 0.3 m in size. Five Sweet potato stands were planted per plot, for a total of 33,333 stands per hectare. Planting was done in July, after the rain had become established. Hand weeding was done four weeks, eight weeks, and twelve weeks after planting (WAP). Compound fertiliser (NPK 15:15:15) was applied at a rate of 400 kg/ha 4 WAP using the band placement method. Data were collected at 120 days WAP (Ezulike et al., 2001) for yield and yield-related parameters: number of roots per plot, market and unmarketable roots per plot, marketable (less than 100 g) and unmarketable (greater than 100 g), yield in tons per hectare (Levett, 1993).

Determination of Dry Matter

Two marketable size fresh storage roots per genotype were sliced into small pieces and 100g of each tuber sample was dried in a hot air oven at 80°C for 24 hours until a constant mass was attained. The dry matter content was calculated by weighing the initial and final weights and dividing by the percentage of dried weight. Same procedure was used for all replications used. Dry matter (%) = Dry weight of the tuber / Fresh weight of the tuber x 100

Starch Content Determination

The dry matter content of storage roots was used to calculate starch content. Dry matter was calculated as a percentage of dry weight to fresh weight of the storage roots using a dry weight conversion method. The starch content in sweet potato was converted using the formula described by Wang et al. (1989), $y = 0.86945x - 6.34587$, where y is the starch content and x is the dry matter content.

Scoring of Sweet Potato Weevil Incidence and Severity

The Sweet potato storage root tubers in each plot were harvested, and the percentages of tubers infected by *C. puncticollis* were determined using a five-point scale (1-5), the severity of the damage was then indicated for each accession as follows:

- 1 represents 0% (no evidence) of sweet potato weevil (*C. puncticollis*) damage to sweet potato tubers.
- 2 represents 1%-25% of sweet potato weevil (*C. puncticollis*) damage to sweet potato tubers.
- 3 represents 26%-50% of sweet potato weevil (*C. puncticollis*) damage to sweet potato tubers.
- 4 represents 51%-75% of sweet potato weevil (*C. puncticollis*) damage to sweet potato tubers.
- 5 represents 76%-100% of sweet potato weevil (*C. puncticollis*) damage to sweet potato tubers.

Data Analysis

Harvest data were subjected to Analysis of Variance (ANOVA), and mean separation was performed using the Least Significant Difference (LSD) test at a 5% level of significance. Pearson's correlation analysis was used to determine the relationship between yield and yield-

related components of sweet potato genotypes. All of the studied characters were also subjected to principal component analysis (PCA) (Sneath and Sokal, 1993).

RESULTS AND DISCUSSION

Table 2 shows the analysis of variance of yield and yield-related traits during the first cropping season. The analysis of variance revealed significant ($P \leq 0.05$) differences between genotypes for marketable root weight, unmarketable root weight, yield, dry matter, and starch contents, but no significant differences for marketable root number, unmarketable root number, *Cylas* incidence, and *Cylas* severity (Table 2). There was no significant difference ($P \leq 0.05$) in the number of marketable storage roots during the first cropping season. The total number of marketable roots produced ranged from 1.67 by LPC/30 to 15.44 by LPC/47. The number of unmarketable roots ranged from 0.00 to 6.33, as measured by LPC/8 and LPC/57. During the first cropping season, the marketable root weights of the sweet potato genotypes studied varied significantly ($P \leq 0.05$). LPC/30 and LPC/13 recorded marketable root weights ranging from 0.38 kg to 12.13 kg. Similarly, during the first cropping season, the unmarketable root weights of the sweet potato genotypes studied showed no significant difference ($P \leq 0.05$). LPC/51 and LPC/13 recorded unmarketable root weights ranging from 0.00 kg to 1.73 kg. There was significant difference ($P \leq 0.05$) in the yields of the sweet potato genotypes studied during the first cropping season. LPC/13 produced the highest yield of 22.50 tons/ha, while LPC/30 produced the lowest yield of 2.76 tons/ha. The fresh storage root yield of both checks used in the study Umuspo 3 and TIS 87/0087 were 11.84 t/ha and 10.73 t/ha, respectively (Table 2). Table 2 also revealed that twelve (12) genotypes produced storage root yields greater than 13 tons/ha, which higher than the yield of both checks used in the study. These genotypes include; LPC/13 (22.50 tons/ha), LPC/12 (21.33 tons/ha), LPC/14 (19.83 tons/ha), LPC/15 (17.44 tons/ha), LPC/47 (17.33 tons/ha), LPC/35 (17.33 tons/ha), LPC/11 (15.56 tons/ha), LPC/17 (14.83 tons/ha), LPC/4 (14.44 tons/ha), LPC/48 (14.39 tons/ha), LPC/6 (13.22 tons/ha), and LPC/38 (13.22 tons/ha). Table 2 further revealed that five genotypes produced fresh root yields less than five (5) tons/ha in the first year. LPC/60 (4.89 tons/ha), LPC/8 (4.48 tons/ha), LPC/58 (4.44 tons/ha), LPC/66 (3.84 tons/ha), and LPC/30 (2.76 tons/ha) are among the genotypes. *Cylas* incidence and *Cylas* severity were significantly different ($P \leq 0.05$) as shown in Table 2. During the first year of the trial, *Cylas* incidence ranged from 0.00 to 3.00. LPC/15 and LPC/30 recorded the maximum and minimum number of *Cylas* incidence, respectively. Similarly, during the first year of the trial, the severity of *Cylas* ranged from 0.00 to 3.3. LPC/56 recorded the maximum *Cylas* severity while LPC/30 recorded the minimum *Cylas* severity. Table 2 also revealed that fourteen (14) genotypes had no observable sweet potato weevil damage, while sixteen (16) genotypes had minimal sweet potato weevil damage. Fifteen (15) genotypes recorded moderate damage caused by sweet potato weevil attack. The result presented in Table 2 showed that dry matter and starch contents differ significantly ($P \leq 0.05$). The starch content ranged from 68.79 mg100g⁻¹ to 13.63 mg100⁻¹. LPC/45 had the highest starch content (68.79 mg100g⁻¹) while LPC/25 had the lowest starch content (13.63 mg100⁻¹). Twenty-one (21) genotypes recorded starch content above 50mg100⁻¹, among which are LPC/45 (68.79 mg100⁻¹), LPC/42 (64.57 mg100⁻¹), LPC/44 (63.95 mg100⁻¹), LPC/38 (58.90 mg100⁻¹), LPC/48 (58.61 mg100⁻¹), LPC/43 (57.73 mg100⁻¹) and LPC/31 (56.86 mg100⁻¹). The mean values of the dry matter of the genotypes ranged from 49.90 % to 26.15 %. LPC/36 recorded the highest dry matter (49.90 %) while LPC/25 had the lowest dry matter (26.15 %).

