NIGERIAN AGRICULTURAL JOURNAL
ISSN: 0300-368X
Volume 49 Number 2, October 2018. Pp. 195-204
Available online at: http://www.ajol.info/index.php/naj

GROWTH AND YIELD RESPONSE OF SWEETPOTATO VARIETIES TO DATE OF VINE CUTTING IN THE HUMID TROPICS OF UMUDIKE, SOUTHEAST NIGERIA

[1]Okpara, D.A., [1]Inyang, P., [1*]Mbah, E.U and [2]Njoku, J.C.
[1]Department of Agronomy, College of Crop and Soil Sciences, Michael Okpara University of Agriculture, Umudike, Nigeria
[2]National Root Crops Research Institute, Umudike, Nigeria
*Corresponding Authors' email: emmaukmbah@gmail.com

ABSTRACT
Two field trials were conducted in 2014 and 2015 at National Root Crops Research Institute, Umudike, Nigeria to assess growth performance and yield responses of two orange-fleshed sweetpotato varieties (*Umuspo* 1, *Umuspo* 3) and one white-fleshed land-race (*Ex-Igbariam*), variety to date of initial cutting of vine (0, 6, 8 and 10 weeks after planting). The trial treatment combinations were laid out as a 3 x 4 factorial fitted in a randomized complete block design with three replications. The results showed that vine cuttings, irrespective of date of initial cutting of vine, produced significantly higher number of branches/plant, leaf area index and vine multiplication ratio. Highest significant ($P<0.05$) reduction in weed growth and highest storage root weight per plant and root yield were obtained under no cutting of vine treatment in both years compared to the other varieties. *Umuspo* 1 had more branches, higher leaf area index, shoot biomass, multiplication ratio, number of storage roots and root yield as well as suppressed weeds more relative to the other varieties. However, *Umuspo* 3 produced the highest amount of carotene content in its storage root flesh while Ex-Igbariam had the lowest carotene content.

Keywords: Orange-fleshed, root yield, shoot multiplication ratio, and variety

Introduction

Sweetpotato [*Ipomoea batatas* (L.) Lam], which is referred to as a food security crop because it has a short growing period and performs well in marginal lands is a perennial crop belonging to the Convolvulaceae family (Xiansong, 2010; Aniekwe, 2014). However, it is widely cultivated within latitudes 40° N and 40° S of the equator as annual crop in the tropics and warmer temperate regions of the world (Husman, 2002; FAO, 2008). According to scientific annual reports on sweetpotato from National Root Crops Research Institute, Umudike, Nigeria (NRCRI, 2009 and 2010), the production, marketing and utilization of sweetpotato in Nigeria have expanded in the last decade (2000 to 2010) across all agro-ecological zones in the vast country with an annual production capacity of 3.46 million metric tonnes. According to Tewe *et al*. (2003), Mbwaga *et al*. (2007) and Stathers *et al*. (2013), the skin and flesh of sweetpotato come in a variety of colours ranging from white to deep purple, although white, yellow and orange-fleshed are most predominant among the various varieties that are used as food for man, feed for livestock or are processed in the industry to obtain a range of products such as starch, noodles, and alcohol among others. Orange-fleshed sweetpotato (OFSP) is a particularly promising crop because it has very high levels of β-carotene (a precursor to vitamin A), thus contributing significantly to vitamin A (RAE: retinol activity equivalent) nutrition in humans (Harvest Plus, 2007). According to United States Department of Agriculture report (USDA, 2003) and International Potato Centre annual report (CIP, 1998), vitamin A is essential for good vision, healthy skin, good bone growth, reproduction, cell division and cell differentiation as well as improves the body's immune system. It is believed to be least expensive and an all-time accessible source of dietary vitamin A to people living in Sub-Sahara Africa. According to Graham and Rosser (2000) as well as Ceballos *et al*. (2012), vitamin A has a positive synergistic effect with iron (Fe) and zinc (Zn) bio-availability in the human body.

In Nigeria, vitamin A deficiency (VAD) is endemic and according to World Health Organization (WHO, 1995 and 2009) about 9 million children (below 5 years) and 6 million pregnant and lactating mothers in the country suffer from low serum retinol (< 0.7 µmol·L). However, the daily recommended intake of retinol (vitamin A) is 400 µg·day for children below 5 years and 900 µg·day for adults. Previous studies by Administrative Committee on Coordination/ Subcommittee on Nutrition of the United Nations (ACC/SCN, 1992); Beaton *et al*. (1993), and West (2003) have proven that improving vitamin A status of children reduces blindness and mortality by 23 to 30 per cent. Further works by Anderson *et al*. (2007) and Egbe (2012) have shown that the strategy of increasing OFSP consumption invariably alleviates vitamin A deficiency for people living in Sub-Sahara Africa. According to Njoku *et al*. (2001) sweetpotato vines and leaves are useful dry forage during lean grazing periods while the fresh succulent shoots serve as vegetable for human consumption. However, inadequate seed system or scarcity of vines at time of planting is a major constraint to sweetpotato production in Nigeria although vines are always available in excess during the harvesting period. Hence, the supply of sweetpotato propagating material does not match its demand since the crop has very low multiplication ratio of 1:20 (Moyo *et al*., 2004). Therefore, time of initial cutting of vine must be determined carefully as to optimize both storage root and vine production. Dahinya *et al.* (1985) and Nwiniyi, (1992) as well as Mcharo and Ndolo (2013) in their various studies submitted that storage root yields of sweetpotato decreased by 31 to 48 % when 25 cm shoot tips were removed and by 48 to 62 % when the entire shoot was removed. Further studies by Aniekwe (2014) showed that pinching back of sweetpotato vines as early as 4 WAP significantly reduced growth and yield parameters of the crop but they were improved significantly at later stage of the crop growth. This implies that the need to identify appropriate date of initial cutting of vine is very important as to develop an alternate method in overcoming the problem of low multiplication ratio associated with the crop. The objectives of the study were to determine the effect of variety and date of initial cutting of vine as well as the combined effect of the main factors on vine production, multiplication ratio, weed presence, storage root yield and carotene content in two orange-fleshed and a white-fleshed sweetpotato variety/ies.

