African Journal of Biotechnology Vol. 9 (30), pp. 4714-4724, 26 July, 2010
Available online at http://www.academicjournals.org/AJB
ISSN 1684–5315 © 2010 Academic Journals

Full Length Research Paper

Effects of synthetic hormone substitutes and genotypes on rooting and mini tuber production of vines cuttings obtained from white yam (*Dioscorea rotundata*, Poir)

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Accepted 5 November, 2009

This study was designed to evaluate the effects of some root - promoting substances on rooting and mini tuber formation using vine cuttings obtained from two genotypes (TDr 335 and TDr 93 - 49) of white yam (*D. rotundata).* The ashes were obtained from rice straw, bamboo, *Gliricidia sepium*, dry leaves of *Azardiracta indica* (neem), and 1% indolebutyric acid (IBA). These were powdered on the nodal wounds of vine cuttings before they were planted in planting media (carbonized rice husk). The plant ashes were mixed at 1, 3 and 5 g each in 100 ml of water. Coconut water was also diluted at 1, 5 and 10 ml in 100 ml of water while pyroligneous acid (PA) was diluted (1 ml each in 500, 1000, 2000 and 3000 ml in 5000 ml of water). Both dilutions were used to treat vine cuttings before planting in cups filled with carbonized rice husk. The vine cuttings were sampled for rooting percentage, number of roots, root length and mini tuber initiation 21 days after treatment (DAT). The number and weight of tubers obtained from IBA and wood ash treated vines were not significantly different. The rice straw ash, IBA and neem leaves powder treated vines produced greater rooting percentage (above 70%) than percent rooting obtained from vines treated with other plant ashes. Rice straw ash (5% concentration) had the highest rooting percentage (80%) relative to other plants ash concentrations. Higher rooting percentage was obtained in coconut water diluted at 1 and 5% than 10 and 100% dilutions. Rooting percentages from vine cuttings treated with pyroligneous acid (PA) dilutions were not better than control (unteeated). The rooting percentages obtained from vines treated with different concentrations of plants ashes, root - promoting substances and control in this study were not significantly different (P = 0.05), except in vine cuttings treated with 5 g rice straw ash in 100 ml of water. Higher values of rooting percentage, number of roots, root length and mini tubers were obtained from genotype TDr 93 - 49 compared with values recorded from vine cuttings obtained from the genotype TDr 335.

Key words: Keywords: Dioscorea, genotypes,cuttings, rooting, mini-tuber, tropics.

INTRODUCTION

Yams belong to the family *Dioscoreaceae* within the order *Dioscoreales* and are members of the genus *Dioscorea*, which produce tubers and bulbils that are economically important (Ayensu, 1972). The genus *Dioscorea* is by far the largest genus of the family and is very important throughout coastal West Africa where approximately 60 million people obtain more huge calories of energy of about 800 KJ day^{-1} from it (Nweke et al., 1994). Food yams are predominantly cultivated in the humid forest, forest/savanna transition and the southern guinea savanna (SGS) zones of West Africa. Large percentages of current production are in the SGS (Scott et al., 2000). Edible yams are very important indigenous source of food to man, which is widely grown, and massively consumed in Nigeria and other African countries (Ferguson and Gumbs, 1976; Orkwor and Ekanayake, 1998). Nigeria produces most of the world's

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annual output of over 27 million tones of yams (FAO, 2004).

The edible part of yam is the underground starchy stem called ‘tuber’ which also serves as the conventional propagules of the crop. Thus, in most parts of Nigeria, up to 30% (3 - 5 t/ha) of the previous harvest may be used to plant a new crop. Yams may be propagated vegetatively or sexually through seed. Up until recently, the traditional and most widely practiced method of growing yams is through the use of tuber or bulbil (Okonkwo, 1985). Traditionally, whole tubers or large pieces of 200 g or more of yams (*Dioscorea* spp.) are usually employed for propagation by planting (Okoli et al., 1982). This means that some marketable tubers must be reserved for planting. The cost of planting material is over 33% of the total outlay for yam production, so there is a need to improve the rate of yam multiplication (Okoli and Akoroda, 1995). Due to difficulties in propagation, the yam is under threat in many traditional areas of production (IITA, 1994). Although yam minisett technology has been developed, notwithstanding, failures in terms of poor sprouting and sensitivity to moisture stress in the soil has been its bane or short comings (Ayankanmi et al., 2005). Seed yam produced by minisett technology and second harvest through milking process are in many occasion not enough to meet the needs of yam growers. Some of these planting materials are lost to pest and diseases such as nematodes and rots.

In view of the large quantities of tubers/bulbils committed to producing new plants, which otherwise would have been available for human consumption, other methods of yam propagation using vine cuttings have been sought after. Propagation from vine cuttings was first reported in non-food yams (Correll et al., 1955) and in recent times, it has been extensively reported in food yams (Vander Zaag and Fox, 1981). Njoku (1963) drew attention to the possibility of raising plants of *D. alata, D. rotundata* and *D. dumetorum* through vine cuttings, as an alternative to propagation by tuber. It was demonstrated that cuttings of the vine excluding a node never rooted, even after being treated with rooting substances. A cutting usually involves a node, made in such a way that about 2.5 cm of vine tissue is left attached below and above the node with the leaf intact (Okonkwo, 1985). The ease with which the vine cuttings can root and establish varies with species and cultivars, and also with physiological factors related to plant growth (Hartman et al., 1990).

Based on the pioneer work of Njoku (1963), interest has been generated in using vine cuttings as propagative material in view of their potentialities as excellent physiological research material e.g. for clonal propagation, replication and uniformity of starting material. Besides, the technique offers hopes of alternative planting material to the tuber otherwise needed as energy food source for animals and man (Vander zaag and Fox, 1981). Moreover, seed tuber production through vine cuttings increase the multiplication of clones beyond levels possible through conventional use of tuber pieces. It also results in seed tubers that are free of nematodes and soil borne pathogens if a sterilized medium is used, and thus offers potential for ‘cleaning up’ declining clones (Wilson, 1978).