Among the sixty-eight (68) genotypes evaluated, fifty-five (55) had dry matter content above 40%.

Table 3 presents the analysis of variance of yield and yield-related traits during the second cropping season. The analysis of variance revealed significant ($P \leq 0.05$) differences among genotypes for unmarketable root number, marketable root weight, unmarketable root weight, yield, dry matter, and starch contents, but there were no significant differences for marketable root number, *Cylas* incidence, and *Cylas* severity (Table 3). There was no significant difference in number of marketable storage roots among the genotypes during the second cropping season. The total number of marketable roots produced ranged from 2.67 by LPC/67 to 14.78 by LPC/12. However, there was significant difference ($P \leq 0.05$) in the number of unmarketable storage roots. The number of unmarketable roots ranged from 0.00 to 7.67, as measured by LPC/8 and LPC/30. During the second cropping season, the marketable root weights of the sweet potato genotypes studied vary significantly ($P \leq 0.05$). LPC/30 and LPC/13 recorded marketable root weights ranging from 0.57 kg to 12.13 kg. Similarly, during the second cropping season, the unmarketable root weights of the sweet potato genotypes studied differ significantly ($P \leq 0.05$). LPC/30 and LPC/13 recorded unmarketable root weights ranging from 0.00 kg to 1.69 kg. The yields of the sweet potato genotypes studied differed significantly ($P \leq 0.05$) during the second cropping season. LPC/14 produced the highest yield of 22.56 tons/ha, while LPC/27 produced the lowest yield of 4.29 tons/ha. The fresh storage root yield of both checks used in the study Umuspo 3 and TIS 87/0087 were 9.84 t/ha and 10.40 t/ha, respectively (Table 3). Table 3 also revealed that eleven (11) genotypes produced storage root yields greater than 13 tons/ha, which higher than the yield of both checks used in the study. These genotypes include; LPC/14 (22.56 tons/ha), LPC/13 (21.23 tons/ha), LPC/17 (19.79 tons/ha), LPC/12 (17.94 tons/ha), LPC/15 (17.76 tons/ha), LPC/35 (17.33 tons/ha), LPC/47 (14.44 tons/ha), LPC/16 (14.22 tons/ha), LPC/48 (13.94 tons/ha), LPC/35 (13.45 tons/ha) and LPC/34 (13.09 tons/ha). *Cylas* incidence and severity also differed significantly in Table 3. During the second year of the trial, *Cylas* incidence ranged from 0.00 to 3.00. LPC/15 and LPC/30 recorded the maximum and minimum number of *Cylas* incidence, respectively. Similarly, during the second year of the trial, the severity of *Cylas* ranged from 0.00 to 3.3. LPC/56 recorded the maximum *Cylas* severity while LPC/30 recorded the minimum *Cylas* severity. Table 3 also revealed that thirteen (13) genotypes had no observable sweet potato weevil damage, whereas seventeen (17) genotypes had minimal sweet potato weevil damage. Twenty (20) genotypes recorded moderate damage caused by sweet potato weevil attack. The result presented in Table 3 showed that dry matter and starch contents differ significantly ($P \leq 0.05$). The results of this study agree with those of (Islam and Shimu, 2018), who reported a tuberous root yield of 9.0 t/ha at 120 DAP. The total storage root yield range mean values in this study are consistent with the findings of Ulas *et al.* (2021), who reported a range of 2.00t/ha to 16.02t/ha for the storage fresh root yield of sweetpotato genotypes. The fresh storage root yields observed in this study were lower than the yield (ranging from 18 to 30 t/ha) reported by the CSIR-Crops Research Institute (MoFA, 2014). According to Vimala and Hariprakash (2011), varieties, location, climate, pests, diseases, and the breeding system all influence sweetpotato yield and dry matter content variation. Dry matter content is an important trait in sweet potato selection, second only to root yield. The dry matter content has been identified as a root quality indicator. According to Vimala and Haripra-kash, (2011), high dry matter content is an essential objective in sweet potato breeding programs. Dry matter