Materials and Methods

Field studies were conducted during the 2014 and 2015 growing seasons at the experimental farm, National Root Crops Research Institute, Umudike Nigeria in the humid tropics which is characterized by a bimodal pattern of rainfall. On the average per month, rainfall, maximum air temperature and sunshine hours were 172.42 mm, 31.7 °C, 4.5 hours (2014) and 173.05 mm, 31.2 °C, 5.2 hours (2015) cropping seasons, respectively (Table 1). Prior to planting, a sub-sample of composite soil samples collected from each experimental plot was subjected to physic-chemical analysis according to the analytical procedures in the Soil Science Laboratory, National Root Crops Research Institute, Umudike, Nigeria.

The results as shown in Table 2 indicated that texturally, the soils of the experimental site in 2014 was sandy loam (ultisol) and that of 2015 was sandy clay loam (ultisol) while both sites exhibited low nitrogen content and pH values.

The sweetpotato cultivars used for the study are two newly released (2012) orange-fleshed sweetpotato cultivars viz: *Umuspo* 1 (characterized by highly vigorous, erect, green coloured, thick vine with lobed leaf outline. The root flesh and skin colour are light orange and pink, respectively while the shape of the root is long elliptic.); and *Umuspo* 3 (characterized by creeping, purple coloured, thin vine with triangular leaf outline. The root flesh and skin colour are dark orange and orange, respectively while the shape of the root is round elliptic); and a land-race (*Ex-Igbariam*) known for its highly vigorous spreading habit with green vine and triangular leaf outline. The root flesh and skin colour are yellow and cream, respectively while the shape of the storage root is long elliptic).

The treatment factors (two orange-fleshed sweetpotato cultivars – *Umuspo* 1, *Umuspo* 2 and a land-race, *Ex-Igbariam* and four dates of initial cutting of vine - 6, 8 and 10 weeks after planting and no vine cutting) were compared in the study. The experiment was laid out as 3 × 4 factorial in a randomized complete block design (RCBD) with three replications. The treatments comprised all possible combinations of the three sweetpotato cultivars and the four dates of initial cutting of vine. However, in all the treatments, further cuttings were done at 4 weeks interval as follows: for the 1st initial cutting at 6 WAP further cuttings were done at 10 and 14 WAP, for 1st initial cutting at 8 WAP further cutting was done at 12 WAP while for 1st initial cutting at 10 WAP further cutting was done at 14 WAP. The twelve treatment combination were randomly allocated into experimental plots of 3 by 3m (9 m^2) with in spacing between plots and between blocks. The field was ploughed, disc-harrowed and ridged before planting. Sweetpotato vine cuttings of 2.5 cm length with at least 4 nodes were planted on the crest of ridges at the spacing of 1 x 0.3 m on 5th June, 2014 and 16th June, 2015, while supplying of vacancies was done at two weeks after planting (WAP) to achieve the described plant population of 33,333 plants/ha in each cropping season. Two weeding regimes were carried out at 4 and 12 WAP, respectively. A compound fertilizer was applied at the rate of 400 kg/ha at 4 WAP while shoot and root harvesting was done at 16 WAP.

The growing plants in the middle row were used for data collection and they include vine length, which was achieved by taking measurement from the base to the terminal bud of each sampled plant with the aid of a meter rule; number of branches per plant and weed density per quadrat of one meter square were determined by counting. Disc method was used to determine leaf area of sweetpotato by sampling 20 fully developed fresh leaves from each plot which were arranged on each other and then punched through with a disc of diameter 2.5 cm. The leaf samples were then oven-dried at 60 ºC until a constant weight was achieved. The dry weight of the cuttings (bores) and the remaining leaf parts were obtained. The leaf area was calculated with the formula: [i] LA = [(Dry weight of whole leaves × Area of the disc cuttings (bores)) / Dry weight of disc cuttings (bores)]. The leaf area index was determined as the ratio of total leaf area to land area occupied by plant. Fresh plant biomass and weed dry weight were obtained by weighing while vine multiplication ratio (MR) was determined as the ratio of weight of harvested shoot biomass to weight of planting material according to Onwueme (1978). Storage root yield per plot was obtained by weighing and then extrapolated per hectare.

