EFFECT OF SETT-SIZE ON THE YIELD OF TWO YAM (*Dioscorea* sp.*)* VARIETIES GROWN IN THE DRY- AND RAINY-SEASONS

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ABSTRACT

The sprouting time of yam tubers had been changed permanently from rainy-season to dry-season period with Giberillic Acid $(GA)_3$ solution. The yield performance of minisetts and peelsetts of two yam varieties were compared in both seasons (using irrigation during the dry periods). Peelsetts (6.25g), obtained from the periderm of yam tubers, and minisetts(25g), which were cut pieces of the yam tubers, were planted in April for the rainy-season crop and in October for the dry-season crop, starting from April 2004 to October, 2005. The yam varieties used were Obiaoturugo (Dioscorea rotundata) and Um 680 (Dioscorea alata). The rainy-season crop matured in November and the dry-season crop matured in May for (D. rotundata) and in June for (D.alata). In the rainy-season harvests, the yields of minisetts and peelsetts per hectare were similar in each variety, whereas in the dry-season harvests, the minisetts of outyielded (P =0.05) the peelsetts while the peelsetts of Dialata, Um680, on the contrary, outyielded the minisetts. Um680 outyielded (P = 0.05) Obiaoturugo in both seasons. On the average, yields were higher in the dry-season than in the rainy-season due mainly to size of tubers rather than number of tubers. The implication of the new technology of growing yams in the dry-season is discussed.

KEYWORDS: Yam, Sett size, Yield, season, Peelsett, minisett,

INTRODUCTION

Traditionally yams (*Dioscorea sp*.) are produced in one season only in a year i.e. during the rainy-season lasting from March/April to October/November in southern Nigeria. Thus yam tubers are planted and harvested at 12-month intervals. Because of this long interval between harvests, a lot of the tubers get rotten in storage and in the markets between June and November.

When yam tubers are harvested in November, they remain dormant for 3-4 months before they sprout in February/March. It is this spouting of yam tubers that triggers off the physiological changes that result in tuber deterioration (Coursey 1961, Passam and Noon 1977). It has been shown that gibberellic acid (GA_3) solution delays sprouting of yam tubers for 4-8 months depending on yam variety (Igwilo 1982, Wickam 1983, Igwilo *et al*. 1988). Because of this yam tuber response to GA_3 treatment, yam tuber sprouting can be delayed to resume sprouting in August /September to be planted in October near the end of the rainy-season and the onset of the dry-season. Thus, yam can now be planted in the dry-season in addition to the traditional rainy-season planting. It has been shown that sprouting of yam tubers is controlled by an endogenous rhythm with annual periodicity (N. Igwilo, unpublished). Consequently, when yams sprout in the dry-season, they maintain a dry-season periodicity permanently. When sprouted tubers are therefore planted in October/ November, they mature in May/June and sprout again in the next October/November ready for another dry-season growth cycle. In other words, there can now be two crops of yam in a year- the traditional rainy-season cropping and the new dry-season cropping with irrigation during the dry period. Thus when the tubers that sprouted in February/ March, at the beginning of the rainy-season, begin to deteriorate in May/June in storage and markets, fresh mature tubers from dry-season planting begin to arrive in the markets and fresh mature tubers are available in the market all year round.

Low availability and high cost of seed-yams in the market have been identified as a major constraint to ware-yam production in Nigeria. As a result, a technique was developed whereby 25g yam pieces (minisetts) are used as planting materials to mass-produce seed-yams of 200-500g weight or even bigger, depending on yam variety. Seed-yams are used as planting materials, for producing the ware (table) yams consumed as food (Okoli *et al* 1982; Igwilo and Okoli, 1988). Increased supply of seed-yams in the market would force down the price of seed-yams and ultimately the price of ware yams.