content is impacted by variety, location, climate, incidence of pests and diseases, cultural practices and soil types. This study observed that twelve (12) genotypes produced storage root yields greater than 13 tons/ha, which was higher than the yield of both checks used in this investigation. These genotypes could be incorporated in multi-locational trials to confirm yield consistency in a diverse of environmental conditions. The dissimilarity in response to sweet potato weevil infestation could be attributed to differences in genetic constitution, environmental conditions, and storage root morphology (Stevenson *et al.*, 2009). In this study, the varied reaction of the sweet potato genotypes to *Cylas* spp. could be attributed to environmental conditions as well as variation in genetic constitution which is responsible for the effect of chemical elements in the storage roots Anyanga *et al.*, 2013). According to Stevenson *et al.* (2009), there is a significant level of hydroxycinnamic acid esters in root latex and caffeic and coumaric acid esters in epidermal and root surface (Anyanga *et al.*, 2013) were chemical elements found in the fresh storage roots of sweet potatoes.

Table 2: Mean values of sweet potato progenies for root yield and nutritional traits for first year trial

Genotypes	MRN	URN	MRW	URW	Yield	Cylas incidence	Cylas severity	Dry matter	Starch
LPC/1	11.71	4.00	4.20	1.27	7.34	0.00	0.00	48.65	31.58
LPC/2	8.00	4.00	3.33	1.17	9.89	0.33	0.67	39.63	35.54
LPC/3	10.67	3.33	5.33	1.60	10.99	0.00	0.00	48.09	33.97
LPC/4	10.33	5.67	6.17	1.47	14.44	1.00	1.00	45.87	23.73
LPC/5	10.67	4.33	5.47	1.20	10.11	0.00	0.00	34.67	19.84
LPC/6	5.78	4.00	5.03	1.70	13.22	1.67	0.67	48.30	21.58
LPC/7	4.67	5.33	2.93	1.63	5.00	1.33	2.00	47.81	24.14
LPC/8	5.53	6.33	3.40	1.37	4.83	0.67	0.67	46.99	24.30
LPC/9	11.11	4.67	5.63	1.50	9.50	0.00	0.00	46.33	24.08
LPC/10	10.33	4.33	6.83	1.20	11.89	0.00	0.00	41.31	21.16
LPC/11	12.70	5.00	7.17	1.00	15.56	1.67	0.67	48.26	26.49
LPC/12	14.11	4.00	9.78	1.60	21.33	0.33	1.00	48.86	28.49
LPC/13	12.00	5.33	12.13	1.73	22.50	0.33	1.00	47.20	26.27
LPC/14	12.67	4.00	11.00	1.17	19.83	0.00	0.00	47.78	29.44
LPC/15	5.00	3.67	6.63	0.67	17.44	3.00	2.33	39.05	22.67
LPC/16	3.67	2.33	1.28	0.13	9.42	0.67	2.00	47.05	21.13
LPC/17	4.33	3.33	2.10	0.13	14.83	2.00	1.67	45.59	21.41
LPC/18	2.67	2.67	1.43	0.13	10.44	0.33	1.00	41.78	20.20
LPC/19	3.33	2.67	1.53	0.10	10.89	0.67	1.67	44.38	20.05
LPC/20	3.00	1.00	1.12	0.03	7.64	0.00	0.00	48.23	26.16
LPC/21	3.67	2.33	1.17	0.09	8.37	0.33	0.67	47.21	21.84
LPC/22	3.33	2.67	1.10	0.06	7.73	0.00	0.00	33.31	16.15
LPC/23	2.67	3.67	0.70	0.15	5.64	1.00	1.00	45.67	25.47
LPC/24	3.00	2.00	1.17	0.03	7.95	0.33	0.67	43.50	25.85
LPC/25	2.67	2.33	0.85	0.02	5.75	0.33	0.67	26.15	13.63
LPC/26	3.33	2.67	1.07	0.06	8.31	2.00	3.33	45.22	22.48
LPC/27	4.00	2.67	0.80	0.05	6.20	0.33	0.67	39.46	19.89
LPC/28	3.00	3.67	1.02	0.13	9.42	3.00	2.67	45.15	42.15