More research works have been carried out on yam propagation using vine cuttings with the aid of auxin or rooting hormones such as indolebutyric acid (IBA) and naphthaleneacetic acid (NAA) (Okoli and Akoroda, 1995; Acha et al., 2004). Acha et al. (2004) suggested that treating vine cuttings of responsive clones of *D. rotundata* with different hormone concentrations before planting in a suitable rooting medium could be valuable in determining the optimum hormone concentration required for effective rooting. The cost implication of using the synthetic hormones (IBA, NAA) is high and the ease with which they are obtained is limited. This therefore means suitable and cheaper natural compound (growth – promoting substances) at optimum concentration for yam vine rooting are required. It is therefore necessary to assess locally sourced root - promoting substances as a substitute to synthetic products (auxins). Cuttings of several yam species have been rooted in sand media without hormones (Ferguson, 1971); however, hormone treatment may accelerate root, shoot and tuber formation (Cabanillas and Martin, 1978). Akoroda and Okonmah (1982) obtained that small tubercles, whose size and quantity were not specified from rooted vine cuttings of yam. Acha et al. (2004) studied the effect of auxin on root development in *D. rotundata* vines and observed the formation of mini tubers. The authors reported that further that treatment of vine cuttings with indolebutryic acid (IBA) significantly increased the number of roots produced by vine cuttings of ten *Dioscorea rotundata* cultivars.

IITA (2000) annual report showed coconut water (10%) as one of the important compositions of basal medium supplements used in tissue culture for obtaining rooting and plantlet formation from immature yam seeds. Coconut water when analyzed showed its main ingredient to include sugar, amino acid, myo - inositol, micro constituent (phenyl urea). It enhances the activity of cytokines and also has IAA and gibbrellic acid. This is usually added to medium at 5-10% (Komamine et al., 1990). Yamasaki and Kurata (1950) reported that paddy rice seedlings (about 35 cm in height), the root of which had been cut off by a knife, were dipped, for 24 h in the 1% solution of rice straw ash, 0.5% of Ca $(OH)_2$, 0.1% KCl_2 and water (control), and cultured in water for a few days during which the root - growth was examined every day. It was reported that the treatments hastened root- growth during the water culture treated with either straw ash of rice or KCl_2, compared with the control, but not under $Ca(OH)_2$ treatment.

Yoshida et al. (2000) stated that the components of pyroligneous acid are acetic acid (basis), alcohols, ketones, carboxylic acids, furans and phenols. Ichikawa et al. (1982) in the experiment conducted on the effect of pyroligneous acid on the growth of rice seedlings, reported that seedlings growth was promoted by the soil treatment with pyroligneous acid and that the rooting activity of rice seedlings was accelerated by the treatment with pyroligneous acid prior to transplanting. It was also found that stem (as against lodge stems) erectness of rice seedlings was increased by the application of pyroligneous acid. The results suggested that pyroligneous acid effectively enhanced activation of auxins. The number of roots, root length and root dry weight of sweet potato seedlings were increased by soaking in a pyroligneous acid solution. When the effect of pyroligneous acid on the growth of sweet potato cultured in pots were examined, it was found that the application of pyroligneous acid promoted the growth of sweet potato root, increased its activity, and promoted the absorption of nitrogen (Hua et al., 1998).

The objectives of this study were; to identify locally sourced substances as alternatives to synthetic rooting hormones (chemical auxin), to determine the optimum concentration of these substances required for rooting yam vine cuttings, and to compare the response of some yam clones vines to the applied rooting - promoting substances.

MATERIALS AND METHODS

The study was conducted at the International Institute of Tropical Agriculture (IITA), Ibadan (7°26'N, 3°54'E), a rainforest - savanna transition zone. Two genotypes of yam (*Dioscorea rotundata* Poir: TDr 335, TDr 93 - 49), obtained from the Germplasm Collection Unit of IITA were used in this study. Yam setts weighing 100 - 150 g were cut and treated with wood ash, allowed to air-dry and planted the following day. These prepared yam setts were planted in the field on ridges 1.0 m apart in April, 2005. To stimulate early branching, vertical stems of the plants were topped 80 days after planting (DAP) at a height of 150 cm. Healthy-looking vines were excised from the plants 160 DAP between 8.30 and 9.30 am and kept in a moist, polythene bag for transfer to the screen house. The vines from middle portion of the lateral branch were prepared into 3-node cutting sizes with six leaves. The base of the cuttings were slantingly cut for more surface area and the two opposite leaves at the point of insertion into the planting medium were removed with a clean scissors. The prepared cuttings were then powdered at the point of cuts with each of the hormone treatments. The treated vine cuttings were then planted in perforated black nylon bags of size 10 x 11 x 25 cm already filled with carbonized rice husk (planting medium). Carbonized rice husks are product of incomplete combustion of organic material. It is prepared by setting fire under half - cut drum containing rice husk. During burning, a stick is usually used to intermittently mix it in order to achieve uniform carbonization. The carbonized rice husks are then cooled with water to prevent it from turning into ashes. Carbonized rice husk is a useful medium for planting seeds and seedlings (Komaki et al., 2002). Five cuttings were planted vertically in a bag. A treatment had three bags (replications). The planted cuttings were watered sparingly. They were left to root, initiate and develop tubers. Formations of the mini tubers were observed 3 months after treatment when the leaves had senesced. The mini tubers were counted and weighed. Each of the experiments was conducted as the new lateral branches develop.

Effects of IBA powder on yam vine cuttings rooting and mini tuber initiation

Healthy-looking vines were excised from the plants 150 DAP between 8.30 and 9.30 am and kept in a moist, polythene bag for transfer to the screen house. The vines from middle portion of the lateral branch were prepared into 3-node cutting sizes having six leaves. The nodal points of the cuttings were wounded with a clean razor blade and dusted with 1% IBA (Acha et al., 2004). The wounded nodal points formed callus from where roots would be formed. The control experiment had incisions but no treatment. Seven vine cuttings were then planted in a horizontal position in three (replicates) plastic boxes (48.5 x 32.5 x 13 cm) filled with carbonized rice husk. The planted cuttings were watered sparingly and the boxes were kept in the screen house. Cuttings in the boxes were sampled for rooting percentage, number of roots and mini tuber initiation 21 days after treatment (DAT).

