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HARVEST TIME AND CUT-SETT SIZE INFLUENCE ON SUBERIZATION AND SPROUTING IN YAM

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ABSTRACT: *Suberization is natural healing of wounds in tubers. It has been used extensively in potato seed production and in curing wounded yams for storage. Its use in the production of cut-sett in yam has not been investigated. Current research was carried out to investigate the effects of harvest time and cut-sett size on suberization and sprouting in yam. The experimental design was a 2x3 factorial fitted into a randomized complete block. The results obtained showed that harvesting in September/October gave close to 100 percent suberized sett, irrespective of cut-sett size. Micro-sett, as small as 5g, could therefore be produced by suberization. Suberization technique will eliminate the need for wood ash or pesticides recommended for use in cut-sett production. This technique may, therefore, encourage the adoption of cut-sett for the production of ware and/or seedling yams. Earlier recommendations on methods and time of yam sett production may be reviewed in the light of current findings.*

KEYWORDS: Suberization, yam cut-sett, yam mega-sett, yam mini-sett, yam micro-sett, harvest time.

INTRODUCTION

Yam (*Dioscorea spp*) is the preferred starchy staple for over 150 million people in West Africa. Yam also plays an important role in the socio-cultural and religious life of the people. Despite its importance, average production and yield of yam appear to have been steadily declining. Total production in 2008 was 54 million metric tones. This dropped to 48.7 million metric tones in 2010 (FAO-Stat, 2011). Previous researchers have identified the shortage of good quality and affordable planting materials as the main constraint militating against increased yam production (Igwilo, 2007; Oguntande *et al*., 2010). Traditional yam planting materials are derived from the edible tubers and these are expensive (50% of the total production cost), bulky to transport and have low multiplication ratio (TECA-FAO, 2013; Nweke *et al.*, 1991). These problems necessitated a search for an alternative technology to produce planting materials rapidly and at a minimum cost.

In the early 80s, the yam mini-sett technique was developed for the rapid production of seed tubers, separated from the production of ware yams (Okoli *et al*., 1982). This technique utilizes a small (20 – 50g) part of a whole, non-dormant, tuber periderm and some cortex parenchyma for planting. The mini-sett are treated either with wood ash or a fungicide plus insecticide against pathogens, then air – dried for two days before planting (IITA, 2013).The resulting tuber from the planted mini-sett is sufficiently

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large to serve as a seed tuber that is suitable for the production of food tubers. For over 30 years, the mini-sett technique remained the only on-farm practical alternative to the use of ware yams for planting. It offers a good opportunity for commercial production of seed yam.

However, research has shown that the mini-sett technique has had limited adoption in Nigeria. A large percentage of farmers who attempted the mini-sett technique has reportedly abandoned it (Iwueke, 1990; Okoro, 2009; IITA, 2013). Okoro (2009), for example, reported that over 79 percent of the farmers who attempted the technique abandoned it because of the low percentage of germination of the sett due to sett drying up or rot. Other reasons for non-adoption were that the technique was cumbersome, difficult to understand, labour intensive, hazardous and expensive due to the need for pesticides. Most of the farmers who attempted the technology reverted to the use of traditional yam planting materials (IITA, 2013).

A recent attempt was made to encourage adoption of the mini-sett technique (IITA, 2013). The large, initial response was short-lived because the "adapted yam mini-sett technique" succeeded in improving on sprouting rate and yield, but failed to address the use of pesticides or made the technique fit into the traditional farming system. One alternative technique that may address most of the issues raised by the farmers for non-adoption is the use of suberization. Suberization is an age-long process of rapid healing of various kinds of wounds that may be inflicted on tubers during harvest, handling and/or seed cutting (Lulai, 2004). In this healing process, the intact suberized layer of the periderm of the tuber provides a durable barrier that is resistant to bacteria and fungi infections (Artshwager and Starrett, 1931). The healing process has been utilized extensively in potato seed production (Menzel, 1985), caladium multiplication (Sheehan, 1955; Wilfret, 1995) and recommended for curing yam for storage (Passam *et al.*, 1976 a & b; Been *et al*., 1977; Passam, 1999).