Carotene content in flesh root of sweetpotato variety was determined using the method described by Delia and Mieko (2004). The sample was first homogenised using acetone solution with the aid of pestle and mortar. The solution was filtered after crushing and the filtrate extracted with petroleum spirit using separating funnel. Two layers of both aqueous and solvent layer were obtained. The upper layer which contains the carotene was washed very well with D-H_2O in order to remove residual water. It was later poured out into the 50 ml volumetric flask through the tap of the separation funnel and made up to 50 ml mark. The absorbance of the solution was read using spectrophotometer at wavelength 450 nm. Carotene content was calculated with the formula: [ii] Carotene content (μg/g) = (($A_{\text{fraction 1}}$ x Volume (mL) x 10^4) / ($A^{1\%}_{1cm}$ x Sample weight (g)) x 1.25), where, $A_{\text{fraction 1}}$ = Absorbance; Volume = Volume of fraction 1 (5 mL); $A^{1\%}_{1cm}$ = Absorption coefficient of β-carotene in petroleum ether (PE) (2592). Multiplying by 1.25, accounts for the use of a 20 mL aliquot taken from a total extract of 25 mL. Data collected were exposed to analysis of variance (ANOVA) using Genstat Discovery Edition 3 (Genstat, 2009) and treatment means separated by using the least significant difference as outlined by Obi (2002).

Results and Discussion

Analysis of variance results (Table 3) indicated that sweetpotato variety significantly ($p<0.05$) affected vine length, number of branches/plant, leaf area index, plant biomass, weed density/m^{-2} and weed dry weight/m^{-2} in 2014. The trend was the same in 2015 cropping season. Apart from number of branches/plant that was significantly affected in both years, initial cutting of vine significantly affected vine length (2014) as well as leaf area index and shoot multiplication ratio (2015) while the interaction between variety and date of initial cutting of vine had no significant ($p>0.05$) effect on all the variants tested.

In both cropping seasons, analysis of variance as shown in Table 4 indicated that variety had significant ($p<0.05$) effect on weed density/m^{-2}, weed dry weight/m^{-2}, root weight/plant, root yield (Mt·ha^{-1}) and β-carotene content in sweetpotato storage roots. Except vine length, the factor (Date of initial cutting of vine) significantly affected all the variants tested in both years. The two factor interaction indicated non-significant difference in all the variants except root weight/plant and root yield/ha in 2015 as well as b-carotene in both years.

Among the sweetpotato varieties (Table 5), *Ex-Igbariam* had the longest vine length while *Umuspo* 1consistently had the highest number of branches/plant and leaf area index in 2014 and 2015 cropping seasons. *Umuspo* 3 produced ($p>0.05$) the least amount of shoot biomass, which was lower by 84.39 and 65.8 % (2014) and 36.42 and 76.94 % (2015) compared with *Umuspo* 1 and *Ex-Igbariam* varieties, respectively.

The effect of date of initial cutting of vine on some variants as shown in Table 6 indicated that no cutting of vine had the lowest number of branches/plant, which ranged from 14.75 to 25.86 (2014) and 10.06 to 15.72 (2015) as well as weed dry weight, which ranged from 4.50 to 20.80 (2014) and 9.52 to 22.14 (2015). Also, the shortest vine length that ranged from 198.2 to 298.8 in 2014 and lowest leaf area index that ranged from 0.96 to 1.45 in 2015 were exhibited under no cutting of vine condition.

The factor interaction between variety and initial cutting of vine (Table 7) indicated that *Umuspo* 1 under initial cutting of vine at 10 WAP had the highest shoot multiplication ratio compared with the other interaction treatments. The highest fresh root weight of 0.34 g was produced by *Umuspo*1 by no cutting of vine interaction while the highest root yield of 27.8 Mt·$ha^{-1}$was recorded by the same variety under the same no cutting of vine condition. However, among the interaction treatments, the interaction of *Umuspo*

3 and date of initial cutting of vine at 10 WAP produced the lowest fresh root yield in 2015 cropping season.

Among the sweetpotato varieties in 2014, shoot multiplication ratio, root weight and fresh root yield ranged from 19.6 to 44.8, 0.13 to 0.29 and 6.80 to 20.6, respectively (Table 8). *Umuspo*1 produced the highest shoot multiplication ratio, root weight and fresh root yield, which was higher by 57.1 and 17.2 %, 55.2 and 55.2 %, and by 67 and 58.3 % relative to *Umuspo* 3 and *Ex-Igbariam* varieties, respectively.

In 2014 cropping season, among the dates of initial cutting of vine evaluated (Table 9), no cutting produced the highest root weight and fresh root yield while initial cutting of vine at 8 WAP induced the lowest fresh root weight and yield in sweetpotato.

Sweetpotato variety by initial cutting interaction (Figs.1a and b) showed *Umuspo* 3 across all the dates of initial cutting of vine had the highest amount of β-carotene in its flesh root while *Ex-Igbariam* had the lowest in 2014. The trend was similar in 2015 cropping season. Furthermore, *Umuspo* 3 variety under initial cutting of vine at 10 WAP (2014) and 8 WAP (2015) gave the highest amount of β-carotene compared with the other interaction treatments. The relationship between date of initial cutting of vine and fresh storage root yield of sweetpotato ($Mt \cdot ha^{-1}$) (Figs. 1c and d) in both years was poly-linear and positive with regression coefficients (R^2) of 1.00 (2014) and 0.999 (2015). However, the results indicated that there was corresponding decline in storage root yield as the date of initial cutting of vine increased from 0 to 10 WAP. In the two cropping seasons (Figs. 1e and f), date of initial cutting of vine exhibited positive poly-linear relationship with the amount of β-carotene content in the flesh root of sweetpotato indicating slight decrease in β-carotene content as the date of initial cutting increased from 0 to 8 WAP.