Effects of plant ashes' powder on yam vine cuttings rooting and mini tuber initiation

The vine cuttings used in this experiment were collected from the two established clones (TDr 335 and TDr 93 - 49) described above. The vines from middle portion of the lateral branch were prepared into 3-node cutting sizes having six leaves. These vine cuttings were wounded at the nodal points with a clean razor blade and then dusted with; Rice - straw ash, Bamboo ash, *Gliricidia sepium* ash, and grounded, dried *Azadiracta indica* (neem) leaves powder. The vine cuttings were then planted in a layered position in plastic boxes (48.5 x 32.5 x 13 cm) filled with carbonized rice husk medium. Ten cuttings were planted in each box. Three boxes (replication) of each nursery medium were prepared for each clone. The planted cuttings were watered sparingly and the boxes were kept in the screen house. Cuttings in the boxes were sampled for rooting percentage, number rooted and mini-tuber bud initiation 21 days after treatment (DAT).

Effects of plants ashes' concentrations on yam vine cuttings rooting and mini tuber initiation

Ashes obtained from these plants - rice straw ash, bamboo ash, and *G. sepium* ash, each at 1, 3 and 5 g were diluted in 100 ml of water to obtain varying concentrations (1, 3 and 5%). Potassium chloride (KCl_2) (1, 3 and 5%) and ordinary water were used as control. Vine cuttings were obtained from two yam genotypes - TDr 335 and TDr 93 - 49 in mid of August 2005. These healthy vines from middle portion of the lateral branch excised from the field were prepared into 3-node cutting sizes having six leaves. The basal parts of the vines were slantingly cut for more surface area. The two opposite leaves at the nodal point of insertion into the planting medium were removed with a clean scissors. The prepared cuttings were dipped in various concentrated solutions of plants ashes and KCl_2 in water. These were left for 24 h before planting in cups already filled with carbonized rice husk. Five vine cuttings were planted per cup and replicated three times using CRBD design. The data on rooting percentage, number of roots, root length and the initiated mini tubers were collected 21 DAP.

Effects of coconut water dilutions on yam vinecuttings

Coconut water was prepared with tap water into 1, 5 and 10% dilutions. Vines from genotypes TDr 335 and TDr 93 - 49 as described above, were also used in this experiment. This experiment was carried out late August, 2005. The vine cuttings were prepared as described in section 3.2.1. Five cuttings were

Table 1. Effects of IBA powder on rooting and mini tuber initiation in yam vine cuttings.

Genotypes	Hormone	Rooting (%)	Number of roots	Length of roots (cm)	Number of Initiated mini tuber
TDr 335	IBA	4.6.46*	3.1*	3.58*	0.5*
	Control	19.87**	3.2*	1.22*	0.3*
	Treatment Mean	33.17	3.2	2.40	0.4
TDr 93 - 49	IBA	58.16*	5.1*	2.72*	0.1*
	Control	17.07**	0.4**	0.98**	0.0
	Treatment Mean	37.62	2.8	1.85	0.01
Grand Mean		35.4	3.0	2.12	0.2
S.E		22.38	2.9	2.12	0.3

Means along the column without * are not significantly different (SE). (Rooting (%) was transformed using arc sine transformation table).

dipped in the cups having coconut water dilutions for 24 h before planting them in cups already filled with carbonized rice husk in three replicates with CRBD design. The data on rooting percentage, number of roots, root length and the initiated mini tubers were collected 21 days after planting (DAP).

Effects of pyroligneous acid dilutions on yam vine cuttings

Pyroligneous acid (PA) used in this experiment is a steam by - product from anaerobic burning of dried bamboo. This method was designed to have a chimney for the collection of the vapour from the steam. Pyroligneous acid was diluted at 1 ml in 5000, 3000, 2000, 1000, 500, 100 ml of water. The control was ordinary water. 300 ml of these stock solutions were dispensed in cups and in triplicates. This experiment was carried out in late September, 2005. Vine cuttings obtained from two yam genotypes (TDr 335 and TDr 93 - 49) were used. The procedure earlier described for the vine cutting preparation was followed. The cuttings were then dipped in the treatments prepared and left for 24 h before planting in cups with carbonized rice husk. Five vine cuttings in three replicate were planted per genotypes. The experiment was left for 21 days after which the data on percentage rooting, number of roots, root length and initiated mini tubers were collected.

The experiments were laid out using completely randomized design (CRD) with five replications. Data which were collected on percentage rooting, number of roots, root length and number and weight of initiated mini tubers were subjected to analysis of variance (ANOVA) and treatments means were separated using standard error (SE) of means.

RESULTS

Effects of IBA powder on yam vine cuttings rooting and mini tuber initiation

Root formation was observed on vine cuttings from TDr 335 and TDr 93 - 49 treated with IBA and control treatments three weeks after planting (WAP). The mean rooting percentage, number of roots, root length (cm) and the number of initiated tubers obtained from TDr 93 - 49 were 37.62%, 2.8, 1.85 cm and 0.1 respectively (Table 1). TDr 335 vines gave 33.17% mean rooting percentage, 3.2 as number of roots, root length (cm) of 2.40 and the number of initiated tubers on vines was 0.4. This result indicated similarity in the response of the two genotypes to IBA and control treatments and hence the lack of significant difference between the genotypes. Rooting percentage differed significantly in vine cuttings treated with 1% IBA and the control, mean rooting percentage of IBA treatment was 52.31% while that of control was 18.47%. The number of roots (4.1), length of roots (3.15 cm), and number of initiated tuber of 0.3 from IBA treatment were more; but not significantly different to control treatments producing 1.8 as number of roots, 1.1 as length of roots (cm) and number of initiated tubers was 0.2. The results of genotypes and hormone interactions showed poor mean rooting percentage of 35.4%, number of roots counted as 3.0, root length of 2.12 (Table 1).

