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EVALUATION OF WHITE YAM PERFORMANCE UNDER DIFFERENT SETT SIZES AND TIME OF IMMERSION IN WATER

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ABSTRACT
A field experiment was conducted to study the effect of sett sizes and time of sett immersion in water on growth and yield of white yam in an ultisol at Umudike, South eastern Nigeria during 2016 and 2017 cropping seasons. The experiment was laid out as a 5 X 4 factorial in randomized complete block design (RCBD) with three replications. Five sett sizes (40; 50; 60; 70g setts and 70g whole seed yam) were combined with four periods of sett immersion in water (0, 12, 24 and 36hrs) to give 20 treatment combinations. In both years, crop establishment was significantly increased by the 70g whole tuber while the 60g sett increased shoot dry matter. The highest tuber yield was obtained from 60g sett. Increasing the time of sett immersion in water to 12 hours increased crop establishment up to 40 -80% and shoot dry matter by 66 – 90% but increasing the time of immersion reduced leaf area index. Time of sett immersion in water did not affect tuber yield but interactions were significant on yield in both cropping seasons. On average, the highest tuber yield was obtained from 60g sett under no immersion in water.

Key words*:* *Dioscorea rotundata,* sett size, immersion in water, tuber yield

INTRODUCTION
Yam (*Dioscorea* spp) is an important food crop which is grown throughout the tropics (Andres *et al,* 2017). Among the most important species, white yam (*Dioscorea rotundata*) is believed to have originated in West Africa around the eastern banks of the river Niger, where it is still the preferred food crop (Coursey, 1967; Hahn *et al,* 1987). The crop has underground structures comprising the fibrous root system and thick storage organs or tuber in which starch is deposited. The tuber is a good source of industrial starch and contains pharmalogically active substances such as dioscorine, saponin and sapogenin (Eka, 1985). Usually, the yam tuber is eaten in boiled or roasted forms and can be processed into pounded yam, fried yam slices, yam chips, flakes and flour.

One of the technologies aimed at reducing the total cost of yam production and generating planting materials is the minisett technique, but the problem associated with this method is the difficulty in obtaining the recommended 25g cut sett (Ikeorgu, 2003), which is also more prone to desiccation than bigger setts. The use of bigger sett sizes or the technique of sett size is based on the principle that any section of the tuber is capable of sprouting provided it has a covering portion of the skin or a viable meristematic region found beneath the skin (Onwueme, 1978, Ile *et al,* 2006). For some white yam cultivars, an increase in sett size can enhance their sprouting potential and yield but agroecological conditions, temperature and relative humidity also play a determining role (Ayankanmi *et al*, 2005; Igwilo, 2009, Hamadina and Asiedu, 2015). Although Ikeorgu (2003) did not obtain significant yield

increased.

Moisture stress may not prevent sprouting entirely but may inhibit bud elongation on the yam tuber (Onwueme, 1975), thereby influencing crop establishment and growth. Priming or the use of water to stimulate shoot initiation in dry seeds and cure dormancy is a form of seed planting preparation in which seeds are presoaked before planting or observed for germination (Khan, 1992, Ileleji et at, 2015; Asonye and Hamadina, 2018). Priming prior to planting is a process of hydrating or planting materials in order to increase germination or sprouting, ensure more uniform emergence under a wide range of field environments and improve vigour (Modi, 2005). Hydro priming (hydration of seed with water only) is an approach used to increase the percent and rate of germination and increase the uniformity of stand establishment under stress conditions especially in dry areas (Clark *et al*, 2001; Mavi et al, 2006; Berchie *et al*, 2010) although Barker et al (1999) found no such advantage by soaking tubers in water on sprouting. McDonald *et al* (2006) noted that seed priming enhances seedling growth by controlling inhibitory conditions and reducing the effects of vagaries of weather. The water imbibed by the planting material activates enzymes and facilitates metabolism of stored starch and protein (Kikuchi *et al*, 2006) and thus, water imbibition is the most important event for ensuring nutrient supply to the embryo and to generate energy for the commencement of seedling growth (Abebe and Modi, 2009). Yam is usually planted during the period of moisture stress in the dry season or at the commencement of the rainy season, but the effect of priming yam tubers and setts on the crop is little known. The objective of this study was to examine the effect of sett size and time of sett immersion in water on growth and yield of white yam in southeastern Nigeria.

