GLOBAL JOURNAL OF PURE AND APPLIED SCIENCES, VOL.8, NO. 3 JUNE 2002:287 - 293

EFFECTS OF TUBER PORTION AND TIME OF HARVESTING ON ACCUMULATION AND PARTITIONING OF DRY MATTER IN WATER YAM *(Dioscorea alata L.)* MINISETT IN UYO, SOUTH EASTERN NIGERIA.

BASSEY A. NDON and NYAUDOH U. NDAEYO

(Received 21 March 2001; Revision accepted 28 August 2001)

ABSTRACT

The high cost of seed yam is a serious constraint to water yam production. Therefore a two-year field trial was conducted at the University of Uyo Teaching and Research Farm to evaluate dry matter accumulation and partitioning among various plant parts in water yam *(Dioscorea alata* L.) minisetts as influenced by portion of tuber planted and time of harvesting. The experiment was laid out in a randomised complete block design with a split-plot arrangement. The main-treatments were portions of tuber planted (head, middle and tail) and the sub-treatments were time of harvesting (90, 180 and 270 days after planting – DAP). The results showed that portions of tuber planted had no significant effect on dry matter accumulation within leaves, vines, roots and tuber. Early in the season (i.e. 90 DAP), leaves, vines and roots collectively accounted for 67, 62 and 57% of the total plant dry matter for the head, middle, and tail portions, respectively; thereafter the dry matter content declined. However, as the plant matured, the partitioning ratios decreased for leaves, vines and roots, but increased for tubers. Similarly, dry matter accumulation differed significantly ($p<0.05$) among times of harvesting. The highest dry matter accumulation was attained at 270 DAP. Therefore, it is recommended that any of the tuber portions could be conveniently used to raise seed yam, while harvesting should not be done before 270 DAP for maximum dry matter accumulation.

Keywords: Water yam, Minisett, Dry matter accumulation.

INTRODUCTION

Yam (*Dioscorea spp*), a starchy staple food crop in Nigeria, constitutes about 20% of the daily caloric intake of the population (FAO, 1974; Onwueme, 1978). The most common species in the West African sub-region are white yam (*Dioscorea rotundata Poir*), water yam (*Dioscorea alata* L.) and yellow yam (*Dioscorea cayenesis* Lam). Water yam comes after white and yellow yam in terms of spatial spread, intensity of cultivation and preference in consumption (Coursey, 1967). Within the culture in which they are grown, they have acquired a heavy burden of religious and magical significance that hardly applies to other crops (Coursey, 1988). It is utilized in various forms viz; the tuber could be simply boiled, fried or roasted and eaten with palm oil (Coursey, 1988; Okuowulu, 1995); made into porridge or the boiled tuber pounded into a fluffy mass (*"usun bia"*). Tubers can also be made into chips and flour of which the later can be reconstituted into *"lafun"* with hot water. It plays significant roles in the socio-cultural and economic life of the people of southern Nigeria as well as provide livestock feed and raw materials for industrial starch and steroid manufacture (Coursey, 1984). Specifically, water yam in addition to the above, is used in the preparation of a traditional relish of Annang, Efik and Ibibio people of south eastern Nigeria called *"Ekpan"* and *"Oto"*. The nutritive value of water yam tuber had been fully documented by Tindall (1983).

Estimates put the world total yam output at 24 million tonnes with Nigeria accounting for 72% of this output (FAO, 1992). Despite this, yam is still regarded as a subsistence rather than a cash crop because of the difficulties associated with its production. Production of yam is limited by the high cost of production which is a reflection of the labour requirement for land preparation, planting, weeding, staking, harvesting and the amount of

BASSEY A. NDON, Department of Crop Science , University of Uyo, Uyo, Nigeria
NYAUDOH U. NDAEYO, Department of Crop Science University of Uyo, Uyo, Nigeria

planting material required (Wilson, 1982). Presently, the cost of seed yams (the main planting materials) constitutes over 20% of the capital outlay in yam production in Nigeria ((Chinaka, 1986).

However, it has been recognised that yam can be propagated by seeds, vine cuttings, bulbils, tissue culture and tuber, but the most popular means is by tubers, that is, vegetative propagation (Chinaka and Odurukwo, 1986). However, Otoo *et al* (1987) study showed that minisett technique could be an improved technology for seed yam production and as a means of overcoming the scarcity and high cost of seed yams in Nigeria. Miege (1967) reported that minisetts obtained from middle and tail portions sprout less readily than the head portion while Coursey (1967) and Onwueme (1973) reported no difference between the rate of sprouting and dry matter accumulation in the head, middle and tail portions. Gurnah (1974) also noted that the portion of tuber planted affected the sprouting and vigour of the resulting plant and the subsequent yield.

