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Original Research Article

Evaluation of selected sweet potato landraces for high harvest index and high root yield indices for parental selection

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The experiment was conducted at the National Root Crops Research Institute, Umudike in South eastern Nigeria with the aim to evaluate and select landraces of sweetpotato with high harvest index and high root yield and to conserve them as parents for future usage in crop improvement programme. Each accession was planted in a 3 × 3m plot in a Plot size of 9m^2 and at a planting distance of 1.0m ×0.3m. The Experimental Design was randomized Complete Block Design. Each block contained 10 plots and replicated 3 times. The planting material was 30cm long. Vine cuttings from symptomless mother vines were planted on ridges when the rains have stabilized and the soil moisture was at field capacity. The experimental field was kept weed-free until harvested 120 days after planting. Fertilizer was NPK 15:15:15 using side application. Data were collected on: Total number of roots, Number of large roots and Number of small roots, total storage root weight, large storage root weight and above ground biomass. Data collected were subjected to Analysis of variance and Means separation was done using standard Error of means. Results obtained indicated that Kwara had 0.51 harvest index, Agege and Buttermilk 0.49 harvest index each, ABOM had 0.48 harvest index and ABCHI and Ex- Igbariam had 0.47 harvest index respectively. Their harvest indices although was lower than the Check variety (TIS87/0087) which had 0.53 harvest index, however, it was higher than the grand mean harvest index of 0.46. Accessions with high harvest index are high root yielding varieties. Therefore accessions with harvest index higher than the grand mean harvest index were recommended for inclusion into the sweet potato breeding programme as parents and should be documented, registered and release as variety. This will enable farmers to carry out commercialization and export of the sweetpotato crop and their products.

Key words: Landraces, harvest index, root yield, parents, breeding programme.

INTRODUCTION

Landraces can make significant contribution in varietal development as progenitors in breeding programme or as varieties in the farming system of the people for the farmer preferred traits (Stephan et al., 2015). In sweetpotato growing States in Nigeria, Sweetpotato farmers depend on the landraces for survival. Sweetpotato is an important security food for poor resource farmers. It is planted and harvested piece meal for home consumption and as such is regarded as security crop. The maturity period is between four and five months when compared with cassava, yam and cocoyam which take 8 to 12 months to mature. This short duration trait could be transferred to their progenies for the development of extra-early maturing varieties. Sweetpotato is a food crop that could easily be boiled and eaten in some cases without salt or even eaten with Sauce. It could be fried, boiled even roasted and could be pounded into fufu or grind together with or without cassava and toast into gari. In commercial value addition of sweetpotato, the roots could be used for bread making, biscuits, processed into starch, doughnuts, chinchin and other food products. This makes the crop versatile and important. In sweetpotato growing states, the crop has been used for income generation and for home consumption. The sale of roots and vines for sweetpotato production in the country offers employment for youths and women. The crop could be put into medicinal use for health improvement. The orange fleshed variety of the sweetpotato crop has been used in combating vitamin A deficiency, a disease that cut short the lives of children below the age of five years or led to blindness. The orange fleshed roots are good food for lactating mothers because of the vitamin A which builds up their immunity (WHO, 1996). As a result of the versatility of the crop, many indigenous landraces exists.

It is important to conserve these landraces by including them in the farming menu in order to have better understanding and reliable information about the diversity of landraces of sweetpotato in the country (Nwankwo et al., 2012) Furthermore, due to the constant change in climate and environment, new pests and pathogens emerge and new genes are required by plant breeders for development of new crop variety and improvement of existing ones (Huamán and De la Puente, 1988). Conservation of these landraces can ensure food security, especially to resource- poor farmers who cannot afford the improved crop varieties. Conservation and preservation strategies of these landraces need to be strengthened to avoid genetic erosion of landraces. This can be achieved by including them in the breeding programme. The new genes required for breeding may be found in these landraces. The reason behind selecting sweetpotato landraces is to achieve the global issues of increase food, food quality and nutritious food which are achievable through the process of plant breeding. This offers the ability to select specific genes from these sweetpotato landraces, crossing them and allowing the crops' progenies to perform at a level which yields the desired results. High yielding genotypes can be evaluated using their harvest index. According to Wikipedia (2017), harvest index is used in agriculture to quantify the yield of a crop species versus the total amount of biomass that has been produced by the plant. The commercial yield which is the economic yield can be the grain, the tuber or the fruit. Therefore, harvest index is the ratio of yield to total plant biomass (shoots plus roots). Wikipedia (2017) observed that the potential values for the harvest index of various crop and horticultural species are not the same. The encyclopedia acknowledged that domesticated plants have been subjected to sustained selection pressures on reproductive development by humans and now reflect wide variation from tuber-forming species such as potato, where over 80% of plant biomass is harvested as storage organs, to high-value flower crops such as tulip where blooms might represent only 20% of the final biomass of whole plants. Mid-range are legumes, cereals and other grain crops where human selection for yield has led to a notable increase in harvest index (HI). Wheat, for example increased from between 0.30 and 0.35 to almost 0.55 over a century. Yield improvement in cereals, cotton, peanuts and soybean which is similarly due to substantial increase in HI, emphasizing that the plant partitioning of photoassimilate more to the economic yield rather than generation of whole-plant biomass was responsible for such yield improvement.

