GLADSTONE ROAD AGRICULTURAL CENTRE
CROP RESEARCH REPORT NO. 6

OPTIMAL HARVEST TIME FOR TWO LATE-MATURING HEIRLOOM VARIETIES OF SWEET POTATO

Kenneth VA Richardson
Department of Agriculture
Nassau, Bahamas
December 2011

ABSTRACT

Two late-maturing heirloom sweet potato varieties, 'NP001' and 'Solomon', were evaluated at the Gladstone Road Agricultural Centre to determine the optimum time to harvest, by harvesting at monthly intervals from August 2010 to February 2011. Different harvest times had a significant effect on tuber yield of the two sweet potato varieties. The ideal time to harvest the two late-maturing sweet potato varieties is 9 months after planting to obtain maximum yields without any loss in tuber quality. Delaying harvest until 10 months does not result in a significant increase in yield and after that harvest time there is a significant reduction in tuber quality and yield.

Rows of late-maturing 'Solomon' sweet potato in the field at the Gladstone Road Agricultural Centre

Introduction:

The sweet potato (*Ipomoea batatas* (L) Lam.) is a perennial vine crop grown widely in tropical, sub-tropical and, in some instances, temperate zones of the world. This crop is well known for its adaptability to adverse environmental conditions, such as drought and poor soils (CIP, 1995), and is tolerant of insect pests and diseases (Lebot, 2009). The sweet potato is an important food crop, yielding remarkably well with low input requirements such as fertiliser and water (Kozai *et al.*, 1996; Ndolo *et al.*, 1998; Carey *et al.*, 1999). It is especially popular among farmers with limited resources, and produces more biomass and nutrients per hectare than any other food crop in the world (Prakash, 1994). The starchy tuber of the sweet potato is usually prepared as a fresh food item, but it can be dried, processed into flour or converted into alcohol through fermentation. Among the root and tuber crops, the sweet potato is ranked third in importance, after the potato (*Solanum tuberosum*) and cassava (*Manihot esculenta* Crantz) (FAO, 2003).

In The Bahamas, where it is grown mostly by small-scale farmers, the sweet potato is, perhaps, the most important of the starchy food crops cultivated. Several varieties of sweet potato are cultivated locally, including older, heirloom varieties such as 'Solomon' from Cat Island and 'Pumpkin' from Long Island, in addition to newer, improved varieties like 'Six Weeks' and 'Antigua'. The newer, improved varieties have been replacing some of the older, traditional varieties for their tuber quality, yield and earlier maturity range. The older, late-maturing varieties may take up to ten months to mature, when grown under rain-fed conditions on marginal soils of the southeastern Bahamas.

The 'Solomon' variety of sweet potato is one of the traditional heirlooms that is still cultivated, because of its good flavour and potato bread making qualities. It is preferred over most varieties on Cat Island where it is a favourite on that island. The variety 'NP001' is another heirloom sweet potato that produces well under adverse growing conditions. This variety has been largely forgotten by most local farmers, but is being conserved at the Gladstone Road Agricultural Centre on New Providence. The local name for this variety has not been identified, hence the accession number 'NP001'.

In spite of the limited research on the older, late-maturing varieties of sweet potato, local studies have shown that these heirlooms have tremendous potential under improved agronomic conditions. During the sweet potato variety trials of 2007 and 2008, conducted at the Gladstone Road Agricultural Centre, 'NP001' produced the largest number of tubers per plant, but due to the early harvest most of these tubers were not of marketable yield. Harvesting too early results in low yields and reduced quality of tubers, while harvesting too late contributes to disease and insect pest problems (Villanueva, 1985; Alcoy *et al*., 1993), which also affect tuber quality and yield.

Tuber quality of the sweet potato is determined by its size, appearance, flavour and texture. According to Collins and Walter (1985), the time to harvest is usually determined by factors such as marketable yield, market demand, weather conditions, labour and equipment constraints, rather than any measure of tuber quality, other than size. Tuber size, total yield and marketable yield are known to change significantly during the harvest season (Scott and Bouwkamp 1975). And according to a study by La Bonte and Picha (2000), sweet potato cultivars show qualitative differences in the dry matter content of their tubers, based on harvest date.

A well-timed harvest plays an important role in obtaining the optimum yields from sweet potato. Farmers generally harvest based on experience. In The Bahamas, late-maturing sweet potato varieties are usually harvested after at least ten months of growth, under rain-fed conditions and without fertilisers. The optimal harvest dates for harvesting late-maturing sweet potato varieties under these conditions are not known. For this reason, a small trial was established to determine whether there was any difference in yield for two late-maturing varieties of sweet potato, harvested at different dates.