Another technique was also developed for mass production of whole tubers of the same weight, or bigger, as the minisett pieces (25g). Whole tubers are better planting materials than cut setts of the same weight in terms of sprouting and establishment. This is called the *Peelsett Technique* (Igwilo 1999, 2000) which involves planting yam peels (*peelsetts*) generally thrown away while preparing yam tubers for food, thereby re-cycling wastable materials into tubers called *minitubers*. This is possible because it has been shown that the sprouting loci of yam tubers are located just below the tuber *periderm* (Onwueme 1973). It has also been shown that the smaller the yam tuber material planted, the proportionately bigger the tuber produced (Igwilo and Okoli 1988, *loc.cit*). Minisetts and minitubers would yield seed- yams which in turn would yield ware yams.

The use of peelsetts to mass produce minitubers which together with the minisetts would yield seed-yams have been established as means of multiplying seed-yams in the rainy-season. The purpose of this study therefore is to explore the possibility of mass-producing minitubers from *peelsetts* and seed-yams from minisetts in the dry-season so as to make planting materials available in the dry-season as in the rainy-season.

MATERIALS AND METHODS

The seasonal growth cycle of tubers of two yam varieties- Obiaoturugo (*Dioscorea rotundata)* and UM 680 (*Dioscorea alata*) had been changed from rainy-season cycle to dry-season cycle using gibberellic acid solution (Igwilo *et. al*, 1988). Dry-season tubers were planted in October/ November and rainy-season tubers in March/April.

Seed-yams of the two yam varieties were cut up into minisetts (25g) and peelsetts (6.25g) and planted on 20th April in 2004 and 2005 for the rainy-season cropping. The seed-rate for both sizes was 1t/ha. The experiment was laid out in a split-plot design with varieties in the main plots and sett-sizes in the subplots. The subplots were beds 5m long and 1m wide with 0.5m distance between sub-plots and replicates. Interplant spacing was 1m x 25cm for the minisetts and 25cm x 25cm for the peelsetts giving populations of 10,000 plants/ha for the minisetts and 40,000 plants/ha for the peelsetts. There were four replicates. The dry-season planting materials were prepared as for the rainy-season planting and were sown on 11th October in both dry-seasons of 2004/5 and 2005/6. Each subplot (bed) was mulched with 10kg dry lawn grass soon after planting. The plots were irrigated for 3 days in a week with 1-2 day intervals between one irrigation and another. The rate of irrigation was 4mm/day using Penman's evapotranspiration estimates (Igwilo 1982b). These plots were weeded by hand as necessary. When sprout emergence started, the sprouts were counted at 10-day intervals. The dry-season yam vines were not staked, as the rainy-season *vines, because* it has been shown that staking yam vines has no effect on tuber yield in the dry-season (Igwilo and Udeh 1987, Igwilo 1989, Igwilo 2001).

The minisetts and peelsetts were obtained by cutting yam tubers, which had just begun to sprout, into yam discs 2cm thick. Each disc was then cut into 4 quadrants. Any quadrant less than 25g was put aside, any one weighing more than 25g had its ground tissue slightly reduced to give 25g. These were the *minisetts* used. Some quadrants had their ground tissues reduced until they were 1cm thick. The reduced quadrants were then cut into 3cm lengths. These were the *peelsetts* used in the experiment. Each subplot was planted up with 500g planting materials whether it was minisetts (20pieces) or peelsetts (80 pieces). Each batch of planting material per subplot was dressed with 1g of commercial carbofuran before planting. For the rainy season crop, harvesting was done in November for both varieties. For the dry-season crop, Obiaoturugo was harvested at the end of May and Um680 at the end of June.

RESULTS

Sprout emergence

In the rainy-seasons of 2004 and 2005, sprout emergence started 36-40 days after planting (36-40DAP) in both varieties and sett-sizes. Sprout emergence was completed within 120days in both years. In the 2004/5 and 2005/6 dry-seasons, sprout emergence started 46-50 DAP in both minisetts and peelsetts of Um680 *(D. alata*) and in the minisetts of Obiaoturugo (*D. rotundata)* only. Sprout emergence of the peelsetts of Obiaoturugo was the slowest 60 to 65 DAP. In the dry-seasons, sprout emergence was also completed within 120 DAP in both varieties and sett-sizes . On the average, maximum percentage sprouting was higher (P = 0.05) in Um 680 than in Obiaotutugo, higher in the minisetts than in the peelsetts; the peelsetts of Obiaoturugo in the dry-season being the least (Table 1).