With the increasing in human population, the production of food needs to increase with it. It is estimated that a 70% increase in food production is needed by 2050 in order to meet the Declaration of the World Summit on Food Security (Wikipedia 2017). But with the degradation of agricultural land, simply increasing plant population per hectare or increasing more areas under cultivation is no longer a viable option. New varieties of sweetpotato plants that generates an increase in yield per plant without relying on an increase in land area can be developed through plant breeding. This has been achieved through not only the use of fertilizers, but through the use of better crops with high harvest index that have been specifically designed for the area (Wikipedia (2017). It was on this base that this study was initiated to evaluate and select landraces with high harvest index and high root yield and to conserve them as parents for future usage in crop improvement programme.

MATERIAL AND METHODS

The experiment was conducted at the National Root Crops Research Institute, Umudike in South eastern Nigeria. Umudike lies between (latitude 05° 29'N; longitude 07 ° 38'E), at 122m above sea level and located in the humid tropical rainforest zone of West Africa. There are two main seasons, namely the rainy season and the dry season (NRCRI Meteorology station 2013 and 2014). The rainy season starts in April and lasts till October with a pronounced break around August, while the dry season lasts from December through February. Temperature is constantly high with annual daily maximum and minimum of 32°C and 24°C respectively. Land clearing and ridge making were done mechanically. The soil was analyzed.

Accession collection

Sixteen accessions were collected by farmers. Farmers were instructed at the collection sites to write the local name for the accessions or the curators' name. The accessions were established and multiplied in the nursery. The varieties used were Landraces collected within Abia State plus three collected outside Abia State (Kwara from Kwara state, Ex-Igbariam from Anambra State and Buttermilk from Nassarawa State). Abia State is divided

Table 1. Soil Physico-Chemical properties of the soil environment of the sweetpotato accessions

Soil characteristic	
Sand(%)	52.40
Slit	22.80
Texture (%)	sandy clay loam
pH (H_2o)	5.45
Available P (mgkg^{+})	20.40
Total N (%)	0.09
Organic carbon (%)	0.99
Organic matter (%)	1.70
Ca^{2+} (coml. kg^{-1})	3.60
Mg^{2+} (coml. kg^{-1})	1.60
K^{+} (coml. kg^{-1})	0.14
Na^{+} (coml. kg^{-1})	0.209
Exchange acidity(Coml. kg^{-1})	3.52
(%) Base saturation	61.19

into three Agricultural zones Abia North, Abia Central and Abia South. It was in these zones that exploration of these sweetpotato accessions took place. After morphological characterization, duplicate accessions were merged to obtain ten accessions for the evaluation.

Accession evaluation

Field experiments of the accessions were conducted in 2016 and 2017 all in the Eastern experimental field of National Root Crops Research Institute, Umudike under rainfed. The soils at the site of the evaluation were well drained deep ultisoil with a mean annual rainfall of 1500mm and mean sunshine of 4.5 hours per day. The first and second trial of the accessions involved yield evaluation. The national standard Check variety TIS87/0087 was used as reference variety.

Each accession was planted in a 3 × 3m plot in a Plot size of 9m^2 and at a planting distance of 1.0m × 0.3m. The Experimental Design was randomized Complete Block Design. Each block contained 10 plots. Replicated 3 times and separated from each other at a space of 1m. The planting material was 30cm long. Vine cuttings from symptomless terminal portion of mother vines planted on ridges with two thirds of the cuttings stick into the soil at the time the rain had stabilized and the soil moisture was at field capacity.

