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Research Paper

Chlorophyll, Relative Water Content and Yield Assessment of Yam (*Dioscorea Rotundata-Poir)* Vine Cuttings for Mini Tuber Production under Varying Environmental Conditions

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Abstract: *Investigations were carried out on the survival, mean root initiation, physiologyand yield of yam (Dioscorea rotundata) vine cuttings under varying environmental conditions. Experiment was carried out at the Botanical nursery of the Department of Botany, University of Ibadan, South western Nigeria. The experiment was laid out in complete randomized design with three replicates. Yam vine cuttings planted were subjected to five environmental conditions; open space (OPS), improvised screen house (ISH), permanent shade (PSH), screen house (SCH) and combination of screen house and permanent shade (SCH+PSH).The results showed that the highest percentage survival was recorded in ISH (96.6%),while the lowest was in OPS (28.6%). Root initiation was enhanced in vine cuttings treated with ISH, SCH and combination of ISH+PSH (7.7) than in OPS (4.7). Leaf chlorophyll content was highest in SCH (75.6) but lowest in ISH+PSH (51.5). SCH treated vines had the highest values for shoot (9.8) and tuber weight (100.3) while PSH had the least values for shoot (3.8) and tuber (51.4). This result showed positive relationship between shoot and tuber weights. In sustainable yam production improvised screen house (ISH) was found to be suitable alternative to screen house (SCH) in yam vine cuttings technology aimed at reducing cost of production.*

Keywords: Improvised screen house, *Dioscorea rotundata*, Screen house, Chlorophyll contents, Relative water contents.

Introduction

Yam (Dioscorea spp) is one of the major food crops grown by small scale farmers which provides staple carbohydrate fibres and low level fats which makes them low dietary source for a large population in the tropics (Oyetunji *et al*, 2003; Craufurd*etal.*,2006; Pannerselvam *et al.*, 2007; Behera *et al.*, 2009). Yams also have medicinal properties, while some of them are among the principal source of diosgenin, which can be converted to medicinal important steroids (Jaleel *et al.*, 2007). Yams are a primary agricultural and culturally important commodity in West Africa, where over 95 percent of the world's yam crop is harvested. Yams are still important for survival in these regions. Some varieties of these tubers can be stored up to six months without refrigeration, which makes them a valuable resource for the yearly period of food scarcity at the beginning of the wet season. Yam cultivars are also cropped in other humid tropical countries. There are over 600 varieties of yams and 95 percent of these crops are grown in Africa (Library of Congress, 2011).

The crop yield depends on how and where the setts are planted, sizes of mounds, interplant spacing, provision of stakes for the resultant plants, yam species, and tuber sizes desired at harvest. The seed yams are perishable and bulky to transport. Farmers who do not buy new seed yams, usually set aside up to 30 percent of their harvest for planting the next year. Yam crops are susceptible to range of insect pests, fungal and viral diseases, as well as nematode (IITA, 2010). For maximum yield, yam requires a humid tropical environment, with an annual rainfall of over 1500 millimeters distributed uniformly throughout the growing season (Calverly, 1998).Yam production requires high labor. The crop has low yield per hectare compared to crops such as Cassava (manioc) or sweet potato. It is not an efficient staple food given the relatively large amount of planting material that is required and its long growing season (Oke, 1990).

In traditional practices, the rural farmers generally use 100 to 600gm or more of tuber piece as seed tuber which was 10 to 30% of the total yam yield, which is a costly method of yam propagation (Behera *et al*, 2009). Over the years, different methods were applied to improve yam cultivation and production, among these is the vine cuttings technique (IITA, 1977). To increase the amount of seed yam available for seed and ware yam production, there is need to develop method of improving the multiplication ratio of yams. The propagation of food yams using yam vine cuttings represents a departure from the conventional method of propagation using tubers.The Yam Mini tuber seed yam production Technique was developed by Yam Research Programme in 2003 as a back up to the Yam Mini sett Technology developed in 1982. The technique has been found to produce micro tubers, mini tubers and seed yams ranging from 30 grams to 150 grams using 6 grams to 10 grams cut setts and could be planted directly into prepared ridges, mounds or beds (Ogbonna *et al.*, 2011). This technology offers a rapid, clean, and cost-effective mass method of multiplying yam. It could effectively address the need for fast and wide distribution of high-quality improved varieties to meet the increasing demand for the crop (IITA, 2009).

