Original Research Article

THE RESPONSE OF LOCAL WHITE GUINEA YAM CULTIVARS TO THE VINE CUTTING PROPAGATION TECHNIQUE USING LOCALLY AVAILABLE ROOTING SUBSTRATES

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ABSTRACT

Good quality planting materials for yam cultivation is a major challenge and adapting the most preferred local varieties to high ratio propagation methods such as the vine cutting could help ameliorate this constraint. An experiment was conducted in the screen house at CSIR-Savanna Agricultural Research Institute to assessthe response of cvs'Labako', 'Nyamenti' and 'Kpamyo' (check) to the vine cutting under different substrates. The experiment was 3 x 6 factorial arranged in a completely randomized design with 3 replications. Single node cuttingsvines were obtainedfrom 3 months old plants and establishedin the various rooting substrates(carbonized rice husk; fermented rice bran; aged rice husk; top-soil ,cocopeat and carbonized rice husk +top-soil; 2:1).Highly significant differences(P<0.001) existed in main effects and interaction of the factors.Allthe cultivars attained 100 % survival in CRH (carbonized rice husk) and cocopeat. Kpamyo and nyamenti had 89.6 % regeneration in cocopeat, FRB (fermented rice bran) and CRH (carbonized rice husk). Labakoexhibitedobtainedthemaximum shoot growth (31 cm)length in CRH (carbonized rice husk), whiles the minimumone (10 cm)was observed in ARH (aged rice husk) for kpamyo. 6 nodes were produced by nyamenti in CRH (carbonized rice husk), whiles kpamyo produced 3 nodes is same substrate. labako initiated 88 % tuberization, higher than kpamyo with 75 %. Generally, the cultivarswere successfully adaptedto the vine-cutting technique in CRH, FRB (locally available) as well as cocopeat.The CRH and FRB are locally available, henceless expensive to acquire and therefore recommended for cost-effective single node propagation of the popular local yam cultivars.

***Keywords**: Vine cutting, seed yam, Rooting substrate, Single node*

INTRODUCTION

Yam, a multi-species starchy tuber crop of the genus *Dioscorea*,is widely cultivated in the tropics. It is regarded as one of the most important staple food crops to over 400 million people in West Africa and provides a vital source of dietary carbohydrates, proteins, minerals, vitamins, and small amount of lipids and income to growers [1]. It is also a source of pharmaceutical compounds and secondary metabolites used for industrial and pharmaceutical purposes [2], while the peels are used to feed livestock [3].

Yam cultivation in Africa covers over 8.6 million hectares, with an annual production of over 73 million tons [4]. More than 98% of the global yam production occurs in Africa, predominantly the "yam belt" of West Africa where the most produced yam species originated [5, 6].

Availability of quality planting materials is a major constraint in yam production.

The crop is primarily vegetatively propagated using tubers, even though botanical seeds emanating from controlled and open pollinated crosses are used in breeding [7]. Nearly, 10,000 seed yams, weighing between 0.2 to 1 kg each, are required to cultivateplant a hectare in traditional yam farming system [8]. Sole production of seed yam for the next seasons planting is rare. Farmers therefore reserve small tubers between 250 g and 1000 g after harvesting and use as planting material for the next season. As much as 30% of the harvest constitutes the planting material for the next season's crop on a similar area as the previous year [9]. The dual role of the harvested tubers as seed and food makesSeed yam not only scares but also expensive, representing in some cases for as much as 63% of the total variable cost of yam production [10].

Traditional methods of yam propagation, such as small whole tubers or cut setts, have a multiplication ratio of 1:6 to 1:8, while the mini-settstechnique have a 1:20 to 1:40 [11]. This low multiplication rates slows down the supply of superior yam genotypes to producers and limits the expansion of yam cultivationproductivity. Beside the low multiplication ratios with the traditional method of yam propagation, the materials are prone to yam mosaic virus, root knot nematodes (*Scutelonema bradys*and*Meloidogyne spp*.) fungi, bacteria diseases when they are planted due to the recycling of the seeds.