Effects of plant ash and their concentrations on yam vine cuttings

The result shows non - significant difference among the four-plant ashes (rice straw ash, bamboo ash, dried - neem leaf) and IBA (control) dusted on the wounded nodal points of the vine cuttings for rooting (Table 2a). The plant ashes had marked effect on the rooting of yam vine cuttings. The grand mean rooting percentage across the treatment combinations was 64%, while that of root number, root length and mini - tuber produced were 6.5, 5.30 cm and 1.2 respectively (Table 2a). There was no significant difference between the genotypes in their response to plant ash treatments. TDr 335 had a mean rooting percentage of 62.65, number of tubers of 6.6, root length of 6.40cm and number of mini tuber initiated was 1.2. For TDr 93 - 49, the mean rooting percentage, number of roots, length of roots and number of mini tuber initiated were 65.54, 6.3, 4.50 cm and 1.1 respectively (Table 2a).

Rice straw ash, IBA, Neem leaves, Bamboo ash and *Gliricidia sepium* ash gave mean rooting percentage of 73.49, 70.44, 54.85 and 50.41 respectively. The mean number of roots from Rice straw ash, IBA, Neem leaves, Bamboo ash and *G. sepium* ash were 7.2 7.7, 7.6, 4.7 and 5.17 in that order. The mean root length (cm) from

Table 2a. Effects of plant ashes' (powder) applications on rooting and mini tuber initiation of vine cuttings of two yam genotypes (TDr 335 and TDr 93 - 49).

Genotypes	Treatment (Plant ashes)	Rooting (%)	Number Of Roots	Root Length(cm)	Number of Mini-Tuber
TDr 335	Rice straw	72.51*	8.7*	6.94*	1.6**
	Bamboo	45.06*	4.3a*	4.11*	0.7**
	Gliricidia	59.71*	6.5*	6.89*	1.5**
	Neem leaf	72.02*	7.4*	6.34*	1.4**
	IBA	63.95*	6.1*	6.20*	0.9**
	Treatment mean	62.65	6.6	6.4	1.2
TDr 93 - 49	Rice straw	74.46*	5.8*	5.22*	0.8**
	Bamboo	64.63*	5.2*	4.74*	1.0**
	Gliricidia	41.11*	3.8*	2.25*	0.5**
	Neem leaf	68.85*	7.7*	5.47*	1.9*
	IBA	78.63*	9.2*	4.81*	1.3**
	Treatment mean	65.54	6.34	4.50	1.1
Grand Mean		64.09	6.5	5.30	1.2
S.E.		23.79	2.51	2.28	0.51

Means with the same letter(s) are not significantly different by Duncan's Multiple Range Test (DMRT). (Original rooting (%) was transformed using arc sine transformation table).

Table 2b. General effects of plants ash treatment on rooting and mini tuber initiation in yam vine cuttings.

Treatments	Rooting (%)	Number of roots	Root length (cm)	Number of Mini tuber
Rice straw ash	73.49a	7.2a	6.08a	1.2ab
IBA powder	71.29a	7.7a	5.51a	1.1ab
Neem leaves	70.44a	7.6a	5.90a	1.6a
Bamboo ash	54.85a	4.7a	4.42a	0.9b
Gliricidia ash	50.41a	5.2a	4.57a	1.0ab
Mean	64.10	6.5	5.30	1.2

Means with the same letter(s) are not significantly different by Duncan's Multiple Range Test (DMRT). (Original rooting (%) was transformed using arc sine transformation table).

Rice straw ash, IBA, Neem leaves, Bamboo ash and Gliricidia sepium ash were 6.08, 5.51, 5.90, 4.42 and 4.57. The mean number of initiated mini tuber obtained from Rice straw ash, IBA, Neem leaves, Bamboo ash and *G. sepium* ash were 1.2, 1.1, 1.6, 0.9 and 1.0 (Table 2b). The results of vine cuttings treatment with various dilutions of the plant ashes showed that there were significant differences ($P \leq 0.01$) between the genotypes in mean rooting percentage, root number, length of the root and mini tuber production. TDr 93 - 49 had a mean rooting percentage of 38.71% while TDr 335 was 25.02%. The mean numbers of roots counted from genotype TDr 93 - 49 were 2.3 while 1.3 roots were gotten from TDr 335. The measured mean length of roots from TDr 93 - 49 vines was 2.09 cm while TDr 335 had root length of 0.91 cm (Figure 1a, b, c and d) The mean number of initiated mini tuber counted from TDr 93 - 49 was 0.5 while 0.3 was counted from TDr 335 vine cuttings. TDr 93 - 49 vines treated with *G. sepium* (Irrespective of the concentration levels) had rooting percentage of 69.17, number of roots of 3.8, root length of 3.65 cm and number of mini tuber of 0.8 greater than other plants ashes, (rice straw ash and Bamboo ash) KCl_2 and control (Table 2b). Rice straw ash had mean rooting of 27.62%, Bamboo ash produced mean rooting of 51.14%, and KCl2 gave mean rooting of 19.31% and 26.29% was counted from control. In case of TDr 335, rice straw ash treatment (irrespective of concentration levels) had greater rooting percentage of 55.35, number of roots of 2.8, root length of 2.30 cm and number of initiated mini tuber of 0.8 than other plants ashes. Bamboo ash had mean rooting of 29.16%, *G. sepium* produced mean rooting of 23.52%, KCl_2 gave mean rooting of 5.5% and 11.55% was counted from control. Different plant ashes applied at varying dilution (concentration) had significant effect ($P \leq 0.01$) on root formed from treated yam vine cuttings (Table 2b).