The experimental field was manually kept weed-free until harvested 120 days after planting. Fertilizer was NPK 15:15:15 using side application. Data were collected based on: Total number of roots, Number of large roots, total storage root weight and large storage root weight. Data on above ground biomass was also collected. Data collected were subjected to Analysis of variance and Means separation was done using standard Error of means (Steel and Torrie., 1981*).* At harvest fresh storage root and above ground biomass yield were measured in kilogram and in tonnes per hectare.

RESULTS AND DISCUSSION

Soil physico-chemical properties of the experimental site: The physico-chemical properties of the soil where the sweetpotato varieties were grown are presented in Table 1.

The results of the soil analysis showed that the soil was sandy loam under the soil textural classification. The pH was 5.45 and 4.7 which indicated that the soil was slightly acidic. The result showed that the total nitrogen content and Organic carbon content of the soil of the experimental site were low. This necessitated the need for the application of nutrients (NPK fertilizer) to enhance the performance of the soil for crop production.

Climatic data: The climatic data for the two years are presented in Tables 2a and 2b.

These results indicated climatic variations for the two years of the study. This variability in the climate may have had considerable influence on the performance of the sweetpotato varieties evaluated during the seasons. For example the mean rainfall for 2016 was 171.8mm and mean sunlight hours was 5.08 while the mean rainfall and sunlight hours for 2017 was 179.93mm and 4.48 hours respectively. All these environmental factors had considerable influence on the roots and above ground biomass performances of the sweetpotato varieties evaluated.

Discernible character variation existed among fresh tuber weight, number of tubers produced per plant and above ground biomass. According to Rangaswarmy (2010), variations in crop yield depends on the plant characters such as the above ground biomass, the climatic factors, soil factors and so on. Part of the observed variation of a trait of a crop is due to environmental conditions and is not heritable. Also, most of the superficial traits of individual crops are not heritable. They are due to environmental effects in the sense that they are not genetically determined. The environmental variations in the two years influenced the performance of the various sweetpotato

Table 2a. The climatic data at the experimental site in 2016

Month	Amount of rainfall (mm)	Number of days	Temperature		Relative humidity %		Sunshine hours
			Max	Min	0900hrs	1500hrs	
January	75.4	2	33.9	22.1	63	46	6.2
February	36.5	3	33.8	23.5	72	50	4.5
March	40.8	8	33.4	24.0	76	62	5.0
April	92.8	9	33.1	24.0	78	65	4.8
May	466.1	16	32.4	23.3	83	69	5.7
June	239.4	14	30.9	22.7	84	78	3.9
July	280.5	18	29.1	22.4	87	73	4.3
August	237.1	15	29.3	22.6	86	75	2.3
September	318	18	29.6	22.9	74	70	2.1
October	184.8	14	31.0	22.9	84	73	4.3
November	99.5	8	31.6	23.2	81	69	4.7
December	90.8	7	31.6	21.6	75	60	6.2
Mean	171.80	11	30.38	22.84	71.33	68	5.08

Table 2b. The climatic data at the experimental site in 2017

Month	Amount of rainfall (mm)	Number of days	Temperature		Relative humidity %		Sunshine hours
			Max	Min	0900hrs	1500hrs	
January	0.0	0	33.4	21.5	72	45	6.4
February	43.7	2	33.9	23.2	76	49	5.2
March	138.8	8	33.2	23.4	80	67	4.4
April	78.7	6	33.2	23.5	79	66	5.5
May	249.2	16	31.9	23.4	81	74	4.9
June	281.8	12	30.5	24.2	81	74	4.9
July	114.9	14	30.0	24.0	86	79	2.8
August	444	20	29.6	23.3	85	79	3.1
September	495.3	22	29.8	22.9	85	79	2.8
October	165.1	12	31.0	23.6	82	71	4.2
November	147.4	11	31.6	23.5	81	66	3.3
December	0.0	0	32.7	21.8	65	47	5.9
Mean	179.93	10.13	31.65	23.34	79.42	65.83	4.48

varieties (Tables 1, 2a and 2b). However, the best yield comes from the variety in a compatible environment. The yield of the sweetpotato crop in terms of number of roots is presented below.