New methods have been developed to mitigate some of the constraints of seed yam quality and quantity. These modern techniques include tissue and organ cultures, aeroponics and semi autotrophic hydroponics (SAH). Although the tissue and organ culture technologies are the fastest methodmeans of multiplying disease free propagules, they are faced with challenges such as high costs of establishment, skilled personnel and specialized equipment. The vine cutting technique is a simple and low cost approach to rapidly increase yams' proliferation rate to over 1:300 whiles producing seed yams that are free of pathogens [12].There is no rivalry with the accessibility of yam for consumer use, because the whole tuber is retained for consumption when using the vine cutting approach, thereby improving the economic value of the yam crop [13, 14].Single node vine cuttings aresuccessfully established in rooting substrate including carbonized rice husk and cocopeat produces mini tubers between 1g to 6g which can then be used to produce seed yam of 160 to 250g [12]. The vine cuttings can equally be established in the field for direct production of seed yam, circumventing the mini tuber stage, however, shading and supplementary irrigation are required in the first 6 weeks for good plant establishment.

The vine cutting technique has been optimised and currently in use with great success rate for the improved yam varieties such as Kpamyo and Asiedu / MankrongPona in both Ghana and Nigeria. The local varieties or landraces are generally known to be recalcitrant and do not respond well to the high ratio multiplication techniques including tissue culture and the mini sett techniques. These local varieties are however in high demand locally and internationally and currently dominate the yam production system due to their superior culinary and organoleptic properties, hence the need to explore ways of rapidly produce more seeds.

An important factor resource required for successful establishment of single node vine cuttings is the growingth media or rooting substrates. Vine cuttings of some *Dioscorearotundata* has been successfully established in rooting substrates including carbonized rice husk and cocopeat [15]. However, these rooting substrates, particularly cocopeat come with an exorbitant cost and not readily available as it is imported. Hence the need for alternative cost effective locally available rooting substratesfor the vine cutting technique. This research therefore investigated the response of two cherished local cultivars of white yam in Ghana ("labako" and "nyamenti") to the vine cutting technique using somedifferent locally available rooting substrates.

MATERIALS AND METHODS

Source of Planting Materials

The study was carried out in a screen house at the CSIR- Savanna Agricultural Research Institute, Nyankpala, Ghana. The institute lies on9°24'23.5"N. 0°59'17.6"W. Twenty (20) small tubers of average weight of 2g each of labako, nyamenti, and kpamyo (check) were obtained from the yam improvement unit of the institute. The tubers were stored at room temperature for 60 days to break dormancy before used in the experiment. Labako and nyamenti are very popular local white yam varieties in Ghana known for their excellent food quality, while kpamyo is an improved high yielding variety with good food quality. The local varieties are perceived to be recalcitrant varieties in terms of their amenability to novel propagation techniques, while the improved variety responds well to these new approaches. In order to establish the mother standsof these varieties to be usedas sources of single node cuttings, the mini tubers were planted in nursery bags filled with cocopeatand arranged according to variety. Two weeks after their establishment, the newly emerged plants were given a boost by applying NPK 15-15-15-10 S fertilizer at 3 g/plant to promote the growth for 3 months .

Treatment Applied in the Research

Different substrates were used as rooting media for sprouting of the single node vine cuttings, including: TS (top-soil) (negative control), CRH (carbonized rice husk), cocopeat (positive control), CRH+TS; 2:1 (carbonized rice husk + top-soil (2:1), FRB (fermented rice bran) and ARH (aged rice husk)(The rooting substrates and planting materials used in the study **are shown in Figure 1**).