This study was therefore initiated to assess the effect of the portion of tuber planted and time of harvesting on the dry matter accumulation in water yam.

MATERIALS AND METHODS

The study was conducted in the early seasons of 1997 and 1998 planting seasons at the Teaching and Research Farm, University of Uyo (Latitude 4^{0}30' and 5^{0}30'N; Longitude 07^{0}05'E and 8.20', with an altitude of 100m above sea level), south-eastern Nigeria. The rainforest zone receives about 2115mm of rainfall annually during the rainy season extending from April to November. The rainfall pattern is bimodal, with the long and short rainy seasons separated by a short dry spell of uncertain length, usually the month of August. The mean relative humidity of the area is 79%, while the mean maximum daily temperature is 30^{0}C (Peters *et al*, 1989). The mean annual earth temperature (at 30cm depth) is about 32^{0}C and the mean annual sunshine hours per day is 3 hours 31 minutes. The soil is acidic and classified as alfisol with well-drained coastal plain sands of Benin formation (Peters *et al*, 1989). Table 1 shows some soil physical and chemical characteristics of the study site.

A randomised complete block design with a split-plot arrangement, replicated four times, was used in both years. Portions of the tuber (head, middle and tail) constituted the main-treatments

TABLE 1: Soil Physico-chemical Properties of the Experimental Site.

Soil properties	0-15cm		15-30cm	
	1997	1998	1997	1998
Total N (%)	0.13	0.13	0.11	0.11
Organic matter (%)	2.67	2.63	2.11	2.07
Available P (mgkg^{-1})	226.66	224.44	186.66	184.44
K (meq/100g)	0.12	0.14	0.11	0.13
Ca (meq/100g)	3.60	3.80	2.80	2.64
Mg (meq/100g)	4.40	4.60	9.60	9.80
Na (meq/100g)	0.10	0.11	0.10	0.10
Exchange acidity	4.64	4.63	4.16	4.14
Bulk density (gcm^{-3})	1.40	1.41	1.50	1.52
pH (1:1) H_2O	4.78	4.78	4.78	4.78
Sand (%)	81.20	81.2	79.8	79.8
Silt (%)	8.30	8.30	8.30	8.30
Clay (%)	9.90	9.90	11.90	11.80
Electrical conductivity	0.08	0.08	0.06	0.07
Effective cation exchange capacity	12.86	12.74	16.77	15.99
Base saturation (%)	63.92	64.11	75.19	76.81

while time of harvesting (90, 180 and 270 days after planting DAP) represented the sub-treatments. Each replicate was 2 x 4 m, respectively. The inter-plot and-replicate spacing was 1m apart.

Cultural details: Healthy seed yams of *D. alata* which have been under storage for four months after harvesting and with weight range of 350 – 400g were obtained from the Department of Crop Science, University of Uyo. Each of these seed yams were measured and divided into three equal parts, viz: head, middle and tail regions. Each of these regions (portions) was cut into 2cm disc of 2 – 4 quarter to obtain yam pieces (minisetts) and standardised by ensuring that each minisett weighs about 50g (Otoo *et al*, 1987). To prevent fungi rot, the minisetts were put in a container and dusted with ash suspension (Onwueme and Sinha, 1991) and sundried for two days. The cured minisetts were then planted manually on the ridges at a spacing of 50 cm within and 1m between rows at a depth of about 10 cm. This gave a population of 20,000 stands per hectare. Mulching (2t/ha) and staking (Pyramid method) were also carried out. Fertilizer (NPK – 20:10:10) was applied across all the treatments at 58 days after planting (DAP) at a rate of 480 kg per hectare. Weeding was done manually thrice at 47, 90 and 115 DAP. Some of the dominant weeds identified included *Calapogonium mucunoides* L., *Chromolaena odorata* Kings and Robinson, *Commelina benghalensis* L; *Panicum maximum* Jacq, *Eleusine indica* Gaertn, *Tridax procumbens* L. and *Aspilia africana* Pers. C. D.

