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A REVIEW OF SEED YAM PRODUCTION BY THE MINISETT TECHNIQUE

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SUMMARY

Seedyams constitute 33-50 per cent of the total outlay in yam production. The traditional method of producing seed yams involves cutting up one seed yam into four pieces (setts) each weighing 150 g . Each sett yields 600 g seed yams that cost ₦1.00 each. This means an outlay of ₦10.000 worth of seed yams to plant one hectare for ware yams. The minisett technique, developed by the National Root Crops Research Institute, Umudike by 1982 has been under field evaluation by Nigerian farmers in the last two years and is aimed at eliminating the constraint imposed by shortage and high cost of seed yams. This paper describes the technique, and reviews the major research efforts at Umudike that have led to the development of the technology. A profit of about ₦3000/ha or more can be realized by farmers who adopt the technique. The cost of producing seed yams is reduced from ₦60 k/kg to 20 k/kg. This technique if properly harnessed will revolutionise yam production in the World and offer farmers a reliable method of economic large scale production of seed yams.

RESUME

Les ignames de semences constituent 33 à 50 pour cent du coût total de la population d'igname. La méthode traditionnelle de production des ignames de semence comporte la fragmentation en quatre d'un tubercule, chaque fragment pesant 150 à 300 g. De chacun d'eux on récoltera environ une igname de semence de 600 g revenant à 1 naira. Il s'en suit une charge d'environ 10 000 nairas pour planter un hectare d'ignames commercialisables. La technique des minifragments, développée par l'Institut National de Recherche sur les cultures de tubercules (Umudike) testée en plein champ par des exploitants nigérians au cours des deux dernières années, vise à éliminer la contrainte imposée par *la pénurie et le coût des ignames de semence. Cette publication décrit la technique et passe en revue les recherches principales qui l'ont engendrées. Les exploitants adoptant cette technique peuvent réaliser un profit d'environ 3000 Naira/ha et plus. Le coût de production des ignames de semences est réduit de deux tiers environ. Cette technique correctement aménagée révolutionnera la production mondiale d'igname et elle offre aux exploitants une méthode fiable de production économique d'igname de semence à grande échelle.*

INTRODUCTION

During the 1984 planting season, 500 g. seed yams cost up to one Naira ($1.40) each in most local markets in Nigeria. This means an outlay, of ₦10,000 for seed materials to plant one hectare. Although other costs especially labour will be incurred in planting, staking, weeding and harvesting, it is seen that the cost of seed yams accounts for a disapproportionate outlay in yam production. Cost of seed yam is put at more than 50 per cent of total production cost of ware yams in Nigeria. This high cost of seed is partly the reason why farmers cannot grow yams extensively in spite of high prices fetched by ware yams in the local markets.

The traditional method of producing seed yams involves cutting a seed yam into 4 pieces called setts. Each sett weighs 100-300 depending on location and tradition. The setts are then planted and seed yams weighing 200-1000 grams are produced. With this low multiplication ratio of 1:4, the number of seed yams produced is small. A "seed" yam production ratio (weight planted : weight harvested) ranging from 2.8 to 5.1 for cultivars of *D. rotundata* is normal. Other yam species except *D. alata* had even lower ratios. This low multiplication ratio in yam compares poorly with the grain crops. In maize (*Zea mays*) for instance, a seed planted may produce 2 cobs each having up to 200 seeds : a multiplication ratio of 1:400. The need therefore existed for a method of rapidly multiplying yam planting materials. The minisett technique was developed to fill this need.

The minisett technique involves - cutting a yam tuber into 2 cm thick quadrants weighing approximately 25 g and planting them after dusting with an insecticide/ fungicide blend. A large number of investigations were carried out into the field handling of the small setts. This report is a review of findings in the agronomy of seed yam production by the minisett technique. It also attempts to indicate areas that need further investigation for full utilisation of this promising seed yam production technology.

