EFFECTS OF HARVEST TIME AND CUT SETT SIZES ON SUBERIZATION AND SPROUTING EFFICIENCIES IN YAM

Utietiang Litio Undie
Department of Agronomy, Obubra Campus, Cross River University of Technology, Calabar

Abstract
Suberization, an age-long process of natural healing of wounds in tubers, is used extensively in potato seed production and in curing wounded yams for storage. Its use in the production of cut setts in yam has not been investigated. Current research was carried out to investigate the effects of harvest time and cut sett sizes of yam on suberization and sprouting rates in yam. The experimental design was a randomized complete block design (RCBD) with factorial arrangement of treatments. The results obtained showed that harvesting in September/November when 50-100 percents of the leaves had dropped gave up to 100 percent suberized cut setts, irrespective of cut sett sizes. Microsetts as small as 5g could be suberized without loss of weight. Similarly, sprouting rates of suberized setts prepared in September/October were over 90 percent, two months after the final harvest of the setts in January. Suberization technique will enable the adoption of cut setts in yam for the production of megasetts, minisetts and microsetts. It will also eliminate the need to burn down forests for wood ash, or expose farmers and the environment to the toxic effects of pesticide use in cut sett production.

Keywords: Suberization, yam, megasett, minisett, microsett, harvest time.

Introduction

Yam (*Dioscorea spp*) is the preferred starchy staple for over 150 million people in West Africa. It 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 tons 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 necessitated a search for an alternative technology to produce planting materials rapidly and at a minimum cost.

In the early 80s, the yam minisett 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 minisetts 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 minisett is sufficiently large to serve as a seed tuber that is suitable for the production of food tubers.

For over 30 years, the minisett 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 minisett technique has had limited adoption in Nigeria. A large percentage of farmers who attempted the minsiett technique have 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 setts due to setts 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 minisett technique (IITA, 2013). The large, initial response may be short-lived because the “adapted yam minisett 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 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 maintaine to prevent desiccation and death of suberizing cells at the wound surface'. Such controlled environments are, however, not available to traditional farmers. 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 detopping techniques in yam also work under the same principle of suberizaiton. Harvesting and preparation of yam cut setts (megasetts, minisetts and microsetts) within this appropriate harvest time may heal the cut setts and improve on sprouting rate of the cut setts.

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 setts of yam in the Rainforest Agroecology of South Eastern Nigeria.

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.

Experimental treatments/design

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 intervals (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 (megasetts), 11 – 100g (minisetts) and 1 – 10g (microsetts). At each harvest time, 100 pieces of cut setts were selected from each size group to give 300 pieces/treatment. The cut setts were returned to the heaps from where yams were harvested and topped up with soil. Final harvest of the cut setts was on 30th January, 2014. The design of the experiment was a randomized complete block with factorial arrangement of harvest time and cut sett size in three replications.

Statistical Analysis

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.

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. Tables 2 present the results of the harvest time and cut sett sizes on suberization rate.

The results showed that there were no significant differences between rates of suberization in September and November at all cut sett sizes. However, there were decreases in suberization rates of minisetts and microsetts in October, though not significantly.

There were significant decreases in suberization rate at all sizes of cut setts at HT_3 and HT_4. By HT_4, suberizaiton rates in cut setts decreased by 74, 70 and 72 percents in mega, mini and microsetts, respectively, over that obtained in HT_1.

Table 3 presents the effects of harvest time and cut sett sizes on sprouting rate of suberized setts. At $HT_{1,}$ HT_2, HT_3 and HT_4, 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 times from HT_1 to HT_4.

Discussion

The high temperatures experienced during the experimental months were ideal for wound healing in yam. Passam (1999) reported that both metabolic activity 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). They 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 setts, low relative humidity has been reported to provoke rapid drying and cracking of suberin layer, consequently resulting in cut setts 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 setts 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 germinated. In ‘adapted yam minisett technique’, IITA (2013) recommended use of bigger, treated setts of 80g to avoid drying up and rotting, and for more effective sprouting. The current research has shown that smaller cut setts (microsetts) less than the 25g recommended can successfully be suberized and used to produce seed yams.

Harvesting and preparation of setts in September gave the highest rate of suberization. Commercial production of yam setts could be undertaken within this period of mass harvest for New Yam celebrations. Early harvesting in September (8 months after planting) gave the yam setts enough time to break dormancy and sprout early. This makes it possible to plant the setts with early rains in February.

Decreasing sprouting rate with harvest time was expected. Setts 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 setts in September or 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 recommended for treating cut setts 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 detopping. 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.

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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Table1: Rainfall and soil temperature during the experiment in 2013/2014

Month	Average rainfall (mm)*	Mean soil temperature (^oC)
August	27059 (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

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

Table 2: Effects of harvest time and cut sett sizes of yam on suberization rate in yam (%)

Harvest time	Cutsetts sizes		
	Megasetts	Minsetts	Microsetts
HT_1	98.6a	97.4a	99.2a
HT_2	97.6a	98.3a	92.5a
HT_3	76.9b	74.9.b	69.8b
HT_4	26.5c	30.0c	24.7c

Means followed by a common letter in a column and in a row are not significantly different at 5% level of probability, SE ± 4.42

Table 3: Effects of harvest time and cut sett sizes of yam on sprouting rate in yam (%)

Harvest time	Cut sett sizes		
	Megasetts	Minisetts	Microsetts
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

Means followed by a common letter in a column are not significantly different at 5% level of probability, SE ± 1.42