LPC/29	3.00	2.67	0.80	0.07	5.75	0.00	0.00	48.41	51.22
LPC/30	1.67	1.67	0.38	0.03	2.76	0.00	0.00	47.65	53.48
LPC/31	2.67	2.00	1.00	0.03	6.84	0.00	0.00	43.79	56.86
LPC/32	3.33	0.67	0.78	0.03	5.42	1.00	2.00	48.17	51.45
LPC/33	4.33	1.67	1.50	0.13	11.70	2.00	1.67	45.70	43.47
LPC/34	3.67	3.00	1.63	0.20	10.50	1.33	2.00	40.12	44.21
LPC/35	9.78	2.00	3.60	0.84	16.96	0.67	1.67	41.80	54.77
LPC/36	8.84	2.67	2.20	0.47	7.50	0.00	0.00	49.90	49.43
LPC/37	7.67	1.67	2.23	0.76	7.01	0.67	1.33	48.15	50.49
LPC/38	11.00	2.33	4.40	0.90	13.22	0.33	0.67	42.49	58.90
LPC/39	10.00	4.67	3.37	0.60	10.49	0.33	0.33	48.60	50.85
LPC/40	9.00	2.33	3.23	0.75	7.77	1.33	1.00	47.74	53.82
LPC/41	4.11	3.00	1.83	1.02	6.11	2.00	2.67	46.33	53.26
LPC/42	5.00	4.33	1.60	0.70	7.63	2.33	2.67	39.46	64.57
LPC/43	4.53	3.67	2.03	0.79	5.40	1.00	1.33	44.43	57.73
LPC/44	11.44	2.33	4.27	0.80	11.39	1.00	1.67	38.46	63.95
LPC/45	10.33	3.00	3.47	0.47	8.72	0.33	0.67	35.87	68.79
LPC/46	11.03	3.00	3.63	0.63	9.28	0.00	0.00	43.92	54.78
LPC/47	15.44	2.00	7.47	1.03	17.33	0.33	1.00	42.40	55.48
LPC/48	13.33	4.33	6.13	0.77	14.39	1.33	2.00	39.92	58.61
LPC/49	14.33	2.33	5.87	0.57	13.05	2.00	2.00	48.02	54.07
LPC/50	4.33	1.33	1.07	0.10	7.78	1.00	1.00	47.67	43.71
LPC/51	4.00	0.00	0.87	0.00	5.78	0.33	0.67	40.29	43.03
LPC/52	2.67	0.67	0.70	0.06	5.06	0.67	0.33	47.80	44.18
LPC/53	3.67	1.33	1.13	0.07	8.00	0.67	0.67	46.42	49.41
LPC/54	3.00	3.00	0.72	0.13	5.24	0.33	1.00	33.13	46.40
LPC/55	3.00	1.67	1.08	0.07	7.64	2.00	2.33	41.58	40.41
LPC/56	4.00	1.33	1.20	0.09	8.62	2.33	3.33	48.61	44.33
LPC/57	4.33	0.00	1.07	0.00	7.17	2.00	2.00	47.49	44.27
LPC/58	2.67	0.67	0.60	0.07	4.44	1.00	1.33	45.10	42.84
LPC/59	2.67	1.33	0.73	0.07	5.33	1.33	2.67	47.82	45.07
LPC/60	3.00	1.33	0.60	0.13	4.89	0.33	0.33	46.71	50.06
LPC/61	3.00	1.33	1.13	0.07	8.00	1.00	2.33	45.94	50.02
LPC/62	3.33	1.33	1.22	0.03	8.31	0.67	1.00	43.48	49.28
LPC/63	3.33	1.33	1.03	0.03	7.09	0.67	0.33	45.77	54.11
LPC/64	3.00	2.33	0.73	0.09	5.49	1.00	1.33	36.72	49.03
LPC/65	3.33	1.67	0.93	0.06	6.64	1.33	2.67	42.46	44.83
LPC/66	2.33	1.00	0.47	0.11	3.84	0.67	0.67	46.07	46.82
LPC/67	3.00	1.33	1.10	0.07	7.78	1.33	3.00	41.87	44.72
LPC/68	4.00	2.67	1.20	0.17	9.22	1.33	1.33	39.14	41.47
Umuspo 3	4.00	1.00	1.60	0.00	11.84	2.00	1.00	43.75	25.36
TIS 87/0087	10.44	1.33	3.27	0.80	10.73	0.00	0.00	40.49	23.73
Total	6.14	2.65	2.78	0.50	9.35	0.88	1.14	44.02	39.47
LSD ($P \leq 0.05$)	NS	NS	5.06	1.09	7.90	NS	NS	7.51	16.97

MRN = Marketable root number, URN = Unmarketable root number, MRW = Marketable root weight, URW = Unmarketable root weight

Table 3: Mean values of sweet potato progenies for root yield and nutritional traits for second year trial