SPECIES RESPONSE TO THE MINISETT TECHNIQUE

OKOLI, IGBOKWE and NWOKOYE (1981) showed that *D. alata* yielded higher than *D. rotundata* cultivars when planted as minisetts. *D. alata* cultivars showed yield potentials of 33-45 t/ha as opposed to 9-14 t/ha in *D. rotundata* cultivars. IGBOKWE (1982) evaluated 9 cultivars from 4 yam species - *D. rotundata* cvs. Nwopoko, Obiaoturugo, Okwacha, Abi and Ekpe ; *D. alata* cvs. UM 680 and Ominelu ; *D. cayenensis* cv. Okumanu and *D. dumetorum* cv. Ona for their response to the minisett technique of seed yam production. Cultivars varied in their multiplication ratios (weight harvested/weight planted) as well as in the percentage of saleable tubers (weighing 200 and above) produced. While *D. alata* cv. Ominelu had a multiplication ratio of the range 10-24, *D. rotundata* cv. Nwopoko had a range of 3-6. Similarly, while *D. alata* cv. Ominelu had 81 per cent of the tubers produced weighing more than 200 g, *D. rotundata* cv. Nwopoko had 44 per cent and *D. dumetorum* cv. Ona had 48 per cent of the tubers weighing more than 200 g. ALVAREZ and HAHN (1983) evaluated clones of *D. rotundata* in a nursery bed for production of seed yams using the pre-sprouted minisett technique. They showed that only 4 clones gave enough germinated material for transplanting to the field early enough. This shows the great variation in the rate of sprouting among cultivars and consequently their potential for seed yam production using the minisett technique. The seed yam yields varied among the 4 clones grown. Tuber yields ranged between 80 g and 1,252 g with a mean of 400 g.

OYOLU (1984) used both traditional seed yams and ware yams of *D. rotundata* cv. Nwopoko to produce minisetts for planting at Nsukka, Nigeria. He noted that while 16-24 minisetts were obtained from seed yams, 48-80 were obtained from ware yams. This however did not affect the cost of the minisett in each case which was calculated to be ₦.02-₦.03 nor their performances in the field. ALVAREZ, HAHN and OTOO (1983) transplanted pre-sprouted minisetts of *D. rotundata* cv. Abi and 6 water yam (*D. alata*) varieties in June spaced 50 cm on ridges 1 m apart and covered with plastic mulch. They showed that the total number of seed yams and percent marketable tubers per plot varied significantly. Fresh weight yields ranged from 10.87 t/ha (TDa 297 - *D. alata*) to 13.24 t/ha for Abi (*D. rotundata*). Similarly, number of marketable seed yams per plot varied from 51.68 per cent to 96.74 per cent. On per plant basis, the number of marketable seed ranged from 1.05 for TDa 5 to 1.70 for Abi. These indicate important species and clonal responses to the minisett technique of seed yam production.

Sett Size Effects

It has been shown that any piece of healthy yam containing the periderm can be made to sprout and grow to yield a tuber. In the minisett technology however, the effort is to obtain sizeable seed yams (greater than 200 g) from small setts. In studies to determine the optimum sett size for seed yam production, IGBOKWE and OKOLI (1982) evaluated 4 sett sizes (15, 30, 45 and 60 g) and 3 widths of periderm (2, 3 and 4 cm), using 2 cultivars from 2 yam species. Results showed that the bigger the sett size, the higher the yield both in total tuber weight and in the percentage of saleable tubers (weighing more than 200 g). However, 15 and 30 g setts gave identical percentage yield of saleable seed yams, in both cultivars. It would therefore appear that nothing will be gained by planting sett sizes greater than 30 g for seed yam production. There was no significant difference in yields as a result of the periderm width. This is understandable since sprouts develop in yam by stimulation of epidermal cells rather than from specialised "eyes". This fact has been further exploited in the production of seed yams by use of "microsetts" pieces weighing between 5 and 10 gm. Scientists at IITA (ANON, 1983) have cut up to 50 microsetts from one mother tuber. IGWILO (1982) used 5 hormones - Indole Acetic acid (IAA), Gibberellic Acid (GA_3), Benzyladenine, Chloroethanol and Thiourea - at different concentrations to induce uniformity in time of sprouting of planted minisetts. He showed that all hormones at the concentrations investigated suppressed and delayed sprouting to varying degrees. ALVAREZ and HAHN (1984) used different concentrations naphthalene acetic acid (NAA) and 6 benzylamino purine (BAP), singly and in combination to induce uniform sprouting and growth. They reported that 500 and 1000 mg/L of NAA greatly increased the percentage of surviving *D. rotundata* that rooted but not *D. alata*. BA at 500 mg/L reduced percentage survival, total number and length of roots in *D. rotundata* but not in *D. alata*. NAA-BA combination had the poorest root formation.