MATERIALS AND METHODS

Field experiments were conducted at the National Root Crop Research Institute (NRCRI), Umudike, south eastern Nigeria under rainfed conditions. The location is situated at latitude $5^0$29'N, longitude $7^0$33'E and at the altitude of 122m above sea level. The soil of the experimental site is an ultisol and was texturally loamy sand in 2016 and sandy clay loam in 2017. The soil had pH (water) 5.1, 1.62% 0M, 0.08%N, 34.2mg/kg P and 0.11 cmol/kg K in 2016 and 4.8 pH (water) 1.66% om, 0.095%N, 21.0mg/kg P and 0.30 cmol/kg K in 2017. The total annual rainfall was 2322.7mm in 2016 and 2079.8mm in 2017 while the mean maximum temperature was 31.6^0C in 2016 and 32.1^0C in 2017.

In each cropping season, the land which was previously under one year fallow was slashed, ploughed and harrowed using disc plough and harrow. The land was ridged1m apart after harrowing. The experiment was a 5 X 4 factorial, laid out in a randomized complete design with three replications. Treatments comprised all combinations of five sett sizes (40g, 50g, 60g, 70g cut setts and 70g whole seed yam) and four periods of sett immersion in water (0, 12, 24 and 36 hours). Each plot measured 4 X 3m (12m^2).

The setts of the white yam cultivar Yandu were planted on the crest of the ridges on 10 April 2016 and 11 April 2017 at a spacing of 1m X 0.3m. This gave a plant population of 33,333 plants/ha. Hoe weeding was carried out at 4, 8 and 12 WAP. Fertilizer NPK (15:15:15) was applied at 400kg/ha at 8 WAP by banding. Pyramidal staking method (2m stake) was done and the vines were periodically trained to the stakes in a clockwise direction. Records were taken on the following: percent establishment at 4, 8, and 12 WAP; leaf area index (LAI) and shoot dry matter (g/plant) at 5MAP and number of tubers/plant tuber weight (kg) and tuber yield (t/ha). Percent crop establishment was estimated as percent of stands with vines greater then 10cm above soil level. Leaf area (cm^2) per plant was obtained using the grid method, where 20 leaves were collected randomly from the base, middle and top of the plant, after which, they were traced on a graph sheet and their dimensions taken. Leaf area was calculated using the formula: $Y = a + bx$ ($Y = 0.46 + 0.194x$) where Y = total leaf area/plant, a = intercept, b = slope and x = length X width of the leaf X number of leaves/plant. Leaf area index was determined using the formula: $LAI = LA/P$, where LA = total leaf area and P = land area. The data collected were subjected to analysis of variance (ANOVA) according to the procedures for a factorial in randomized complete block design using GenStat (2007) statistical package (GenStat Discovery Edition 3).

RESULTS

At 4 and 8 WAP, the 70g whole tuber had significantly higher percent establishment than the setts regardless of size in both 2016 and 2017 cropping seasons (Fig 1a, b). Among the sett sizes in 2016, the smaller 40g sett had higher percent establishment than the 50g sett at 4 WAP and the 70g sett at 8 WAP. Similarly, in 2017, the 40g sett had significantly higher percent establishment than the 60g sett at 4 WAP and the 50g sett at 8 WAP. Except at 12 WAP, the 70g whole tuber consistently had higher percent establishment than the 70g sett, in both years. Across sampling dates and both years, establishment was 15-16 percent higher in 70g whole tuber than in the setts. In all instances, percent establishment was significantly higher when the setts were immersed in water for 12 hours than when not (control) or when immersed in water for longer periods of 24 and 36 hours in both years (Fig. 2a, b). Averaged across sampling dates and years, increasing the 12 hours increased crop establishment by 40 – 80 percent compared to other times of sett immersion in water. Leaf area index in 2016 cropping season was increased significantly by planting 70g sett or whole tuber than the smallest 40g sett (Table 1). In 2017, however, the 50g and 70g sett weights produced significantly higher leaf area index than the 70g whole tuber and other sett sizes. Generally, leaf area index decreased with increase in time of sett immersion in water in both years but, significant differences were established in 2017 only. Leaf area index in 2017 was higher in the no immersion control than when sett was immersed in water for 24 or 36 hours. Sett size X time of immersion in water interaction effects were significant on leaf area index in 2016. Leaf area index in 2016 was highest in the 70g sett or whole tuber and the control (no immersion).