Further discussion shows that in the two cropping seasons, cutting of vine resulted in greater number of branches/plant, longer vines and consequently higher leaf area index perhaps due to the absence of apical dominance. Similarly, An *et al.* (2003) in their study on harvesting intervals and defoliation of sweetpotato leaves as well as Asiegbu (1983) in his study on the effect of apical dominance on number of leaves on fluted pumpkin (*Telfairia occidentalis* L. Hook) submitted that the removal of apical bud of the main stem induced greater production of lateral branches and invariably greater number of leaves/plant. Leaf area index was generally higher when date of initial cutting of vine was delayed to 10 weeks after planting (WAP) than when cutting was done at 6 or 8 WAP. Initial cutting of vine at 10 WAP had more multiplication ratio than other cutting schedules. Consequently, the average multiplication ratio of 1:35 obtained in our study when initial cutting commenced at 10 WAP was higher by 75 % in contrast to Moyo *et al*. (2004) who reported a ratio of 1:20 for sweetpotato. This implies that date of initial cutting of vine could be made flexible, depending on the purpose of cultivation. If cultivation is to raise planting materials, then date of initial cuttings could be done early. However, if the purpose is to obtain both planting materials and root yield, then date of initial cutting may be delayed beyond 10 WAP.

The lower weed growth obtained under no cutting treatment or date of initial cutting done at 10 WAP was essentially due to the longer presence of canopy cover or higher leaf area index, which provided shade that smothered most of the weeds and invariably reduced weed dry matter in the treatments. No cutting of vine produced highest storage root yield in contrast to the cutting treatments. Date of initial cutting of vine reduced storage root yield by 81, 84 and 74 per cent when vine clippings were done at 6, 8 and 10 weeks after planting (WAP), respectively, relative to no cutting of vine. The yield reductions of 74 to 84 % obtained in our study when the shoot was removed within 20 cm from the ground were higher than the 31 to 48 % yield reductions reported by Dahinya *et al.* (1985) and 63 % yield reductions reported by Nwiniyi (1992) when the shoot was removed 20 cm from the ground level. Furthermore, Ahn (1993) submitted that storage root initiation in sweetpotato occurs at about 7 to 9 WAP and root enlargement and development at 4 to 14 WAP depending on cultivar while Aniekwe (2014) reported pinching back of sweetpotato vine as early as 4 WAP reduced growth and yield because the physiological processes of growth and tuberization were strongly interrupted. Similar studies by Uddin *et al.* (1994) in Bangladesh and Kiozya *et al*. (2001) in Tanzania indicated that defoliation had significant depressing influence on storage root production in sweetpotato. This is so because according to Hahn and Hozyo (1984) crop tuberization is a function of both sink capacity and source potential, which are associated with photosynthesis. Crop yield is invariably reduced when it is a limiting factor. More so, the cutting treatment produced root yields with superior carotene content compared to the other treatments.

In the two cropping seasons, *Umuspo* 1 had more branches, higher leaf area index, shoot biomass or multiplication ratio, suppressed weeds more efficiently and greater root yield relative to the other varieties. Earlier works on photosynthesis and photosynthate partitioning by Bhagsari and Harmon

(1982) showed that high yields obtained in some crop varieties were due to the inherent genetic ability to accommodate more assimilates in their storage roots, hence are considered high yielder varieties. Averaged over two cropping years, the storage root yield of Umuspo 1 was 233 % higher than *Umuspo* 3 while the latter with average carotene content of 82.7 μ/mg, was 252 % superior to the former in carotene content. Our findings corroborate previous studies by Kapinga *et al*. (2002), Ogbologwung *et al*. (2014) and Akpainyang *et al*. (2015) in which they reported significant amount of carotene content in *Umuspo* 3 orange-fleshed sweetpotato variety relative to other orange-fleshed sweetpotato varieties tested in their works. *Umuspo* 1 variety characterized by an erectophilic growth posture and moderately lobed leaves (NRCRI, 2014), intercepted more solar radiation, hence had higher storage root yield. Similarly, Peter *et al*. (1983) and Mulungu *et al*. (2006) submitted that crops with erectophile leaf posture have an advantage in intercepting more light with higher photosynthetic rate and photosynthetic efficiency. The interaction effects indicated that storage root yield was higher in *Umuspo* 1 with no cutting while carotene content was highest in *Umuspo* 3 with date of initial cutting of vine at 10 WAP in 2014 and 8 WAP in 2015 cropping seasons.

Conclusion

The cutting of sweetpotato vine irrespective of the date of initial cutting significantly increased the number of branches/plant, vine length and leaf area index but reduced storage root yield. In contrast, no cutting produced the highest storage root yield and suppressed weed growth more efficiently, which was closely followed when date of initial cutting of vine was delayed up to 10 WAP. *Umuspo* 1 consistently exhibited more weed competitiveness because it produced more branches, higher leaf area index, more shoot bio-mass, multiplication ratio and storage root yield relative to the other varieties. However, *Umuspo* 3 had higher amount of carotene content in its flesh compared to the other varieties. Sweetpotato farmers in the agro-ecological zone can therefore be encouraged to avoid vine cutting as to ensure high storage root yield in both orange- and white-fleshed sweetpotato varieties while delaying date of initial cutting to 10 WAP should be adopted to guarantee high vine and satisfactory root yields from the varieties. The use of appropriate date of initial cutting of vine to multiply vines will guarantee the availability of improved planting materials and ensure stable growth and yield of orange- and white-fleshed sweetpotato varieties in Sub-Sahara Africa.

References

ACC/SCN. (1992). Administrative committee on coordination, Sub-committee on nutrition: Second report on the world nutrition situation. United Nations, Geneva: ACC/SCN/IFPRI.

Akpaninyang, F., Okpara, D.A. and Njoku, J.C. (2013). Integrated nutrient management for orange-fleshed sweetpotato in south eastern Nigeria. *Uganda Journal of Agricultural Science,* 14 (2): 117-123.

