

Original Research Article

Growth and Yield Components of Sweetpotato (*Ipomoea batatas* L.) and their relationships with Root Yield

ABSTRACT

Aims: To assess the extent of the relationships of various growth and yield related characters. To evaluate the direct and indirect contributions of these characters to root yield, a basis of selection for further improvement.

Study design: Field Experiment, in Randomized Complete Block Design.

Place and Duration of Study: Teaching and Research Farm of Bayero University, Kano (11°58'N and 8°25'E) and Agricultural Research Station Farm, Minjibir (12°11'N and 8°32'E) located in the Sudan Savanna of Nigeria between July-October, 2014.

Methodology: Sixteen (16) sweetpotato advanced lines: Centennial, AYT/08/055, TIS8164, TIS87/0087, NRSP/12/097, UMUSPO/2, UMOSPO/1, SOLOMON1, EA/11/022, EA/11/025, EA/11/003, UM/11/015, NRSP/12/095, UM/11/001, UM/11/022, and a local check (Kantayi idda) were evaluated using a randomized complete block design with three replications. Data were collected on number of leaves per plant, vine length, vine weight, number of roots per plant, average root weight and the root yield. Simple and partial correlations between root yield (Y), growth and yield components (X) and within the growth and yield components themselves were worked out.

Results: Root yield was found to be significant ($p<.01$) and positively correlated with number of leaves per plant, number of roots per plant and average root weight. Vine length was negatively correlated to average root weight and root yield, whereas number of roots per plant was positively correlated to the average root weight and root yield. The path analysis also revealed that average root weight registered the highest direct contribution to root yield. The highest indirect effect on root yield also came from the number of roots per plant via the average root weight.

Conclusion: The average root weight's contribution to root yield was much higher than those of vine length and vine weight both directly and indirectly. Thus, emphasis should be given towards increasing the average root weight and number of roots per plant as criteria and basis of selection of sweetpotato for higher root yield.

Keywords: Sweetpotato, Correlation, Path Analyses, Growth, Yield Components, Root Yield.

1. INTRODUCTION

Sweetpotato (*Ipomoea batatas* (L.) Lam) is a member of the morning glory family *Convolvulaceae*, producing edible roots and leaves. The crop originated from Latin America with China being the top producer, growing 85 million ton annually with Uganda being the major producer in the sub-Saharan Africa [1]. The crop has great potential to alleviate hunger, malnutrition and poverty in developing countries, since it is source of food, feed and processed products [2]. Sweetpotato production in Nigeria has increased over the last two

decades from 143,000 tonnes in 1990 to over three million tonnes in 2013 [3]. The crop is presently cultivated in all agro-ecologies of Nigeria. Low resistance to sweetpotato virus disease, susceptibility to sweetpotato weevil, lack of tolerance of some important cultivars to random drought, poor soil fertility are among the production constraints of sweetpotato. Erroneous beliefs tied to its consumption such as male sterility, **impotence, pile and poor marketing mechanism and utilization as well as lack of improved desirable varieties have militated against its consumption in the country** [1]. Developing appropriate genetic and/or crop management strategies towards increasing the yield of any crop require the knowledge of important traits that influence it, and the relationships among those traits. This is because **increasing total yield is easier by improving its components** [4]. This is **because** many economically important traits of plants are **often related to each other** in several ways. **Thus** understanding **of** the nature and magnitude of genetic diversity and interrelationships among sweetpotato genotypes for **these** traits **is** vital to its effective improvement [5]. In a study of some growth attributes and their interrelationships with yield, leaf size and number of **roots** per plant were reported to be closely connected with yield in sweetpotato [6]. **Other authors have also reported findings on relationships among important yield components and yield** [7-10]. However, there were no adequate information on the character associations as well as percentage contributions of the various growth and yield related components to root yield in the study area. Therefore, this study **was** aimed **to** assess the extent of the relationships of the various growth and yield related components, as well as to evaluate **their** direct and indirect contributions to root yield **so as to** form a basis of selection for further improvement.

2. MATERIAL AND METHODS

2.1 Study Areas

Two field trials were conducted in 2014 rainy season at the Teaching and Research Farm of Bayero University, Kano (**BUK** 11°58'N and 8°25'E) and Agricultural Research Station Farm, Minjibir (**MJB** 12°11'N and 8°32'E) between July to October, 2014.

2.2 Soil Sampling and Analysis

Soil samples were collected from the experimental fields at 0-30cm depths prior to planting. **These were bulked and composite samples used to determine their physical and chemical properties** (Table 1). The soils were sandy loam and moderately acidic with low organic matter, **and organic carbon contents, and high available phosphorus.**

Table 1: Physico-chemical properties of soils (0-30cm) at experimental sites.