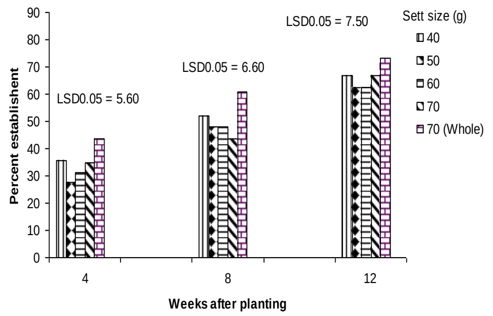

Fig. 1 a: Effect of sett size (g) on percent establishment of white yam at 4, 8 and 12 WAP in 2016

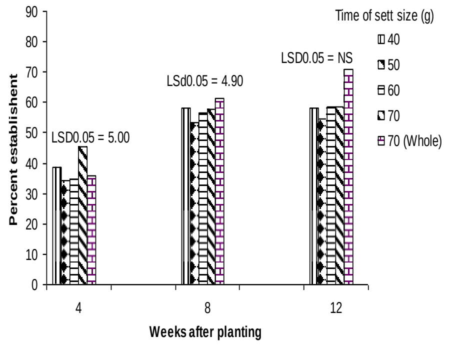

Fig. 1 b: Effect of time of sett size (g) in water on percent establishment of white yam at 4, 8 and 12 WAP in 2017

In both cropping seasons, shoot dry matter increased significantly with increase in sett size up to 60g, beyond which decline in dry matter occurred (Table 2). On average, increasing the sett weight above 60g resulted in 11.4% and 28.0% reductions in shoot dry matter for the 70g cut sett and 70g whole tuber respectively. Generally, the 70g cut sett produced significantly higher shoot dry matter than the 70g whole tuber. Similarly, immersing sett in water for 12 hours remarkably increased by 60 to 90 percent dry matter accumulation in the shoot than other times of immersion in water or the control in both years. Interactions were significant. In all instances, the 60g sett immersed in water for 12 hours had higher shoot dry matter than other sett sizes and times of immersion in water.

In 2016, there were no statistical differences in the number of tubers harvested per plant (Table 3). However, in 2017, the smaller 40g sett had significantly higher number of tubers than the bigger 50, 60 or 70g setts, which gave similar results. The 70g whole tuber did not differ from 70g sett, but had lower number of tubers than 40 and 60g setts. On the other hand, in 2016, the trend was for a depression in number of tubers with immersion of sett in water, but significant differences were established when setts were immersed in water for 12 or 24 hours compared to the control (no immersion in water). There were no differences in number of tubers in 2017 with time of immersion of sett in water, although, values appeared lower when setts were immersed in water than when not. Interactions were significant in 2017, with the 60g sett under no immersion in water (control) producing the highest number of tubers while, the 40g sett regardless of time of sett immersion in water produced the lowest number of tubers.

Unlike the results obtained for number of tubers, tuber weight increased significantly with sett size up to 70g setts in 2016 (Table 4). The 70g whole tuber had lower weight of tubers than the 70g sett. Also, tuber weight in 2017 showed similar trend but, no significant differences occurred between the sett sizes. There was no clear trend for time of immersion in water in 2017, as setts immersed in water for 12 or 36 hours produced significantly higher tuber weight than the control or with immersion in water for 24 hours. Interactions were significant

On average, white yam yield was greater in 2016 than in 2017 (Table 5). In both years, tuber yield followed similar trends but, it was only in 2017 that significant differences occurred with sett size. Tuber yield in 2017 increased significantly with the 60g sett compared with the smaller 40g sett. There were no yield differences between the bigger setts of 50, 60 and 70g. Increasing the sett size from 60 to 70g seemed to depress tuber yield, although no statistical significance was established.

