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EFFECT OF PROGRESSIVE REMOVAL OF GROUND TISSUE WITH INCREASING PLANT POPULATION ON THE GROWTH AND YIELD OF YAM (Dioscorea sp) GROWN FROM MINISETTS

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ABSTRACT

A field experiment was conducted in 1991 and 1992 to explore the possibility of using smaller yam pieces than the minisett (25g pieces) to multiply seed yams (Dioscorea sp.) which is a major cost item and a constraint in yam production. Yam minisetts were reduced in size by slicing off the ground tissue (cortex) to give yam pieces of varying thickness: 0.25cm, 0.5cm, 1cm, 1.5cm and 2cm with corresponding populations of 15, 10, 7, 5, 4 pieces per plot. The minisett, with average thickness of 2.4cm and 4 pieces per plot served as control. Approximately 100g of each sett size was planted per plot. One yam variety only - Um 680 (D. alata L.) - was used in 1991 and two varieties - Obiaoturugo (D. rotundata Poir) and Um 680 - were used in 1992.

Thinner setts yielded more than thicker setts with 0.5cm - sett in Um 680 and 1cm - sett in Obiaoturugo giving the largest tuber yields. On the average, the minisetts gave the lowest yields. Propagules from the thinner setts produced earlier foliation and higher leaf area index (LAI) which was highly correlated with tuber yield.

It is recommended that the thinner setts of 0.5 - 1cm thickness which approximate to the thickness of peels thrown away when processing yam tubers for food be used as a better and cheaper method

of mass multiplication of seed yams. It is a major advancement on the currently used Minisett Technique. The new method will greatly enhance sustainability of yam production in the tropics at the farmer's level and will increase the availability of starchy foods from yam tubers to stem the present food shortage.

INTRODUCTION

Previously, yam farmers used to reserve as much as 25-33 per cent of their current tuber harvest as planting material for this subsequent planting season. Planting material therefore accounted for 38-45 per cent of the total outlay on yam production (Hahn et al., 1987). The recommended average seed size for ware yam production is 250g and at the population of 10,000 plants/ha amounts to 2.5t/ha. It has been observed that 25g yam pieces called "Minisetts" at 40,000 pieces per hectare (1 tonne/ha) under good management of early planting, staking and timely weeding, produced similar or higher yields than the 2.5t of seed yams. These minisetts yielded yam tubers 51-87% of which weighed 200g or more in individual sizes (Okoli et al., 1982). Thus a new, cheap and specialised method of seed yam multiplication has been developed reducing the cost of yam production (NRCRI, 1983). Therefore the minisetts gave higher multiplication ratios (ration of yield to planting material per plant) than the seed yam. This improved technology for seed yam production has been widely adopted in yam- producing Africa and beyond (IITA 1988/89, Otoo et at., 1997).

The higher efficiency of the minisett propagules compared with the seed-yam propagules has been attributed to earlier foliation and enhanced net assimilation rate (NAR) at early seedling stage coupled with similar or higher leaf area index (LAI) at maximum foliation (Igwilo, 1988; Igwilo and Okoli, 1988). This implies that yam setts smaller than the minisett might yield even greater efficiency than the minisett. This was investigated in 1991 and 1992 at the Institute Farm of the University of Port Harcourt (04°45'N, 07°08 E) in the high rain-forest zone in Nigeria.

MATERIALS AND METHODS

The experiment was conducted in 1991 and 1992. In 1991, only one yam variety was used - Um 680 (D. alata). Healthy seed yams were cut into discs 2cm thick and each disc was then cut into 4 equal pieces of approximately 25g called minisetts. The number of minisetts could be more or less than 4 depending on the diameter of the disc (Okoli et al., 1982; Igwilo and Okoli 1988). The yam minisetts were further reduced in size by slicing off the ground tissue (cortex) to give yam pieces of varying thickness: 0.25cm, 0.5cm, 1cm, 1.5cm and 2cm. The minmisett with an average thickness of 2.4cm served as control. Approximately 100g of each sett size was planted per plot giving rise to varying number of yam setts per plot. The number of setts per plot and sett weights are given in Table 1.