The objective of this work is to investigate the physiological and yield related parameters of yam vine cuttings planted under different environmental conditions.

Materials and Method

Study Location and Experimental Design

The study was carried out at the nursery farm, Department of Botany, University of Ibadan, and the Botanical garden, University of Ibadan, Ibadan, South-West Nigeria in 2012 and 2013.The experimental design used for the experiment was complete randomized design with three replicates.

Planting Procedure

Healthy vines of *D.rotundata* were excised from the plants 130-140 days after planting using a sharp razor blade in the morning between 7.00-9.00 am. Vines were placed in a moist transparent polythene bags immediately after collection in order to maintain moisture. From the middle portion of each vines, 20cm long cutting with three nodes and six leaves were prepared. Vines were carefully wounded by scraping to remove the epidermis at the lower end of the nodes; this is to promote root initiation. With the use of hand shallow ditches of 2-3cm depths were made on the bagged soil. The vines were layered horizontally with their leaves upright to trap sunlight in order to produce more assimilates that will be translocated to the rooting zone. The planted vines were then subjected to different environmental conditions which represent the treatments. The Improvised screen house(ISH) was made with wood and a transparent nylon, Permanent shade (PSH) under the tree canopy, Screen house (SCH)made with glass and Open space (OPS) un-shaded environment.

Data Collection

Chlorophyll Content Determination

Chlorophyll content determination was done using pocket chlorophyll meter MO-SPC-SPAD 502 (Konica Minolta, USA) at week2, 6, 10, 14, and 18of planting.

Determination of Relative Water Content (RWC)

Fresh leaves collected from each treatment were cut with cork borer into small discs, which were weighed and recorded as sample's fresh weight (W). The samples were then hydrated to full turgidity in distilled water for 4 hours under normal room condition. These were removed from the water after 4 hoursand quickly dried off with filter paper adhering moisture and immediately weighed as the turgid weight (TW). Samples were then dried in an oven at 80^{o}C for 24 hours, cooled in a desiccator and later weighed as the dry weight.

The following formula was used to determine the Relative water content (RWC).

$$RWC\ (\%) = \frac{W - DW}{TW - DW} * 100$$

Where W = sample fresh weight; DW = sample dry weight; TW = sample turgid weight.

Statistical Analysis

Statistical analysis was done using the analysis of variance (ANOVA) and different means of treatments were compared using Duncan Multiple Range Test (DMRT).

Results and Discussion

Percentage survival of yam vine cuttings under varying environmental conditions at different weeks of planting: Percentage survival of yam vine cuttings under varying environmental conditions was as shown in table 1. At 2 weeks after planting (WAP), OPS recorded the lowest percentage survival (0.0%), while SCH had the highest (35.23%).At 3WAP ISH had the highest percentage survival (66.0%), while OPS had the least survival percentage (22.7%). Similar values were observed at 4WAP. SCH and ISH+PSH also had higher values for percentage survival at 4WAP (87.92% and 89.92% respectively). This may be due to the high number of roots initiated by these treatments and increased humidity and temperature of the rooting medium (Leakey, *et al.*, 1981).

Root Initiation: Table 2 shows the average number of roots of yam vine cuttings without rooting chemicals under different environmental conditions at different weeks after planting. Yam vine cuttings in an open space (OPS) had the lowest value (0.00) for mean roots at 2WAP, while ISH+PSH had the highest (3.0). At 3WAP highest mean roots was also observed in combination of ISH+PSH (5.3), with OPS having the lowest value (2.3). Highest root mean value was recorded in vines treated with ISH, ISH+PSH and SCH (7.7) at 4WAP, but this value was not different from vines treated with PSH (7.3), while OPS had the lowest value. The higher number of roots in vines under the improvised screen house and the screen house may not be unconnected with the increased temperature in the propagators. This work corroborates the findings of Leakey, *et al* (1981) that percentage of cuttings rooting increased when temperature of propagating beds were raised above 20^{o}C. All the treatments had appreciable number of roots; this was in agreement with Acha *et al* (2004), that with or without hormone treatment, clonal variations for mean percentage rooting of vines were not significant P> 0.05.