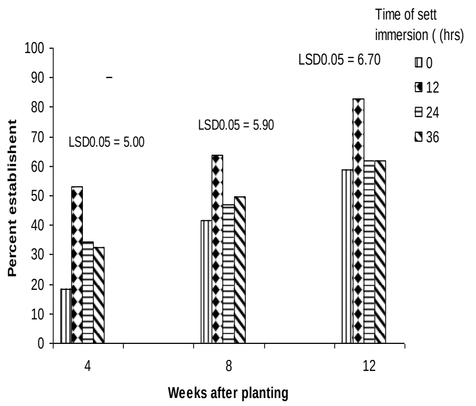

Fig. 2 a: Effect of time of sett size immersion (hrs) in water on percent establishment of white yam at 4, 8 and 12 WAP in 2016

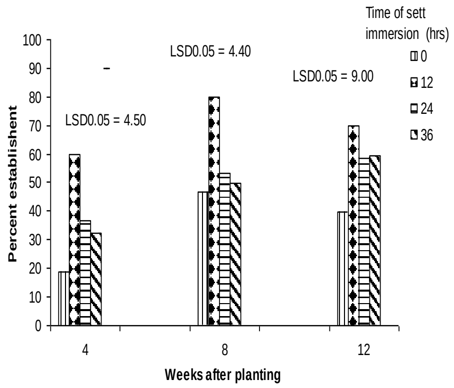

Fig. 2 b: Effect of time of sett immersion (hrs) in water on percent establishment of white yam at 4, 8 and 12 WAP in 2017

Table 1: Effect of sett size and Time of sett immersion in water on leafarea index of Yandu White yam cultivar at 5WAP

	Time of Immersion in water (Hours)				
Sett size (g)	0	12	24	36	Mean
		2016			
40	0.34	0.25	0.27	0.64	0.38
50	0.63	0.65	0.40	0.46	0.54
60	0.36	0.64	0.63	0.39	0.50
70 (Cut)	0.74	0.53	0.66	0.42	0.59
70 (Whole)	0.81	0.59	0.38	0.51	0.57
Mean	**0.58**	**0.53**	**0.47**	**0.49**	
		2017			
40	0.33	0.22	0.28	0.67	0.37
50	0.92	0.71	0.67	0.64	0.74
60	0.54	0.64	0.41	0.36	0.49
70 (Cut)	0.92	0.74	0.67	0.41	0.68
70 (Whole)	0.77	0.36	0.31	0.41	0.46
Mean	**0.70**	**0.53**	**0.47**	**0.49**	
				2016	**2017**
$LSD_{(0.05)}$ for sett size (S) means =				0.16	0.20
$LSD_{(0.05)}$ for Time (T) of immersion in water means =				NS	0.18
$LSD_{(0.05)}$ for S X T means =				0.31	NS

Time of sett immersion in water did not significantly influence tuber yield in both 2016 and 2017 cropping seasons. Interactions were significant. In 2016, the highest tuber yields (44.4 – 52.6t/ha) were mostly obtained from all sett sizes (except 70g cut sett) or 70g whole seed yam and no immersion in water, while in 2017, the 60g sett with zero immersion in water had the highest tuber yield of 40.6t/ha.

DISCUSSION

Crop establishment in white yam was consistently enhanced by the use of whole tubers than by the use of cut tuber portions. The better establishment of 70g whole tuber may be due to the presence of apical dominance conferred by the primary nodal complex (PNC) or corm-like structure attached to the head region of the tuber (Degras, 1993). The corm-like structure is known to have greater tendency to produce sprouts or shoot than non-corn possessing setts from other regions (Onwueme, 1975; Wilson *et al.*, 1998) due to its faster ability to complete the *de novo* formation of primary modal complex (PNC), which is the origin of yam roots, sprout or shoot and tubers (Hamadina, 2012l Awologbi and Hamadina, 2016). The greater tendency of whole tubers to produce sprouts is coupled with their undisturbed (by the cutting process, which creates surface for swift moisture loss) nature to enable early and better interaction with factors of the growing environment that promote vine or shoot elongation.