Objectives:

The purpose of this study was to determine the optimal time to harvest two late-maturing sweet potato varieties by examining the effects of different harvest times on tuber quality and yield.

Materials and Methods:

The study was carried out at the Gladstone Road Agricultural Centre, New Providence, from March 2010 to February 2011. The two late-maturing varieties used in this study were 'NP001' and 'Solomon'. They are characterised by their rapid, vigorous growth and spreading habit. Both of them are older, heirloom varieties that have been, or still are, utilised within the cropping systems of local farmers.

Two-node cuttings of the two sweet potato varieties were rooted in polystyrene trays containing a potting mixture. The plantlets were propagated under green house conditions until they produced a well-developed root system and at least two fully expanded leaves. After two weeks of growth, the plants were transplanted directly to four 100-ft long raised beds, each divided into four plots of 25-ft length. The varieties were assigned to the experimental plots in a completely randomised design.

The usual cultural practices were observed to ensure that an even stand of plants was established in the field plots. The sweet potato plots were grown under rain-fed conditions. Fertiliser was applied at a rate of 250 kg per hectare (220 lb per acre) one month after planting, then again at three months after planting. Before each application of fertiliser, the plots were weeded and cultivated.

Random samples of each of the two sweet potato varieties were harvested from these plots during August of 2010, after 5 months of growth, followed by monthly harvestings until February of the following year. At each harvest, data on the total number of tubers, number of marketable tubers, total weight of tubers and weight of marketable tubers were recorded for each of six plants sampled. Clean, medium to large sized tubers were classified as the marketable yield, while those tubers that were small, damaged and of unacceptable quality were classified as unmarketable.

The mean monthly maximum temperature for the trial period was recorded at 31.0^{o}C (87.8^{o}F), while the mean monthly minimum temperature was 18.5^{o}C (65.3 ^{o}F). The total rainfall for the period was 1159.6 mm (45.7 in). Mean monthly sunshine duration for the period was 8.4 h. Weather data (Table 1) on maximum and minimum temperatures, rainfall and sunshine duration were obtained from the Meteorological Department of the Commonwealth of The Bahamas.

Table 1. Weather data on rainfall, hours of sunshine and mean maximum and minimum temperatures for New Providence for the period of April 2010 to March 2011, courtesy of the Meteorological Department of The Bahamas.

Month	Total rainfall (mm/inches)	Mean monthly radiation (h)	Mean maximum temperature (ºC/ºF)	Mean minimum temperature (ºC/ºF)
March 2010	**35.6**/1.4	**8.5**	**29.8**/85.6	**11.8**/53.2
April 2010	**85.3**/3.4	**9.0**	**30.9**/87.6	**17.1**/62.8
May 2010	**75.4**/3.0	**10.3**	**32.9**/91.2	**21.5**/70.7
June 2010	**72.4**/2.9	**9.4**	**35.2**/95.4	**23.0**/73.4
July 2010	**191.3**/7.5	**8.9**	**34.9**/94.8	**23.9**/75.0
August 2010	**203.7**/8.0	**8.4**	**35.4**/95.7	**23.0**/73.4
September 2010	**191.3**/7.5	**8.5**	**35.1**/95.2	**23.3**/73.9
October 2010	**194.1**/7.6	**7.1**	**32.2**/90.0	**20.5**/68.9
November 2010	**47.2**/1.9	**7.7**	**30.5**/86.9	**16.0**/60.8
December 2010	**45.2**/1.8	**6.8**	**23.6**/71.8	**16.1**/61.0
January 2011	**13.5**/0.5	**6.8**	**24.7**/76.4	**17.4**/63.4
February 2011	**4.6**/0.2	**9.2**	**26.8**/80.6	**18.9**/66.0

Note: Monthly mean values have been rounded up to the nearest tenth

Statistical Analyses:

All experimental results were analysed using Instat+™ and ASSISTAT. Instat is an interactive statistical package, copyright © 2006, Statistical Services Centre, University of Reading, UK. All rights reserved. ASSISTAT, Version 7.6 beta (2011), website – http://www.assistat.com, by Fransisco de Assis Santos e Silva, Federal University of Campina-Grande City, Campina Grande, Brazil.