Leaf chlorophyll contents: Leaf chlorophyll contents of yam vine cuttings under different environmental conditions at different weeks after planting was investigated and results was as shown in table 3.At 2WAP, highest value was observed in vines treated with ISH (57.5), while OPS treated vines had the least value (28.8). There was a sharp decrease in the values of chlorophyll contents at 6WAP with SCH treated vines having the highest value (38.2) and PSH having the lowest value (30.1). At 10WAP, highest chlorophyll value was observed in SCH (63.4), while ISH+PSH had the least value (35.6).This was in line with the report of Alem (2010), that there is a sharp decline in the chlorophyll contents after severing and gradually recovered in propagation after root initiation. At 14WAP, SCH treated vines had the highest value for chlorophyll contents (74.7), the lowest value was recorded in vines treated with ISH+PSH. Similar results were observed at 18WAP. Chlorophyll content was lowest in PSH and ISH+PSH treated vines, this may be because enough light cannot be received by the vines due to shade.This support the work of Oyetunji and Afolayan, 2007, that chlorophyll synthesis may be slowed or stopped by low temperature and relative water contents (RWC).This work also corroborates the reports of Alem (2010) that unrooted cuttings had relatively low photosynthetic rates compared to rooted cuttings. It was interesting to observe that at 4WAP, values for root initiation was very high for PSH and ISH+PSH but does not correspond to high chlorophyll contents, may be because the vines were heavily shaded.

Relative Water Contents (RWC): Table 4 shows the Relative water contents(RWC) of yam vines under varying environmental conditions at different weeks of planting (WAP).At 2WAP, RWC of yam vines ranged from 32.97 in ISH treated vines to 18.16 in OPS treated vines. This may be because OPS treated vines were subjected to direct rays of the sunlight; as a result there was high transpiration rate. Highest water content was recorded in SCH treated vines (38.69) while the lowest was in ISH+PSH treated vines (31.42) at 6WAP. There was an improvement in the water content of vines treated with OPS at 6WAPmay be because the plants had rootedand absorption of water had increased.Remarkable improvement was observed in the RWC of vine cuttings at 10WAP,1SH treated vines had the highest values (63.22) while ISH+PSH had the lowest (48.5).Relative water contents (RWC) of vine cuttings observed at 14WAP was similar to that of 10WAP with ISH having the highest value (72.5), and ISH+PSH had the least value.At 18WAP ISH treated vines had the highest watercontents (77.41), while PSH treated vines recorded the lowest (69.5) water content.

Yield characters of yam vine cuttings under varying environmental conditions: The yield characters of yam vine cuttings were investigated and presented in table 5.

SCH treated vines had the highest values for shoot weights (9.8) which was not different from ISH treated vines (9.6) but significantly different from PSH treatments which had the lowest value for shoot weight (3.8). Highest value was observed in SCH treated vine cuttings for the tuber weight (100.3),while PSH vine cuttings had the least (51.4) which was not different from ISH+PSH vines (58.6).This was similar to the report of Alem (2010), that high number of roots results in high photosynthetic assimilates. SCH had the highest root weights (2.05) but not different from ISH treated vines (1.99), this may due toincreased humidity and temperature of the rooting medium (Leakey, *et* *al*., 1981).Vine cuttings treated with combination ISH+PSH had the lowest values for root weight (1.13). This may be because the plants were heavily shaded.

Table 1: Percentage survival of vine cuttings under varying environmental conditions at different weeks of planting (%)

	Weeks after Planting		
Treatment	2	3	4
OPS	0.00	22.70	28.61
ISH	33.36	66.00	96.00
PSH	10.59	38.48	53.62
SCH	35.23	62.31	87.92
ISH+PSH	35.68	52.55	89.92

OPS = Open space; ISH = Improvised screen house; ISH+PSH = Improvised screen house under permanent shade; PSH = Permanent shade; SCH = Screen house (control).