Table 2: Effect of sett size and Time of sett immersion in water on shoot dry matter (g/plant) of Yandu White yam cultivar at 5WAP

	Time of Immersion in water (Hours)				
Sett size (g)	0	12	24	36	Mean
			2016		
40	21.00	56.70	26.70	28.30	28.20
50	32.70	52.70	31.70	30.00	36.80
60	35.70	74.70	37.70	28.00	44.00
70 (Cut)	27.70	55.00	44.30	28.30	38.80
70 (Whole)	26.70	36.00	25.00	38.30	31.50
Mean	28.76	55.02	33.08	30.58	
			2017		
40	21.00	58.00	27.00	28.00	37.60
50	33.00	53.00	32.00	30.00	45.00
60	36.00	73.00	38.00	28.00	62.30
70 (Cut)	28.00	55.00	44.30	28.30	46.80
70 (Whole)	27.00	36.00	25.10	66.00	38.30
Mean	29.00	55.00	33.28	30.52	
				2016	2017
$LSD_{(0.05)}$ for sett size (S) means =				5.00	5.00
$LSD_{(0.05)}$ for Time (T) of immersion in water means =				4.50	4.50
$LSD_{(0.05)}$ for S X T means =				10.00	10.00

Table 3: Effect of sett size and Time of sett immersion in water on number of tubers/plant of Yandu White yam cultivar

		Time of Immersion in water (Hours)			
Sett size (g)	0	12	24	36	Mean
			2016		
40	1.75	1.23	1.42	1.11	1.45
50	2.12	2.37	1.48	1.55	1.65
60	1.77	1.27	1.64	1.40	1.65
70 (Cut)	1.91	1.51	1.62	1.21	1.71
70 (Whole)	1.64	1.61	1.45	1.41	1.53
Mean	1.84	1.41	1.52	1.62	
			2017		
40	1.19	1.14	1.24	1.11	1.67
50	1.27	1.24	1.22	1.55	1.32
60	1.76	1.10	1.46	1.40	1.43
70 (Cut)	1.45	1.21	1.18	1.21	1.26
70 (Whole)	1.26	1.37	1.21	1.07	1.23
Mean	1.38	1.21	1.26	1.27	
				2016	2017
$LSD_{(0.05)}$ for sett size (S) means =				NS	0.17
$LSD_{(0.05)}$ for Time (T) of immersion in water means =				0.25	NS
$LSD_{(0.05)}$ for S X T means =				NS	0.33

The 40 to 80 percent increase in crop establishment associated with immersion of setts in water for 12 hours rather than for the control (no immersion) or more hours of immersion, and the generally better (15-26 percent) establishment recorded by whole tuber indicate that the tuber skin constricts movement of water into the tuber and that the tuber has enough moisture to support vine growth. Shoot dry matter and tuber yield were however dependent on sett size. The greater accumulation of dry matter of shoot at 60g sett weight indicates that bigger setts resulted in larger crop canopy relative to that from smaller setts, even when the smaller 40g sett showed higher initial crop establishment at 4 and 8 WAP. Similar differences in crop growth have been reported in cassava (Okeke, 1994; Eke-Okoro *et al.*, 2001), yam (Ekpe et al, 2005; Ikeorgu, 2003), cocoyam (Ndaeyo *et al.* 2013), and sweet potato (Law-Ogbomo *et al,* 2014) with different stake or sett sizes.