Genotypes	MRN	URN	MRW	URW	Yield	Cylas incidence	Cylas severity	Dry matter	Starch
LPC/1	8.84	3.00	2.13	0.52	7.37	0.00	0.00	48.65	31.58
LPC/2	7.33	4.00	3.27	1.15	6.22	0.33	0.67	39.63	35.54
LPC/3	10.67	3.00	5.37	1.57	10.96	0.00	0.00	48.09	33.97
LPC/4	9.67	6.00	6.03	1.43	12.11	1.00	1.00	45.87	23.73
LPC/5	9.33	5.67	5.33	1.23	9.44	0.00	0.00	34.67	19.84
LPC/6	4.78	4.33	4.33	1.63	8.10	1.67	0.67	48.30	21.58
LPC/7	4.00	5.00	2.22	1.56	4.81	1.33	2.00	47.81	24.14
LPC/8	4.87	7.67	2.60	1.39	5.65	0.67	0.67	46.99	24.30
LPC/9	11.11	5.67	5.43	1.53	10.59	0.00	0.00	46.33	24.08
LPC/10	10.00	5.00	6.63	1.15	11.98	0.00	0.00	41.31	21.16
LPC/11	11.70	5.33	6.37	1.03	12.67	1.67	0.67	48.26	26.49
LPC/12	14.78	4.00	9.87	1.60	17.94	0.33	1.00	48.86	28.49
LPC/13	12.00	4.33	12.13	1.69	21.23	0.33	1.00	47.20	26.27
LPC/14	13.67	4.67	11.40	1.20	22.56	0.00	0.00	47.78	29.44
LPC/15	4.67	4.33	6.53	0.67	17.76	3.00	2.33	39.05	22.67
LPC/16	4.67	2.67	1.93	0.20	14.22	0.67	2.00	47.05	21.13
LPC/17	4.67	3.00	2.77	0.20	19.79	2.00	1.67	45.59	21.41
LPC/18	4.00	1.67	2.40	0.10	16.68	0.33	1.00	41.78	20.20
LPC/19	3.67	1.00	1.87	0.07	12.90	0.67	1.67	44.38	20.05
LPC/20	3.33	0.67	1.30	0.07	9.11	0.00	0.00	48.23	26.16
LPC/21	4.00	0.67	1.40	0.07	9.77	0.33	0.67	47.21	21.84
LPC/22	4.00	1.67	1.40	0.03	9.53	0.00	0.00	33.31	16.15
LPC/23	3.00	3.00	0.73	0.17	5.99	1.00	1.00	45.67	25.47
LPC/24	3.33	2.00	1.27	0.07	8.86	0.33	0.67	43.50	25.85
LPC/25	3.33	2.00	1.32	0.00	8.75	0.33	0.67	26.15	13.63
LPC/26	3.33	2.67	0.93	0.06	6.64	2.00	3.33	45.22	22.48
LPC/27	3.67	2.67	0.57	0.08	4.29	0.33	0.67	39.46	19.89
LPC/28	2.67	3.67	0.82	0.12	6.18	3.00	2.67	45.15	42.15
LPC/29	4.00	1.33	1.22	0.03	8.29	0.00	0.00	48.41	51.22
LPC/30	2.67	0.00	0.78	0.00	5.20	0.00	0.00	47.65	53.48
LPC/31	2.67	1.00	1.00	0.00	6.64	0.00	0.00	43.79	56.86
LPC/32	3.67	1.67	1.28	0.03	8.73	1.00	2.00	48.17	51.45
LPC/33	4.67	1.33	1.85	0.10	12.95	2.00	1.67	45.70	43.47
LPC/34	4.33	2.33	1.80	0.17	13.09	1.33	2.00	40.12	44.21
LPC/35	10.11	2.67	3.60	0.87	13.45	0.67	1.67	41.80	54.77
LPC/36	8.84	3.67	2.53	0.47	9.70	0.00	0.00	49.90	49.43
LPC/37	8.33	2.33	2.57	0.73	9.05	0.67	1.33	48.15	50.49
LPC/38	10.33	2.67	4.00	0.90	10.53	0.33	0.67	42.49	58.90
LPC/39	9.33	4.33	3.13	0.55	8.98	0.33	0.33	48.60	50.85
LPC/40	9.67	2.00	3.55	0.70	9.53	1.33	1.00	47.74	53.82
LPC/41	4.44	3.33	1.93	1.03	6.89	2.00	2.67	46.33	53.26

LPC/42	5.00	4.00	1.53	0.69	7.34	2.33	2.67	39.46	64.57
LPC/43	5.20	3.33	2.30	0.77	7.06	1.00	1.33	44.43	57.73
LPC/44	10.78	1.67	3.97	0.77	9.16	1.00	1.67	38.46	63.95
LPC/45	10.00	3.00	3.33	0.43	7.61	0.33	0.67	35.87	68.79
LPC/46	10.37	3.33	3.27	0.67	7.05	0.00	0.00	43.92	54.78
LPC/47	14.78	2.00	7.03	1.03	14.44	0.33	1.00	42.40	55.48
LPC/48	13.33	4.00	6.07	0.77	13.94	1.33	2.00	39.92	58.61
LPC/49	14.00	2.00	5.87	0.53	12.83	2.00	2.00	48.02	54.07
LPC/50	4.33	1.33	1.07	0.10	7.78	1.00	1.00	47.67	43.71
LPC/51	4.00	0.00	0.87	0.00	5.78	0.33	0.67	40.29	43.03
LPC/52	3.00	0.33	0.97	0.03	6.62	0.67	0.33	47.80	44.18
LPC/53	4.00	1.33	1.43	0.07	10.00	0.67	0.67	46.42	49.41
LPC/54	3.00	3.33	0.92	0.13	6.57	0.33	1.00	33.13	46.40
LPC/55	2.67	2.00	0.90	0.06	6.40	2.00	2.33	41.58	40.41
LPC/56	3.67	2.33	1.07	0.13	7.95	2.33	3.33	48.61	44.33
LPC/57	4.33	0.33	0.97	0.03	6.69	2.00	2.00	47.49	44.27
LPC/58	3.00	0.33	0.90	0.03	6.28	1.00	1.33	45.10	42.84
LPC/59	2.67	0.67	0.73	0.03	5.11	1.33	2.67	47.82	45.07
LPC/60	2.67	1.67	0.70	0.13	5.55	0.33	0.33	46.71	50.06
LPC/61	3.00	1.33	1.10	0.10	8.00	1.00	2.33	45.94	50.02
LPC/62	3.33	0.00	1.25	0.00	8.31	0.67	1.00	43.48	49.28
LPC/63	4.33	0.00	1.45	0.00	9.62	0.67	0.33	45.77	54.11
LPC/64	3.67	2.00	0.90	0.06	6.35	1.00	1.33	36.72	49.03
LPC/65	3.00	3.33	0.87	0.09	6.35	1.33	2.67	42.46	44.83
LPC/66	2.67	1.67	0.57	0.11	4.53	0.67	0.67	46.07	46.82
LPC/67	2.67	1.00	0.90	0.08	6.55	1.33	3.00	41.87	44.72
LPC/68	3.33	1.67	1.07	0.10	7.77	1.33	1.33	39.14	41.47
Umuspo 3	3.67	1.67	1.45	0.03	9.84	2.00	1.00	43.75	25.36
TIS 87/0087	10.11	1.33	3.22	0.80	10.40	0.00	0.00	40.49	23.73
Total	6.12	2.56	2.78	0.49	9.53	0.88	1.14	44.02	39.47
LSD ($P \leq 0.05$)	NS	3.26	5.14	1.10	7.75	NS	NS	7.15	16.97

