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Effect of Vine Cuttingon Multiplication Ratio and Yield of Three Orange-fleshed Sweetpotato (*Ipomoea batatas* (L) Lam) Varieties in South Eastern Nigeria

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Abstract: A major constraint to sweetpotato production in Nigeria is the lack of clean and sufficient quantities of vine cutting at the time of planting in May or June. Inorder to obtain planting materials, farmers subject sweetpotato to vine harvest at various times but there is dearth of information on the effect of the level or intensity of defoliation on the crop. In this study, the response of three orange-fleshed sweetpotato varieties to cutting regimes in 2014 and 2015 cropping seasons in a tropical ultisol of South eastern Nigeria was evaluated. In each year, the experiment was laid out as 3 x 4 factorial arranged in randomized complete block design with three replications. Treatments comprised all combinations of three orange-fleshed sweetpotato varieties (Umuspo 1, Umuspo 3 and Ex-Igbariam) and four cutting regimes (6, 10 and 14 weeks after planting [WAP], 8 and 12 WAP, 10 and 14 WAP and no-cutting). Cutting regimes did not influence fresh shoot biomass in both year but cutting at 10 and 14 WAP significantly increased multiplication ratio compared to no-cutting or other cutting schedules. Storage root yield was, however, significantly higher with no-cutting than with the 4 weekly cuts, regardless of cutting dates. In all situations, Umuspo 1 produced significantly higher multiplication ratio and higher top and storage root yields than other varieties. Conversely, Umuspo 3 produced higher carotene yield at 10 and 14 WAP cutting compared to other varieties and cutting regimes.

Keywords: Orange-fleshed Sweetpotato, Vine Cuttings, Multiplication Ratio, Beta-carotene, Yield

1. Introduction

Sweetpotato (*Ipomoea batatas* (L) Lam) is a perennial food crop belonging to the morning glory family, Convolvulaceae [34, 5] but widely cultivated as annual crop in tropical and warmer temperate climates [17]. The crop has a short growing period, stores well in the soil, performs well in marginal lands and hence is referred to as a food security crop [18, 10]. On poor acid soils, it gives satisfactory yields [9, 27].

Orange-fleshed sweetpotato is a particularly promising crop because it has extremely high levels of beta-carotene (a precursor to vitamin A), thus contributing significantly to vitamin A (retinol) nutrition in humans. Orange-fleshed sweetpotato varieties are believed to be least expensive and an all time accessible source of dietary vitamin A to the poor, rural as well as the entire populace. There is a growing evidence that vitamin A has a positive synergistic effect with iron and zinc bio-availability [16, 8]. Orange-fleshed sweetpotato has provided one of the means of reducing vitamin A deficiency that has previously been addressed using the expensive and inadequate vitamin A capsules [20]. Vitamin A deficiency (VAD) is endemic in Nigeria. About 9 million children (below 5 years) and 6 million pregnant and lactating women suffer from low serum retinol (< 0.7μmol/L) [33, 8]. Daily recommended intake of retinol (vitamin A) is 400μg/day for children below 5 years and 900μg/day for adults. The dietary inability to meet this target in Nigeria has resulted in vitamin A deficiency (VAD). Improving vitamin A status of children reduces mortality rate by 23% to 30% [1, 6, 32, 8]. The strategy of increasing orange-fleshed sweetpotato (OFSP) consumption helps alleviate vitamin A deficiency [4, 14].

However, lack of efficient seed system or unavailability of vines at time of planting is a major constraint to sweet potato production in Nigeria. Vines are always available in excess at harvesting period and scarce during the period of planting. Propagating material (vine cutting) does not match demand since sweetpotato has low multiplication ratio of 1:20 [21] which is much lower when compared to that of maize 1:300 [11, 21]. If sweetpotato vine is to be used as planting material, the timing of cutting must be determined carefully to optimize both storage root and vine production. Dahinya et al. [12] reported that storage root yields decreased by 31% to 48% when 25cm shoot tips were removed and by 48 – 62% when the entire shoot was removed. Nwinyi [23] also reported a decrease in storage root yield up to 63% when shoots were removed to within 20cm from the ground during several harvesting periods. According toAniekwe [5], pinching back of sweetpotato vines as early as 4 weeks after planting (4 WAP) significantly reduced the growth and yield parameters but these improved significantly later. There is need, therefore, to determine carefully an appropriate cutting interval and develop an alternate method to overcome the problem of low multiplication ratio. This will optimize storage root yield so that the resource poor farmers can take advantage of going into vine production and still get a satisfactory marketable storage root yield at harvest.