In yam curing, suberization of cut surfaces is reported to be optimally induced in laboratories at high temperatures (35^{o}C) and relative humidity of 85 – 90 percents (Passam, 1999).Similarly, Lulai (2004) recommended that 'during suberization, high relative humidity must be maintained to prevent desiccation and death of suberizing cells at the wound surface'. Such controlled environments are, however, not available to traditional farmers in Nigeria. Nevertheless, traditional farmers harvest and rebury yam tubers that are too big or small for food in the soil and these suberize completely if done at the appropriate time. Milking and topping techniques in yam also work under the same principle of suberizaiton. Harvesting and preparation of yam cut-sett (mega-sett, mini-sett and micro-sett) within this appropriate harvest time may heal the cut-sett, thus eliminate the need for wood ash or pesticides recommended for wound treatment.

This research was undertaken with an objective of ascertaining the most appropriate harvest time and cut-sett size for optimizing suberization and sprouting rates of cut-sett of yam in the Rainforest Agro-ecology of South Eastern Nigeria.

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MATERIALS AND METHODS

The study was conducted at the Research and Teaching Farm of the Department of Agronomy, Cross River University of Technology, Obubra Campus, Nigeria. Obubra (06^o 05' and 06^o 10' N; 08^{o}21' and 08^{o}25'E) lies in the Tropical Rainforest agro-ecology of the Equatorial Climatic Belt. The area experiences a mean annual rainfall ranging from 2000mm to 2250mm, well distributed over 8 months of the year (Inyang, 1975). Average annual temperature of Obubra ranges between 28^{o}C to 32^{o}C and with an average relative humidity of 50 & 80% during the dry and rainy seasons, respectively.

The experimental materials were various sizes of white yam (*Dioscorea rotundata* Poir) harvested from an experimental farm planted on February 1, 2013. Treatments consisted of four harvest times regularly spaced at 30 days interval (September 1 [HT_1], October 1 [HT_2], October 30 [HT_3] and November 29 [HT_4]), and 3-yam cut-sett sizes of 101 – 200g (mega-sett), 11 – 100g (mini-sett) and 1 – 10g (micro-sett). The design of the experiment was a 4 x 3 factorial arrangement of harvest time and cut-sett size in randomized complete block design with three replications. At each harvest time, 30 pieces of cut-sett were randomly prepared for each size group to give 360 pieces for all treatments. The cut-sett were returned to the heaps from where the yams were harvested and topped up with soil to suberize. Final harvest of the cut-sett was on 30th January, 2014. After harvest, each of the 30 pieces of cut-sett at each harvest interval and in each size group was sorted as per treatment for storage in sawdust media. Ten pieces from each of the 30 pieces made up a replication.
Analysis of variance was performed on all data sets using Window SPSS Version 14. Treatment means were separated and compared using Duncan Multiple Range Test (Gomez and Gomez, 1984).

RESULTS

The mean monthly rainfall was highest during the month of September, decreasing progressively from September to November (Table 1). Average monthly soil temperatures during the experimental months showed little or no variation between the months.
Table 2 presents the results of the harvest time and cut-sett sizes on suberization rate.
Table1: Rainfall and soil temperature during the experiment in 2013/2014

Month	Average rainfall (mm)*	Mean soil temperature (^{o} C)
August	2759 (10)	32
September	1715 (9)	31
October	1520 (13)	31
November	1509 (6)	30
December	680 (2)	29
January	125 (1)	28
February	415 (2)	30

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Source: Department of Agronomy Meteorological Services. * Figures in brackets are number of rainy days in the month.