The result of different ashes concentration levels in

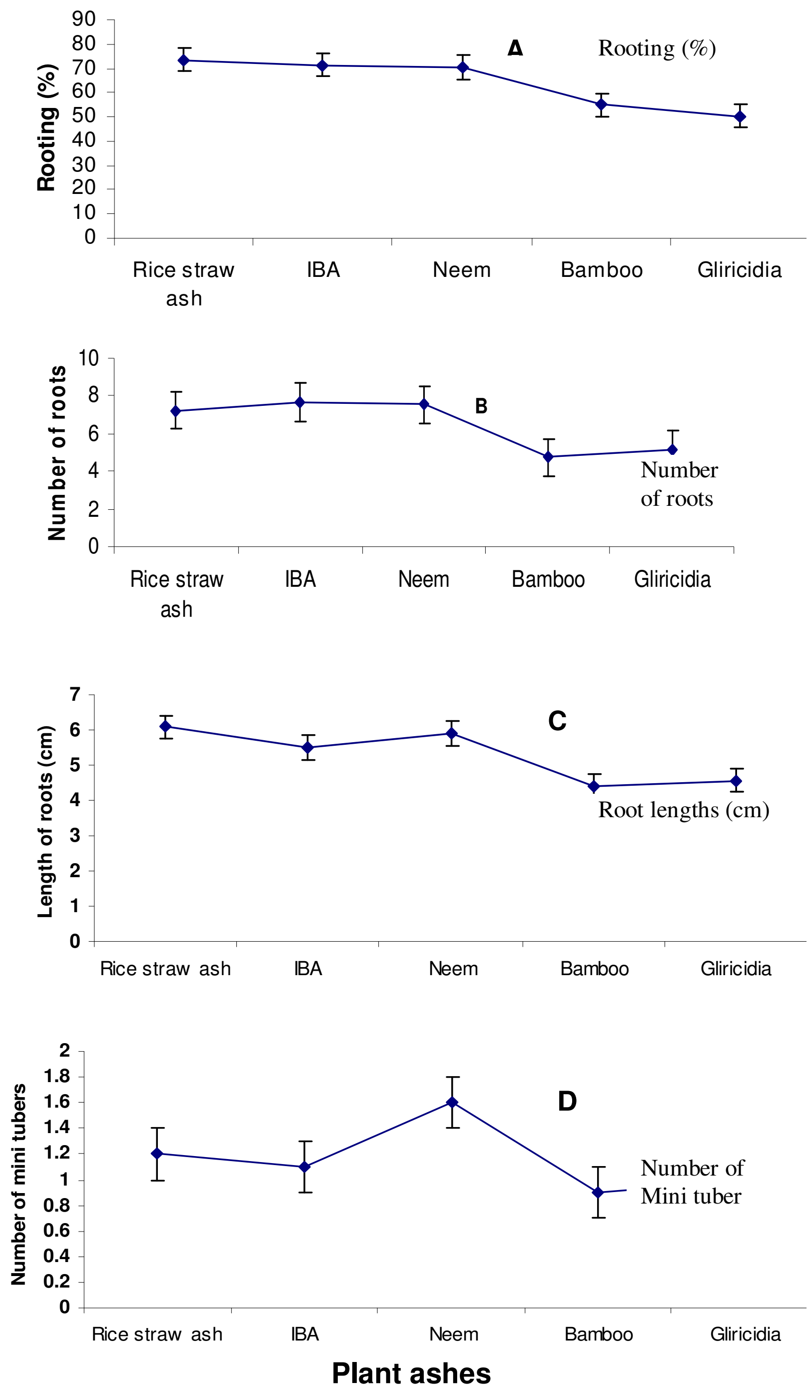

Figure 1. Effects of plants ashes (dust) applications on the (A) rooting (%), (B) number of roots, (C) length of roots (cm) and (D) number of initiated mini tuber of yam vine cuttings of TDr 335 and TDr 93 - 49. The bar represented SE at $P < 0.05$ probability level.

water showed vine cuttings treated with 5% rice straw ash producing outstanding rooting percentage than any other treatment irrespective of the genotype used (Figure 2a and b). The mean rooting percentage from 5% rice straw treatment was greater than 80% while the other plants ashes levels including KCl_2 and control gave less than 60%. The mean number of roots obtained from 5% rice straw ash was 5.7 while that obtained from other levels were less than 3.7. The measured mean root length from 5% rice ash treated vines was 4.10 cm and less than 3.25 cm was obtained from the remaining treatment levels and control (Figure 2b).