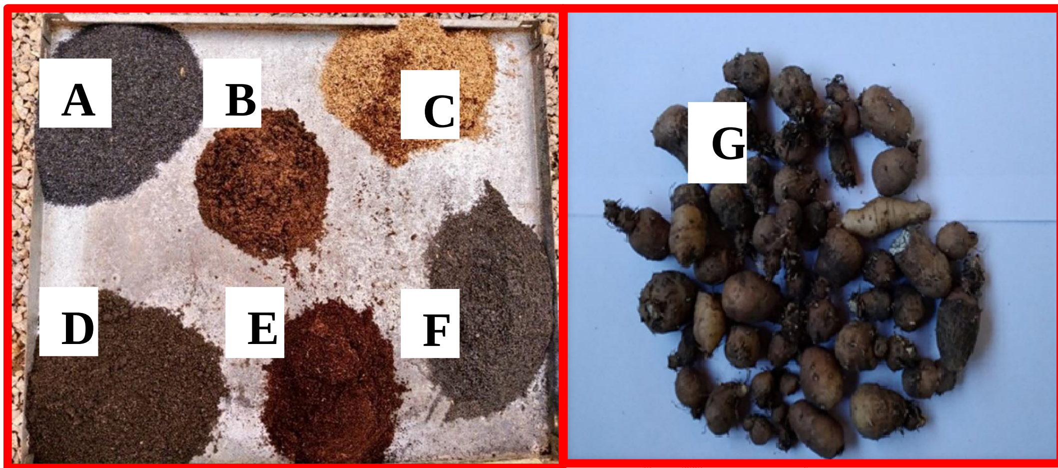

Figure 1: Treatments applied in the study[**Six different rooting Substrates** (**A**: carbonized rice husk; **B**: fermented rice bran; **C**: aged rice husk;**D**: top-soil; **E**: cocopeat; **F**: carbonized rice husk +top-soil; 2:1) and **G**: minitubers (< 10 g)] .

Preparation of Rooting Substrates

Carbonized Rice Husk (CRH)

The incomplete or partial burning of rice husks results in carbonized rice husk. In this process, it is converted to carbon by pyrolysis at temperatures usually more than 400 °C with small amount of oxygen [16]. A chimney with a cone-shaped base and pores is used to carbonize the rice husk. A wood fire is lighted to initiate the carbonization, and it is immediately covered by the chimney. The rice husk is now directly loaded over the furnace, forming a cone that comes into contact with the chimney.The rice husk was repeatedly turned for 2 hours whiles maintaining a temperature below 400 °Cthroughout the carbonization process to maintain uniform combustion. When the rice husk had completely carbonized, it was fetched and spread on a levelled cemented surface and water was sprinkled on it to end the burning. After being carbonized, the resultant rice husk (biochar) was prepared for use.

Fermented Rice Bran (FRB)

In the screen house, the rice bran was fermented aerobically by piling it up on a black plastic sheet, moistening it with water, and covering it for two months at a temperature of 25 to 40 °C in the screen house. Within the first several days, the content's temperature rose quickly and significantly up to 70 °C, showing the metabolic activity of the microorganisms in the heap.The quality of the compost depends on this period of maximum heating since it kills pathogens and weed seeds. After that, the fermented rice bran was opened and spread out to dry on the plastic sheet for 3 days. The fermented rice bran was ready for use.

Aged Rice Husk (ARH)

The pile of rice husks was exposed to the sun for a full year. The husks become whitish-brown as they age.

Cocopeat

The cocopeat block was submerged in water for four hours for optimal water absorption and to loosen it. Because cocopeat is extremely absorbent and is likely to accumulate a lot of salt, it was crucial to wash it thoroughly. Washing it in fresh water would reduce the salt concentration, making it ideal for plant growth.

Single Node Vine Cuttings Preparation and Propagation

Lateral vines were excised from 3 months old plants in the morning and dipped in clean water to keep the vines hydrated. The single nodes were excised using sharped scissors and were quickly immersed in a mancozeb solution of 4 g/L. The single node vine cuttings were planted in seed trays (12 x 6 cells) filled with moist rooting substrates. Planting was accomplished by covering the node's base, including the cut stalk with the substrates (Figure 2).