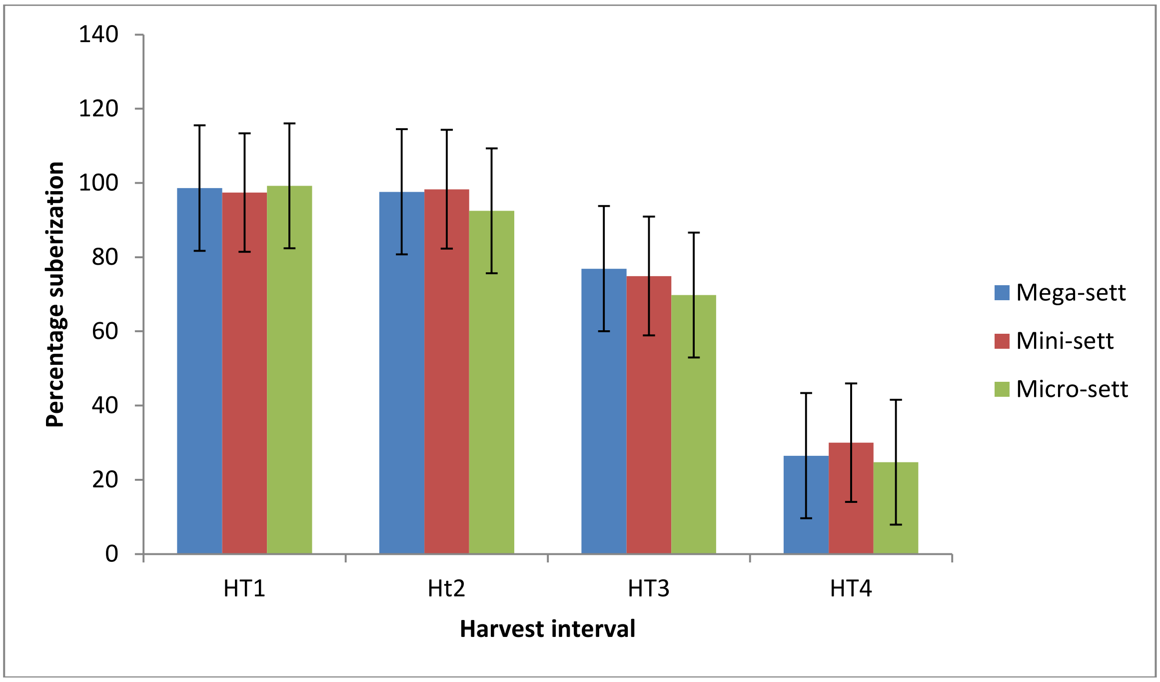

Figure 1: Effects of harvest time and sett size on suberization rate in yam (%). HT1 = September 1, HT2 = October 30, HT3= October 29, HT4 = November 28 .
SE ± 4.42

The results showed that there were no significant differences between rates of suberization within cut-sett sizes. Between harvest intervals, there were significant decreases in suberization rates from October 1 t0 November 28. By November 28, suberizaiton rate in cut-sett decreased by 74, 70 and 72 percents in mega-, mini- and micro-sett, respectively, over that obtained in September 1.
Table 3 presents the effects of harvest time and cut-sett size on sprouting rate of suberized sett. At any of the harvesting intervals, there were no significant differences in sprouting rates between the cut-sett sizes. However, in each of the cut-sett sizes, there was a progressive decrease in sprouting rate at all harvest intervals from September 1 to November 28.

Table 3: Effects of harvest time and cut-sett size on sprouting in yam (%)*

Harvest time	Cut-sett size		
	Mega-sett	Mini-sett	Micro-sett
HT_1	99.1a	97.6a	98.3a
HT_2	94.8b	93.3b	94.2b
HT_3	74.3c	81.5c	73.7c
HT_4	26.3d	30.2d	29.1d

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*Cumulative emergence at 3 months after harvest. Means followed by a common letter in a column are not significantly different at 5% level of probability. . HT_1 = September 1, HT_2 = October 30, HT_3 = October 29, HT_4 = November 28
SE ± 1.42

DISCUSSION

The high temperatures experienced during the experimental months were ideal for wound healing in yam. Passam (1999) reported that both metabolic activities and the rate of wound repair in yam were critically dependent on temperature and moisture. He observed that at 35^{o}C, suberizaiton occurred within 2 days and periderm formation in 4 days. At lower temperatures (25^{o}C or 17^{o}C), he observed progressive delay in suberization (3 – 5 days) and periderm formation (5 – 10 days). He also observed visible infections by pathogens within 3 – 4 days when tubers were stored at 17 or 25^{o}C. These were not observed at 35^{o}C.