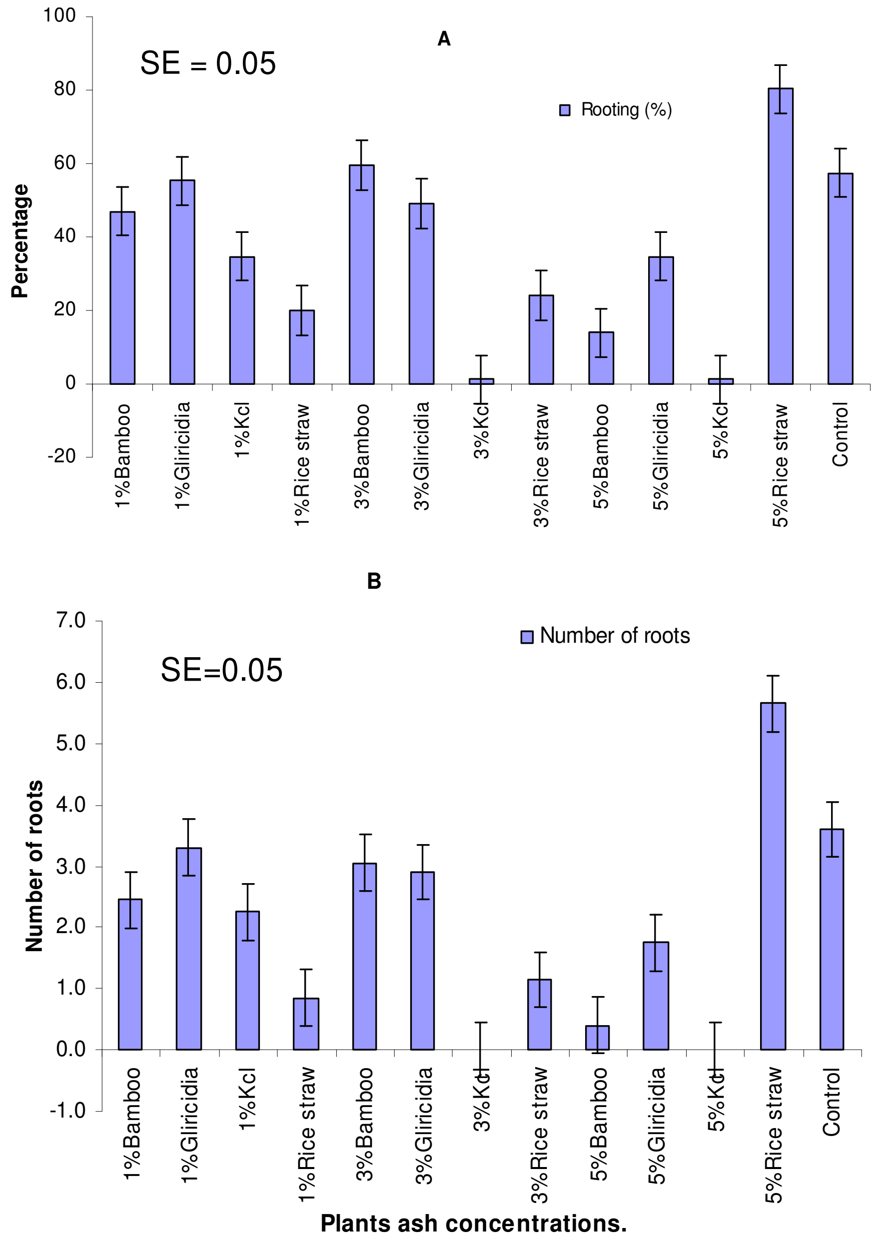

Figure 2. Effects of plants ashes concentration's levels on (A) rooting (%) and (B) number of roots of yam vine cuttings.

Effect of coconut water dilutions on yam vines rooting and mini tuber initiation

The responses of vine cuttings obtained from the two genotypes soaked in different dilutions of coconut water for 24 h before planting in carbonized rice husk were significantly different ($P < 0.01$) (Table 3a). TDr 93 - 49 had better root formation, which ranged from 54.99% - 67.64% compared to clone TDr 335 with a range of 9.7 - 38.85%. The mean rooting percentage observed from TDr 93 - 49 was 63.43% while 28.50% mean rooting was gotten from TDr 335. The mean number of roots, length of roots (cm), and number of initiated mini tuber from TDr 93 - 49 were 3.5, 3.10 cm and 0.9 respectively. For TDr 335, the mean number of roots, length of roots (cm), and number of initiated mini tuber were 0.8, 0.90 cm and 0.2 respectively (Table 3a). There were no significant differences among dilution levels of coconut water and control (ordinary water) on mean root formation, mean root number, mean root length except the number of initiated mini tuber from the treated vine cuttings (Table 3b). Mean rooting of 51.15% were found on vines treated with both 1 and 5% coconut water dilutions while 42.89 and 38.67% were the mean rooting percentage from 10% and control respectively. The mean number of roots, root length (cm) and number of initiated mini tubers from vine

Table 3a. Effects of coconut water concentrations on rooting and mini tuber initiation in vine cuttings of tow yam genotypes.

Genotypes	Coconut water Dilutions (%)	Rooting (%)	Number of roots	Root length (cm)	Mini tuber number
	1	38.85bc	1.1b	1.38bcd	0.2c
	5	34.65cd	1.3b	1.27abc	0.3bc
TDr 335	10	30.78	0.7b	0.37d	0.0c
	Control	9.70d	0.4b	0.58cd	0.1c
	Mean	28.50	0.8	0.90	0.2
	1	63.44ab	3.6a	3.19ab	0.9a
	5	67.64aa	4.1a	3.22ab	1.9ab
TDr 93 - 49	10	54.99abc	3.1a	2.47abc	0.2c
	Control	67.64aa	3.1aa	3.51abc	0.5abc
	Mean	63.43	3.5	3.10	0.9
Grand Mean		45.96	2.2	2.00	0.4
S.E		16.56	0.9	1.11	0.3
C.V (%)		36.0	43.0	55.5	78.4
LSD $_{(0.5)}$ Genotypes (G)		14.34	0.8	0.96	0.3
LSD $_{(0.05)}$ Treatment (T)		20.27	1.3	1.36	0.4
LSD $_{(0.5)}$ Genotypes GXT		28.67	1.6	1.92	0.5

Means with the same letter(s) are not significantly different by Duncan's Multiple Range Test (DMRT). (Original rooting (%) was transformed to arc sine rooting (%) using arc - sine transformation table).

Table 3b. Effects of coconut water dilution's levels on rooting and mini tuber initiation in yam vine cuttings.

Coconut water dilutions level	Rooting (%)	Number of roots	Root length (cm)	Number of mini tuber
1%	51.15a	2.4a	2.29a	0.6ab
5%	51.15a	2.7a	2.25a	1.1a
10%	42.89a	1.9a	1.42a	0.1b
Control	38.67a	1.8a	2.05a	0.3ab
Mean	45.97	2.2	2.00	0.5ab
LSD$_{(0.05)}$ treatment (T)	20.27	1.3	1.36	0.4

Means with the same letter(s) are not significantly different by Duncan's Multiple Range Test (DMRT). (Original rooting (%) was transformed to arc sine rooting (%) using arc - sine transformation table).

cuttings treated with 1% coconut water were 2.4, 2.29 cm and 0.6 in that order. The result of 5% coconut water on vine cuttings showed 2.7 as mean number of roots, 2.25 as root length (cm) and 1.1 as number of initiated mini tubers. The coconut water at 10% dilutions for treatment had 1.9 as mean number of roots, 1.42 for the length of roots observed and 0.1 as the number of initiated mini tubers. The control treatment also had 1.8 for the mean number of roots, 2.05 as length of roots and 0.3 as the number of initiated mini tuber (Table 3b). The grand mean of the rooting percentage, root number, root length and mini tuber produced in this experiment were 45.96%, 2.2, 2.0 cm and 0.4 respectively (Table 3a). Genotype TDr 93 - 49 was found responsive and better than TDr 335 to 3 dilution levels of coconut water for the rooting, number of roots, length of roots and number of initiated mini tubers.