Table 1: Planting material and spacing used in the experiment

Sett Thickness (cm)	No. of Setts/ Plot	Spacing (cm)		Average Sett weight(g)		
		Inter-row	intra-row	1991	1992	
				Um 680	Um 680	Obiaoturugo
0.25	*15	50	16.7	6.9	7.3	7.7
0.5	10	50	20.0	10.5	10.4	11.0
1	*7	50	33.0	16.0	16.0	16.4
1.5	*5	50	50.0	21.7	21.5	22.1
2	4	50	50.0	25.9	22.5	25.5
Minisett (2.4cm)	4	50	50.0	26.6	27.5	26.3

**for the odd number of setts/plot, the odd sett was planted between the two rows.*

Plot size was 1m^2. In 1991, the six sett sizes were laid out in a randomized complete block design with five replicates. Each replicate was a seed-bed 9m long, 1m wide and about 40cm high. The plots were separated by a distance of 0.5cm. The beds were arranged side by side between which were 0.5cm furrows. In 1992, two yam varieties were used - Um 680 (D. alata) and Obiaoturugo (D. rotundata). The seed beds were 18m long, otherwise similar to those of 1991. The 12 factorial treatment combinations of two varieties and six sett sizes were again arranged in a randomized complete block and replicated 8 times - five replicates were used for yield and three for leaf area determination.

Before planting, the yam setts were dressed with 1g Carbofuran per 100g of planting material. In 1991 the yam setts were planted on 2 June and on 14 May in 1992. On sprouting, the yam vines were linked with raphia fibres (piassava) to wooden stakes for support. Fertilizer (NPK 15.15.15 at 40g/plot or 400g/ha) was applied 85 days after planting (DAP). In 1992, 54 days after planting, number of fully expanded leaves, number of nodes and plant height were used to measure the stage of development of the yam plant. At maximum foliation, 142 days after planting, leaf area was measured. Two plants were sampled at random from each plot in 3 replicates. The laminae were detached, leaf discs were punched out of the leaves using cork borers (No. 12). Complete leaf discs without notches, 100 in number, were selected in each plot and dried to constant weight in ventilated ovens at 70^{0}C. The remaining leaves were also similarly dried. Leaf area was determined from dry weight/area ratio of the leaf discs.

Harvest of tubers was done in December of each year after the yam vines had dried up. The yam tubers were classified into three sizes, counted and weighted. The size categories were: Class A (tubers >200g), Class B (50-200g) and class C (mini-tubers < 50g).

RESULTS

Fresh tuber yield

In 1991, highest tuber yield per plot was observed with 0.5cm sett (Table 2) but there was no significant difference in yield between 0.25 - 1.5cm setts. These sett sizes pooled together out-yielded ($P<0.01$) 2cm - sett and the minisett between which there was no significant difference.

Table 2: Effect of thickness of yam minisetts on sprouting and tuber yield of Um 680, 1991 Data

Sett Thickness (cm)	Maximum % sprouting	Tuber yield (kg/Plot)	Multiplication Ration
0.25	97.3	0.96	11.7
.5	92.0	1.22	13.2
1	97.1	0.99	11.2
1.5	100.0	0.93	9.9
2	96.0	0.64	8.9
Minisett	100.0	0.63	6.3
Mean	97.1	0.90	10.2
LSD (0.05)	N. S.	0.32	5.1

In 1992, tuber yield per plot increased with sett thickness up to a maximum and declined (Table 3).