Number of sweetpotato roots

The sweetpotato roots are classified as large roots (> 100g) and small roots (< 100g or 4cm in diameter). Large roots are for commercial purposes although small roots may be sold for specific special purpose such as for animal feed but not considered as important as large roots. The number of roots produced by the sweetpotato varieties is presented in Table 3.

Number of roots

The total number of roots produced by the sweetpotato landraces in 2016 ranged from 46.7 roots per plot (ABRO) to as high as 68.8 roots per plot (Kwara) with mean root number of 55.5 roots per plot. Also, the percentage of large number of sweetpotato roots ranged from 64.2 to as high as 83.7% with grand mean of 70.4% (Table 3). However, the variations in the mean number of roots produced by the sweetpotato varieties were not significant (P>0.05). Also, there were no significant (P>0.05) variation in the mean number of large roots produced by the sweetpotato accessions in the same seasons. Nevertheless, sweetpotato varieties with percentage number of large roots lower than the grand mean percent of 70.4 will not be the ideal for selection for inclusion in the hybridization block since the additional aim was to produce for commercial roots.

In 2017 cropping season, the total root number of the various varieties ranged from 48.4 (TIS87/0087) to 71.7 roots per plot for Kwara variety with grand mean of 53.8 roots per plot, while the commercial roots which is the large roots ranged from 35.7 per plot (TIS87/0087) to 65.2 roots per plot (Kwara) with grand mean of 41.6 roots per plot. The percentage number of large roots ranged from 64.5 (ABOM) to 90.9% (Kwara) with grand mean of 75.9%

Table 3. Total number of roots, mean number of large roots, and mean number of roots per plant and percentage of large roots produced by the sweetpotato varieties in 2016 1nd 2017

	2016			2017				
Accession name	**Total number of roots/plot in 2016**	**Mean number of large roots/plot**	**% number of large roots /plot**	**Total number of roots/plo t in 2017**	**Mean number of large roots/plot**	**% number of large roots/plot**	**Mean number of roots/plot for 2016 and 2017**	**Ranking**
Agege	51.7	35.0	67.7	54.0	41.0	75.9	52.9	6
ABRO	46.7	30.0	64.2	52.2	33.7	64.5	49.5	9
ABOM	62.7	43.3	69.1	55.8	42.0	75.2	59.3	2
ABCHI	57.7	44.0	76.3	47.5	35.6	74.9	52.6	7
ABOE	52.3	36.7	70.2	48.8	37.5	76.8	48.0	10
ABEE	57.7	48.3	83.7	49.6	38.3	77.2	53.7	5
Ex-igbariam	50.7	34.0	67.1	53.5	41.4	77.4	52.1	8
Buttermilk	57.0	35.7	62.6	66.4	55.6	83.7	56.3	3
Kwara	68.8	51.2	74.42	71.7	65.2	90.9	70.3	1
TIS87/0087	62.0	46.7	75.3	48.4	35.7	73.8	55.2	4
Mean	55.5	39.2	70.4	53.8	41.6	75.9	55.0	
Significant .level	Ns	Ns		Ns	Ns			

per plot. Just as it were in 2016, the variations in the mean number of roots produced by the sweetpotato varieties were not significant (P>0.05) and there were no significant (P>0.05) variation in the mean number of large roots produced by the sweetpotato accessions in the same seasons 2017 (Table 3). However, the combined mean total number of roots for both years ranged from 48.0 (ABOE) to 70.3 (Kwara) with grand mean of 55.5 per plot for the two years. Kwara variety gave the highest number of roots per plot (70.3 roots) and was given the rank first followed by ABOM with 59.2 roots per plot and was ranked second, while ABOE with 48.0 roots per plot came tenth (Table 3).

The grand mean number of root across the accessions in 2016 was 55.5 roots per accession while in 2017 there was a reduction to the grand mean number of root yield across the accessions by 53.8 roots per accession which was only 3.06% less than the previous year 2016. The variation in the grand mean number of root yield in both years may be attributed to climatic conditions. This showed that Climatic factors influenced the number of tuberous root produced by the sweetpotato varieties (Tables 2a and 2b). The total amount of rainfall in 2016 was 171.8mm and average sunshine hours for the day was 5.08 hours while in 2017 the amount of rainfall was 179.93 and daily average sunshine hours was 4.48.