MRN = Marketable root number, URN = Unmarketable root number, MRW = Marketable root weight, URW = Unmarketable root weight

Pearson Correlation Coefficients (γ) for Yield Parameters of 68 Sweet Potato Progenies

The Pearson correlation coefficients (γ) for the storage root parameters for 68 genotypes were shown in Table 4. Results presented in table 4 indicated that total storage root yield was highly significant ($P < 0.01$) and positively correlated with marketable root number ($r = 0.571$), unmarketable root number ($r = 0.301$), marketable root weight ($r = 0.793$) and unmarketable root weight ($r = 0.4812$), respectively. Storage root yield had a negative relationship with both dry matter and starch ($r = -0.009$ and -0.102 , respectively). *Cylas* incidence ($r = 0.175$) had a significant ($P < 0.05$) and positive relationship with storage root yield, whereas *Cylas* severity had a positive relationship with storage root yield ($r = 0.131$). Correlation studies help breeders understand the mutual component characteristics on which to base selection for genetic improvement. Ulasi *et al.* (2021) found a significant and positive relationship between total storage root yield and marketable storage root number and marketable fresh storage root

weight, which is consistent with the findings of this study. Also, the findings of Yohannes *et al.* (2010) which indicated that the total marketable number of roots, as well as the total unmarketable number of roots, had a positive correlation with total storage root yield is in agreement with the result from this study. Tesfaye (2007) discovered a link between total storage root yield and marketable storage root yield. According to Islam *et al.* (2002), traits with negative correlation coefficients could not be improved with total storage root yield in a positive direction.

Table 4: Pearson correlation coefficients (y) for the storage root parameters of 68 sweet potato progenies

	MRN	URN	MRW	URW	Yield	Cylas incidence	Cylas severity	Dry matter	Starch
MRN									
URN	0.415**								
MRW	0.769**	0.507**							
URW	0.662**	0.649**	0.805**						
Yield	0.571**	0.301**	0.793**	0.481**					
Cylas incidence	-0.040	0.138*	-0.011	0.013	0.175*				
Cylas severity	-0.062	0.129	0.001	0.031	0.131	0.770**			
Dry matter	0.005	-0.114	-0.021	-0.003	-0.009	0.065	0.020		
Starch	0.020	-0.171*	-0.109	-0.126	-0.102	0.099	0.141*	-0.024	
**. Correlation is significant at the 0.01 level (2-tailed).									
*. Correlation is significant at the 0.05 level (2-tailed).									

MRN = Marketable root number, URN = Unmarketable root number, MRW = Marketable root weight, URW = Unmarketable root weight

Principal Component Analysis of 68 Sweet Potato Progenies.

The principal component (PC) analysis had four main principal component axes with eigenvalues up to 1.0, resulting in a cumulative variance of 81.64% (Table 5). Principal component one (PC1) contributed 38.32% of total variability with an eigenvalue of 3.49, while PC2 contributed 20.46% of total variability with an eigenvalue of 1.84. Principal component one (PC3) contributed 11.48% of total variability with an eigen value of 1.03, while PC4 contributed 211.36% of total variability among the 68 sweet potato genotypes with an eigen value of 1.02. Table 5 showed that in PC1, the traits that accounted for most of the 38.32% observed variability among the 68 genotypes were number of marketable roots (0.824), unmarketable storage root number (0.685), weight of marketable roots (0.945), weight of unmarketable roots (0.876), and yield (0.773). In PC2, the traits that accounted for most of the 20.46% observed variability among the 68 genotypes were *Cylas* incidence (0.926 vector loading) and *Cylas* severity (0.928). In PC3, the traits that accounted for the majority of the 11.48% observed variability among the 68 genotypes included dry matter with a vector loading of 0.82. Starch with a vector loading of 0.85 was the trait that accounted for most of the 11.36% observed variability among the 68 genotypes in PC4. According to Afuape *et al.* (2011), PCA is a technique for determining which plant traits are most responsible for the observed variation within a collection of genotypes. In this study, four main principal components identified accounted for 81.64% of the cumulative variance, which is consistent with findings of Ulasi *et al.* (2021), who reported a cumulative variance of 73.10% for the three axes in the evaluation

of thirty-six sweet potato genotypes. According to the findings of Koussao *et al.* (2014), four main principal components (PC) were identified, accounting for 67.22% of the total variation between accessions. Placide *et al.* (2015) used PCA to investigate the variability of 54 sweet potato genotypes and discovered a cumulative variance of 77.83% from the first seven major component axes.

Table 5: Principal component analysis of 68 sweet potato progenies.