Ahn, P.M. (1993). Tropical soils and fertilizer use. International Tropical Agricultural Series. Longman Science and Technology, Ltd, Uk.

An, I.V., Frankow-Lindberg, B.E. and Lindberg, J.E. (2003). Effect of harvesting interval and defoliation on yield and chemical composition of leaves, stems and tubers of sweetpotato (Ipomoea batatas (L.) Lam) plant parts. *Field Crops Research*, 20:49-58.

Anderson, P., Kapinga, R., Zhang, D. and Hermann, M. (2007). Vitamin A for Africa (VITAA): An entry point for promoting orange-fleshed sweetpotato to combat vitamin A deficiency in sub-Sahara Africa. In: Proceedings of the 13th ISTRC Symposium, Tanzania: Arusha, Tanzania, pp. 711-720.

Aniekwe, N.I. (2014). Influence of pinching back on the growth and yield parameter of sweetpotato varieties in south eastern Nigeria. *Journal of Animal and Plant Sciences*, 20 (3): 3194-3201

Asiegbu, J.E. (1983). Effects of method of harvest and interval between harvests on edible leaf yield in fluted pumpkin. *Scientia Horticulturae*, 21 (2):129-136.

Baeton, G.H., Mortorell, R., Aronson, K. J., Edmonston, B., McCabe, G., Ross, A.C. and Harvey, B. (1993). Effectiveness of vitamin A supplementation in the control of young child morbidity and mortality in developing countries. ACC/SCN state of the act series, nutrition policy. Paper No. 3. Switzerland: World Health Organization (WHO), Geneva.

Bhagasari, A.S. and Harmon, S. A. (1982). Photosynthesis and photosynthate partitioning in sweetpotatogenotypes. *American Journal of Horticultural Science*, 107: 506-510.

Ceballos, H., Luna, J., Escobar, A.F., Ortiz, D., Perez, J.C., Sanchez, T., Pachon, H. and Dufour, D. (2012). Spatial distribution of dry matter in yellow-fleshed cassava roots and its influence on carotenoid retention upon boiling. *Food Research International*, 45: 52-59.

CIP (International Potato Centre) (1998). Annual Report, Lima Peru, pp.68.

Dahinya, M.T., Hahn, S.K. and Oputa, C.O. (1985). Effect of shoot removal on shoot and root yields of

sweetpotato. Experimental agriculture, 21: 183-186.
Delia, B. and Mieko, K. (2004). Harvestplus Handbook for Carotenoid Analysis. Washington, D. C. pp. 34-38.
Egbe, O.M. (2012). Relative performance of three sweetpotato varieties in sole and intercrop systems in Southern Guinea Savanna ecology of Nigeria. *Global Journal of Science Frontier Research and Biology*, 12: 37-43.
FAO (Food and Agriculture Organization) (2008). Food and Agriculture Organization of the United Nations. Statistical Year Book, 2008, Rome, Italy.
Graham, R. D. and Rosser, J.M. (2000). Carotenoids in staple foods: Their potential to improve human nutrition. *Food and Nutrition Bulletin*, 21: 404-409.
Genstat Discovery Edition 4. (2009). Genstat 12th ed. VSH International Bioscience Software and Consultancy, Hemel Hemstead, U.K.
Hahn, S.K., and Hozyo, Y. (1984). Sweetpotato: In: Physiology of Tropical Field Crops (eds. Goldworthy, P.R. and Fisher, N.M). pp.551-558. John Wiley, Chichester.
HarvestPlus. (2007). Vitamin A sweetpotato project, trainer's manual: a nutrition training course for extension workers. Uganda: HarvestPlus. 62pp.
Husman, Z. (2002). Systematic botany and morphology of sweetpotato plant, Sweetpotato germplasm management (*Ipomoea batatas* (L.) Lam). CIP (International Potato Centre) Training Manual Section.
Kapinga, R., Ortiz, O., Ndunguru, J., Omiaf, E. and Tumwegamire, J. (2002). Handbook on sweetpotato: Integrated Crop Management Research Outputs and Programme for East Africa (1995-2006). Kampala, International Potato Centre (CIP).
Kiozya, H.C., Mtunda, K. Kapinga, R., Chirimi, B. and Rwiza, E. (2001). Effect of leaf harvesting frequency on growth and yield of sweetpotato in the lake zone of Tanzania. *African Crop Science Journal*, 9 (1): 97-103.
Mbwaga, Z., Mataa, M. and Msabaha, M. (2007). Quality and yield stability of orange fleshed sweetpotato (*Ipomoea batatas* (L.) Lam) grown in different agro-ecologies. African Crop Science Conference Proceedings, 8: 339-345.
Mcharo, M., and Ndolo, P. (2013). Root-yield performance of per-release sweetpotato genotypes in Kenya. *Journal of Applied Bioscience*, 65: 4914- 4921
Moyo, C.C., Mahungu, M.N., Sandifolo, S.V., Mhone, K.R.A., Chipungu, F. and Mkumbira, J. (2004). Quality seed and production procedures for cassava and sweetpotato. In: Successful community-based seed production strategies. Sentimela, S.P., Monyo, E. and Banzinger, M. (eds.). Cabi Publishing. Oxon. pp. 572-580.
Mulungu, I.S., Mwailana, D.J., Shazia, S.O.W.R., Tarimo, J.P.A., Apia, W.M. and makundi, R.H. (2006). Evaluation on the effect of topping frequency on yield of two contrasting sweetpotato (*Ipomoea batatas* (L.) Lam) genotypes. *Journal of Applied Science*, 6 (5): 1132-1137.
Njoku, J.C., Okpara, D.A. and Asiegbu, J.E. (2001). Growth and yield responses of sweet potato inorganic nitrogen and potassium in a tropical ultisol. *Nigerian Agricultural Journal*, 32: 30-41.
NRCRI, (2009). National Root Crops Research Institute Umudike, Annual Report, sweetpotato programme 2009.
NRCRI, (2010) National Root Crops Research Institute Umudike, Annual Report, sweetpotato programme 2010.
NRCRI, (2014). National Root Crops Research Institute Umudike, Annual Report, sweetpotato programme 2014.
Nwiniyi, S.C.O. (1992). Effect of age at shoot removal on tuber and shoot yields at harvest of five sweetpotato (*Ipomoea batatas* (L.) Lam) cultivars. *Field Crops Research*, 29: 47-54.
Obi, I.U. (2002). Statistical Methods of Detecting Differences between Treatment Means Methodology Issues in Laboratory and Field Experiments. AP Express Publishing Company, Limited, Nsukka, Nigeria.116pp.
Ogbologwung, I.P., Okpara, D.A. and Njoku, J.C. (2014). Effect of plant spacing and variety on growth and yield of orange-fleshed sweetpotato in humid agro-ecological zone of Nigeria. In: Proceedings of 2nd Biennial National Agricultural Research Organization (NARO) Scientific Conference, 3rd – 7th November, 2014. Speke Resort Munyonyo, Kampala, Uganda.
Onwueme, I.C. (1978). The Tropical Tuber Crops-Yams, Cassava, Sweetpotato and Cocoyams. John Wiley and Sons, Chichester, 3-97.
Peter, J., Cemy, V. and Hrusk, I. (1983). Yield formation in the main field crops. Amsterdam, Elsevier Science Publishers, pp.33-36.
Stathers, T., Benjamin, M., Katcher, H., Blakenship, J. and Low, J. (2013). *Everything You Ever Wanted to Know about Sweetpotato*: Reaching Agents of Change ToT Manual 2: Orangefleshed sweetpotato and nutrition. International Potato Center, Nairobi, Kenya. Vol.2.
Tewe, O.O., Ojeniyi, F.E., and Abu, O.A. (2003). Sweetpotato to production, utilization, and marketing in Nigeria. Social Sciences Department, International potato center (CIP), Lima, Peru. http://www.eseap.cipotato.org/MF-ESEAPI/FI-Library/SP in Nigeria