Character	Values		Methods
	BUK	MJB	
Particle Size (%)			
Sand	72.96	80.76	
Silt	16.00	5.70	
Clay	11.04	6.54	
Textural class	Sandy loam	Sandy loam	
Chemical properties			

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pH (H ₂ O)	5.27	6.10	Glass Electrode pH meter
Organic carbon (gkg ⁻¹)	0.618	0.487	Walkley-Black Method
Total Nitrogen (gkg ⁻¹)	0.28	0.18	Micro Kjeldahl Method
Available P (mg kg ⁻¹) soil	15.90	14.43	Bray 1 Method
Organic matter (gkg ⁻¹)	1.07	0.84	Multiplying Organic Carbon by 1.724
Exchangeable bases (Cmol kg⁻¹)			
Ca ⁺⁺	2.12	0.30	Ammonium Acetate
Mg ⁺⁺	1.01	2.12	Ammonium Acetate
K ⁺	0.61	0.54	Ammonium Acetate
Na ⁺	0.32	0.32	Ammonium Acetate
CEC	4.31	4.11	Ammonium Acetate (pH7) Extraction

BUK – Bayero University, Kano., MJB - Minjibir

2.3 Treatments and Experimental Design

The treatments consisted of sixteen (16) sweetpotato **genotypes**: Centennial, AYT/08/055, TIS8164, TIS87/0087, NRSP/12/097, UMUSPO/2, UMOSPO/1, SOLOMON1, EA/11/022, EA/11/025, EA/11/003, UM/11/015, NRSP/12/095, UM/11/001, UM/11/022, and a local check (Kantayi idda). These were arranged in randomized complete block design and replicated three times.

2.4 Agronomic Practices

Sweetpotato vines of 30cm long bearing at least four nodes were planted on 40cm high erected ridges at 30 x 75 spacing. **Un-established** stands were **replaced** after 7 days of planting. Each plot consisted of 4 rows of 3 meter long with a net plot of 4.5m² (1.5 x 3m). Weeds were controlled manually using hoe at 3 and 6 weeks after planting, while NPK 15 – 15 – 15 was applied at 400kg/ ha as recommended [12]. Vines were cut at the soil surface to facilitate curing at physiological maturity and left for 7 days after which the roots were manually harvested using hoe.

2.5 Data Collection and Analysis

Data were collected on number of leaves per plant, vine length, vine weight, number of roots **per plant, average root weight and root yield**. Simple correlation coefficients between root yield (Y), growth and yield components (X) and within the growth and yield components themselves were worked out using the following equation [13]

$$R_{xy} = SP_{xy} / \sqrt{SSx \cdot SSy}$$

Where Y = Correlation coefficient, SP_{xy} = Sum of products of x and y

SS_x = sum of squares of x SS_y = sum of squares of y

The calculated coefficients were further used to develop the following simultaneous equations in order to partition the correlations into cause and effect relationships by working out the path coefficients (P_i)

$$r_{16} = p_1 + p_2r_{12} + p_3r_{13} + p_4r_{14} + p_5r_{15}$$

$$r_{26} = p_1r_{12} + p_2 + p_3r_{23} + p_4r_{24} + p_5r_{25}$$

$$r_{36} = p_1r_{13} + p_2r_{23} + p_3 + p_4r_{34} + p_5r_{35}$$

$$r_{46} = p_1r_{14} + p_2r_{24} + p_3r_{34} + p_4 + p_5r_{45}$$

$$r_{56} = p_1r_{15} + p_2r_{25} + p_3r_{35} + p_4r_{45} + p_5$$

Comment [E1]: Any appropriate word to replace un-established?

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From the above equations p_1, p_2, p_3, p_4 and p_5 are the path coefficients (direct effects) while $p_1r_{13}, p_1r_{23}, p_1r_{34}, p_1r_{45}, p_2r_{23}, p_2r_{24}, p_2r_{25}, p_3r_{34}, p_3r_{35}$ and p_4r_{45} are the indirect effects while $r_{12}, \dots, r_{56}$ are the correlation coefficients. The individual and combined percentage contributions of any two characters were also computed using the following relation [14]

$$E = (p_i)^2 \times 100, \quad E_{ij} = 2p_i p_j r_{ij} \times 100$$

Where E = Percent individual contribution

E_{ij} = Combined percent contribution of characters i and j

r_{ij} = Coefficient of correlation between i and j

p_i and p_j = Path coefficients of characters i and j

The residual factor (R_x), which represents the unaccounted error by the direct and combined effects **were** calculated by the following relation:

$$R_x = 1 - (p_1r_{16} + p_2r_{26} + p_3r_{36} + p_4r_{46} + p_5r_{56})$$

While the sum of the percent contribution (individual and combined) as well as the residual should add up to 100%.