Number of roots per plant per variey and per plot is a function of yield and an indication of the performance of a variety (Nwankwo et al*.,* 2012). Number of sweetpotato roots contributed to the fresh root weight of the sweetpotato varieties. The number of roots produced by the sweetpotato varieties influenced the fresh root weight positively or negatively depending on the size of the roots. Results obtained indicated that four of the varieties produced high percentage number of commercial roots more than the Check varieties. High number of storage roots could be an indicator of sink/bulking capacity in sweetpotato. In Sweetpotato, fresh root weight depends on the number and size of storage roots per plant and as observed by Wilson et al. (1989), large root size has high root weight. Sweetpotato varieties with high percentage number of large roots will contribute to high fresh root weight and should be selected as commercial crop. It could also be selected for genetic recombination in transferring the genes for large roots and high number of roots to their progenies (Wilson et al*.,* 1989).

Fresh root weight

The total fresh root weight, large fresh root weight, fresh root weight per plant and above ground fresh weight biomass performances of the varieties are presented in Table 4.

There were variation in the total fresh root weight, large fresh root weight, and above ground fresh weight biomass performances of the varieties however, the differences were not significant (P>0.05) (Table 4). The non significant variations in the sweetpotato fresh root weights for the two seasons was an indication that the sweetpotato landraces might have adapted to the area. The varieties were however, grouped into three classes according to NARO (National Agricultural Research Organization of sweetpotato breeding programme (Mwanga et al., 2002)), High yielding (18.0 - 30t/ha), moderately yielding (11.0 - 17 t/ha) and low yielding (less than 11.0t/ha). Varieties like ABCHI are high yielding ones, produced 18.93t/ha of total fresh root yield and 18.6t/ha of large fresh root yield almost at par with the National check cultivar (TIS87//0087) which produced 19.27t/ha of total fresh

Table 4: Total fresh root weight, large fresh root weight, fresh root weight per plot and above ground fresh weight biomass performances of the varieties

	2016			2017			2016 and 2017	
Accession name	**Total fresh root weight (t/ha)**	**Large Fresh root weight (t/ha)**	**Above ground biomass (t/ha)**	**Total fresh root weight (t/ha)**	**Large Fresh root weight (t/ha)**	**Above ground biomass (t/ha**	**Fresh root weight in kg per plot**	**Fresh root weight t/ha**
Agege	10.4	9.8	11.1	11.93	10.52	9.4	11.17	10.05
ABRO	9.63	8.8	20.2	8.34	7.01	10.4	8.99	8.09
ABOM	13.4	13.1	14.2	10.42	9.44	8.9	11.91	10.72
ABCHI	18.93	18.6	17.8	19.75	17.58	21.0	19.33	17.39
ABOE	12.87	12.5	16.8	13.44	11.95	12.6	13.16	11.84
ABEE	17.60	17.1	27.1	16.57	15.64	13.3	17.09	15.38
Ex-Igbariam	11.93	11.5	10.3	12.95	11.47	14.2	12.44	11.20
Buttermilk	14.89	14.5	12.7	13.68	12.00	14.0	14.29	12.86
Kwara	17.72	16.3	15.2	16.54	15.83	14.2	17.13	15.42
Tis87/0087	19.27	18.6	18.0	16.45	12.60	16.5	17.86	16.07
Mean	14.4	14.18	16.34	14.01	12.40	11.5	14.34	12.90
Sig.level	Ns	Ns	Ns	Ns	Ns			

Ns = not significant

root yield and 18.6t/ha of large fresh root yield. Also, the root yield per plant of the cultivar ABCHI was high, producing 0.63t/ha root weight per plant per hectare very close to the national check which produced 0.64t/ha of total fresh root yield per plant per hectare. Sweetpotato landraces with high root yield should be included in the breeding programme since one of the objectives of breeding programmes is to enhance the fresh root yield potentials of the crop progenies. The least total root yield per plant was 9.63 (ABRO) while the highest total root yield per variety was 19.27t/ha (TIS87/0087) with grand mean of 14.4t/ha. This showed that almost all the varieties of the landraces yielded almost close to average an indication of high yielding ability. Varieties with high number of roots may not have high root weight as result of the size of the roots. Root size of varieties is an indication of fresh matter accumulation as a result of the photosynthetic efficiency which may vary genetically. Nevertheless, superior performing varieties should be selected for inclusion in the breeding programme (Freyre et al., 2004) using the harvest index. Fresh root weight is the amount of fresh matter accumulation which could be used in calculating the harvest index of the crop.