	Component			
	1	2	3	4
MRN	0.824	-0.143	0.189	0.212
URN	0.685	0.083	-0.365	-0.163
MRW	0.945	-0.098	0.099	0.066
URW	0.876	-0.073	-0.036	-0.035
Yield	0.773	0.103	0.156	0.040
Cylas incidence	0.102	0.926	-0.031	-0.107
Cylas severity	0.091	0.928	-0.072	-0.042
Dry matter	-0.037	0.076	0.852	-0.452
Starch	-0.151	0.254	0.311	0.853
Total	3.449	1.842	1.033	1.023
% Of Variance	38.328	20.469	11.481	11.366
Cumulative %	38.328	58.796	70.277	81.643

MRN = Marketable root number, URN = Unmarketable root number, MRW = Marketable root weight, URW = Unmarketable root weight

CONCLUSION

The results from this study indicated that most of the yield and yield contributing traits; marketable root weight, unmarketable root weight, yield, dry matter, and starch contents during both cropping seasons differed significantly ($P < 0.05$) among the F_1 progenies of the sweet potato genotypes. Also, this study revealed that marketable root number, unmarketable root number, *Cylas* incidence and *Cylas* severity did not vary significantly. During the first-year trial, LPC/13 produced the highest yield of 22.50 tons/ha while LPC/14 produced the highest yield of 22.56 tons/ha in the second-year trial. In the first-year trial, twelve (12) genotypes produced storage root yields greater than 13 tons/ha, which higher than the yield of both checks used in the study, while in the second-year trial, revealed that eleven (11) genotypes produced storage root yields greater than 13 tons/ha, which higher than the yield of both checks used in the study. Based on these results, the storage root yields of the sweet potato genotypes were consistent in both years. Results from this study showed that fourteen (14) genotypes had no observable sweet potato weevil damage, whereas sixteen (16) genotypes had minimal sweet potato weevil damage. Fifteen (15) genotypes recorded moderate damage caused by sweet potato weevil attack. LPC/45 had the highest starch content, $68.79 \text{ mg}100\text{g}^{-1}$ and twenty-one (21) genotypes recorded starch content above $50\text{mg}100^{-1}$. LPC/36 recorded the highest dry matter (49.90 %). Total storage root yield was highly significant ($P < 0.01$) and positively correlated with marketable root number ($r=0.571$), unmarketable root number ($r=0.301$), marketable root weight ($r=0.793$) and unmarketable root weight ($r=0.481$), respectively. This indicated that sweet potato farmers aiming to higher yield should consider number of marketable roots, weight of marketable roots and total storage root yields as

important traits in selection. The agronomic performance of these F₁ progenies indicated that these elite sweet potatoes are suitably adapted to humid rain forest zone of Nigeria. From this study, LPC/13 and LPC/14 which produced the highest yield in both years could be included into the list of high-performing sweet potato genotypes well adapted this environment for mass production. Consequently, these sweet potato genotypes are recommended to be incorporated into sweet potato breeding program for the development of high-yielding and resistant genotypes.

References

- Afuape, S. O., Okocha, P. I., & Njoku, D., (2011). Multivariate assessment of the agro-morphological variability and yield components among sweet potato (*Ipomoea batatas* (L.) Lam) landraces. *African Journal of Plant Science*, 5(2), 123-132.
- Anyanga, M. O., Muyinza, H., Talwana, H., Hall, D.R., Farman, D. I., Ssemakula, G. N., Mwanga, R.O.M., & Stevenson, P.C. (2013). Resistance to the weevils *Cylas puncticollis* and *Cylas brunneus* conferred by sweet potato root surface compounds. *Journal of Agriculture, Food and Chemical*, 61, 8141-8147.
- Aywa, A. K., Nawiri, M. P., & Nyambaka, H. N. (2013). Nutrient variation in colored varieties of *Ipomea batatas* grown in Vihiga County, Western Kenya. *International Food Research Journal*, 20(2).
- Burri B. J. (2011). Evaluating sweet potato as an intervention food to prevent vitamin A deficiency. *Compr Rev Food Sci Food Saf* 10: 118-130.
- FAO (2015). Food and Agriculture Organization of the United Nations-Crop Production Statistics. Available: <http://faostat.fao.org/>.
- FAOSTAT, 2009. Global Production and Consumption of Root and Tuber. In FAO Corporate Document Repository. Report on the Inter-Center Review of Root and Tuber Crops Research in the CGIAR. <http://www.fao.org>. Accessed in June15 2009
- FAOSTAT. 2012. Global Production and Consumption of Root and Root in FAO Corporate Document Repository. Report on the Inter-center Review of Root and Root Crops Research in the CGIAR. <http://www.fao.org>. [October 24, 2016].
- Islam, M. J., Haque, M. Z., Majumder, U. K., Haque, M.M. & Hossain, M. F. (2002). Growth and yield potential of nine selected genotypes of sweet potato. *Pakistan Journal of Biological Sciences* 5(5): 537-538.
- Koussao, S., Gracen, V., Asante, I., Danquah, E. Y., Ouedraogo, J. T., Baptiste, T. J., Jerome, B., & Vianney, T. M (2014). Diversity analysis of sweet potato (*Ipomoea batatas* [L.] Lam) germplasm from Burkina Faso using morphological and simple sequence repeats markers. *African Journal of Biotechnology*, 13(6), 729-742.
- Levett, M. P. (1993). The effects of methods of planting cuttings of sweetpotato (*Ipomoea batatas* (L) Lam) on yield. *Tropical Agriculture (Trinidad)*, 70(2), 110-115.
- Loebenstein G. (2009). Origin, Distribution and Economic Importance. In: Loebenstein G., Thottappilly G. (eds) *The Sweetpotato*. Springer, Dordrecht. https://doi.org/10.1007/978-1-4020-9475-0_21986
- MoFA, (2014). Sweet potato production guide. pp 14.
- Mwanga, R., Yencho, G. & Moyer, J. (2002). Diallel analysis of sweetpotatoes for resistance to sweetpotato virus disease. *Euphytica* 128: 237-248.
- National Root Crops Research Institute (2012). *Annual Report of the National Root Crops Research Institute, Umudike*.