CULTURAL MANAGEMENT OF MINISETTS

(a) Seed Dressing

In minisetts, a good deal of cut surface is exposed for possible entry of rot causing organisms. OKOLI et al (1982) used Aldrex T (a fungicide and insecticide combination) to protect the cut surface in order to minimize rotting. NWANKITI (1982) avaluated 5 chemicals - Aldrex T., RE49 (Halophen), Thiram, Thiabendazol and Benlate in powder formations for their effectiveness in protecting yam minisetts from rotting and hence on their yield. None of the chemicals was to the yam plant. It appeared that treatment with Thiram gave the lowest incidence of *Sclerotium rolfsii*. The chemicals seemed to have no effect on *Botryodiplodia theobromae* and *Fusarium* spp. - other rot causing organisms.

Sprouting was also better in Thiram than in the control. No significant yield differences were observed.

NWANKITI (1983) evaluated chemicals along with "curing" (leaving in the open for up to 4 days before planting). He found that yams planted 3 days after cutting sprouted as well as those treated with the best chemical. He therefore proposed that curing caused suberization and development of a wound periderm which acted as effective barrier against rot organisms. ATU (1983) showed that mixtures of benlate and carbofuran at the rate of 1:1 was as effective as Aldrex T in ensuring sprouting of minisetts.

(b) Seedbed Preparation

Seed yams be planted on ridges, mounds or flats in different parts of Nigeria, IGBOKWE and ENE (1982) compared the effect of planting on ridges, mounds or flat on the performance and yield of yam minisetts. Although no significant yield differences were recorded (88.7 per cent, 85.6 per cent and 90.0 per cent saleable tubers for mounds, flat and ridges respectively), it was observed that establishment count was less and harvesting more difficult in plots planted on the flat. IGBOKWE et al (1983) included planting on the bed in the comparison ; again, there were no significant yield differences between the different seed bed preparations.

On loose sandy loam or alluvial soils, minisetts may be planted on flats, while on clay or heavy loam soils, planting on ridges or mounds should be preferred.

(c) Planting Minisetts

Seed yams are usually planted 10-15 cm below the surface of mounds or ridges. Observations had shown that minisetts planted at depths less than 5 cm from the surface were soon exposed by heavy rainfall. They then dry up and fail to sprout. Enyinnaya (1983) investigated the effect of depth and orientation of planting on the sprouting and yield of minisett yams. Depths 3, 6, 9 and 12 cm of planting were investigated while orientations consisted in placing the periderm side up, down or sideways. At 12 weeks after planting, there were no differences in the sprouting of the minisetts either as a result of the depth or orientation of planting.

(d) Spacing of Minisetts

Seed yams are usually closer spaced than ware yams. Spacing varies but populations for seed yams are 20-30,000 plants/ha. OKOLI, IGBOKWE and NWOKOYE (1981) investigated the effect of stage of transplanting propagules (pre-sprouted minisetts) on the yield of seed yams. Propagules were transplanted at the zero, one, two and three leaf stages. No significant differences were obtained in the yield of the treatments although yams transplanted at the zero - and one - leaf stage showed minimum transplanting shock. Transplanted propagules survived readily achieving 87 - 96 per cent establishment 12 weeks after planting.