Adams. There were minor insect attacks by *Zonocerus variegatas* L; *Empoasca spp.* and *Gymnogryllus lucens* (Wlk.). Control was achieved by hand picking and the use of an insecticide – Carbofuran (Furadan), at the rate of 0.095 Kg ha^{-1}.

DATA COLLECTION AND ANALYSIS

Three random samples of water yam were collected from each sub-plot at 90, 180, and 270 DAP for dry matter accumulation determination. The plants were carefully dug up from the soil, the roots washed before being separated into vines, leaves (including petiole), roots and tubers. They were then oven-dried (Gallenhamp, Model 300 Series) to a constant weight at 65^{0}C for 48 hours and the dry matter determined using an electronic weighing balance (Mettler Toledo, Model PG 2002). Dry matter partitioning ratios were then calculated by dividing the dry weight of a given plant part by the total dry weight per plant (Goenaga and Irizarry, 1994). The data generated were subjected to analysis of variance and means that showed significant differences were separated using least significant difference at 5% probability level (Gomez and Gomez, 1984).

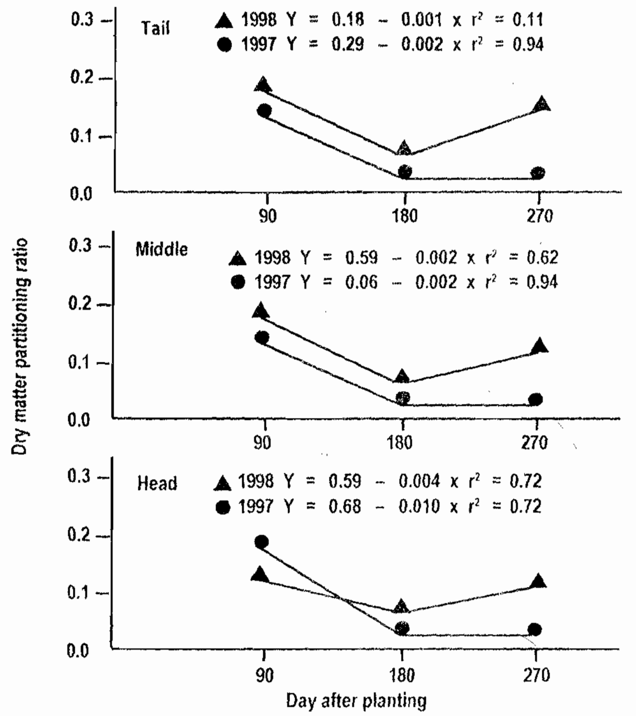

Figure 1: Dry matter partitioning of yam leaves as influenced by portion planted and time of harvesting

RESULTS AND DISCUSSION

Dry matter partitioning :

Early in the season (90 DAP), the plants allocated a greater percentage of their dry matter to leaves, vines and roots (Figures 1, 2, and 3). These organs collectively accounted for 67, 62 and 57% (means of both 1997 and 1998) of the total dry matter for the head, middle and tail portions, respectively.

On the other hand, as the plants matured, the partitioning ratio decreased significantly for leaves, vines and roots, but increased for tubers (Figures 1–4).

Within each of the two years, there was no significant difference in dry matter partitioning in leaves, vines, roots and tubers due to portion of yam planted. The partitioning ratio of roots to total dry matter decreased almost linearly through out the growing seasons (Figure 3). The above response could be linked with the fact that during the early growth stage, plants become autotrophic and less dependent on stored assimilates from the planting materials for growth (Squire, 1990). The significance of the planted seed piece as a primary source of assimilates for initial growth is