Biomass yield and harvest index

The result of the above ground biomass (t/ha), Mean fresh root weight (t/ha), Total biomass (t/ha) and Harvest index of the sweetpotato varieties in 2016 and 2017 combined are presented in Table 5.

There were high significant (P<0.05) variation in the yield of above ground biomass and this varied from 11.1t/ha (Agege) to 27.1t/ha (ABEE) with grand mean of 16.34t/ha in 2016. In 2017 the above ground biomass ranged from 9.4t/ha (Agege) to 21.0t/ha (ABCHI) with grand mean of 11.5t/ha. The variation in the grand mean might have been considerably influenced by the variation in the climatic factors for the two years (Table 1 and 2). This had affected the fresh root weight of the various sweetpotato varieties. The total sweetpotato above ground biomass ranged from 20.5t/ha for Agege to 36.79t/ha for ABCHI with grand mean of 33.37t/ha (Table 5). The above ground biomass had influence on the harvest index. The above ground biomass partitioned the photosynthate that goes to the sink/roots and to the above ground areas. The amount of photosynthate that goes to the sink is genetically determined. Nevertheless, the harvest index for the various sweetpotato varieties for the two seasons ranged from 0.35 for ABRO to 0.53 for TIS87/0087 with grand mean of 0.46 (Table 5).

The fresh root weight and the above ground biomass were used in the calculation of the harvest index. The Check variety had the highest harvest index of 0.53. This was followed by the variety Kwara with 051, while the least was ABRO with 0.35 harvest index. High yielding varieties in terms of fresh root weight generally have a higher harvest index than low yielding varieties. Harvest index indicated that these varieties have high efficiency in storage root formation relative to their biological yield. Harvest index gives an indication of the relative distribution of photosynthates between the storage root and the rest of the above ground biomass of the plant. High yielding varieties generally have a higher harvest index than low yielding varieties (Kays, 1985). Varieties with high harvest index

Table 5. Above ground biomass (t/ha) , Mean Total Fresh root weight (t/ha) , Total biomass (t/ha) and Harvest index of sweetpotato accessions in 2016 and 2017 combined

Accession name	Above ground biomass (t/ha) 2016	Above ground biomass (t/ha) 2017	Above ground biomass (t/ha) 2016 and 2017	Mean Fresh root weight t/ha 2016 and 2017	Total Biomass	Harvest Index
Agege	11.1	9.4	10.3	10.05	20.5	0.49
ABRO	20.2	10.4	15.3	8.09	23.39	0.35
ABOM	14.2	8.9	11.6	10.72	22.32	0.48
ABCHI	17.8	21.0	19.4	17.39	36.79	0.47
ABOE	16.8	12.6	14.7	11.84	26.54	0.45
ABEE	27.1	13.3	20.2	15.38	35.58	0.43
Ex-Igbariam	10.3	14.2	12.3	11.20	23.50	0.47
Buttermilk	12.7	14.0	13.4	12.86	26.26	0.49
Kwara	15.2	14.2	14.7	15.42	30.12	0.51
Tis87/0087	18.0	16.5	17.3	16.07	33.37	0.53
Mean	16.34	11.5	14.9	12.90	27.80	0.46
Significant level	$P<0.05$	$P<0.05$	$P<0.05$	NS		

should be selected since this will increase the root yield per unit area although Kays (1985) observed that selection of varieties based on both total biomass and fresh root yield depends on crop management and environment.

CONCLUSION

The following varieties were selected based on high harvest index: Kwara with 0.51 harvest index, Agege and Buttermilk had 0.49 harvest index each, ABOM had 0.48 harvest index and ABCHI and Ex- Igbariam had 0.47 harvest index respectively. Their harvest index although is lower than the Check variety TIS87/0087 which had 0.53 harvest index, however their harvest index was higher than the general mean harvest index which was 0.46 (Table 5). These accessions could also, be selected as high yielding and are therefore recommended for inclusion into the sweetpotato breeding programme. These sweetpotato accessions could also be documented registered and release to farmers as variety/varieties. This will enable the farmers to carry out commercialization and export of the crops and their products.

Conflict of interests

The authors declare that they have no conflicting interests.

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