Table 2: Mean number of roots of yam vine cuttings under varying conditions after different weeks of planting

	Weeks after planting		
Treatment s	2	3	4
OPS	0.00 ± 0.00^{b}	2.33 ± 0.33^{b}	4.67 ± 0.33^{b}
ISH	2.67 ± 0.33^{a}	5.00 ± 0.00^{a}	7.67 ± 0.33^{a}
PSH	2.33 ± 0.33^{a}	4.67 ± 0.33^{a}	7.33 ± 0.33^{a}
ISH+PSH	3.00 ± 0.00^{a}	5.33 ± 0.33^{a}	7.67 ± 0.33^{a}
SCH(Control)	3.00 ± 0.00^{a}	5.00 ± 0.58^{a}	7.67 ± 0.33^{a}

Means with same letter along the column are not significantly differentp>0.05(Duncan Multiple Range

Table 3: Leaf Chlorophyll contents of yam vines cuttings under varying environmental conditions after different weeks of planting (WAP)

	Weeks after planting (WAP)				
Treatment	2	6	10	14	18
OPS	28.83 ± 4.07^{b}	32.60 ± 4.05^{a}	45.30 ± 1.59^{b}	47.50 ± 1.28^{d}	64.50 ± 2.17^{b}
ISH	57.53 ± 0.73^{a}	34.17 ± 2.34^{a}	57.67 ± 0.72^{a}	69.77 ± 0.28^{ab}	72.57 ± 2.27^{ab}
ISH+PSH	51.87 ± 2.51^{a}	31.07 ± 0.48^{a}	35.57 ± 2.09^{c}	42.80 ± 1.99^{d}	51.47 ± 0.93^{c}
PSH	44.93 ± 6.89^{a}	30.07 ± 1.12^{a}	36.63 ± 3.94^{c}	53.97 ± 1.93^{c}	52.17 ± 2.12^{c}
SCH(Control)	49.93 ± 1.78^{a}	38.17 ± 4.48^{a}	63.43 ± 1.04^{a}	74.67 ± 2.83^{b}	75.63 ± 3.29^{a}

Means with same letter along the column are not significantly different (Duncan Multiple Range Test, $p>0.05$)

Table 4: Relative water content (RWC) of yam vine cuttings under different environmental conditions after different weeks of planting

	Weeks after planting				
Treatment	2	6	10	14	18
OPS	18.16 ± 1.12^{d}	36.85 ± 1.14^{a}	62.13 ± 0.80^{a}	60.35 ± 0.20^{b}	69.61 ± 0.59^{a}
ISH	32.97 ± 1.43^{a}	37.10 ± 1.60^{a}	63.22 ± 1.76^{a}	72.50 ± 1.12^{a}	77.41 ± 1.21^{a}
PSH	27.01 ± 0.69^{c}	31.66 ± 0.93^{a}	60.17 ± 1.11^{ab}	59.01 ± 0.86^{b}	69.50 ± 5.14^{a}
SCH	30.71 ± 1.28^{ab}	38.69 ± 3.90^{a}	57.17 ± 0.59^{b}	61.41 ± 1.03^{b}	72.15 ± 1.06^{a}
ISH+PSH	28.57 ± 0.28^{bc}	31.42 ± 1.03^{a}	48.50 ± 0.66^{c}	52.09 ± 2.01^{c}	70.83 ± 1.69^{a}

Means with same letter along the column are not significantly different (Duncan Multiple Range Test, $p>0.05$)

Table 5: Mean Yield Characters of yam vine cuttings under varying environmental conditions

Treatment	Shoot weight	Tuber weight	Root weight
OPS	7.40 ± 1.08^{b}	72.00 ± 2.56^{b}	1.91 ± 0.01^{a}
ISH	9.60 ± 0.31^{a}	99.37 ± 4.04^{a}	1.99 ± 0.02^{a}
PSH	3.80 ± 0.26^{c}	51.43 ± 3.35^{c}	1.27 ± 0.15^{b}
SCH	9.77 ± 0.19^{a}	100.33 ± 0.99^{a}	2.05 ± 0.03^{a}

ISH+PSH	4.40 ± 0.23[c]	58.57 ± 4.98[c]	1.13 ± 0.11[b]

Means with same letter along the column are not significantly different (Duncan Multiple Range Test, p>0.05)