Results:

The analysis of variance (ANOVA) for tuber yield responses over time are summarised in Table 2. The table showed significant effects of harvest time on total number of tubers, number of marketable tubers, total tuber weights and weight of marketable tubers at a 1.0 % level of confidence. There was a significant difference between the two varieties, at a 5% level of confidence, for the total number of tubers. The variety 'NP001' in past trials has produced a significantly larger number of tubers than any of the other sweet potato varieties examined.

There was a significant interaction of harvest time with variety, indicating different responses of the two varieties to the different times of harvest. The interactive effect was for the number of tubers per plant and total weight of tubers per plant. There was no significant interaction between variety and harvest date for the number of marketable tubers per plant and the weight of marketable tubers per plant.

Table 2. Analysis of variance (ANOVA) for total number of tubers, number of marketable tubers, total tuber weights and weight of marketable tubers among two sweet potato varieties harvested at different times. Std Err is for each treatment mean. Error mean square has 83 df. *, ** and *** denote statistical significance at 5, 1 and 0.1% level of confidence, respectively. df, degrees of freedom; std err, standard error; ns indicates differences between means not significant.

		----------Significance levels----------			
Source	**df**	**Total no. of tubers/plant**	**No. of marketable tubers/plant**	**Total weight of tubers/plant (kg)**	**Weight of marketable tubers/plant (kg)**
Time	6	**	**	**	**
Variety	1	*	ns	ns	ns
Time x Variety	6	*	ns	**	ns
Error	70				
Std. Err		0.41	0.22	0.09	0.05

Mean values for the root yields, harvested at monthly intervals, are shown in Table 3. The total number of tubers per plant for the two varieties changed significantly with time of harvest, but differed significantly from each other only at the eighth month's harvest. The maximum total number of tubers per plant was produced by 'NP001' at eight months. Significant differences in the total number of tubers per plant among different sweet potato varieties have been reported by various researchers (Lowe and Wilson, 1975; Bhagsari and Ashley, 1990; Rajib *et al.,* 2007).

The results (Table 3) indicate that the total tuber weights per plant increased significantly with each consecutive harvest date. At the earliest harvest (at five months), the total weights were 0.09 kg per plant and 0.06 kg per plant, respectively, for 'NP001' and 'Solomon'. The maximum weights per plant were obtained at ten months, 1.57 kg for 'NP001' and 1.98 kg for 'Solomon', but declined thereafter. Comparison of the means of the two varieties also revealed that 'NP001' produced a significantly larger total weight

of tubers per plant than 'Solomon' did during the seventh and eighth month harvest dates. No other harvest dates showed a significant difference between the two varieties for the total weight of tubers per plant.

Table 3. Mean values of yield responses of two sweet potato varieties assessed over 7 harvest dates from August 2010 to February 2011.

Harvest date	Total no. of tubers/plant		No. of marketable tubers/plant*		Total weight of tubers/plant (kg)		Weight of marketable tubers/plant (kg)*	
Variety	NP001	Solomon	NP001	Solomon	NP001	Solomon	NP001	Solomon
Five months	1.17dA	1.00cA	0	0	0.09cA	0.06bA	0	0
Six months	5.00cA	3.83bcA	0.67	0	0.78bA	0.22bA	0.2	0
Seven months	6.50bcA	4.67bA	1.33	0	1.13abA	0.18bB	0.38	0
Eight months	10.5aA	4.00bB	3.00	1.50	1.37abA	0.56bB	0.55	0.28
Nine months	8.83abA	9.00aA	3.17	4.17	1.47aA	1.93aA	0.79	1.04
Ten months	8.17 abA	8.33aA	3.00	4.00	1.57aA	1.98aA	0.81	1.01
Eleven months	8.33 abA	8.00aA	2.83	3.50	1.48aA	1.87aA	0.64	0.80

The t-test at a level of 5% probability was applied. For each harvest date, means within rows bearing different uppercase letters differ significantly at 5% level of confidence. For each variety, means within columns bearing different lowercase letters differ significantly at 5% level of confidence. *The t-test of comparison of means was not applied as there was no significant interaction between variety and harvest date for the number of marketable tubers per plant and the weight of marketable tubers per plant.