Uddin, M.K., Mahbub, A.S.M., Alam, M.J. and Hogue, A.K.M.Z. (1991). Fodder and root yield of sweetpotato as affected by dates of vine cutting and varieties. *Bangladesh Journal of scientific and Indus Research*, 29 (2): 47-53.

USDA (United States Department of Agriculture) (2003). USDA National Nutrient Database for Standard Reference, Release 16.

West, K.P. (2003). Vitamin A deficiency disorders in children and women. Food and Nutrition Bulletin, 24: 578-590.

WHO (World Health Organization). (1995). Global prevalence of Vitamin A deficiency, micronutrient Deficiency Information System, Working Paper No. 2, (Catalog No. WHO/NUT/95.3). WHO, Geneva, Switzerland.

WHO (World Health Organization). (2009). Global prevalence of vitamin A deficiency in populations at risk. 1995-2005, Geneva, Switzerland.

Xionsong, Y. (2010). Rapid production of virus-free plantlets by shoot tip culture in vitro of purple-coloured sweetpotato (*Ipomomea batatas* (L.) Lam). *Pakistan Journal of Biology,* 42 (3): 2069-2075.

Table 1: Some of the meteorological data of the experimental site in 2014 and 2015 cropping seasons

Month	Rainfall (mm)	Temp. (°C)		RH (%)[1]	Sunshine	Rainfall (mm)	Temp. (°C)		RH (%)	Sunshine
		Min	Max		(Hour)		Min	Max		(Hour)
January	0.0	21.5	33.4	72	6.4	8.4	22	33	39	6.1
February	43.7	23.2	33.9	75	5.2	81.7	25	34	57	5.3
March	138.8	23.4	33.2	80	4.4	130.5	24	33	61	5.1
April	78.7	23.5	32.2	79	5.5	61.7	23.8	33.4	58	5.9
May	249.2	23.4	31.9	81	5.2	246.8	23.4	32.7	63	2.3
June	281.8	24.2	30.5	81	4.9	346.2	23.5	29.8	76	2.2
July	114.9	24.0	30.0	86	2.8	129.2	22.4	27.3	81	2.7
August	444.2	23.3	29.6	85	3.1	366.2	24.0	29.0	80	4.6
September	405.3	22.9	29.8	85	2.8	276.0	23.0	29.0	78	4.1
October	165.1	23.6	31.0	81	4.2	380.2	24.0	31.0	74	4.2
November	147.4	23.5	31.6	65	3.3	49.7	24.0	33.0	60	6.1
December	0.0	21.8	32.7	64	5.9	0.0	22.9	30.0	38	6.2
Total	2069.1	-	-	-	53.7	2076.6	-	-	-	54.8
Mean		23.2	31.7	79.3	4.5	-	23.5	31.2	63.8	4.6

RH = Relative humidity. Source: Meteorological station, National Root Crops Research Institute, Umudike, Nigeria