Design of Experiment and Data Collection

The experiment was conducted in a Completely Randomized Design (CRD) with 18 treatments consisting of 2 factors. The factors were rooting substrates at six levels [CRH (carbonized rice husk), FRB (fermented rice bran), TS (top-soil), cocopeat, CRH+TS; 2:1 (carbonized rice husk + top-soil (2:1)) and ARH (aged rice husk)] and varieties at 3 levels(nyamenti, labako and kpamyo (check)).Each experimental unit or plot comprised 16 single node vine cuttings replicated thrice.

Eight plants were sampled per plot for data collected on the following parameters: 1) Plant survival: Number of plants established per plot was counted and recorded. 2) Regeneration of single nodes:This was assessed by counting the number of single node vine cuttings that developed new shoots. 3)Number of shoots per plant: This was counted for each regenerated nodalcutting. 4) Plant / shoot height:The plant or shoot height individual plants was measured with graduated rule. 5)Number of roots:This was counted for each regenerated plant.6) Root length:The length of roots perplant wasmeasured with a metre rule.7) Number of nodes and (8) leaves per plants were counted and recorded. (9) Plant establishment or survival of single node cuttings was assessed at 4weeks after planting by counting the number of established plants per treatment. 10) Tuber initiation: The number of single node cuttings that developed small tubers were also counted and recorded. Plant survival and regeneration was assessed at 4 weeks after planting(4WAP), while data on the remaining parameters were recorded at 6 weeks after planting(.6WAP)

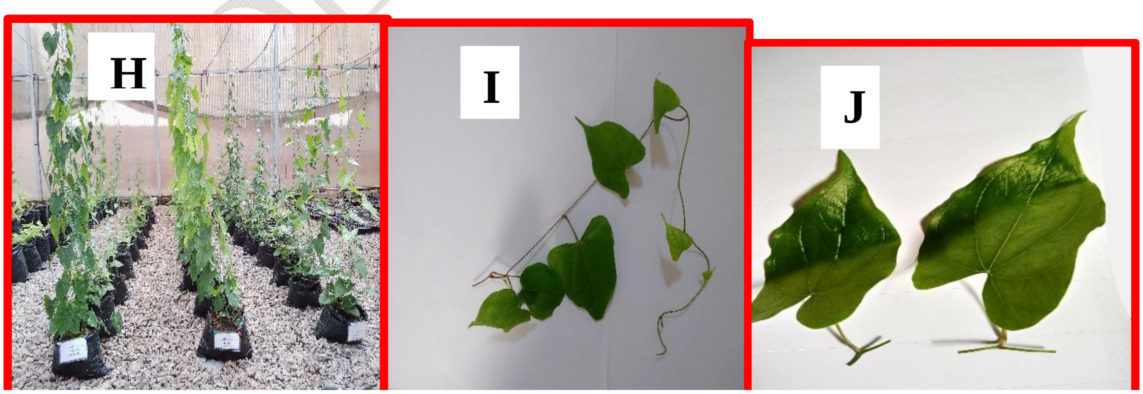

Figure 2: Steps involved in the single node vine cutting propagation [**H**: established mother plant for vine cuttings,**I**: harvested vine, **J**: excised single nodes and **K**: single nodes planted in six varieties

Statistical Analysis

The resulting data were subjected to analysis of variance (ANOVA) and least significant difference (LSD) at P ≤ 0.05 threshold of significance was used to examine the differences in means between the substrates and genotypes.

RESULTS

Percentage Survival of Single Node Vine Cuttings

There was highly significant (*P*<.001) difference in both main and interaction effects for percentage survival of single node cuttings at 4 weeks after planting (Figure 3). Kpamyo recorded 100% plant survival rate on all the substrates with the exception of fermented rice husks (FRH) where 97.9% of the nodal cuttings survived. Labako recorded 100% survival rate in carbonized rice husk (CRH), cocopeat and CRH + top soil while 93.8% was recorded in both top soil and aged rice husk(ARH) . For Nyamenti, 100% survival was observed for CRH and cocopeat, followed by CRH + top soil and FRH with 97.9% and 93.8%, respectively, while the lowest was attained with top- soil(with 72.9%).