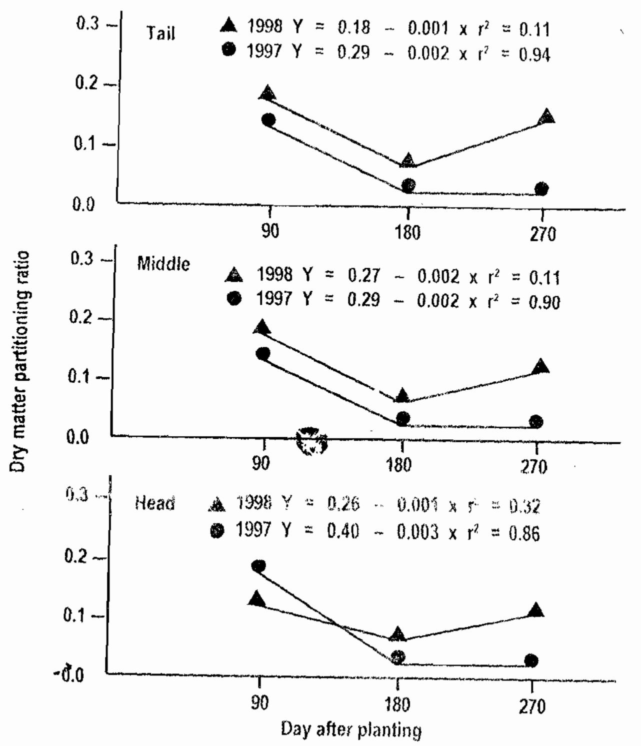

Figure 2: Dry matter partitioning of yam vines as influenced by portion planted and time of harvesting

shown by the reduction in the tuber partitioning ratio (tuber/total dry matter) that occurred at the early season (90 DAP). These findings are in

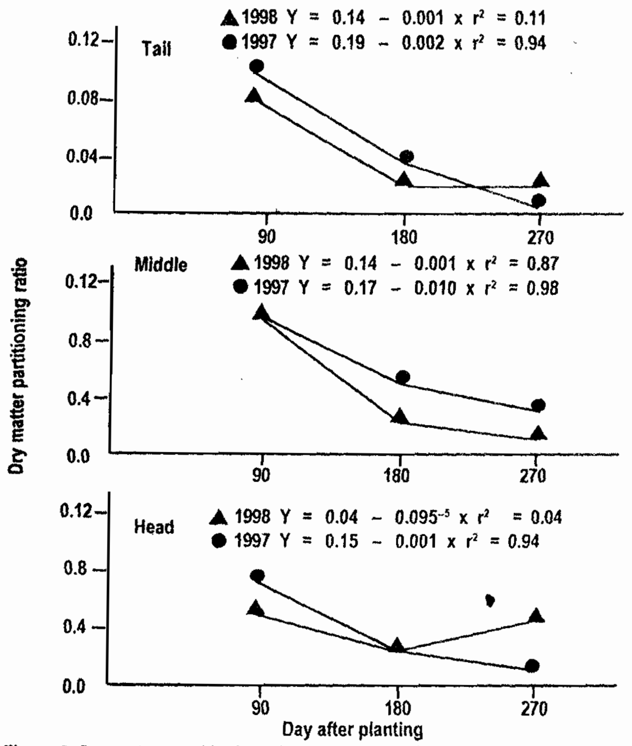

Figure 3: Dry matter partitioning of yam roots as influenced by portion planted and time harvested

Early in the season (90 DAP), the plants allocated a greater percentage of their dry matter to leaves, vines and roots (Figures 1, 2, and 3). These organs collectively

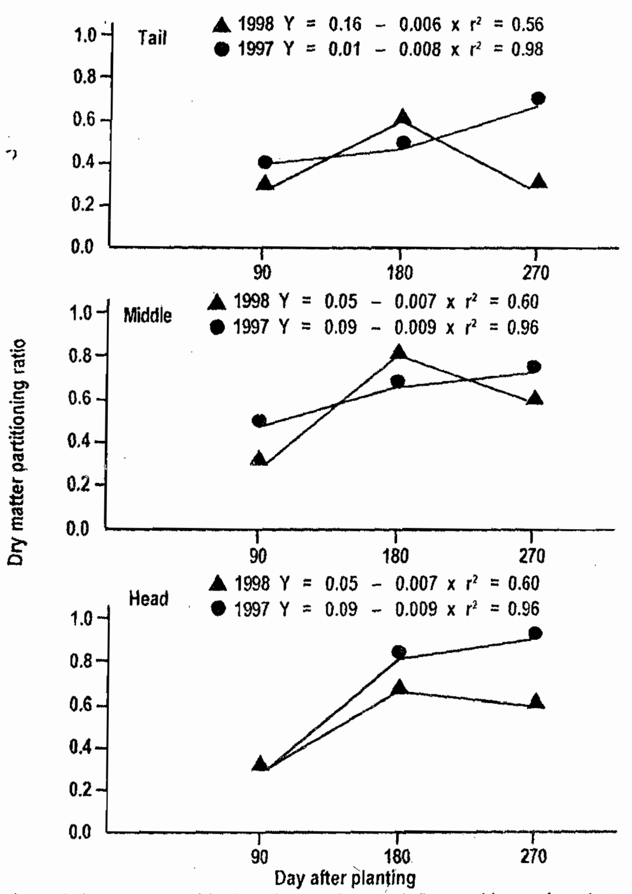

Figure 4: Dry matter partitioning of yam tubers as influenced by portion planted and time of harvesting