For transplanted propagules, total tuber yields increased significantly when the population increased from 20,000 to 40,000 plant/ha. for both *D. rotundata* and *D. alata*. Further increases up to 100.000 stands/ha had no significant effect on yield. They concluded that 25 cm spacing within the row and 1 m between the rows seems adequate for yams established using propagules. For directly sown minisetts, no significant different in total tuber yields was found due to plant population but the percentage of saleable seed yams weigh 200 g each or more up to 1000 g was higher at lower plant populations (20,000 and 40,000 plants/ha). IGBOKWE, OKOLI and ENE (1982) compared minisetts populations of 25, 50 and 100,000 plants per hectare established directly in the field. The effects of inter - (50 and 100 cm) and intra - (10, 20, 40, 80 cm) row spacings were investigated. The highest total tuber yield (19.94 t) was produced at a population of 100,000 plants/ha. However, only 59 per cent of the yield was saleable. On the other hand, 75.2 per cent of the 7.67 t produced in 50,000 plants/ha plot and 72.5 per cent of the yield in 25,000 plants/ha sown 25 cm without the row and 100 cm between the rows is recommended for each ease of mechanization.

(e) Fertilization

Conflicting reports have been given on the response of yams to fertilization in different areas and no standard recommendations have been made for yam production in Nigeria. IGBOKWE, OKOLI and ENE (1982) investigated the effect of 0, F_1 and F_2 rates of fertilizer (where 0 = No fertilizer applied F_1 = mixture of 50 kg N, 50 kg P_2O_5 ; 70 kg K_2O and 10 kg MgO ; F_2 - twice F_2) applied in a single dose 12 weeks after planting on the yield of yams established from minisetts. There was no significant yield increase over the control as a result of fertilization.

A mixture of 75 kg N, 45 kg P_2O_5, 90 kg K_2O and 15 kg MgO was applied to minisetts at planting 2, 4, 6, 8, 10 and 12 weeks after planting at Umudike. One cultivar of *D. alata* and one of *D. rotundata* were used in the evaluation. With the *D. alata* cultivar, highest yields were obtained for fertilizer application made 8-10 weeks after planting. The results were however inconsistent with *D. rotundata* .

(f) Staking

Supporting yam vines on stakes or trellises has been shown to increase tuber yield in most cultivars. The need to stakes yams established from minisetts appears critical in view of the small and tender nature of the vines produced. In a study to determine (a) the effect of staking, (b) height of staking (c) type of staking on the yield, ENYINNAYA (1982) showed that :

(i) staking increased the tuber yields

(ii) that height of staking in excess of 1 metre did not increase yield

(iii) that the number of yams trailed on one stake did not affect yield significantly.

In 1983 season however, ENYINNAYA, IGBOKWE and IBEZIM showed that while yams staked singly gave the highest tuber yield of 15.02 t/ha, compared with 10.3 t/ha for unstaked yams, the cost of staking (cost of stakes and of labour for placing them) rose to 69.19 per cent of the total cost of production and different significantly from other treatments.

In other studies, intercrops of maize, sorghum and millet were planted at various populations to serve also as stakes for yams grown from minisetts (ENYINNAYA, 1982). It was shown that maize at 5,000 stands/ha could be used to support yam vines without appreciably decreasing the yield of yams. Sorghum and millet depressed yields of yams substantially probably because of profuse tillering in those crops.

ALVAREZ and HAHN (1983) used a modified staking system in arched ½ inch PVC pipes supporting 4"plastic mesh. They showed that this staking method allowed the plants to make a canopy which subsequently suppressed weeds. They also showed that while the bamboo stakes were readily infested with termites before harvest, the PVC pipes and plastic mesh provided good material for staking and not damaged by termites and could be re-used for several years.