The objective of the study was to evaluate the effect of cutting interval on multiplication ratio, carotene and yield of three orange-fleshed sweetpotato varieties.

2. Materials and Methods

The study was conducted at the National Root Crops Research Institute (NRCRI), Umudike, South Eastern Nigeria, during the 2014 and 2015 planting seasons. Umudike is located on latitude 5°29'N and longitude 7°33'E and at altitude of 122m above sea level. Umudike is a typical rain forest vegetation with relative humidity of 50 – 95% and a bimodal rainfall pattern. The soil of the site is classified as an ultisol. The experimental sites were previously under fallow for one year. The field was slashed on 12 May, ploughed on 20 May, harrowed on 27 May and ridged on 2 June, 2014. In 2015, the field was slashed on 20 May, ploughed on 28 May, harrowed on 5 June and ridged on 12 June. Ridges were made 1m apart. The experiment was a 3 x 4 factorial laid out in a Randomized Complete Block Design (RCBD) with three (3) replications. Treatments comprised all possible combinations of two orange-fleshed sweetpotato varieties and a landrace (UMUSPO 1, UMUSPO 3 and Ex-Igbariam) and four cutting intervals (6, 10 and 14 WAP, 8 and 12 WAP, 10 and 14 WAP and no cutting). The twelve treatment combinations were randomly allocated to each plot. Each plot measured 9m^2 (3m x 3m) and 1m alleys between plots was maintained, giving a total of 36 plots. The dimension of the entire experimental site was 47m x 11m (0.0517ha). Sweetpotato vine cuttings of 25cm length with at least 4 nodes were planted on the crest of ridges at the spacing of 1m x 0.3m on the 5th June in 2014 and on 16th June in 2015. This gave a plant population of 33,333 plants/ha for each year. Weeding was done manually with hoe at 4 WAP and 12 WAP respectively. A compound fertilizer (NPK 15:15:15) was applied at the rate of 400kg/ha at 4 weeks after planting. Vines were pruned at 4 weekly interval at 10cm from the base. Harvesting was done at 16 weeks after planting. Both the above ground portion (shoot) and the roots were harvested and weighed. Multiplication ratio was determined following the method of Onwueme [26]. Carotenoids were extracted in duplicate following the method ofRodriguez-Amaya et al. [29, 30] as reported in HarvestPlus Handbook.

The data collected were subjected to analysis of variance and the mean that differed significantly were separated using Fisher's Least Significant Difference test at 5% probability level using statistical package [15].

3. Results

Table 1. *Effect of cutting intervals and variety on multiplication ratio in 2014 and 2015.*

Variety	Cutting Intervals (Weeks After Planting)				Mean
	6, 10, 14	8, 12	10, 14	No cutting	
2014					
Umuspo 1	44.5	39.6	52.4	42.5	44.8
Umuspo 3	14.9	21.5	22.7	19.1	19.6
Ex-Igbariam	29.2	49.7	37.7	31.7	37.1
Mean	29.5	36.9	37.6	31.1	
2015					
Umuspo 1	29.3	24.2	47.2	19.7	30.1
Umuspo 3	16.5	17.5	24.1	16.2	18.6
Ex-Igbariam	19.8	19.9	28.0	20.4	22.0
Mean	21.8	20.5	33.1	18.8	

		2014	2015
$LSD_{(0.05)}$ for variety (V) mean	=	12.7	2.9
$LSD_{(0.05)}$ for cutting interval (C) mean	=	NS	3.3
$LSD_{(0.05)}$ for V x C mean	=	NS	5.7

Sweetpotato multiplication ratio was significantly higher with vine pruning at 10 and 14 WAP than with no cutting or other cutting schedules in 2015 (Table 1). In both cropping seasons, Umuspo 1 variety produced significantly higher multiplication ratio than Ex-Igbariam, which also had higher values than Umuspo 3. Interaction effects in 2015 showed that Umuspo 1 had significantly the highest multiplication ratio of 1:47 when cutting was scheduled at 10 and 14 WAP.