3. RESULTS AND DISCUSSION

3.1 Simple Correlation

Results of simple correlation between root yield, growth and yield components in sweetpotato is shown in Table 2. Number of leaves per plant, number of roots per plant and the average root weight were significantly ($p < 0.01$) and positively correlated to root yield. Similar results **have been were** reported [15] in which root yield in sweetpotato was positively and significantly ($p < 0.01$?) correlated to root diameter, **average root weight** and number of roots per plant. Close relations between root yield and number of roots per plant were also reported [6]. On the other hand, vine length was negatively correlated to average root weight and root yield, whereas number of roots per plant were positively correlated ($p < 0.01$) to the average root weight and root yield. **This is an indication of the roles of these characters in influencing yield.** Similar observation was reported for improved yield in garlic [16].

3.2 Partial Correlations

The direct, indirect effects **and** the total contributions of some growth and yield components to root yield of sweetpotato are presented in Table 3. The total contribution of the number of leaves per plant was highly significant (0.6210), while its direct contribution was small and negative (-0.0443). Similarly, the indirect contribution of number of leaves via vine length was found to be -0.0006, while those via the vine weight, number of roots per plant and the average root weight were 0.0199, 0.0929 and 0.5531, respectively.

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Table 2: Matrix of simple correlation coefficients showing association among some growth and yield related components to root yield of [sweet potato](#) [sweetpotato](#) [genotypes](#) [varieties](#).

	<u>Character</u>				
	Number of Leaves per Plant	Vine Length	Vine Weight	Number of Roots per Plant	Average Root Weight
Number of Leaves Per Plant	1.00				
Vine Length	-0.058	1.00			
Vine Weight	0.160	0.051	1.00		
Number of Roots Per Plant	0.512**	0.139	0.291*	1.00	
Average Root Weight	0.720**	-0.065	0.153	0.316**	1.00
Root Yield	0.621**	-0.006	0.288	0.439**	0.812**

** $P < .01$

* $P < .05$

Table 3: Direct, Indirect and Total contributions of some growth and yield components to total root yield of [sweetpotato genotypes sweet potato varieties](#).

	Effect Through					
	Number of Leaves per Plant	Vine Length	Vine Weight	Number of Roots Per Plant	Average Root Weight	Total Correlation
Number of Leaves per Plant	<u>-0.0443</u>	-0.0006	0.0199	0.0929	0.5531	0.6210**
Vine Length	0.0026	<u>0.0098</u>	0.0063	0.0252	-0.0499	0.0060
Vine Weight	-0.0071	0.0063	<u>0.1243</u>	0.0528	0.1117	0.2880
Number of Roots Per Plant	-0.0227	0.0014	0.0362	<u>0.1814</u>	0.2428	0.4391**
Average Root Weight	0.0319	-0.0006	0.0190	0.0573	<u>0.7682</u>	0.8120**

Under lined = Direct effect.

192 | ~~Respectively~~ This implied that improvement of any of these characters could result in a
193 | partial decrease in the other character [17].

194 |
195 | The results of the study further indicated that 0.0060 was the total contribution of the vine
196 | length to root yield. Out of this, ~~only~~ 0.0098 was directly contributed by the vine length.
197 | Similarly, 0.0026, 0.0063, 0.0252 and -0.0499 were contributed indirectly via number of
198 | leaves, vine weight, number of roots and average root weight, respectively. The total
199 | contribution of vine weight and root yield was 0.2880. Out of this, only 0.1243 was directly
200 | contributed by the vine weight. The indirect contributions of vine weight via the number of
201 | leaves, vine length, number of roots and average root weight were -0.0071, 0.0063, 0.0528
202 | and 0.1117, respectively. This might be due to the influence of fresh leaf weight on root and
203 | the number of roots per plant [18].

204 |
205 | The total contribution of number of roots per plant and root yield under this study was found
206 | to be 0.4391, out of which 0.1814 was directly contributed by the number of roots per plant.
207 | However, -0.0227, 0.0014, 0.0362 and 0.2428 were contributed indirectly via number of
208 | leaves, vine length, vine weight and average root weight, respectively. Similar results ~~have~~
209 | ~~been were also~~ reported ~~for in which fresh root weight per plant in sweetpotato had a~~
210 | ~~significant and positive phenotypic correlation with number of roots per plant~~ [5].