(g) Weed Control

Although yams produce a lot of leaves, the architecture of the plant is such that the canopy hardly covers the ground. Thus, weed growth is encouraged. In seed yam production using minisetts, there is the added disadvantage that sprouting is delayed and the sprouts are weak and tender offering no effective competition to weeds. UNAMMA and MELIFONWU (1983) showed in their two years study that the critical period of weed interference in *D. rotundata* cv. AKALI grown from 25 g minisetts under Umudike conditions is the first 12 weeks from planting. They suggested selecting a pre-emergent herbicide that could keep the crop weedfree for the first 12 weeks of growth as "hoe weeding is tedious and uneconomic". They also showed that chloramben, Simazine Fluometuron and Linuron applied pre-emergent at the dealers recommended rate gave as good weed control as the weed-free check in a seed yam farm established from minisetts. Depending on availability and costs it would appear that any of the herbicides listed above can be effectively used for weed control in seed yam production.

ALVAREZ and HAHN (1983) used a mixture of cotoran and applied at the rate of 2 kg a.i./ha each as pre-emergence herbicide immediately after planting. They also compared the use of black and white polythylene plastic mulch placed on the plot after germination. They showed that pre-emergence herbicide combination of cotoran and dual gave very good weed control. Hand weeded plots required a minimum of 3 weedings whereas the herbicide treated plots were sprayed only once with one subsequent hand weeding throughout the growth cycle of the plants. They also noted there was no noticeable herbicidal phytotoxic effect on the plants.

(h) Harvest and Storage

Yams are usually harvested when the leaves and vines have died back. Since seed yams are planted late, they are harvested late. In traditional yam farming, seed yams are harvested as close to subsequent planting as possible. This minimizes losses in weight and rotting in storage and ensures early and vigorous sprouting when planted. Seed yams should be harvested carefully to minimize cuts and wounds. Harvested tubers should be sorted in airy, well shaded or covered barns. Although they may be stored for up to 4 months, seed yams are best planted within 3 months of harvestings them.

Economics of Seed Yam Production Using the Minisett Technique

CHINAKA et al (1983) determined the economics of 3 methods of staking yam minisetts on a 4 ha. plot at Umudike. Each of the staking methods covered 1.35 ha. Although yam yields were highest (7 t/ha) under the pyramid staking method followed by the trellis method (5 t/ha) and then 4 t/ha using maize stalk method, it was found that using maize stalk for staking gave the highest net return (₦2,275). Pyramid staking and trellis method gave net returns of (₦2,275 and ₦1,125 respectively). HAHN and ALVAREZ (1983) obtained a benefit of more than $2000/ha by using growing minisetts of *D. rotundata* cv. Abi unstaked, and using herbicide combination (cotoran and dual) to control weeds. OYOLU (1984) showed that cost of producing one hectare of seed yams from minisetts at NSUKKA was ₦2,704.75 at a yield of 28.531 seed yams weighing 200 g, profit of over 37 per cent was estimated. This did not take into account the 4,269 smaller tubers (micro tubers) also obtained.

Physiology of the Minisett Technology

The basis of the minisett technique is that any piece of yam with a healthy periderm will produce one or more sprouts when placed under favourable conditions.

IGWILO and OKOLI (1984) showed that there was variation in time, rate and percentage of sprouting among nine cultivars from four species of yams. Minisetts sprouted irrespective of the part of the tuber head, middle or tail - from where cut. Minisetts from the head region sprouted first though it is possible that dominance or polarity affected cultivars differently.

Observations showed that in yams, larger planting materials produce more vigorous sprouts, greater total vine and branch lengths and higher numbers of leaves. NJOKU, et al (1973) suggested that dependence of the new yam plant on the reserve nutrients for a considerable period delayed functioning of leaves and roots. In the minisett grown seed yams however, the reserve nutrients is small ; consequently, the new yam plant is "forced" to exploit its environment much earlier in the growth cycle.