Table 3: Effect of thickness of minisett on fresh tuber yield (kg/m^2), 1992 Data

Yam variety	Thickness of yam set (cm)						
	0.25	0.5	1	1.5	2	m (minisett)	Variety Means
Obiaoturugo	0.83	0.90	0.92	0.80	0.43	0.37	0.71
Um 680	1.63	1.90	1.57	1.05	1.09	0.71	1.33
Thickness Means)	1.23	1.40	1.25	0.93	0.76	0.54	1.07
	between varieties -			0.16			
LSD (0.05	" thicknesses -			0.27			
" "	" thicknesses - in each variety -			0.38			

With Obiaoturugo (D. rotundata) tuber yield increased with thickness of sett to a maximum at 1cm-sett and declined in thicker setts whereas in Um 680 (D. alata) maximum yield was obtained at 0.5cm - sett. On the average, thinner setts (0.25 - 1cm thick) pooled together gave higher yields (P <0.01) than thicker setts

(1.5cm to minisett) pooled together. Multiplication ratios followed similar pattern as tuber yield with maximum values corresponding with maximum tuber yields (Tables 2 and 4). Thus thinner and smaller setts produced higher yield and multiplication ratios than the minisetts.

Table 4: Multiplication Ratios, 1992 Data

Yam variety	Thickness of yam set (cm)						
	0.25	0.5	1	1.5	2	M	Variety Means
Obiaoturugo	7.5	8.7	9.1	8.7	5.6	5.2	7.5
Um 680	14.9	16.4	14.4	13.1	12.1	8.8	13.4
Thickness Means	11.2	12.6	11.8	10.9	8.9	7.0	10.5
LSD (0.05)	between varieties		-	1.7			
" "	" thickness		-	3.0			
" "	" thickness in each variety		-	4.3			

Seed yams used in traditional ware yam production generally weigh 200g and above (Class A seed yams). Table 5 shows that all sett sizes of Obiaoturugo in 1992 produced an average of 1.1 class A seed yams per plot and Um 680 2.4 seed yamsper plot. There were no significant differences between sett sizes in the production of this category of seed yams but the difference between varieties were significant(P<0.01). However, 1cm-sett produced the largest number of class A seed yams in both varieties. Thinner setts produced larger number of class B (50- 200g) group of seed yams than thicker setts (P<0.01) although 1.5cm - sett and thicker setts were similar. Thus 0.25cm-sett produced 7 folds and 1cm-sett 3.5 folds the number produced by the minisett. There was no significant difference between varieties in this class of seed yams. In the class C group of seed yams (mini-tubers, 50g), the same pattern as in class B prevailed. Thus the thinner the sett, the greater the total number of tubers produced per plot (Table 5).

Table 5: Tuber size distribution (numbers/m²), 1992 Data

Sett thickness (cm)	Class A (Seed Yam >200g)			Class B (Small-medium seed yams: 50-200g)			Class C (mini-tubers: <50g)			Total		
	Obia	Um 680	Ave	Obia	Um 680	Ave	Obia	Um 680	Ave	Obia	Um 680	Ave
0.25	0.6	2.4	1.5	7.6	8.0	7.8	6.4	4.6	5.5	14.6	15.0	14.8
.5	1.0	2.8	1.9	5.0	6.2	5.6	2.2	4.2	3.2	8.2	13.2	10.7
1	1.8	2.6	2.2	3.0	4.6	3.8	1.4	2.2	1.8	6.2	9.4	7.8
1.5	1.2	2.4	1.8	2.0	1.6	1.8	1.0	0.4	0.7	4.2	4.4	4.3
2.	1.0	2.2	1.6	1.2	1.0	1.1	0.6	0.4	0.5	2.6	3.6	3.1
Minisett	0.8	1.8	1.3	1.2	1.0	1.1	0.8	0.6	0.7	2.8	3.4	3.1
Mean	1.1	2.4	1.7	3.3	3.7	3.5	2.1	2.1	2.1	6.4	8.2	7.3
LSD (0.05) between variety means:		0.3	-		1.4		-	0.9			0.8	-
LSD (0.5) between thickness		-	-		-	-		-	-		-	1.4
LSD (0.05) between thicknesses in each variety:		-	-		-	-		-	-		2.0	-
LSD (0.05) for variety/thickness interaction:		-	-		-	-		-	-		2.8	-