Table 2. *Effect of cutting intervals and variety on fresh shoot biomass (t/ha) of orange-fleshed sweet potato at 16WAP in 2014 and 2015.*

Variety	Cutting Intervals (Weeks After Planting)				Mean
	6, 10, 14	8, 12	10, 14	No cutting	
2014					
Umuspo 1	48.9	49.9	57.2	46.4	50.6
Umuspo 3	6.0	8.7	9.2	7.7	7.9
Ex-Igbariam	20.8	22.3	26.9	22.6	23.1
Mean	25.2	27.0	31.1	25.6	
2015					
Umuspo 1	24.8	23.8	25.8	21.2	23.9
Umuspo 3	3.9	4.9	8.8	4.5	5.5
Ex-Igbariam	16.7	14.5	21.0	17.1	17.3
Mean	15.1	14.4	18.5	14.3	

		2014	2015
$LSD_{(0.05)}$ for variety (V) mean	=	8.9	3.5
$LSD_{(0.05)}$ for cutting interval (C) mean	=	NS	NS
$LSD_{(0.05)}$ for V x C mean	=	NS	NS

The data for individual re-growth shoot yields are not presented but those for total top yields are shown in Table 2. Although significant differences were not detected in both cropping seasons, increasing delay in date of first cut appeared to result in progressive increase in shoot yield on average. Umuspo 1 generally produced significantly higher shoot yield than Ex-Igbariam which also had higher biomass than Umuspo 3. There were no significant effects of interactions on fresh shoot biomass

Table 3. *Effect of cutting intervals and variety on storage root weight/kg of orange-fleshed sweetpotato in 2014 and 2015.*

Variety	Cutting Intervals (Weeks After Planting)				Mean
	6, 10, 14	8, 12	10, 14	No cutting	
2014					
Umuspo 1	0.217	0.130	0.203	0.590	0.285
Umuspo 3	0.053	0.087	0.077	0.287	0.126
Ex-Igbariam	0.027	0.043	0.050	0.333	0.133
Mean	0.099	0.087	0.110	0.403	
2015					
Umuspo 1	0.143	0.127	0.190	0.337	0.199
Umuspo 3	0.050	0.050	0.107	0.160	0.092
Ex-Igbariam	0.050	0.060	0.150	0.217	0.119
Mean	0.081	0.079	0.149	0.238	

		2014	2015
$LSD_{(0.05)}$ for variety (V) mean	=	0.069	0.022
$LSD_{(0.05)}$ for cutting interval (C) mean	=	0.080	0.025
$LSD_{(0.05)}$ for V x C mean	=	NS	0.044

In both years, no pruning produced significantly higher weights of storage roots than vine pruning irrespective of cutting dates (Table 3). Increasing delay of the initial cutting date to 10 and 14 WAP also produced higher root weight than cutting earlier at 6, 10 and 14 WAP or 8 and 12 WAP in 2015. The varieties showed significant differences in weight of storage roots, with Umuspo 1 producing higher root weight than Umuspo 3 and Ex-Igbariam. Interactions were significant such that Umuspo 1 with no cutting produced higher storage root weight than other varieties and other cutting schedules, except 10 and 14 WAP cut where it had significantly higher root weight than Umuspo 3 alone.

Table 4. *Effect of cutting intervals and variety on storage root yield(t/ha) of orange-fleshed sweet potato in 2014 and 2015.*

Variety	Cutting Intervals (Weeks After Planting)				Mean
	6, 10, 14	8, 12	10, 14	No cutting	
2014					
Umuspo 1	14.5	6.7	10.7	50.6	20.6
Umuspo 3	1.8	3.3	2.8	19.1	6.8
Ex-Igbariam	1.0	1.4	1.6	30.3	8.6
Mean	5.7	3.8	5.0	33.3	
2015					
Umuspo 1	8.0	7.2	10.3	27.8	13.3
Umuspo 3	1.1	1.7	5.3	5.2	3.3
Ex-Igbariam	1.6	3.1	7.2	14.1	6.5
Mean	3.6	4.0	7.6	15.7	

		2014	2015
$LSD_{(0.05)}$ for variety (V) mean	=	9.3	1.5
$LSD_{(0.05)}$ for cutting interval (C) mean	=	10.8	1.7
$LSD_{(0.05)}$ for V x C mean	=	NS	2.9