IGWILO (1984) compared the growth and yield of yams grown from 25 gm minisetts and regular 250 g seed yams.*D. rotundata* cv. NWOPOKO and *D. alata* cv. UM 680 were used in the study. He found that the earlier stages of growth, yam plants grown from 250 g tubers had higher leaf area index (LAI) than those grown from 25 gm minisetts but that the crop growth rates (CGR) were similar for both planting materials sizes.

This suggest that at stage of growth, plants grown from 25 g minisetts had higher photosynthetic rate than plants from 250 g seed yams. Multiplication ratio or seed yield factor (weight harvested/weight planted) is specially high in minisett produced seed yams. ALVAREZ and HAHN (1984) reported 1:90 using phytohormones on microsetts pre-sprouted and transplanted. Most reported work on minisetts at NRCRI gave a seed yield ratio range of 1:20 to 1:40. In traditional seed yam production OKOLI (1981) gave a range of 2.82 for *D. rotundata* cv. Obiaoturugo to 5.07 for cv. Nwopoko. Thus, the minisett technique gives higher available yield percentage (weight harvested minus twice the weight planted) (OKOLI et al 1984) probably as a result of greater efficiency in utilizing the growth environment (better exposure of leaves to sunlight, less number of leaves and vines to feed, altered source/sink relationships etc.) OYOLU (1984) reported that "reproductive coefficient" of efficient minisett averages 800, this being more than double the value in *D. rotundata* under traditional production. Studies on source/sink relationships in minisett yams may throw some more light on the increased yield of minisett grown yams.

CONCLUSION

Small pieces of yams will grow to produce plantable seed yams if given adequate cultural management. It has been established that setts 25 g in weight and having 2 cm wide back when planted 25 cm within the ridges which are 1 m apart will produce up to 80 per cent of the yield as plantable or saleable seed yams (each weighing 200 g or more). The minisett technique presents a rapid and cheap multiplication method for seed yams. Physiologically healthy seed yams are produced. These in turn give bigger ware yam yields. It also offers a chance to reduce the production cost of yam.

Curing the cut setts in the open air for about 3 days before planting directly into the field is recommended. Cut setts may be planted immediately after cutting if they are dusted with Aldrex T at the rate of 10 gm for 10 kg minisetts.

Planting should be as soon as rains becomes steady in the area. Cultivars of some yam species, notably, *D. alata* seem to respond bes to the minisett technique.

Pre-emergent herbicides such as chloramben, fluometuron, cotoran etc. which can supress weeds up to 12 weeks after planting may profitably be used for weed control in yam minisett fields.

Work on the fertilization of yam minisetts seems inconclusive. Similarly, indications are that higher plant populations can be further exploited with advantage for increased tuber and saleable yield. Intercrop of maize at no more than 5,000 stands/ha may be used for as staking materials for the yams. It mays even be possible to drop staking if plants are planted closer especially between rows, and if a low planophile crop is interplanted with the yams.

Where nematodes occur, available nematicides may be used to control infestation and damage.

The seed yams should be harvested when the leaves and vines have died and as close to planting during the next season as possible.

Only wound-free tubers should be stored in airy, covered barns. The minisett technique of growing yams has made possible the early evaluation of clonal materials in yam breeding programmes. Similarly agronomic and physiologic studies of the yam will be simplified as planting materials can be made uniform thereby removing that source of variability.

While pre-sprouting can be used to ensure uniformity in transplanted propagules - a factor especially important in areas with short rain periods, the problem of uniformity of sprouting in field swon minisetts remains. Since minisetts take 4-12 weeks to sprout, supply to replace unsprouted materials is ruled out. Therefore studies to obtain early and uniform sprouting so as to achieve a higher percentage of field establishment needs investigations.

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