Table 2: Some chemical characteristics of the soil of the experimental study site (0 - 20 cm)

Soil characteristics	**value**	
	2014	**2015**
Sand (%)	75.90	67.20
Silt (%)	11.60	9.00
Clay (%)	12.50	23.80
Soil pH (1 : 2; Soil : Water) (%)	4.50	5.20
Organic matter (%)	2.22	0.87
Total N (%)	0.09	0.082
Available P (mg kg^{-1})	43.00	67.8
Exchangeable K (cmol kg^{-1})	0.20	0.37
Exchangeable Na (cmol kg^{-1})	0.22	0.19
Exchangeable Ca (cmol kg^{-1})	2.80	2.80
Exchangeable Mg (cmol kg^{-1})	2.80	1.60
ECEC (cmol kg^{-1})	4.74	6.82
BS (%)	76.35	68.35

Source: Soil Science Laboratory, National Root Crops Research Institute, Umudike, Nigeria

Table 3: Analysis of variance for date of initial cutting of vine, variety and their interaction on vine length, number of branches/plant, leaf area index, plant biomass and shoot multiplication ratio of three orange-flesh sweetpotato

Source of variation	**Vine length (cm)**	**No. branches/ plant**	**Leaf area index**	**Shoot biomass (g)**	**Shoot Multiplication Ratio**
	2014				
Date of initial cutting of vine (D)	*	*	ns	ns	ns
Variety (V)	*	*	*	*	*
D×V (Interaction)	ns	ns	ns	ns	ns
	2015				
Date of initial cutting of vine (D)	ns	*	*	ns	*
Variety (V)	*	*	*	*	*
D × V (Interaction)	ns	ns	ns	ns	ns

ns. = non-significant, *. = significant at P≤0.05, **. = significant at P≤0.01, ANOVA.

Table 4: Analysis of variance for date of initial cutting of vine, variety and their interaction on weed density, weed dry weight, root weight/plant, root yield/hectare and β-carotene content in three orange-fleshed sweetpotato varieties

Source of variation	**Weed density (m^{-2})**	**Weed dry weight ($g \cdot m^{-2}$)**	**Root weight ($kg \cdot plant^{-1}$)**	**Root yield ($Mt \cdot ha^{-1}$)**	**β-Carotene (μg·g)**
	2014				
Date of initial cutting of vine (D)	ns	*	*	*	*
Variety (V)	*	*	*	*	*
D×V (Interaction)	ns	ns	ns	ns	*
	2015				
Date of initial cutting of vine (D)	ns	*	*	*	*
Variety (V)	*	*	*	*	*
D × V (Interaction)	ns	ns	*	*	*

ns. = non-significant, *. = significant at P≤0.05, **. = significant at P≤0.01, ANOVA.

Table 5: Effect of cultivar on vine length, number of branches/plant, leaf area index and shoot biomass of three orange-fleshed sweetpotato varieties in 2014 and 2015 cropping seasons

Variety	**Vine length (cm)**	**No. branches /plant**	**Leaf area index**	**Shoot biomass (t/ha)**
	2014			
Umuspo 1	210.2	26.88	3.12	50.60
Umuspo 3	185.4	18.21	1.30	7.90
Ex-Igbariam	337.6	15.62	1.90	23.10
$LSD_{(0.05)}$	32.37	4.28	0.52	8.90
	2015			
Umuspo 1	138.1	17.94	1.87	17.30
Umuspo 3	134.8	10.58	0.66	5.50
Ex-Igbariam	284.4	11.15	1.05	23.90
$LSD_{(0.05)}$	31.0	2.09	0.21	3.50

Table 6: Effect of date of initial cutting of vine on vine length, number of branches/plant, weed dry weight in 2014 cropping season and on number of branches/plant, leaf area index and weed dry weight in 2015 cropping season

	2014			2015		
	No. branches/plant	**Leaf area index**	**Weed dry weight (g)**	**No. branches/ plant**	**Leaf area index**	**Weed dry weight (g)**
No cutting of vine	198.2	14.75	4.50	10.06	0.96	9.52
Initial cutting of vine at 6 WAP	298.8	21.97	20.8	15.72	1.22	19.46
Initial cutting of vine at 8 WAP	222.6	18.86	13.4	12.56	1.14	22.14
Initial cutting of vine at 10 WAP	257.9	25.36	8.80	14.56	1.45	12.10
$LSD_{(0.05)}$	37.26	4.95	10.26	2.41	0.24	5.15

Table 7: Effect of interaction of variety and date of initial cutting of vine on shoot multiplication ratio, fresh root weight and fresh root yield of three orange-flesh sweetpotato in 2015 cropping season

Variety x	**Date of initial cutting of vine (WAP)**	**Shoot multiplication ratio**	**Fresh root weight (g)**	**Fresh root yield ($Mt·ha^{-1}$)**
Umuspo 1	No cutting of vine	19.7	0.34	27.8
	Initial cutting of vine at 6 WAP	29.3	0.14	8.00
	Initial cutting of vine at 8 WAP	24.2	0.13	7.20
	Initial cutting of vine at 10 WAP	47.2	0.19	10.3
Umuspo 3	No cutting of vine	16.2	0.16	5.20
	Initial cutting of vine at 6 WAP	16.5	0.05	1.10
	Initial cutting of vine at 8 WAP	17.5	0.05	1.70
	Initial cutting of vine at 10 WAP	24.1	0.11	5.30
Ex-Igbariam	No cutting of vine	20.4	0.22	14.10
	Initial cutting of vine at 6 WAP	19.8	0.05	16.10
	Initial cutting of vine at 8 WAP	19.9	0.06	3.10
	Initial cutting of vine at 10 WAP	28.0	0.15	7.20
$LSD_{(0.05)}$		5.70	0.044	2.90