Similar to the data on root weight per plant, storage root yield was significantly higher with no-cutting than with 4 weekly cuts regardless of cutting dates in both cropping seasons (Table 4). Average storage root yield obtained from no- cutting was 24.5t/ha and this was higher than the yield obtained from vine pruning at 10 and 14 WAP, 8 and 12 WAP and 6, 10 and 14 WAP by 289%, 528% and 427%, respectively. Delaying the initial cutting date to 10 and 14 WAP also produced respectively 90% and 111% higher storage root yields than 8 and 12 WAP and 6, 10 and 14 WAP cuts in 2015. Between the varieties, Umuspo 1 produced significantly higher storage root yield than Umuspo 3 and Ex-Igbariam in both years. Interaction effects were significant in 2015, with Umuspo 1 and no- cutting producing higher yield than other varieties at all cutting regimes. Compared to no-cutting, average yield reductions for Umuspo 1 were 63% for 10 and 14 WAP, 74% for 8 and 12 WAP and 71% for 6, 10 and 14 WAP cut.

Table 5. *Effect of cutting intervals and variety on β-carotene (μg/g) of orange-fleshed sweet potato at 16 WAP in 2014 and 2015.*

Variety	Cutting Intervals (Weeks After Planting)				Mean
	6, 10, 14	8, 12	10, 14	No cutting	
2014					
Umuspo 1	20.2	21.0	16.5	19.3	19.3
Umuspo 3	67.7	56.8	85.8	84.8	73.8
Ex-Igbariam	9.7	8.5	8.0	10.6	9.2
Mean	32.5	28.8	36.8	38.2	
2015					
Umuspo 1	45.4	16.7	6.0	42.5	27.7
Umuspo 3	65.1	112.3	105.8	83.3	91.6
Ex-Igbariam	4.2	3.6	5.3	7.2	5.1
Mean	38.2	44.2	39.0	44.3	

		2014	2015
$LSD_{(0.05)}$ for variety (V) mean	=	5.1	1.2
$LSD_{(0.05)}$ for cutting interval (C) mean	=	5.8	1.3
$LSD_{(0.05)}$ for V x C mean	=	10.1	2.3

Carotene yield obtained from no-cutting was statistically similar to that from vine pruning at 10 and 14 WAP in 2014 but significantly higher than those obtained when cutting was scheduled at 6, 10 and 14 WAP or 8 and 12 WAP (Table 5). In 2015, however, no-cutting produced higher carotene yield than vine pruning at 10 and 14 WAP or 6, 10 and 14 WAP but not 8 and 12 WAP. In both years, Umuspo 3 variety produced significantly higher β-carotene level than Umuspo 1, which also had higher values than Ex-Igbariam. Interaction effects showed that Umuspo 3 consistently produced significantly the highest carotene yield with no- cutting or with cutting at 10 and 14 WAP while the lowest carotene levels were obtained from Ex-Igbariam at all cutting schedules.

4. Discussion and Conclusion

Although significant differences were not established, increasing delay in initial cutting date appeared to result in progressive increase in shoot yield as reported on some forage crops by Omaliko [25]. Consequently, vine pruning at 10 and 14 WAP produced higher multiplication ratio than other cutting schedules on average. The average multiplication ratio of 1:35 obtained with cutting at 10 and 14 WAP was higher than the 1:20 reported for sweetpotato [21] by 75 percent. This implies that the date of first cut could be sufficiently flexible, depending on the purpose of cultivation. If the aim of cultivation is for nursery to expand the production area due to high cost or scarcity of vine cuttings, then date of first cut could be done early. However, if the purpose of cultivation is for both vine and root production, initial cutting date may be delayed beyond 10 WAP. Vine pruning at 4 weeks interval regardless of cutting dates reduced root yields by 81% for 6, 10 and 14 WAP, 84% for 8 and 12 WAP and 74% for 10 and 14 WAP compared to no cutting, which produced the highest average root yield of 24.5t/ha. The yield reductions of 74 – 84% obtained in this study when the shoot was cut at 10cm from the ground were higher than the 31 – 48% yield reductions reported by Dahinyaet al. [12] and 63% yield reduction reported by Nwinyi [23] when the shoot was removed within 20cm from the ground. Ahn [2] reported that storage root initiation occurs at about 7 to 9 WAP and root enlargement and development at 4 to 14 WAP while Aniekwe [5] noted that pinching back of sweetpotato vines as early as 4 WAP reduced growth and yield. Uddinet al. and Low et al. [31, 19] also observed that defoliation had a depressing influence on storage root production in sweetpotato. Usually, tuberous root yield is a function of both sink capacity and source potential, and yield is reduced when either is limiting. Besides producing the highest storage root yield, the no cutting treatment also had superior carotene yield than vine pruning on average. Bhagasariet al. [7] noted that high yields obtained in some varieties were due to the tendency to have a strong ability to accommodate more assimilates in the storage root by the high yielders. Umuspo 1 had average storage root yield of 17.0t/ha and this was 233% higher than that of Umuspo 3 while the latter with average carotene yield of 82.7µg/g was 252% superior to the former in carotene content. Similar results were reported by Akaninyanget al. [3] and Ogbologwunget al. [24]. The Umuspo 1 variety which produced the highest root yield, had erectophilic and moderately lobed leaves. Mulunguet al., Peter et al. [22, 28] and Donald [13] reported that crops with erectophilic leaf posture have an advantage in intercepting more light with higher photosynthetic rate and hence higher photosynthetic efficiency. In all, interaction effects showed that average storage root yield was highest in Umuspo 1 with no cutting while carotene yield was highest in Umuspo 3 with 10 and 14 WAP cut in 2014 and with 8 and 12 WAP cut in 2015.