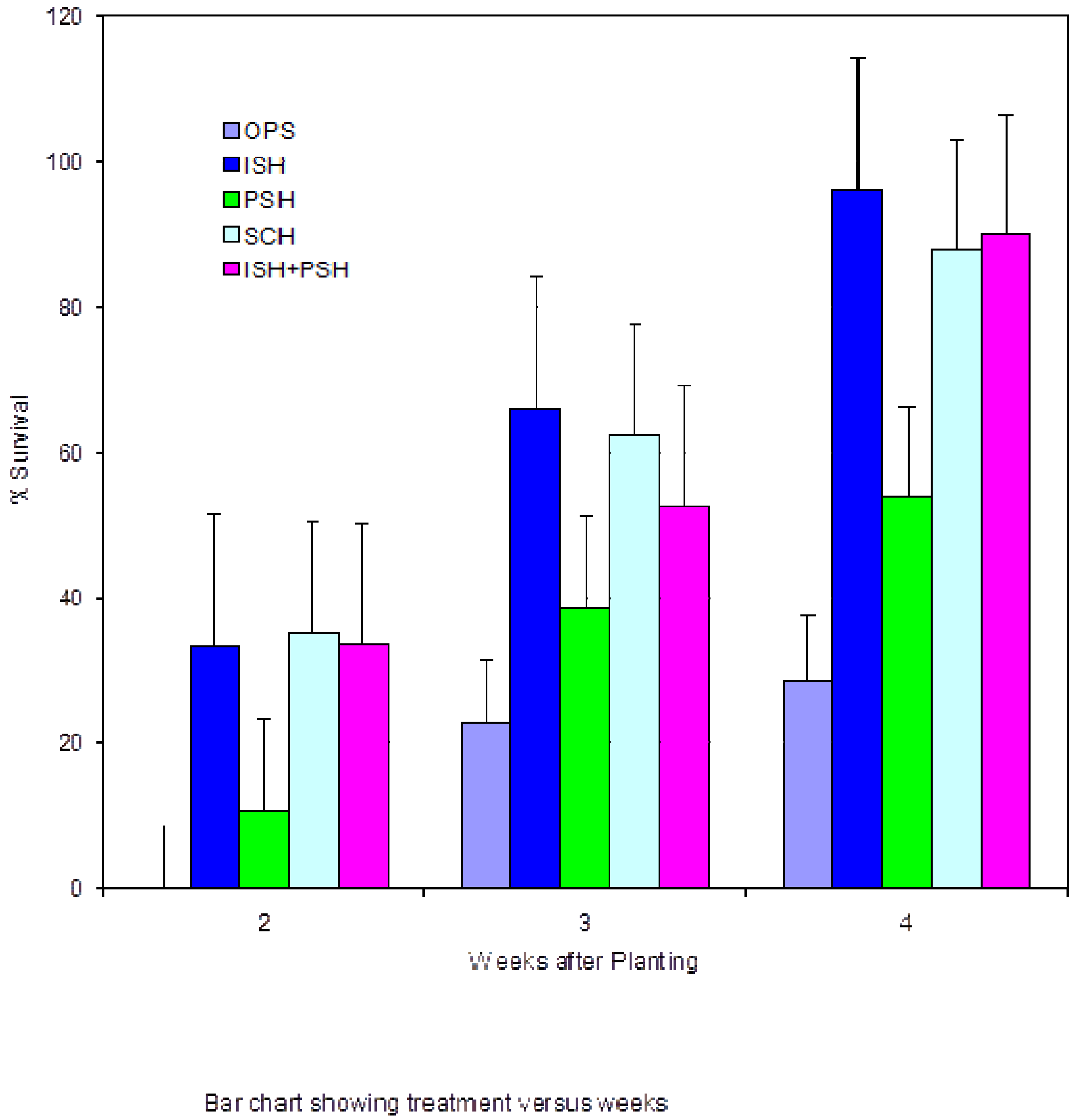

Figure 1: Percentage survival of yam vine cuttings under different environmental conditions at different weeks of planting

Conclusion

This study therefore suggests that the four treatments; Improvised screen house (ISH), Permanent shade (PSH), Screen house (SCH) and combination of improvised screen house and permanent shade (ISH+PSH) enhanced vine cuttings survival and root initiation at 4WAP.But only SCH and ISH greatly enhanced chlorophyll content, water contents, tuber and shoot weights of the yam vine cuttings.Improvised screen house (ISH) proved to be good as screen house (SCH) in vine cuttings technology. This will be a useful means of reducing the high cost of yam production by the local farmers in the humid and sub – humid tropics.

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