Similar to the effect on crop growth, tuber yield increased significantly on average, as sett size increased to a maximum of 60g (2t/ha), but, beyond this, further yield advantages did not occur. The yield differences between the sett sizes were attributable to differences in food reserves in favour of bigger sett sizes as reported by Okeke (1994). In this study, mean tuber weight increased with sett size such that the values obtained for 40, 50, 60 and 70g setts were 553g, 580g, 608g and 761g respectively. Ikeorgu and Igbokwe (1999) reported that growing sett weight below 25g produced mostly minitubers and seed yams not exceeding 200g, whereas 26 – 50g sett weight could produce about 45% seed yams of 200 – 500g, while using sett weight of 51 – 75g, produced over 86% seed yams of 200 – 1000g. Igwilo (1988) observed that growth of tubers is positively geotropic and larger setts tend to produce larger tubers, which encounter greater soil resistance to penetration, and as a consequence, smaller setts give higher yield than bigger setts. The bigger 70g whole tuber which gave higher establishment and the 70g sett did not improve tuber yield over the smaller 60 and 50g setts. The results of this investigation would therefore favour the use of 60g or 50g setts for seed yam production. Although, immersing the white yam setts in water for 12 hours enhanced crop establishment and accumulation of dry matter in the shoot, it did not improve tuber yield. The higher leaf area index associated with the control or setts that were not immersed in water was an indication of greater photosynthetic activity which slightly increased tuber yield, on average, as yield reductions obtained when setts were immersed in water for 12, 24 and 36 hours were 20%, 24% and 16% respectively. The decreasing trend of leaf area index with increased period of immersion in water suggests adverse effect on leaf development and a reduction in the photosynthetic activity of leaves. Consequently, there was no effect on yield or even the tendency to depress yield following immersion of sett in water.

Table 4: Effect of sett size and Time of sett immersion in water on tuberweight (kg/plant) of Yandu White yam

	Time of Immersion in water (Hours)				
Sett size (g)	0	12	24	36	Mean
		2016			
40	0.82	0.63	0.67	0.56	0.67
50	0.50	0.93	0.70	0.63	0.71
60	0.74	0.63	0.69	0.76	0.70
70 (Cut)	1.34	0.79	0.89	1.04	1.01
70 (Whole)	0.76	0.74	0.61	0.82	0.73
Mean	0.852	0.74	0.71	0.76	
		2017			
40	0.42	0.54	0.43	0.33	0.43
50	0.41	0.45	0.44	0.46	0.44
60	0.68	0.49	0.35	0.49	0.50
70 (Cut)	0.45	0.63	0.45	0.46	0.50
70 (Whole)	0.39	0.52	0.48	0.51	0.47
Mean	0.47	0.53	0.43	0.45	
				2016	2017
$LSD_{(0.05)}$ for sett size (S) means =				0.17	NS
$LSD_{(0.05)}$ for Time (T) of immersion in water means =				NS	0.07
$LSD_{(0.05)}$ for S X T means =				NS	0.16

T**able 5:** Effect of sett size and Time of sett immersion in water on tuber yield (t/ha) of Yandu White yam cultivar

	Time of Immersion in water (Hours)				
Sett size (g)	**0**	**12**	**24**	**36**	**Mean**
		2016			
40	47.90	27.20	33.00	22.70	22.70
50	44.40	43.10	35.20	35.00	39.40
60	45.60	27.00	38.80	49.20	40.20
70 (Cut)	33.30	38.70	48.30	62.70	45.80
70 (Whole)	52.60	39.80	30.00	26.40	37.20
Mean	**44.80**	**35.20**	**37.00**	**39.20**	**39.10**
		2017			
40	17.40	20.90	17.90	12.60	17.20
50	18.00	19.10	18.40	23.90	19.80
60	40.60	18.20	16.70	24.00	24.90
70 (Cut)	22.90	25.90	17.90	19.20	21.50
70 (Whole)	17.70	23.80	19.60	18.30	19.80
Mean	**23.30**	**21.60**	**18.10**	**19.60**	**20.60**
				2016	**2017**
$LSD_{(0.05)}$ for sett size (S) means =				NS	5.50
$LSD_{(0.05)}$ for Time (T) of immersion in water means =				NS	NS
$LSD_{(0.05)}$ for S X T means =				22.60	10.90
$LSD_{(0.05)}$ for Year means =				3.80	

Lebot (2009) reported that the moisture content of yam tubers at sprouting time is sufficient to initiate root growth and that, plant development depends almost exclusively on tuber reserves for nutrients and moisture until the initial stem emerging from the corm produces leaves. This probably explains the lack of effect of immersion of setts in water on tuber yield. Overall, immersion of whole yam tubers or setts in water before planting proved to be unnecessary, as it tended to depress tuber yields. In general, time of sett immersion in water did not affect tuber yield significantly, probably because of the fairly high moisture content in the yam tuber.