Table 1: Maximum percentage sprouting in the rainy-seasons and dry-seasons

Variety	Sett-size	Rainy-season		Dry-season	
		2004	2005	2004/05	2005/06
Obiaoturugo (*D. rotundata)*	peelsett	77.0	78.2	65.5	63.1
	minisett	82.2	87.3	84.7	85.0
Um 680 (*D. alata)*	Peelsett	84.0	98.5	82.3	78.1
	Minisett	97.5	100.0	99.5	98.8
	Mean	88.2	91.0	83.0	81.3
LSD 0.05) between Varieties :		4.5	17.8	9.2	7.2
Between sett -sizes in each variety:		0.4	NS	11.9	11.4

Yield and yield components

Yam plants matured for harvesting after about 220 DAP in Obioaturugo and 250DAP in Um680 in both seasons, irrespective of date of sprout emergence. In the rainy-season crops, the yams matured for harvesting in October /November whereas in the dry-season, maturity took place in May/June. Um680 yields were 4.0 folds higher (P= 0.05) in the rainy-season and 2.3 folds higher (P = 0.05) in the dry-season than the yields of Obiaoturugo (Table 2). In the rainy-season, tuber yields per hectare were similar between the peelsetts and the minisetts of Obiaoturugo as well as between those of Um680, although the peelsett yields per hectare were slightly higher (15.4%) than the minisetts, pooled together, in both varieties. In the dry-season, however, yield trends were different. The minisetts of Obiaoturugo outyielded the peelsetts whereas in Um680 the peelsetts outyielded the minisetts. The interaction was significant (P= 0.05).

Single plants yielded single tubers except with Um680 minisetts where 23.5% of the plant stands yielded more than one tuber in both seasons (Table 3) but there was no significant difference in number of tubers between seasons in each variety. The average weight per tuber (tuber size) was bigger in the dry-season than in the rainy-season. In Obioaturugo, tubers yielded by minisetts were 70.2% larger (P= 0.05) and those from the peelsetts were 24.0% larger in the dry season than in the rainy-season, whereas in Um680, tubers from the peelsetts were 38.4% larger in the dry-season than in the rainy-season.

On the contrary, tuber sizes yielded by the minisetts of Um680 planted during the dry-season were 10% smaller than the minisetts planted during the rainy-season. The effect of the variation in season, variety and sett-size on tuber size distribution is shown in Table 4. Table 4 also shows the tremendous array of minitubers (20-200g) and seed yams (200- 1,000g) provided by the peelsetts and minisetts respectively for increased ware-yam production in Nigeria, more in the dry-season (partly irrigated) than in the rainy-season (rain-fed).

Table 2: Tuber yield (t/ha) in rainy-seasons and dry-seasons of 2004/2005 and 2005/06 respectively

Variety	sett-size	Rainy-seasons			Dry-seasons		
		2004	2005	Mean	2004/05	2005/06	Mean
Obiaoturugo (D. rotundata)	peelsett	4.64	5.96	5.31	6.57	8.78	7.68
	minisett	4.61	5.94	5.28	8.86	10.11	9.49
Um 680 (D. alata)	peelsett	26.21	27.53	26.87	32.74	32.72	32.73
	minisett	25.34	27.26	26.35	23.00	24.42	23.71
	mean	15.20	16.67	15.95	17.79	19.01	18.40
LSD (0.05) between:							
Varieties :		4.50	1.92		7.45	8.10	
Sett-sizes in each variety:		10.41	3.33		8.98	12.19	
Rainy-seasons and dry-seasons :				2.01			

Table 3: Yield components during 2005 rainy-season and 2005/6 dry-season

		2005 rainy –season			2005/2006 dry -season		
Variety	Sett-sizes	Yield per stand (g)	Tuber size (g)	No of tubers per stand	Yield per stand (g)	Tuber size (g)	No. of tubers per stand
Obiaoturugo	Peelsett	56.4	56.4	1.0	96.0	96.0	1.0
	Minisett	216.7	216.7	1.0	268.8	268.8	1.0
Um680	Peelsett	193.5	193.5	1.0	267.9	267.9	1.0
	Minisett	756.3	632.3	1.0	806.4	697.4	1.0
LSD(0.05) Between							
Variety:		21.3	23.5	N.S.	27.4	30.1	N.S.
Sett-sizes in each variety:		36.9	67.7	N.S.	41.3	40.9	N.S.