The marketable yields (kg) of the two sweet potato varieties are shown in Figure 1. The variety 'Solomon' produced larger marketable weights of tubers than did 'NP001', even though 'NP001' produced marketable sized tubers much earlier, after six months, than did 'Solomon'. The variety 'Solomon' did not produce any marketable tubers until the eighth month. These differences in tuber development corroborate the research of Lowe and Wilson (1974), who investigated differences in tuber initiation, tuber growth and the partition of assimilates during sweet potato tuber development. Their results showed that the differences in the patterns of tuber development were not related to final tuber yield.

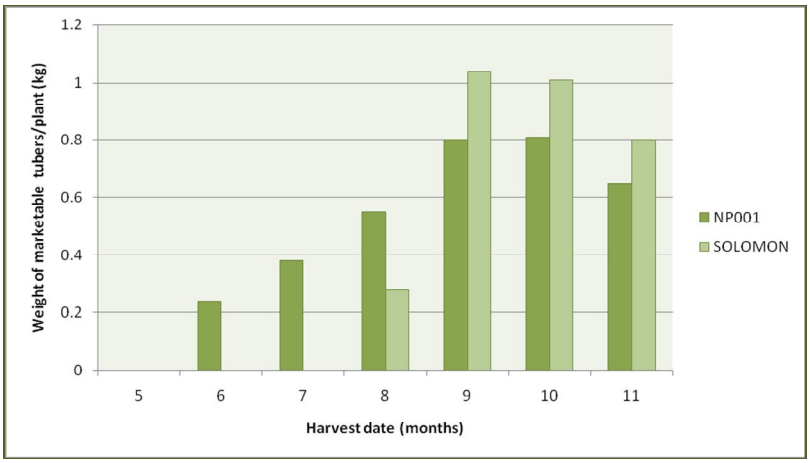

Fig. 1. Changes in marketable tuber weights (kg) per plant of the sweet potato varieties 'NP001; and 'Solomon' over time (months).

Between the ninth and tenth months, tuber weights increased, producing the largest marketable weights by both varieties, followed by a significant decline in production during the eleventh month. The decline in tuber yield over time was the result of increasing numbers of the tubers becoming unmarketable due to weevil damage, cracks and other defects. This increase in weight of marketable tubers with each consecutive harvest followed by a decline was also observed by Monamodi *et al*. (2003). Varietal

differences with respect to weight of marketable tubers were also reported by Lowe and Wilson, (1975), Rajib *et al*., (2007), and Mukhtar *et al*., (2010).

Discussion:

The results of this study demonstrated that in both sweet potato varieties, the time to harvest affected tuber yield. These results conform with those of Monamodi *et al*., 2003, who observed similar results, but further demonstrated that time had an effect on dry matter accumulation in tubers, which increased with time. The number of marketable tubers per plant increased as they were allowed to develop over time. These results are consistent with those of Muli and Agili (2010), whose study demonstrated that the number of marketable roots per plant, percentage of marketable roots and percent dry matter increased as more time was allowed for tuber development, before harvesting.

There was a significant increase in marketable tuber weight per plant from six months after planting to eight months after planting. This remained steady until about the tenth month, and then decreased dramatically in both varieties. The higher yielding 'Solomon' sweet potato variety gave an acceptable yield at nine months, which is three months later than that normally expected for early-maturing varieties. Yield from the variety 'NP001' were not as high, but it produced marketable tubers as early as six months after planting.

The ideal time for harvesting the variety 'Solomon' is nine months after planting, for 'NP001' it is between nine and ten months after planting. After these harvest times, there is a significant reduction in yield of marketable tubers. Based on these results, it would appear that for both varieties, the tuber yield at the optimal harvest date was due to an increase in total tuber weight, rather than an increase in total tuber number.

This study has demonstrated that tuber quality and yield differed with different harvesting dates. Delaying harvesting resulted in a decline in marketable tubers. By harvesting their sweet potato crop at the right time, and with the appropriate management practices, local farmers could expect optimum returns on their investment (Schultheis *et al*., 1999). This study suggests that the optimal time for harvesting of the late-maturing sweet potato varieties 'NP001' and 'Solomon' is at nine months after planting, to obtain maximum yields without any loss in tuber quality.

General Comments:

From the above discussion we saw that delaying harvest until ten months does not result in a significant increase in yield and after that harvest time there is a significant reduction in tuber quality and yield. It is recommended that local farmers used improved agronomic practices to enhance tuber development during the growth phase and harvest at the earliest times, between eight and nine months, to achieve maximum yields.

References:

Alcoy, A.B., Garcia, A.G., Baldos, D.P., Robles, R.P. and Cuyno, R.V. (1993). Influence of planting material and time of harvest on plant to plant yield variability of sweet potato. *Philipp. J. Crop Sci.* **18**(3), 187-193.