CONCLUSION

White yam (yandu) crop establishment was consistently and significantly higher with the use of 70g whole tuber than with the use of setts, regardless of sett size. The 60g sett, however, produced higher dry matter in the shoot and higher tuber yield than the 70g whole tuber. The highest tuber yield was obtained from 60g sett, although 50g sett weight gave similar results. Increasing the time of sett immersion in water decreased white yam leaf area index, but increasing the time of immersion to 12 hours significantly increased crop establishment and shoot dry matter on average. Time of immersion of sett in water had no effect on tuber yield.

REFERENCES

Abebe A.T. and A.T. Modi (2009). Hydro primary in dry bean (*Phaseolus vulgaris L.*). Res. J. Seed Sci. **2,** 23-31

Andres C., Ade Oluwa O.O. and Bhullar. G.S. (2017). Yams (*Dioscoreaspp*): Encyclopedia of Applied Plant Sciences **3**, 435-441.

Asonye P.C. and Hamadina, E.I. (2018). Germinating *Allanblackia floribunda* seeds with slightly thickened seed coat using water. Scholars Academic Journal of Biosciences. **6 (4),** 373-377.

Awologbi E. and Hamadina E.I. (2016). Early induction of sprouting on seed tubers of yam soon after tuber initiation in a hydroponics system. Experimental Agriculture **52 (3),** 405-417.

Ayankanmi T., Shiwachi H. and Asiedu R. (2005). Sprouting and yield of yam (*Dioscoreaspp*) minisetts in relation to sett size, soil moisture and agroecology. Tropical Science **45,** 23-27.

Barker D., Keatinge J.D.H. and Asiedu R. (1999). The potential of physical mean for the manipulation of yam tuber dormancy. Tropical Science **39 (4),** 204-213

Berchie J.N., H. Adu-Dpagh J. Sarkodie-Addo, E. Asare, A. Agyemang, S. Addy and J. Donkoh (2010). Effect of seed priming on seedling emergence and establishment of four Bambara groundnut (*Vigna subterranean L. verdc*) Landraces, J, Agron., **9,** 180-183.

Clark L.J., W.E. Whalley J. Ellis-Jones, K, Dent, and H.R. Rowse*et al* (2001). On far, seed priming in Maize: A physiological evaluation. Proceeding of the 7th Eastern and South Africa Regional Maize Conference, February, 11-15, Kenya. Pp: 268-273.

Coursey D.G. (1967). Yams. Longmans, Green and Company Limited, London 230 pp.

Dagras L.M. (1993). The yam. A Tropical Root Crop. Macmillan Press Ltd. London.

Eka, O.U. (1985). The chemical composition of yam tubers. In G. Osuji (Ed.): Advances in yam Research, Nigeria: Frontline Publisher, Enugu.

Eke-Okoro O.N., Okereke, O.U., Okeke J.E. (2001). Effect of stake sizes on some growth indices and yield of three cassava cultivars. J. Agric. Sci. (Cambridge): **113,** 419-426.

Ekpe E.O., Chinaka, C.C., Otto Ndaeyo N.U., Okoro E.A. and Emah V.E. (2005). Comparative Evaluation of Bulbils and sett sizes on growth pattern and yield of water yam (*Dioscoreaalata L.*) Nigerian Journal of Agriculture, Food and Environment, **2 (1),** 42-46.

GenStat Discovery Edition 3 (2007). Lawes Agricultural Trust (Rothamsted Experimental Station), UK P. 324.

Hahn S.K., D.S.O. Osiru M.O. Akoroda and J.A. Otoo (1987). Yam production and its future propects. Outlook on Agriculture **16**, 105-110.