- Nedunchezhiyan, M., Byju, G., & Naskar, S.K. (2007). Sweet potato (*Ipomoea batatas* L.) as an intercrop in a coconut plantation: Growth, yield and quality. *Journal of Root Crops*, 33, 26-29.
- Nwankwo, I. I. M., Bassey, E. E., Afuape, S. O., Njoku, J., Korieoda, D. S., Nwaigwe, G. & Echendu, T. N. C. (2012). Morpo-agronomic characterization and evaluation of in-country sweet potato accessions in south eastern Nigeria. *Journal of Agricultural Science*, 4(11): 281-288.
- Placide, R., Shimelis, H., Laing, M., & Gahakwa, D. (2015). Phenotypic characteriza-tion of sweet potato genotypes grown in east and central Africa. *South Afri-can Journal of Plant Soil*, 32, 77-86
- Pradhan D. M. P., Mukherjee A., George J., Chakrabarti S. K., Vimala B., Naskar S. K., Sahoo B. K. & Samal S. (2015). High starch, beta carotene and anthocyanin rich sweet potato: ascent to future food and nutrition security in coastal and backward areas. *Intl J Trop Agric* 33 (2): 397- 400 (Part I).
- Rees, D., Van Oirschot, Q. E. A., Kapinga, R. E., Mtunda, K., Chilosa, D., Mbilinyi, L. B., Rwiza, E. J., Kilima, M., Kiozya, H., Amour, R., Ndondi, T., Chottah, M., *et al.* (2003). Extending root shelf-life during marketing by cultivar selection. In: Rees, D., Quirien, O., Kapinga, R., editors. Sweet Potato post- harvest assess-ment. *Experiences from East Africa*. London: University of Greenwich.
- Smit, N. E. J. M., Downham, M. C. A., Laboke, P. O., Hall, D. R., & Odongo, B. (2001). Mass- trapping male *Cylas* spp with sex pheromones; a potential IPM com-ponent in sweet potato production in Uganda. *Crop Protection*, 20, 643-651.
- Sneath P. H. A. & Sokal R. P. (1993). *Numerical Taxonomy: The Principles and Practices of Numerical Classification*. W.H. Freeman & Co., San Francisco, USA. 573p.
- Stathers, T.E., Rees, D., Kabi, S., Mbilinyi, L., Smit, N., Kiozya, H., Jeremiah, S., Nyan-go, A., & Jeffries, D. (2003) Sweet potato infestation by *Cylas* spp. in East Africa: I. Cultivar differences in field infestation and the role of plant factors. *International Journal of Pest Management*, 49, 131-140.
- Thottappilly, G. & Loebenstein, G. (2009). Introductory remarks. In The sweet potato. G. Thottappilly and G. Loebenstein (eds). Springer Science+ Business Media B. V. 2009. Springer, New York.
- Trancoso-Reyes A., Ochoa-Martínez L. A., Bello-Pérez L. A., Morales-Castro J., Estévez-Santiago R., Olmedilla-Alonso B. (2016). Effect of pretreatment on physicochemical and structural properties, and the bioaccessibility of β-carotene in sweet potato flour. *Food Chem* 200:199-205.
- Tsegaye E, Dechassa N., & Devakara Sastry E. V. (2007). Genetic variability for yield and other agronomic traits in sweet potato. *J Agron* 6 (1): 94-99.
- Ulası, J. I., Okim, R. S., & Rivers, E. U. (2021). High yield and pest resistant genotypes of sweet potato (*Ipomoea batatas* (L.) Lam.) for cultivation in Umudike, Southeastern, Nigeria. *Archives of Agriculture and Environmental Science*, 6(4), 563-569, <https://dx.doi.org/10.26832/24566632.2021.0604020>
- Vimala, B., & Hariprakash, B. (2011). Variability of morphological characters and dry matter content in the hybrid progenies of sweet potato [*Ipomoea batatas* (L.) Lam.]. *Geneconserve*, 10, 65-86.
- Willcox D. C., Willcox B. J., Todoriki H., Suzuki M. (2009). The Okinawan diet: health implications of a low-calorie, nutrient-dense, antioxidant-rich dietary pattern low in glycemic load. *J. Am. Coll. Nutr.*28(Suppl):500S-516S.
- Yohannes, G., Getachew, B. & Nigussie, D. (2010). Genotypic and phenotypic cor-relations of root yield and other traits of orange-fleshed sweet potatoes [*Ipomoea batatas* (L.) Lam.]. *Journal of the Dry Lands*, 3(2), 208-213.

Harry, G. I., Ulasi, J. I., & Rosemary, K. E. (2023). Field Trail of F1 Population of Elite Sweet Potato (*Ipomoea Batatas* (L.) Lam) For Yield and Yield Related Traits in Humid Rainforest of Umudike, Southeastern Nigeria. *European Journal of Applied Sciences*, Vol - 11(3). 555-568.

Zhao J, Chen Z, Jin Z, Buwalda P, Gruppen H. & Schols H. A. (2015). Effects of granule size of cross-linked and hydroxypropylated sweet potato starches on their physicochemical properties. *J Agric Food Chem* 63 (18): 4646-4654.