Sprouting, growth and development

There was a tendency for the thicker setts to start sprouting earlier than the thinner setts in Obiaoturugo (D. rotundata) but not in Um 680 (D. alata). Sprout counts taken 82 days after planting (DAP) in 1991 and 103 DAP in 1992 to determine maximum percentage sprouting showed that percentage sprouting in Um 680 ranged between 92 and 100 percent and there were no significant differences between sett thicknesses (Tables 2 & 6). However in Obiaoturugo (Table 6), thinner setts gave higher percentage sprouting than thicker setts. Setts 0.25 - 1cm thick pooled together gave higher percentage sprouting than 1.5cm-minisett pooled together ($p<0.01$). UM, 680 gave higher percentage sprouting than Obiaoturugo ($P<0.01$).

Table 6: Effect of thickness of sett on maximum percentage sprouting, 103 DAP, 1992 Data

Yam variety	Thickness of yam set (cm) 0.25	0.5	1	1.5	2	M	Variety Means
Obiaoturugo	94.7	96.0	94.3	84.0	75.0	95.0	86.5
Um 680	100.0	100.0	100.00	100.0	100.0	95.5	99.2
Thickness	97.4	98.0	97.2	92.0	87.5	85.0	92.9
Means		between varieties	-	6.0			
LSD (0.05)		" thickness	-	10.4			
" "		" thickness	-				
" "		in each variety	-	14.6			

Propagules from thinner setts tended to develop faster than those from thicker setts. Data collected at the early seedling stage (54 DAP) in 1992 showed that the number of fully expended leaves per plot (Table 7) declined with increase in sett thickness (P<0.01). However 1.5cm - sett to minisett were similar and produced significantly fewer leaves per plot than the thinner setts. The 0.25cm - sett had the largest number of leaves per plot at this stage of growth. Um 680 had more leaves per plot than Obiaoturugo (P<0.01). The number of fully expanded leaves per plant (Table 7) varied with sett thickness (P<0.01), increasing with increase in thickness to a maximum at 1cm - sett and declining in thicker setts. Um 680 produced at least twice more leves per plant than Obiaoturugo (P<0.01). Size of fully expanded leaves were similar between sett sizes of each variety averaging 39.3cm^2 in Obiaoturugo and 41.0cm^2 in Um 680. Number of nodes per plant at this early growth stage (54 DAP) tended to follow a similar pattern as number of leaves per plant with maximum value at 1cm-sett except that the value for the minisett was closer to this maximum than the other sett sizes in both varieties. Plant height followed almost similar pattern as number of nodes/plant (Table 7). Plant height increased with sett thickness (P<0.01) to a maximum at 1cm - sett in Obiaoturugo and 0.5cm-sett in Um 680 and decline thereafter in thicker setts.

Table 7: Morphological Data at Early Seedling Stage, 54 DAP, 1992 Data

Sett thickness (cm)	Number of fully expanded leaves per plot			Number of fully expanded leaves per plant			Number of nodes per plant			Plant Height (cm)		
	Obia	Um 680	Mean	Obia	Um 680	Mean	Obia	Um 680	Mean	Obia	Um 680	Mean
0.25	29.0	77.2	53.1	2.2	5.1	3.7	7.3	14.2	10.8	41.6	46.0	43.8
0.5	18.8	68.0	43.4	2.6	6.8	4.7	6.4	21.0	13.7	44.4	69.2	56.8
1	18.6	50.8	34.7	3.7	7.4	5.6	7.6	21.7	14.7	57.8	67.6	62.7
1.5	9.4	15.8	12.2	2.4	3.4	2.9	5.7	12.7	9.2	43.6	30.4	37.0
2.	3.2	15.8	10.0	1.4	4.8	3.1	5.1	14.4	9.8	37.8	32.8	35.3
Minisett	6.0	18.6	12.0	2.2	5.3	3.8	6.8	17.9	12.4	50.6	44.8	47.7
Mean	14.2	41.0	27.6	2.4	5.5	4.0	6.5	17.0	11.8	46.0	48.5	47.2
LSD (0.05) between variety means:	4.4			0.6			2.1			n. s		
LSD (0.5) between thickness			7.5			1.1			3.6			5.6
LSD (0.05) between thickness in each variety:	10.7			1.6			5.1			9.7		