Effects of pyroligneous acid dilutions on yam vines rooting and mini tuber initiation

The treated vine cuttings of the two genotypes in this experiment show significant difference ($P \leq 0.05$). TDr 93 - 49 was found better than TDr 335 in all the parameters observed. The mean rooting percentage, mean number of roots, mean root length and mean number of mini tuber from TDr 93 - 49 were 56.7%, 2.6, 2.13 cm and 0.6 respectively (Table 4a). TDr 335 had a mean rooting percentage of 29.21%, mean number of roots of 1.5, mean root length of 0.67 cm and mean number of mini tuber of 0.01 (Table 4a). The result of the pyroligneous acid dilution levels on yam vine cuttings showed non significant different among them (x500, x1000, x2000, x3000, x5000). The mean rooting percentage from vines treated with x500, x1000, x2000, x3000, x5000 dilutions

Table 4a. Effects of Pyroligneous acid dilutions on yam vine cuttings' rooting and mini tuber initiations of yam genotypes.

Genotypes	Pyroligenous acid dilutions	Rooting (%)	Root number	Root length (cm)	Number of mini tubers
TDr 335	x500	26.58def	1.3efg	0.67fgh	0.00d
	x1000	9.71f	0.1g	0.02h	0.0d
	x2000	43.08bcde	1.5defg	0.53fgh	0.1cd
	x3000	13.93ef	0.9fg	0.38gh	0.0d
	x5000	39.23cdef	2.0cdefg	1.15efgh	0.0d
	Control	42.7bcde	3.1abcde	1.22efgh	0.3bcd
	Mean	29.21	1.5	0.67	0.01
TDr 93 - 49	x500	46.92bcd	2.0cdefg	1.34efgh	0.5abcd
	x1000	63.42abc	3.1bcde	2.68abcde	0.6abc
	x2000	59.57abc	2.7bcdef	2.34bcde	0.8ab
	x3000	51.50bcd	2.2cdefg	1.83defg	0.4bcd
	x5000	71.87ab	3.0bcdef	2.60abcde	0.7ab
	Control	46.92bcd	2.5cdef	2.00cdef	0.4bcd
	Mean	56.7	2.6	2.13	0.6
Grand Mean		42.95	2.0	1.40	0.32
LSD $_{(0.05)}$ Genotypes		22.43	1.0	0.63	0.23
LSD $_{(0.05)}$ GXPA		31.72	2.4	1.55	0.6

Means with the same letter (s) are not significantly different by Duncan's Multiple Range Test (DMRT). (Rooting (%) was transformed using arc - sine transformation table).

Table 4b. Effects of coconut water dilution's levels on rooting and mini tuber initiation in yam vine cutting.

Coconut water dilutions level	Rooting (%)	Number of roots	Root length (cm)	Number of mini tuber
1%	51.15a	2.4a	2.29a	0.6ab
5%	51.15a	2.7a	2.25a	1.1a
10%	42.89a	1.9a	1.42a	0.1b
Control	38.67a	1.8a	2.05a	0.3ab
Mean	45.97	2.2	2.00	0.5ab
LSD $_{(0.05)}$ Treatment (T)	20.27	1.3	1.36	0.4

Means with the same letter(s) are not significantly different by Duncan's Multiple Range Test (DMRT). (Original rooting (%) was transformed to arc sine rooting (%) using arc - sine transformation table).

and control were 36.75, 36.57, 51.33, 32.72, 55.55 and 44.81, respectively. The mean number of roots from x500, x1000, x2000, x3000, x5000 dilutions and control were 1.7, 1.6, 2.1, 1.6, 2.5 and 2.8 in that order. The mean length of the roots measured from vines treated with x500, x1000, x2000, x3000, x5000 dilutions and control were 1.01, 1.35, 1.44, 1.11, 1.88 and 1.61 cm, respectively. The result of the mean number of initiated mini tubers from x500, x1000, x2000, x3000, x5000 dilutions and control were 0.3, 0.3, 0.5, 0.2, 0.4 and 0.4, respectively (Table 4b). The grand mean of the rooting percentage was 42.96, mean number of roots was 2.1, mean length of roots was 1.40 cm and the mean number of the initiated mini tubers was 0.4. The mean rooting percentage recorded for each of the five levels of dilutions except x2000 (43.08%) was lower than (<) control (42.7%) in clone TDr 335. The mean rooting percentage from TDr 335 was less than (<) 50%. For TDr 93 - 49, x5000, x1000, x3000 had rooting percentage greater than (>) 50% while x500 and control were lesser than (<) 50%. The pattern of root formation from treated vine cuttings with pyroligneous acid diluted at x500, x1000, x2000, x3000 and x5000 was found inconsistent (Table 4a and b).

DISCUSSION

It was observed in this study that vine cuttings from two yam genotypes treated with root - promoting substances and planted in carbonized rice husk, rooted and formed tubers. The mean number of mini-tubers obtained from TDr 335, TDr 97/00940 was 0.6 and 0.7 and weighed 1.30 and 1.44 g, respectively. These mini tuber weights were less than what was reported by Kikuno (2006) where vine cuttings produced approximately 30 g mini tuber under open field condition, although variations in tuber sizes range from 2.7 - 97.7 g. Shiwachi (2005) also stated that when vine cuttings of seven cultivars were planted in the carbonized rice husk in the nursery, the developed mini tuber had mean weight of 3.0 ± 2.7 g and 1.7 ± 0.8 tubers per vine cuttings. He stated further that vines planted in bags with carbonized rice husk in the screen house for three months produced mini tuber with number in the range of 0.3 - 1.3 and mean length of 0.26 - 5.37 cm. Perhaps, the lowered number of mini tubers obtained in this study was due to the age of vine cuttings (above five months) and the prevailing temperature (average of 27°C) during the vine propagation.