consonance with those earlier reported elsewhere (Irizarry and Rivera, 1989; Goenega and Irizarry, 1994). Regression analysis of the partitioning ratio revealed a higher coefficient of determination in 1997 than 1998 cropping season. This is attributable to vagaries of weather as more rainfall and less sunshine hours were noted for 1997 than 1998. The pre-planting soil nutrient status (Table 1) was adequate to support optimum growth of this yam cultivar, even without the application of fertilizer. Analysis of the soil revealed that organic matter, nitrogen, phosphorus and potassium levels for instance were capable of supporting the growth of yams (Ferguson and Haynes, 1970; Sobulo, 1972; Obigbesan and Agboola, 1978; Vander Zaag *et al* 1980; Goenaga and Irizarry, 1994). Also, cultivars of *D. alata* have been reported to be more tolerant of low-fertility soils than most of the other edible yam species (Norman *et al* 1984). This perhaps accounts for the high dry matter production observed.

Accumulation of dry matter:

Table 2 presents the leaf and vine dry matter accumulation as influenced by portions of yam tuber planted and time of harvesting. The results revealed that portions of yam tuber planted and time of harvesting did not significantly influence dry matter accumulation in both the leaves and vines in 1997. However, on the average, the use

TABLE 2: Effects of portion of tuber planted and time of harvest on dry matter content of water yam leaves and vines.

Portion of tuber planted	Time of harvesting(DAP)*	Leaves g plant⁻¹		Vines g plant⁻¹	
		1997	1998	1997	1998
	90	14.73	13.78	8.83	7.78
Head	180	14.83	15.90	10.16	9.91
	270	20.40	21.05	23.90	23.10
	Mean	16.99	16.91	14.30	13.59
	90	13.57	12.38	6.63	6.98
Middle	180	14.02	12.99	6.76	6.82
	270	19.63	22.22	17.97	17.48
	Mean	15.74	15.86	10.45	19.62
	90	7.50	10.27	4.53	5.40
Tail	180	15.35	14.10	7.20	7.15
	270	19.03	20.20	24.93	22.70
	Mean	13.96	14.85	12.22	11.75
LSD (0.05) due to portion of tuber planted		NS**	NS	NS	NS
LSD (0.05) due to time of harvesting		NS	5.73	2.64	0.15

* Days after planting
** Not significant.

of head portion (16.99 g plant $^{-1}$) exceeded the middle and tail portions by 7 and 18%, respectively.

Time of harvesting also indicated that harvesting at 270 DAP was better than those of 90 and 180 DAP by 27 – 28%, 29 – 31%, and 19 – 61% for the head, middle and tail portions, respectively. In 1998, dry matter accumulation due to portions of yam tuber planted did not differ significantly whereas time of harvesting significantly ($p<0.05$) affected the leaf dry matter accumulation. The values of dry matter content as influenced by tuber portions planted were 16.91, 15.86 and 14.85 g per plant for the head, middle and tail, respectively. The result showed that delaying harvesting for up to 270 DAP resulted in more dry matter accumulation than harvesting at 90 and 180 DAP by 24 – 35%, 42 – 44%, and 30 – 49% for the head, middle and tail portions, respectively. Average across the years also maintained this trend.

Dry matter accumulation in the yam vines did not differ among portions of yam tuber planted in both years (Table 2). The mean value of head portion however exceeded those of middle and tail by 27 and 15% in 1997 whereas in 1998, middle portion performed better than the head and tail portions by 31 and 40%, respectively. However in both years, significant ($p<0.05$) differences were observed among time of harvesting. In 1997, harvesting at 270 DAP superseded the 150 and 180 DAP by 57 – 63%, 62 – 63%, and 71 – 82% for the head, middle and tail portions, respectively. Similarly, in 1998, harvesting at 270 DAP resulted in a higher dry matter accumulation than the 90 and 180 DAP by 51-66%, 11-60%, and 69-76% for the head, middle and tail portions, respectively.