Table 4: Tuber size distribution (%) in 2005 rainy and dry seasons

Tuber size class (g)	2005 Rainy –Season				2005 Dry –Season			
	(Obiaoturugo) D. rotundata		(Um 680) D. alata		(Obiaoturugo) D. rotundata		*Um 680 D. alata*	
	Peelsett	Minisett	Peelsett	Minisett	Peelsett	Minisett	Peelsett	Obiaoturugo
< 20	12.1	20.0	0.0	0.0	9.6	0.0	7.0	0.0
20-30	19.3	20.0	2.6	0.0	7.9	0.0	4.2	0.0
30-50	31.8	10.0	11.5	0.0	13.5	15.6	9.9	0.0
50-100	27.3	26.7	16.7	8.3	30.7	12.5	18.3	2.4
100-200	4.5	13.2	34.6	15.5	32.6	6.2	15.5	18.8
200-300	0.0	4.0	27.3	32.7	5.7	18.2	25.4	8.2
300-500	0.0	0.0	5.5	31.2	0.0	31.3	16.9	23.5
500-1,000	0.0	0.0	0.0	9.5	0.0	15.6	2.8	29.4
> 1,000	0.0	0.0	0.0	2.5	0.0	0.0	0.0	17.6

DISCUSSION

Planting yams in the dry-seasons increased the tuber yield (Table 2) in Obiaoturugo (*D.rotundata)* by 62.0% averaged over sett-sizes; also increased the yield of peelsetts of Um680 by 21.8% but reduced the yield of Um680 minisetts by 10% when compared with tuber yields during the rainy-seasons. The seasonal interaction was significant ($P \leq 0.05$). This implies that white yams (*D. rotundata)* are more suited for dry-season production in Nigeria than the water-yams (*D.alata)*. The water-yam originated from the heavy monsoon forests of south-east Asia and is therefore more sensitive to water stress than the white yams (Onwueme 1978, Igwilo 2001, loc cit). The yield interaction between season, variety and sett-size was caused by the fact that sprouts of minisetts of Obiaoturugo emerged from the ground 46-50 DAP and sprouts from the peelsetts emerged 60-65DAP but the two sett-sizes matured for harvesting at the same time (220 DAP). So what the peelsetts of Obiaoturugo gained by plant population, they more than lost in leaf area duration (Allen 1978, Watson 1947). Hence the minisetts in Obiaoturugo outyielded the peelsett counterpart per hectare. In the case of Um680 in the dry-season, sprouts of minisetts and peelsetts emerged from the ground at the same time (46-50DAP) and matured for harvesting at the same time (250DAP) and the peelsetts with larger population gained yield advantage over the minisetts throughout the growing period in the dry-season. Thus the peelsetts of UM680 outyielded the minsietts by 79.7% (P= 0.05). In the rainy-season, the yields of minisetts and peelsetts were similar in Obiaoturugo as they were in Um680 (Table 2).

In general, in both seasons Um680 outyielded Obiaoturugo by more than 2-4 folds because of the inherent differences between the two varieties. Dry-season yields were higher than the rainy-season yields in Obiaoturugo (*D.rotundata)* because of the higher insolation prevalent in the dry-season when compared with tuber yields in the rainy-season. In the dry-season in Um 680, peelsetts outyielded the minisetts because the water-yams are much more sensitive to water stress, a response related negatively to leaf area per plant of Um680. The minisetts plants of Um680 have a larger leaf area per plant exposed to the evaporative effect of sunshine than the peelsetts of Um680. This also suggests that the minisetts of UM680 required more frequent irrigation than was given in this study. The average increase in tuber yield in the dry-season compared with the rainy-season was due to tuber size rather than number of tubers per plant (Tables 3 and 4). More sunshine hours in the dry-season than in the rainy-season might have elicited the increase in yield. Yield is usually correlated with the sunshine hours to which crops are exposed (Igwilo 1982b).