Based on the conditions of this investigation, no cutting produced significantly the highest average storage root yield followed by delaying the date of first cut to 10 and 14 WAP. Cutting at 6, 10 and 14 WAP or 8 and 12 WAP produced lowest root yield and highest weed growth. No cutting which produced highest storage root yield, also had higher carotene content than vine pruning except 10 and 14 WAP cut in 2014 and 8 and 12 WAP cut in 2015. Umuspoproduced more shoot biomass, multiplication ratio and storage root yield than other varieties while Umuspo 3 had higher carotene yield. To obtain substantially high orange-fleshed sweetpotato yields of high quality, no cutting should be adopted while for both high vine and satisfactory root yields, vine pruning could be delayed to 10 and 14 WAP.

References

[1] ACC/SCNAdministrative committee on coordination, Subcommittee on nutrition (1992): Second report on the world nutrition situation. United Nations. Geneva: ACC/SCN/IFPRI.

[2] Ahn, PM: 1993. Tropical soils and fertilizer use, International Tropical Agric. Series. Longman Sci. and Tech. Ltd, UK.

[3] Akaninyang, F., Okpara, D. A., Njoku, J. C., Ogbologwung, P., Okpara B., Akpan, A. E. and Jan, L. (2015). Optimum combinations of organic and inorganic fertilizers for vine, carotene and root yields in orange-fleshed sweetpotato in a humid tropical location. Nigerian Agricultural Journal vol. 46 (Nigeria).

[4] 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-Saharan Africa. In proceedings of the 13th ISTRC symposium, Tanzania: Arusha, Tanzania, pp 711–720.

[5] Aniekwe, N. L. (2014): Influence on pinching back on the growth and yield parameter of sweetpotato varieties in south eastern Nigeria. Journal of Animal and Plant Sciences, 20 (03): 3194–3201.

[6] 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 art series, nutrition policy paper no. 13. Switzerland: World Health Organization Geneva.

[7] Bhagasari, A. S. and S. A. Harmon. (1982): Photosynthesis and photosynthate partitioning in sweetpotatogynotypes. J. Amer. Sot. Hort. Sci., 107: 506-510.

[8] 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 Inter. 45: 52-59.

[9] Chipangura B., Jackson S. (2003). SweetPotato for high yield in Zimbabwe, Farming World, Harare, pp 5–12.

[10] CIP (1998): International Potato Centre (CIP) Annual Report, Lima, Peru, pp. 68.

[11] Cock, J. H. (1985): Rapid propagation techniques for cassava in: Cock J. H.; Reyes, J. A. (eds). Cassava Research, Production and Utilization. Centro Internationel de Agriculture Tropical, Cals, Columbia, pp 747.

[12] Dahinya, M. T.; Hahn, S. K. and Oputa, C. O. (1985): Effect of shoot removal on shoot and root yields of sweetpotato. Exp. Agric 21: 183–186.

[13] Donald, C. M. (1968). The design of the white ideotype. In proceeding of 3rd International Wheat Genetic Symposium, pp 377–387.

[14] 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 agriculture and biology - vol 12, pp 37–43.