211 |
212 | The results of the path analysis also indicated 0.8120 as the total contribution of the average
213 | root weight and the root yield. Out of this, 0.7682 was directly contributed by the average
214 | root weight. This indicated average root weight ~~as~~ important in contributing to root yield in
215 | sweetpotato and hence could be given prime importance in selection of trait for yield
216 | improvement [15]. Similarly, the indirect contributions via number of leaves, vine length, vine
217 | weight and number of roots were 0.0319, -0.0006, 0.0190 and 0.0573, respectively. This is
218 | expected because more roots will translate to increased yield, hence this ~~is~~ important in
219 | deciding the root yield ~~in~~ sweetpotato [15].

220 | 221 | 3.3 Percentage Contributions

222 |
223 | When the individual percent contributions of the growth and yield components were
224 | examined, it was noted that the percentage (direct) contribution of number of leaves was
225 | 0.1961 (Table 4). Similarly, the individual percentage (direct) contributions of the vine length,
226 | vine weight, number of roots and average root weight were 0.0096, 1.5442, 3.2907 and
227 | 59.0114, respectively. This re-emphasize the importance of number of roots and the average
228 | root weight in contributing to root yield in sweetpotato [15, 6].

229 |
230 | The combined contributions of number of leaves and vine length to root yield was small
231 | (0.0050). Negative trend was observed for the combined effects of number of leaves and
232 | vine weight, number of leaves and number of roots, as well as number of leaves and
233 | average root weight in which -0.1761, -0.8227 and -4.8991 were contributed, respectively.

234 |
235 | Similarly, the combined contribution of vine length and average root weight was negative (-
236 | 0.0980). However, 0.0124, 0.0495, 1.3119, 2.9210 and 8.8070 were contributed by the
237 | combined effects of vine length and vine weight, vine length and number of roots, vine
238 | weight and number of roots, vine weight and average root weight and number of roots and
239 | average root weight, respectively. These characters were reported as significant in
240 | influencing root yield in sweetpotato [18]. Out of these contributions, 28.8368% could not be
241 | accounted for and were regarded as residuals (Table 4). This could be attributed to the
242 | effect of new environment as reported in cowpea [19]. Similarly, the delayed leaf
243 | senescence observed in some varieties could have been the reason for these large
244 | residuals [20].

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Table 4: Direct, Combined Contributions (%) and Residual Effects of some Growth and Yield Characters to Root Yield of Sweetpotato genotypes Sweet Potato Varieties.

Character	Percentage Contribution	
<u>Direct contributions</u>	<u>$(P_i)^2 \times 100$</u>	
Number of Leaves per Plant	$(P_1)^2$	0.1961
Vine Length	$(P_2)^2$	0.0096
Vine Weight	$(P_3)^2$	1.5442
Number of Roots per Plant	$(P_4)^2$	3.2907
Average Root Weight	$(P_5)^2$	59.0114
<u>Combined contributions</u>	<u>$(2r_{ij}p_i p_j) \times 100$</u>	
Number of Leaves and Vine Length	$(2r_{12}p_1 p_2)$	0.0050
Number of Leaves and Vine Weight	$(2r_{13}p_1 p_3)$	-0.1761
Number of Leaves and Number of Roots	$(2r_{14}p_1 p_4)$	-0.8227
Number of Leaves and Average Root Weight	$(2r_{15}p_1 p_5)$	-4.8991
Vine Length and Vine Weight	$(2r_{23}p_2 p_3)$	0.0124
Vine Length and Number of Roots	$(2r_{24}p_2 p_4)$	0.0495
Vine Length and Average Root Weight	$(2r_{25}p_2 p_5)$	-0.0980
Vine Weight and Number of Roots	$(2r_{34}p_3 p_4)$	1.3119
Vine Weight and Average Root Weight	$(2r_{35}p_3 p_5)$	2.9210
Number of Roots and Average Root weight	$(2r_{45}p_4 p_5)$	8.8070
Residual	$1 - (p_1 r_{16} + p_2 r_{26} + p_3 r_{36} + p_4 r_{46} + p_5 r_{56})$	28.8368
Total		100.0000

~~senescence observed in some varieties could have been the reason for these large residuals [20].~~

4. CONCLUSION

Significant and positive correlations were observed between number of leaves per plant, number of roots per plant, average root weight and root yield of sweetpotato varieties. Upon partitioning the correlation coefficients into direct and indirect effects, average root weight

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had the highest contribution to root yield, while the highest indirect effect to root yield came from the number of roots per plant via the average root weight. This indicates that average root weight is the significant contributor to root yield. Breeders must therefore, pay attention to average root weight when breeding for storage root yield in sweetpotato.