This study has shown that Nigeria can increase its annual output of yams by growing yams twice in a year- in the rainy- season as well as in the dry-season (partly by irrigation). This new technology solves the problem of availability of fresh mature tubers in the market throughout the year. Usually, by traditional practice, when yams are harvested in November, there is no other harvest until the next November. Sprouting starts 3-4 months after maturity. Sprouting triggers off rapid and increasing tuber damage caused by physiological and biotic factors. This damage causes tuber shortage in the market especially after tubers are planted in March/ April. Planting in October/ November will bring fresh mature tubers into the market in May/June. This will prevent the shortage of yams experienced in the market after June. These new harvests will come into market before the usual immature tubers brought into the market in July/August from the riverine areas (the fadamas) usually flooded (seasonally) at this time of the year. However, when this dry-season technology is fully adopted, the riverine farmers will plant their yams in October/November and harvest mature tubers in May/June. The riverine farmers usually plant their yams even before the tubers sprout in February/March and are forced by the level of flood water in July/August to harvest their yams prematurely at this time. The riverine farmers plant their yams before or after February in the dry-season because the terrains which are naturally-flooded in the rainy-season still contain adequate soil moisture in the dry-season to support yam growth and development (Obi and Akamigbo 1981). Upland farmers normally plant their yams in March/April at the onset of the rainy-season. Planting yams in the dry-season will also reduce the expenditure and effort currently expended on prolonging the shelf-life of yam tubers in storage.

Planting yams in the dry-season implies that the plants will be irrigated during the dry periods and that adds to the cost of yam production. However, when yams are planted in the dry-season, it is not necessary to support the yam vines on stakes. It has been shown that it is the leaf and vine damage caused by flood-water during the rainy-season that necessitates the staking of yams (Igwilo & Udeh 1987, Igwilo 1989, Igwilo 2001). Oyolu (1978) had estimated that staking of yams in the rainy-season costs 25% of the total outlay on yam production, the cost which increases with increase in human population and pressure on land. Irrigation will cost far less than 25% of the total outlay on yam production in the long run. There are dams for irrigation in Nigeria especially in the northern region. Water supply through the borehole is increasingly available in Nigeria. Without stakes, yams can now be grown along with vegetables in the dry-season, at the backyard and homestead farms, watered from the taps.

The minitubers recycled from wastable yam peels and the minisetts will yield abundant seed-yams thereby reducing the cost of seed-yams and ware-yams in the market. Eventually the minibers will replace the minisetts as planting materials in seed-yam multiplication, making yam production cheaper. Dry-season yam production under irrigation will expand the frontiers of yam production in Nigeria northwards. It is envisaged that the yam production industry will be divided into three sectors- minituber producers (using wastable yam peels) selling to seed-yam producers who in turn sell to ware yam producers.

Finally, growing yams without stakes will reduce deforestation and improve biodiversity in the bushes and secondary forests from where stakes are obtained.

CONCLUSION AND RECOMMENDATIONS

This study shows that yams grown by irrigation in the dry-season even without stakes give higher tuber yields than yams grown in the rainy-season-mediated through larger tuber sizes rather than larger tuber numbers. Secondly the study also shows that yam can be grown in all the ecological zones of Nigeria. Thirdly, two half-yearly yam harvests will make fresh tubers available in the market all year round and will eliminate storage losses experienced in the barn when yams are stored for twelve months hitherto practiced in the yam production industry. Two seasons of yam harvests in a year without storage losses will boost annual yam production tremendously. Peelsetts gave a higher tuber yield than minisetts in both yam varieties and in both seasons suggesting that yam tubers can be multiplied using yam peels usually thrown away when processing yam tubers for food, thereby re-cycling what otherwise would have been wasted back into the production system.

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