[15] Genstat Discover Edition 3 92007). Lawes Agriculture Trust (Rothamsted Experimental Station), Uk.

[16] Graham, R. D., and Rosser, J. M. (2000): Caroteniods in staple foods: Their potential to improve human nutrition. Food and Nutrition Bulletin, 21: 404-409. http://www.cipotato.org/Market/PgmRprts/pr99-00/34waternpdf.

[17] Husman, Z. (2002): Systematic botany and morphology of sweet potato plant, sweet potato germplasm management (*Ipomeabatatas*) CIP Training Manual Section.

[18] Kapinga, R.; Ortiz, O.; Ndunguru J.; Omiaf, E. and Tumwegamire, J. (2007): Handbook ofsweetpotato: Integrated Crop Management Research Outputs and Programme for East Africa (1995–2006). Kampala, International Potato Center (CIP).

[19] Kiozya H. C, Mtunda, K., Kapinga, R., Chirimi, B., Rwiza, E. (2001). Effect of leaf harvesting frequency on growth and yield of sweet potato in the Lake Zone of Tanzania. Afri. Crop Sci. J., 9 (1): 97-103.

[20] Low, J. W., Arimond, M., Osman, N., Cunguara, B., Zano, F. And Tschirley, D. (2007): "A food-based approach introducing orange-fleshed sweetpotato increasing Vitamin A intake and serum retinol concentrations in young children in rural Mozambique" J Nutr, 137: 1320-1327.

[21] 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 (ed) Sentimela S. P.; Monyo, E. and Banzinger, M.

[22] Mulungu, L. S., D. J. Mwailana; S. O. W. R. Shazia, J. P. A. Tarimo, W. M. Apia and R. H. Makundi. (2006). Evaluation on the effect of topping frequency on yield of two contrasting sweet potato (Ipomoea batatas L.) gnotypes. J. of Appl. Sci. 6 (5): 1132-1137.

[23] Nwinyi S. C. O. (1992): Effect of age at shoot removal on tuber and shoot yields at harvest of five sweetpotato (*Ipomeabatatas (*L.) Lam) cultivars, field crops Res. 29: 47–54.

[24] Ogbologwung, L. 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 agroecological zone of Nigeria. Proceedings of Second Biennial National Agricultural Research Organisation (NARO) Scientific Conference, 3-7 November 2014, Speke Resort Munyonyo, Kampala, Uganda.

[25] Omaliko, C. P., E. (1980). Influence of initial cutting date and cutting frequency on yield and quality of star, elephant and Guinea grasses. Grass and forage sci., vol. 35, 139–145.

[26] Onwueme, I. C. (1978): The Tropical Root Crops; Yam, Cassava, Sweetpotato and Cocoyam. John Wiley and Sons, Chichester 234 pp.

[27] Parwada C.; Gadzirayi, T. C. and Sithole, B. A. (2011): Effect of ridge height and planting orientation on *Ipomeabatatas* (sweetpotato) production. Journal of Agricultural Biotechnology and Sustainable Development vol 3 (4) pp 72–76.

[28] Peter, J. V. Cemy and L. Hrusk (1988). Yield formation in the Main Field crops. Amsterdam, New York, pp 336.

[29] Rodriguez-Amaya, D. B. (2001). A guide to carotenoids analysis in foods. Washington D.C.: ILSI Press.

[30] Rodriguez-Amaya, D. B., and Kimura, M. (2004). HarvestPlus. Handbook for carotenoids Analysis. HarvestPlus Technical Monograph Series 2.

[31] Uddin, MK, Mahbub, ASM, Alam, MJ, Hogue, AKMZ: 1994. Fodder and root yield of sweetpotato as affected by dates of vine cutting and varieties, Bangladesh J. Scientific and Indus. Res. 29 (2): 47-53.

[32] West, K. P., Jr. (2003): Vitamin A deficiency disorders in children and women. Food and Nutrition Buelletin, 24: 578-590.

[33] WHO (2009): Global prevalence of Vitamin A deficiency in populations at risk 1995-2005: Geneva Switzerland.

[34] Xiansong, Y. (2010): Rapid production of virus-free plantlets by shoot tip culture in vitro of purple-colouredsweetpotato (*Ipomeabatatas (*L.) Lam). Pakistan Journal of Biology, 42 (3): 2069–2075.