Table 8: Effect of variety on shoot multiplication ratio, fresh root weight/plant and fresh root yield of three orange-flesh sweetpotato in 2014 cropping season

Variety	**Shoot multiplication ratio**	**Fresh root weight/plant (g)**	**Fresh root yield ($Mt·ha^{-1}$)**
Umuspo 1	44.8	0.29	20.6
Umuspo 3	19.6	0.13	6.80
Ex-Igbariam	37.1	0.13	8.60
$LSD_{(0.05)}$	12.7	0.069	9.30

Table 9: Effect of date of initial cutting of vine on root weight per plant and fresh root yield of sweetpotato in 2014 cropping season

Date of initial cutting of vine (WAP)	**Root weight/plant (g)**	**Fresh root yield ($Mt·ha^{-1}$)**
No cutting of vine	0.40	33.3
Initial cutting of vine at 6 WAP	0.10	5.70
Initial cutting of vine at 8 WAP	0.09	3.80
Initial cutting of vine at 10 WAP	0.11	5.00
$LSD_{(0.05)}$	0.08	10.8

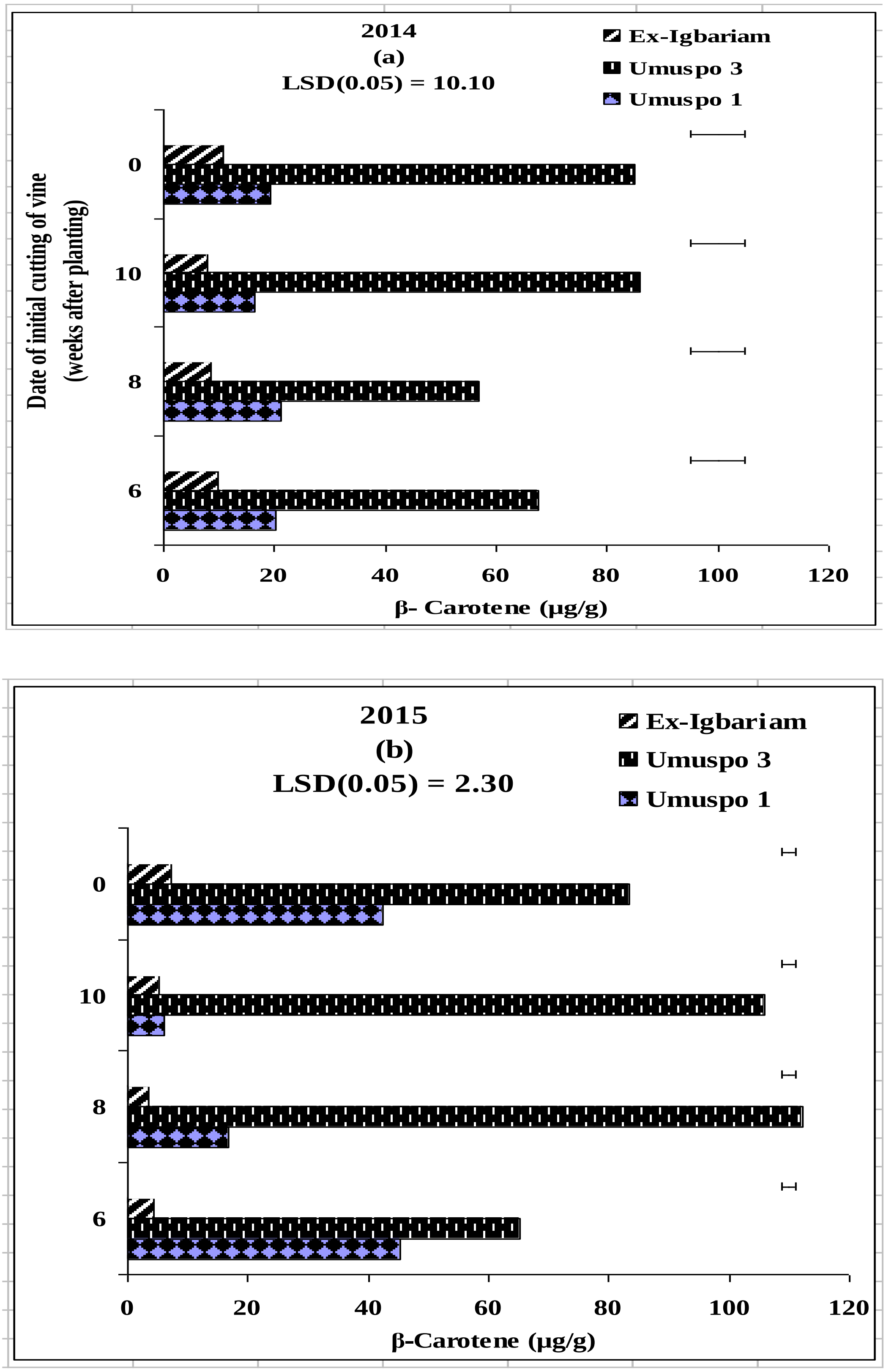

Fig. 1: (a and b) Bar charts showing the effect of sweetpotato cultivar and date of initial vine cutting on β-carotene content in storage root yield of three orange fleshed sweetpotato with error bars on charts representing standard error in 2014 and 2015 cropping seasons, respectively.