The genotypes were similar in their response in terms of number of tubers produced from them and their weight when treated with 1% IBA and wood ash. This was in agreement with the report of Acha et al., (2002) that three out of five clones tested with IBA had better and almost the same percentage rooting while the other two clones rooted poorly. However, tubers obtained from vine cuttings treated with IBA had greater number of tubers 0.8 weighing 2.14 g compared with wood ash treated vines having 0.5 tubers weighing 1.38g. This was in agreement with Acha et al. (2002) statement that with and without hormone treatment, clonal variations for mean percentage rooting of vines were not significant ($P \leq 0.05$).

In the IBA powder and the control (non - treated) experiment, significance differences ($P \leq 0.05$) were found between the two. The mean rooting percentage of IBA treatment was 52.31% while that of control was 18.47%. The number of roots (4.1), length of roots (3.15 cm), and number of initiated tuber of 0.3 from IBA treatment were more; but not significantly different to control treatments producing 1.8 as number of roots, 1.1 as length of roots (cm) and number of initiated tubers was 0.2. This result was in agreement with Acha et al. (2004) who reported the effect of auxin on root development in *D. rotundata* vines and observed the formation of mini tubers. They stated further that treatment of vine cuttings with IBA significantly increased the number of roots produced by vine cuttings of ten *D. rotundata* cultivars.

When plant ashes (rice straw, bamboo ash, *G. sepium* ash, and dry - neem leaf powder) and IBA powder as control were tested for their root formation potential on vine cuttings, they gave mean rooting percentage in the range of 41.1 - 78.63% and grand mean of 64.1%. The result obtained from plants ashes treatments (irrespective of genotypes) showed insignificance difference among them. Rice straw ash, IBA, Neem leaves, Bamboo ash and *G. sepium* ash gave mean rooting percentage of 73.49, 70.44, 54.85 and 50.41, respectively. This experiment revealed that plant ash materials especially rice straw ash, neem leaves powder and bamboo ash (> 70% rooting percentage) can be used instead of IBA especially when the powder application method on wounded nodal points is preferred for use. In this study, significant differences were found for rooting potentials of yam vine cuttings using the various concentrations of growth substances (plant ashes and KCl_2). The reason for this could be that some of the concentrations imposed were intolerable by vine cuttings or toxic to the vines. Vine cuttings treated with 5% rice straw ash was noted for promoting higher rooting percentage of up to 80% (irrespective of the clones) relative to other treatments having lees than 60%. This was in line with the result obtained by Yamasaki and Kurata, (1950) when paddy rice seedlings (about 35 cm in height), the root of which had been cut off by a knife, were put for 24 h in the 1% solution of rice straw ash, 0.5% of Ca $(OH)_2$, 0.1% KCl_2 and water (control) respectively. Treating paddy rice seedlings with rice straw ash or KCl_2 were noticed to have hastened the root- growth compared with the control, but $Ca(OH)_2$ was not effective. This result indicates that hastening of root - growth by rice straw ash is likely due to the physiological action of potassium but not of calcium contained in the material.

Soaking vine cuttings of clone TDr 335 and TDr 93 - 49 with various plant ashes' concentrations produced significant effect on rooting. Clone TDr 93 - 49 gave higher rooting percentage than clone TDr 335. This could mean ability of clones to absorb different level of concentration of some substances without been adversely affected. Poor rooting performance of KCl_2 on vine cuttings were noticed. Perhaps, KCl_2 concentrations higher than 0.1% could be inhibitory to root formation and toxic to the treated vines as revealed in this study where it had the least mean rooting percentage of 12.40%.

IITA in her annual report (2000), showed coconut water (10%) as one of the important compositions of basal medium supplements used in tissue culture for obtaining rooting and plantlet formation from immature yam seeds. Coconut water contains sugar, amino acid, myo - inositol, and micro constituent (phenyl urea). It enhances the activity of cytokines and also has IAA and gibbrellic acid. Coconut water was diluted in water at 1, 5 and 10% and yam vine cuttings were soaked and planted and root initiation and mini tuber formation were observed. The response of rooting of clone TDr 335 and TDr 93 - 49 vine cuttings were found to be significantly different ($P \leq 0.05$). The mean rooting percentage from TDr 93 - 49 vine cuttings were greater than 50% while TDr 335 had less than 40%. The levels of dilutions used in this experiment did not show definite pattern on rooting of vine cuttings. Sixty - seven percent (67%) mean rooting was obtained from vine cuttings of clone TDr 93 - 49 treated with ordinary water (control). This indicated that the vine cuttings not treated before planting in carbonized rice husk did not hinder rooting and the production of mini tubers. IITA (2000) recommended the use of 10% coconut water in tissue culture for promoting rooting and plantlet formation from immature yam seeds). Our results contradicted this recommendation where 5% and less gave more rooting percentage. Perhaps, the coconut dilution level required in rooting immature yam seeds in tissue culture could be different from that required for rooting yam vine cuttings from open field.

Rooting activity and growth of rice seedling was promoted by the soil treatment with pyroligneous acid prior to transplanting (Chikawa et al., 1982). The results suggested that pyroligneous acid effectively enhanced activation of auxins. The use of pyroligneous acid dilutions as treatment in this study did not prevent root formations. The treated vine cuttings of clone TDr 335 and TDr 93 - 49 responded differently to rooting. The mean rooting percentage from clone TDr 93 - 49 was more. Rooting under control (water) treatment was not significantly different from pyroligneous dilution treatments and other parameters such as, number of roots, root length and mini tuber production. This result showed that successful rooting of vine cuttings did not mainly depend on the treatment imposed; perhaps it could be as a result of factors such as the rooting medium (carbonized rice husk), prevailing temperature in the screen house (27°C), age of the vine cuttings (above four months) and the genotype.

Conclusion

Rice straw ash and neem leaf powder could serve as substitute to IBA hormone as root promoting substance in yam vine cuttings using carbonized rice husk as planting medium. If the soaking method was preferred, 5% rice straw ash enhanced rooting of vine cuttings of the genotypes tested. Coconut water at 5% dilution in water was also found useful as a root - promoting substance for vine cuttings. The non treated vines (control) planted in carbonized rice husk had roots on them and initiated mini tubers.

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