REFERENCES

1. www.sweetpotatoknowledge.org. International Potato Center (CIP) web site. May, 2012.
2. CIP. The Effect of Women Farmers Adoption of Orange Fleshed Sweetpotato. Stories from field: International Potato Center Annual Report; 1999.
3. FAOSTAT. Food and Agriculture Organization Statistics Division, February 10, 2014.
4. Grafius JE. Heterosis in Barley. Agron. J. 1959; 51, 554-567. 1959.
5. Solankey SS, Singh PK, Singh RK. Genetic diversity and interrelationship of qualitative and quantitative traits in sweet potato. International Journal of Vegetable Science. 2014.
6. Maity S, Chatterjee BN. Growth attributes of potato and their interrelationship with yield. Potato Research. 1977; 20(4): 337 – 341.
7. Islam MJ, Haque MZ, Majunder UK, Haque MM, Hossain MF. Growth and yield potential of nine genotypes of sweetpotato. Pakistan J. Biol. Sci. 2002; 5 (5): 537-538.
8. Tsegaye E, Devakara SEV, Dechassa, N. Correlation and path analysis in sweetpotato and their implications for clonal selection. J. Agron. 2006; 5 (3): 391-395.
9. Alcoy AB. Plant to plant yield variability of sweetpotato (*Ipomoea batatas* (L.) Lam) as affected by plant material and time of harvest. MMSU Sci. Techn. J. 2007; 1(1): 43-50.
10. Afuape SO, Okocha PI, Njoku D. Multivariate assessment of the agromorphological variability and yield components among sweetpotato (*Ipomoea batatas* (L.) Lam) landraces. African Journal of Plant Science. 2011; 5 (2): 123-132.
11. Afuape SO, Nwankwo IIM, Omodamiro RM, Echendu TNC, Toure A. Studies on some important consumer and processing traits for breeding sweetpotato for varied end-uses. American Journal of Experimental Agriculture. 2014; 4(1): 114-124.
12. Alleman J. Fertilization, Irrigation and Weed Control. In: Guide to Sweetpotato Production in South Africa. Neidrsweiser, J (ed.). Pp27-38 ARC, Pretoria, -Republic of South Africa ISBN 86849-292-3; 2004.
13. Poohlman JM. Breeding Sugarbeets. Breeding Field Crops. Holt Rinehart and Winston Inc., New York. 1959; pp. 329 – 352
14. Gomez KA, Gomez AA. Statistical Procedures for Agricultural Research, 2nd ed. John Wiley and Sons Inc., New York; 1984.

- 338 15. Hossain MD, Rabbani MG, Mollah MLR. Genetic variability, correlation and path analysis
339 of yield contributing characters in sweet potato (*Ipomoea batatas* L.). Pakistan
340 Journal of Scientific and Industrial Research. 2000; 43(5): 314 – 318.
341
342
343 16. Miko S, Ahmed MK, Rufai I, Dadari SA, Falaki AM. Simple correlation and path
344 coefficient analysis between bulb yield and other yield components in garlic. 7th
345 Annual Conference of Botanical Society of Nigeria, NAERLS, Ahmadu Bello
346 University, Zaria, Nigeria; 1995.
347
348 17. Shahid Iqbal Tariq M, Tahira MA, Muhammad A, Muhammad S. Path coefficient analysis
349 in different genotypes of soybean (*Glycine max* (L.) Merrill). Pakistan Journal of
350 Biological Science. 2003; 6(12): 1085 – 1087.
351
352 18. Dongh L, Wang F, Junfeng FU, Junfeng LI, Jiao L. Path analysis on main quantitative
353 traits to root tuber weight per plant in sweet potato. Chinese Agricultural Science
354 Bulletin. 2005; 3: 1-3.
355
356
357 19. Summerfield RJ, Minchin FR, Roberts EH, Hadley P. Cowpeas. In Smith, W. H. and
358 Yoshida, S. (eds). Potential Productivity of Field Crops under different
359 environments IOS Banos. Phillipines. 1983; IRRI pp249 – 280
360
361 20. Gwathmey CO, Hall AE, Madore MA. Adaptive attributes of cowpea genotypes with
362 delayed monocarpic leaf senescence. Crop Science. 1992; 32, 765 – 772.