There were also high amount of rains during the experimental months of September and October with progressive decrease towards November. Available moisture may also have aided suberization as observed in those months (Table 2). Artshwager and Starrett (1931) reported that low moisture reduced rate of wound repair in potato and sweet potato. In yam cut-sett, low relative humidity has been reported to provoke rapid drying and cracking of suberin layer, consequently resulting in cut-sett infection through the cracks, even at 35^{o}C, with considerable loss (Passam, 1999). This moisture and temperature requirements also agreed with the work of Lulai (2004) who recommended temperature range of 30-35^{o}C and a relative humidity of 90 % for curing potato. However, Passam (1999) reported that if the wounded surface of yam was kept in such a way that the starch layer contained a high percentage of moisture, the degree of infection increased even at 35^{o}C. The rapid and complete healing of cut-sett as observed in this study under very high moisture content is in contrast with his report.

In tropical ambient conditions, it is expected that if non-sterile yam wounds are not treated to heal, rots appear within a few days. However, it has been observed that when yam tubers are cut, they respond by immediate increase in metabolic activity (Passam *et al*., 1976b). They also observed induction in activities of certain enzymes, notably amylase and invertase, with a concomitant mobilization of food reserves in the wound. These activities in resting or sprouting tubers require mobilization of resources from the food reserve in the yam. Actively metabolizing tubers in yams still photosynthesizing may have a large reserve of reducing and non-reducing sugars for faster suberin deposition. There may also be active plant substances in photosynthesizing plants that help protect the tuber against pathogenic attack.

Cut-sett size had no significant effect on suberization at all harvest times. Within the appropriate time, suberization occurred irrespective of the size of the cortical parenchyma. However, only cortical parenchyma with an attached periderm

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germinated. In 'adopted yam mini-sett technique', IITA (2013) recommended use of bigger, treated sett of 80g to avoid drying up and rotting, and for more effective sprouting. The current research has shown that smaller cut-sett (micro-sett) less than the 25g recommended can successfully be suberized and used to produce seed yams (Undie, 2014).

Harvesting and preparation of sett in September gave the highest rate of suberization. Commercial production of yam sett could be undertaken within this period when farmers mass harvest yams for New Yam celebrations. Early harvesting in September (8 months after planting) gave the yam sett enough time to break dormancy and sprout with early rains. This makes it possible to plant the sett with early rains in February.
Decreasing sprouting rate with harvest time was expected. Sett prepared in September had longer time to wash away sprout inhibitors and break dormancy. Sprout inhibitors such as abscisic acid (ABA) are known to be highly associated with tuberization (Menzel, 1985).

CONCLUSION

This research demonstrated the role of harvest time and cut-sett size on suberization and sprouting rates in yam in Obubra, South Eastern Nigeria. Timely harvesting of yams and preparation of cut-sett in September or early October as observed in this research will allow for effective suberizaiton and eliminate the need to burn down forests for wood ash or expose the peasant farmers and the environment to the hazards of pesticides as recommended for treating cut-sett or wounded yam. Suberization technique is not cumbersome or risky and does not introduce any extra cost to the traditional farming system. It should fit into the farmers' age-long practice of milking and topping. It is expected that the technique will be highly adopted by farmers to facilitate increased production of yam to meet up with the current and growing demand.

FUTURE RESEARCH

It is recommended that this research be replicated in all yam producing agro-ecologies for appropriate time of sett production to be recommended.

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