Bhagsari, A.S. and D.A. Ashley. 1990. Relationship of photosynthesis and harvest index to sweet potato yield. *J. Amer. Soc. Hort. Sci*. **115**:288-293.

Carey, E.E, Gichuki, S.T, Maisiba, G, Tana, P.O, Lusweti, C, Ngugi, J, Maina, D.K, Malinga, J, Omari, F, Kamau, J.W, Kihurani, A, Ndolo, P.J. (1999). Sweetpotato variety selection for Kenya: Food, feed and income. Final report of the KARI Agricultural Research Fund Project: The International Potato Center (CIP) and Kenya Agricultural Research Institute (KARI).

Collin, W.W. and Walter, M.H., Jr. (1985). Fresh roots for human consumption. Pages 153-l74 *in* J. C. Bouwkamp, ed. Sweet potato products: A natural resource for the tropics. CRC press. Boca Raton, FL.

Food Agricultural Organization (2003). Bull. Stat. 4: 46-47 FAO Secretariat Rome, Italy.

International Potato Center (CIP). (1995). People centered research for sustainable production. Circular, Vol. **21** (21:1).

Kozai, T., Kubota, C. and Kitaya, Y. (1996). Sweet potato technology for solving the global issues on food, energy, natural resources and environment in the 21st century. *Environ. Control in Biol*. **34**:105–114.

La Bonte D.R., Picha D.H., Johnson H.A. (2000). Carbohydrate related changes in sweet potato storage roots during development. *J Am Soc Hort Sci* **125**:200–204

Lebot, V., 2009. Tropical root and tuber crops cassava, sweet potato, yams and aroids, CABI, Oxfordshire, UK, pp. 91-274.

Lowe, S.B. and Wilson, L.A. (1975). Yield and yield components of six sweet potato (Ipomoea batatas) cultivars I. Contribution of yield components to tuber yield. *Exp. Agric.*, **11**: 39–48.

Lowe, S.B. and Wilson, L.A. (1974). Comparative analysis of tuber development in six sweet potato [*Ipomoea batatas* (L.) Lam] cultivars: I. Tuber initiation, tuber growth and partition of assimilate. *Ann. Bot.* **38**:307-317.

Monamodi, E.L., Bok, I. and Karikari, S.K. (2003). Changes in nutritional composition and yield of two sweet potato (*Ipomoea batatas* L.) cultivars during their growth in Botswana. *UNISWA J. Agric*., **11**: 5-14.

Mukhtar, A.A., Tanimu, B., Arunah, U.L., and Babaji, B.A. (2010). Evaluation of the agronomic characters of sweet potato varieties grown at varying levels of organic and inorganic fertilizer. *W. J. of Agric. Sci.,* **6** (4): 370-373.

Muli, M.B. and Agili, S. (2010). Performance of orange-fleshed sweet potato as influenced by genotype, harvesting regime and farmer preference. (*http://www.kari.org/biennialconference/conference12/docs/* Performance of orange-fleshed sweet potato as influenced by genotype, harvesting regime and farmer preference.*pdf*)

Prakash, C.S. (1994). "Sweet Potato Biotechnology: Progress and potential." *Biotechnology and Development Monitor*, No. **18**, p. 18-19/22.

Rajib Nath, A., Chattopadhyay, C.K., Kundu, A., Majumder, S.K.J., Islam, Sunil Gunri and Sen, H. (2007). Production potential of sweet potato in red and laterite zones of West Bengal. *Journal of Root Crops*, Vol. **33** No. 2, 97-103.

Ndolo, P.J., Malinga, J., Ndinya, C. and Mutebi, W. (1998). On-farm evaluation of sweet potato varieties in important sweet potato production areas in Western Kenya-Kakamega: KARI.

Schultheis, J.R., Walters, S.A., Adams, D.E. and Estes, E.A. (1999). In-row plant spacing and date of harvest of 'Beauregard' sweetpotato affect yield and return on investment. (abstract) *HortSci*. **34**, 7, 1171-1191.

Scott, L.E. and Bouwkamp, J.C. (1975). Effect of chronological age on composition and firmness of raw and processed sweet potatoes. *HortScience* **l0**: 165-168.

Villanueva, M.R. (1985). Technology for sweet potato production in Southeast Asia. *The Radix* **7**(2): 8-12.