Hamadina E.I. (2012). Origin of vines, feeder roots and tubers in Yam: The tuber head or the Primary Nodal complex? Nigerian Journal of Agricultures, Food and Environment **8 (1),** 67-72.

Hamadina E.I. and Asiedu R. (2015). Effect of provenance and storage agroecology on duration of yam tuber dormancy. Agriculture, Forestry and Fisheries **4 (3),** 95-100.

Igbokwe M.C., Okoli, O.O., Ene, L.S.O. and Obasi, M. (1988). Advances in vegetative propagation of yams: Effect of size of minisett and area periderm from *D alata* and *D rotundata* on yield of seed yams in the rainforest zone of Nigeria. Nigerian Agricultural Journal **23,** 144-152.

Igwilo N.O. (1988). Field performance of yam grown from minisetts and seed yams: 1. Fresh tuber yield. Nigerian Agricultural Journal **23,** 11-16.

Igwilo N.O. (2009). Effect of sett size on the yield of two yam varieties grown in the dry season and rainy season. Nigerian Agricultural Journal **40,** 93-99.

Ikeorgu J.E.G. (2003). Effect of sett size and spacing of mini tubers on yield of three selected yam cultivars in the humid tropics of

Nigeria. Nigerian Agricultural Journal **34**, 58-62,

Ikeorgu J.E.G. and Igbokwe M.C. (1999). Effects of various sizes of mini tubers on seed yam size and yield. Annual Report, National Root Crops Research Institute (NRCRI), Umudike pp 36-40.

Ile E.I., Craufurd P.O., Battey N.H. and Asiedu R. (2006). Phases of tuber dormancy in yam. Annals of Botany **97,** 497-504.

Ileleji F.O., Hamadina E.I. and Orluchukwu J.A. (2015). Germination of *Allanblackia floribunda* seeds: The effect of soak duration in fluridone on germination and seedling growth. Agriculture, Forestry and Fisheries **4 (3),** 142-147

Khan A.A. (1992). Preplant physiological conditioning. Hort Rev. 13:131-181.

Law-Ogbomo K.E., Osaigboro A.U., Asekunle A.T. and Nwaoguala, C.N.C. (2014). The influence of sett size on growth and fresh tuber yield of *Ipomeabatatas L*. Journal of Applied Agricultural Research **6,** 259-264.

Lebot V, (2009), Tropical Root and Tuber crops: cassava sweet potato, yams and Aroids. Crop production science in Horticulture no 17, CABI Publishing UK, 413 P. a book summarizing the available information regarding the origin, taxonomy, breeding, physiology, agronomy, pathology and processing of cassava, sweet potato, yams and Aroids,

Mavi K.,S. Ermis and L. Demire (2006). The effect of priming on Tomato root stock seeds in rlation to seedling growth. Asian J. Plant Sci. **5,** 940-947.

McDonald M.B., Sullivan J. and Lauer M.J. (2006). The pathway of water uptake on maile seed. Ohio State University, Columbus, USA.

Modi A.T. (2005). Assessment of pepper seed performance using dessication sensitivity. Seed Sci. Technol. 33:19-30.

Ndaeyo N.U., Udeme K.U., Ikeh A.O., Akpan E.A, Udoh E.I and Akata O.R (2013). Effect of sett weight on the growth and yield of some cocoyam species in Uyo, south eastern Nigerian. Nigerian Journal of Crop Science **1,** 47-53.

Okeke J.E. (1994). Productivity and yield stability in cassava as affected by stake weight. Journal of Agricultural Sciences **122,** 61-66.

Onwueme I.C. (1975). Tuber formation in yam: Effect of moisture stress and contribution of the parent sett. Journal of Agricultural Sciences **85 (2),** 267-269.

Onwueme I.C. (1978). The Tropical Tuber Crops, yams, cassava, sweet potato and cocoyams, John Wity and Sons. New York, 234pp.

Wilson L.A., Wickham I.D. and Ferguson T. (1998). Alternative manifestations in origin, form and function of the primary nodal complex of yams: a review. Tropical Agriculture (Trinidad) **75 (1),** 77-83.