Roots and tuber dry matter accumulation did not differ significantly among yam tuber portions planted in both 1997 and 1998 (Table 3). However, on the average, the middle portion (5.62 and 4.64 g plant $^{-1}$) indicated more root dry matter than the head and tail by 3 and 16% in 1997 and by 11 and 14% in 1998. Also, on the average, tuber dry weight of the head portion was 26 and 22% higher relative to the middle and tail portions in 1997 whereas in 1998, there was no significant effect. The values for the 1998 were 85.15, 84.85 and 85.22g per plant for head, middle and tail portions, respectively.

In 1997, time of harvesting showed significant ($p<0.05$) differences in root dry weight. The root dry weight at 270 DAP (6.93 g plant $^{-1}$) exceeded those of 90 and 180 DAP by 56 and 8% when the head portion was used while the 180 DAP (7.30 g plant $^{-1}$) exceeded that of 90

TABLE 3: Effects of portion of tuber planted on Dry Matter accumulation of Water Yam Roots and Tubers at different time of harvesting.

Portion of tuber planted	Time of harvesting	Root g plant^{-1}		Tuber g plant^{-1}	
		1997	1998	1997	1998
	90	3.03	2.47	13.11	12.22
Head	180	6.35	4.81	180.88	115.65
	270	6.93	5.10	1214.95	127.57
	Mean	5.44	4.13	469.65	85.15
	90	3.63	3.01	17.33	12.30
Middle	180	7.30	6.10	97.16	115.52
	270	5.93	4.81	933.82	126.72
	Mean	5.62	4.64	349.44	84.85
	90	2.87	2.88	12.67	12.55
Tail	180	5.93	4.14	94.12	115.30
	270	5.40	4.89	994.72	127.82
	Mean	4.73	4.06	367.17	85.22
LSD (0.05) due to portion of tuber planted		NS**	NS	NS	NS
LSD (0.05) dut to Time of harvesting		2.27	2.11	173.70	10.15

* Days after planting

** Not significant

and 270 DAP by 50 and 18%, and by 52 and 10% when the middle and tail portions were used, respectively. This pattern was maintained in 1998, with 270 DAP superseding the 90 and 180 DAP by 52 and 6% and 41 and 18% for the head and tail portions, respectively whereas 180 DAP was better than the 90 and 270 DAP by 30 and 21% for the middle portion. Harvesting at 270 DAP produced higher tuber dry weight relative to that of 90 and 180 DAP in both years (Table 3). It was consistently higher than that of 90 and 180 DAP by over 85, 90 and 91% for the head, middle and tail portions, respectively in 1997 and by over 9, 9, and 10%, respectively for head, middle and tail in 1998.

In this study, the yam tuber had more dry matter than other respective component parts of the plant apparently because the tuber is the main storage organ. Kunkel (1968) stated that tuber is the primary sink for photosynthesis during development and consequently of dry matter in the tuber which is an important process in the yield production. Also, Irizarry and Rivera (1989) reported that after 150 DAP, the tuber represented the most active sink in the plant with other plant components exhibiting drastic reduction in dry matter content. The lack of significant differences in dry matter accumulation among the tuber portions planted is in line with that reported by other researchers (Coursey, 1967; Onwueme, 1973) that there was no difference in dry matter accumulated within the head, middle and tail portions. There is general indication that maximum dry matter accumulation is achieved by prolonged time of harvesting (270 DAP) apparently due to contributions of assimilates from older, senescing leaves and by-products of current photosynthesis translocated to the tuber. Similar results had earlier been reported by Goenaga and Irizarry (1994) that accumulation of dry matter in water yam increases slowly up to 237 DAP and either remain constant or decreased slightly thereafter.

CONCLUSIONS

This study revealed no significant differences in dry matter among portions of tuber planted. This implies that farmers can conveniently use any of the portions for rapid seed yam production. Also, the dry matter production, which was highest at 270 DAP, indicated that harvesting of yam minisett should not be earlier than 270 DAP.

REFERENCES

Chinaka, C.C., 1986. Seed yam production. A paper delivered at the Federal Department of Agriculture Crop Production Workshop for Extension Workers, Ugunobo and Ubiaja, 10pp.

Chinaka, C.C. and Odurukwo, S. O., 1986. Available crop varieties potential and cropping package. Invited paper delivered at Imo River Basin Training Workshop. 7pp.

Coursey, D. G., 1967. Yams. Longman, London. 220pp.

Coursey, D. G., 1984. Potential utilization of major root crops with specialemphasis on the human, animal and industrial uses. In the proceedings of the 2nd Triennial Symposium of the ISTRIC – AB, Doula Cameroons (1983) pp.231.