Data collected at the maximum foliation of the yam plants (142 DAP) maintained the same trends observed during the early seedling stage (Table 8). Leaf area per plot varied with sett thickness (P< 0.01) and was again maximal at 1cm-sett in Obiaoturugo and at 0.5cm-sett in Um 680. UM 680 produced more leaf area than Obiaoturugo (P<0.01) with average leaf are index (LAI) of 3.5 and 1.4 respectively. Leaf are per plot was highly correlated with tuber yield per plot (r=0.94, P<0.01). Leaf area per plant which did not show a consistent and significant trend was maximal at 1cm - sett in Obiaoturugo and 0.5cm - sett in Um 680. Um 680 produced more leaves per plant than Obiaoturugo (P<0.01).Number of nodes per plant followed the same trend as number of leaves per plant. Averaged for the two varieties, 1cm-sett produced the tallest vines which were significantly taller than the thinner setts pooled together ($P<0.05$) but similar to the thicker setts.

Table 8: Morphological Data At Maximum Foliation, 142 DAP, 1992 Data

Sett thickness (cm)	Leaf Area/Plot (cm^2)			Number of Leaves per plant			Number of nodes/ plant			Plant Height (cm)		
	Obia	Um 680	Mean	Obia	Um 680	Mean	Obia	Um 680	Mean	Obia	Um 680	Mean
0.25	192.1	452.3	322.2	53.0	89.9	71.5	56.8	88.8	72.8	176.2	192.4	184 3
0.5	195.4	541.9	386.7	48.4	146.8	97.6	47.6	118.6	83.1	148.4	226.0	187 2
1	208.7	372.5	290.6	80.6	129.8	105.2	86.4	117.4	101.9	222.8	259.4	241 1
1.5	72.0	306.3	189.2	46.8	139.4	93.1	61.2	112.2	86.7	178.6	165.6	222 1
2.	87.8	221.4	154.6	71.0	153.0	103	70.6	108.6	89.6	189.4	240.2	214 8
Minisett	66.2	226.7	146.5	56.0	139.4	97.7	63.0	113.8	88.4	157.4	246.2	201 8
Mean	137.0	353.5	245.3	59.3	130.1	94.7	64.3	109.9	87.1	178 8	238.3	208 5
LSD (0.05) between variety means:	47.6			20.0			15.1			22.6		
LSD (0.5) between thickness			82.5			34.7			-			39.2
LSD (0.05) between thickness in each variety:	116.7			49.1			-			55.4		

DISCUSSION

The Minisett Technique of yam multiplication has been widely adopted in the yam-producing tropics as a rapid and cheap method of multiplying seed yams (Hahn et al., 1987; Otoo et al., 1987; Iwueke 1990) especially in Nigeria that produces more than 70% of the world output of yams. Seed yams constitute the largest cost item and therefore a major constraint in yam production. This study has shown that progressively slicing off the ground tissue of the yam minisett (25g pieces) and compensating with more setts per unit land area enhanced tuber yield, reaching peak yields when only 1cm of the flesh in *D. rotundata* and 0.5cm in *D. alata* was left on the planting material (Tables 2 & 3). Thus 1cm - setts for *D. rotundata* and

0.5cm-setts for D. alata are the best planting materials for seed yam multiplication. The new planting materials are derived from part of the yam tuber usually thrown away when processing yam tubers for food. Samples of yam peels thrown away during yam processing showed that the thickness of the peels ranged between 0.3 to 0.7cm for D. alata and 0.3 to 1.2cm for D. rotundata. It has been recently suggested (Akoroda, 1987) that yam peels could be incorporated in yam flour probably because of the small crude protein content of the peels (6-11% of dry weight of peels). The peels constitute only 1.2 - 4.0% of fresh weight of tuber depending on yam variety and tuber size.