Coursey, D. G. , 1988. Interaction of yams and man. Journal d' Agriculture Tropicale et de Botaniquee, 28: 5-21.

FAO, 1974. Food and Agriculture Organization (FAO). Production Year Book pp. 41-89.

FAO, 1992. Food and Agriculture Organization (FAO) Production Year Book pp. 21-57.

Ferguson, T. U. and Haynes, P. H., 1970. The response of yams (*Dioscorea* spp.) to nitrogen. phosphorus, potassium, and organic fertilizers. P. 93-96. In D. L. Pluckett (ed.) Proc. Int. Symp. Trop. Root and Tuber Crops, 2nd, Honolulu, HI.

Goenaga, R. J. and Irizarry, H., 1994. Accumulation and partitioning of dry matter in water yam. Agronomy Journal, 86 (6) 1083-1087.

Gomez, K. A. and Gomez, A. A., 1984. Statistical procedures for Agricultural Research. 2nd ed. John Wiley and Sons, New York. 608p.

Gurnah, M. M., 1974. Effects of spacing, setts, weight and fertilizers on yield components of yam. Exp. Agric., 10(1):17-22.

Irizarry, H. and Rivera, E., 1989. Management of the Binugas yam (*D. alata*) in Puerto Rico. P. 183-191. in: L. Degras (ed.). Proc. Annual Meeting. Carribbean Food Crops Soc. 25th, Gosier, Guadeloupe.

Kunkel. R., 1968. The effects of planting dates, fertilizer rate, and harvest date yield, Culinary qualities and processing qualities of Rushet Burbank potatoes in Columbia Basin of Washington. P. 90 – 99. Proc. 19th annual Confab. Solem. Oreg.

Miege, J., 1967. Influence of colour on the charater of tubers. J. Agric. Tropical Bot. Appli., 4(7/8): 315-342.

Norman, M. J. T., Pearson, C. J. and Searle, P. G. E., 1984. Yams (*Dioscorea spp.*). P. 285 – 270. IN: The ecology of tropical food crops. Cambridge Univ. Press. Cambridge.

Obigbesan, G. O. and Agboola, A.A., 1978. Uptake and distribution of Nutrients by yams (*Dioscorea spp.*) in western Nigeria, Exp. Agric, 14:349-355.

Okwuowulu, P. A., 1995. Yield response of edible yam (*Dioscorea spp.*) to time of fertilizer application and age at harvest in an ultisol in the humid zone of south-eastern Nigeria. African Journal of Roots and Tuber Crops, 1(1):1-4

Onwueme, I. C., 1973. The sprouting process in yam tuber pieces. J Agric. Sc. (Camb.) 81: 373-375.

Onwueme, I. C., 1978. The Tropical Tuber Crops. John Wiley and Sons. Chichester. 234pp.

Onwueme, I. C. and Sinha, T. D., 1991. Field crop production in Tropical Africa: Principles and Practice. CTA, Ede, The Netherlands 480pp.

Otoo, J. A., Osiru, O.S.O., Ng, S.Y.C. and Hahn, S.K. , 1987. Improved technology for seed yam production. IITA, Ibadan, Nigeria. Pp. 11-14.

Peters, S. W., Usoro, E. J. Udo, E. J., Obot, U. W. and Okpon, S.N(eds), 1989. Akwa Ibom State: Physical background, Soils and Land Use and Ecological problems. A Technical Report of the Task Force on Soils and Land Use Survey, Akwa Ibom State. 603p.

Sobulo, R. A., 1972. Studies on white yam (*Dioscorea rotundata*): II. Changes in nutrient content with age. Exp. Agric. 8:107-115.

Squire, G. R., 1990. The physiology of tropical crop production. C. A. B. International Willington. 238pp.

Tindall, H. D., 1983. Vegetables in the Tropics. Macmillan Ltd. Houndmills. P. 213-217

Van der Zaag, P., Fox, R. L. Kwakye, P. K. and Obigbesan, G. O., 1980. The Phosphorus requirements of yams (*Dioscorea spp.*). Trop, Agric. (Trinidad) 57:97-106

Wilson, J. E., 1982. Progress in the breeding of yam (*Dioscorea spp.*). In: yams Igame (eds.) Miege, J. and Lyonga, S. N. (eds.) Yams, Ignames.. Oxford, Clarendon Press. Pp. 17-22.