This study shows that the yam peels, normally wasted, are the planting materials to be used in raising seed yams while the bulk of the cortex or ground tissue serves as food for man and livestock. Onwueme (1973) has shown that yam tubers have no dormant buds and that the meristematic tissue from which the sprouts develop is located just below the thin periderm. Again the Minisett Technique has the limitation that the seed tuber is the ideal source of minisetts because the seed tuber has a smaller diameter for obtaining 25g pieces than the ware tuber which has wider diameter and larger ground tissue. These thin setts (hereby called Peel Setts) can be obtained from both seed and ware tubers and perhaps, more easily, from the ware tubers which have wider curvatures.

The total number of tubers produced increased inversely with sett size (Table 5). With Obiaoturugo (D. rotundata) where 1cm-sett was the best, the total number of tubers produced in 1992 was 2.2 folds the number produced by the minisett. With Um 680 (D. alata) where 0.5cm - sett was the best, the total number of tubers produced was 3.9 folds the number produced by the minisett counterpart. In the tuber size categories, the much-desired size A category (>200g) generally used for ware yam production, the minisett was out-numbered by the smaller sett sizes except 0.25cm - sett (Table 5). Thus the minisett in Obiaoturugo had the potential of producing 8,000 standard size A seed yams per hectare whereas the 1cm - sett had the potential of producing 18,000/ha. With Um 680, the corresponding numbers were 18,000/ha for minisett as against 28,000/ha for the 0.5cm sett. In the smaller tuber size categories, the minisett was greatly outnumbered - 2.5 and 6.2 folds in the size B category (50-200g) and 1.8 and 7.0 folds in the size C category (<50g) when compared with the 1cm-sett in Obiaoturugo and 0.5cm - sett in Um 680 respectively. The larger tubers in the B size category can be used to raise ware yams while the smaller tubers together with the C category of tubers can be used to raise class A category of tubers the following season by planting them whole or cutting them into minisetts.

The smaller the sett size the higher the percentage sprouting especially with Obiaoturugo and the higher the multiplication ratio (Table 2, 4, & 6). The cause of the reduction in percentage sprouting with increase in sett size in Obiaoturugo is not fully understood. It is likely that since it took longer time for Obiaoturugo to start and complete sprouting compared with Um 680 (35 DAP against 22 DAP for onset and 78 DAP against 50 DAP for completion of sprouting respectively) the larger ground tissue of the larger setts provided nourishment for the multiplication of rot fungi and nematodes of yams (Onwueme, 1978) which might have damaged some of the larger setts before they had chance to sprout. It has been reported that yam peels contain anti-fungal substances (Ogundana et al., 1983). Perhaps Um 680 contains more of these compounds than Obiaoturugo. The higher multiplication ratios of the smaller compared with the larger setts was medidated through earlier foliation (Table 7) and higher leaf area index (Table 8) which was highly correlated with tuber yield. A similar trend has been reported earlier when the growth of minisett propagules was compared with the growth of seed yam propagules (Igwilo, 1988; Igwilo and Okoli, 1988).

The use of peel setts to generate seed yams will greatly enhance the sustainability of yam production in the tropics by further increasing the availability and thereby reducing the cost of seed yams, the major cost item in yam production. Both seed yams and ware yams are the sources of these peel setts unlike the minisetts which are cut from seed yams only.

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