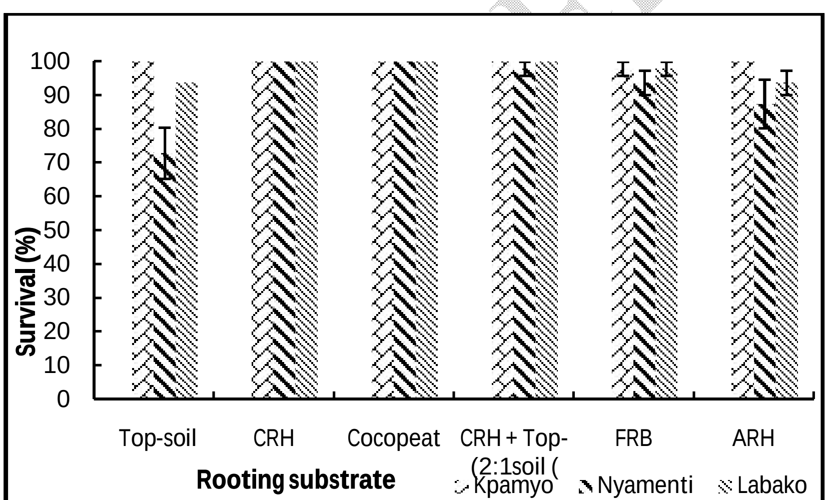

Figure 3: Percentage survival of single nodes, 4 WAP

Percentage Regeneration of the Nodal Cuttings

Analysis of variance revealed significant differences (*P*<.001)among the varieties (V), substrates(S) and VxS interaction for percentage regeneration of the single node vine cuttings.Kpamyovariety recorded the highest regeneration of 89.6% in the positive control (cocopeat) and ARH (Figure 4), followed by FRB and CRH with 85.4 and 77.1% respectively.Similarly, Nyamentivarietyhada higher regeneration rate of 89.6% but in CRH, followed by the ARH with 77.1%. Nodal cuttings of Labakoplanted in CRH gave the highest regeneration of 87.5% followed by ARH with a regeneration rate of 60.4%. The lowest regeneration rate of single node vine cuttings of all three varieties was observed in the top soil treatment, except for labako where the lowest was recorded by CRH + top soil. The positive control, cocopeat was outperformed by CRH and ARH for nyamenti and CHR, ARH, top soil, and FRH for labako for this trait.(Figure 5L&M shows 6 weeks old regenerated single nodes).

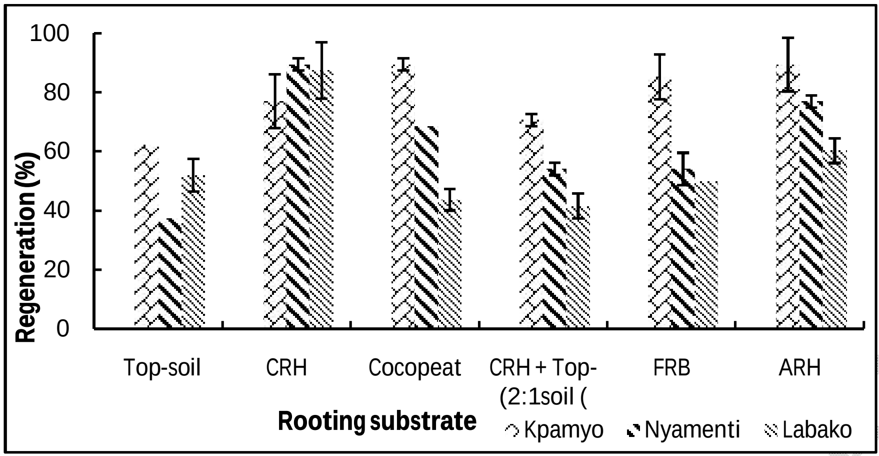

Figure 4: Percent regeneration/sprouting of single nodes, 4WAP

Figure 5: regenerated single node vines
[**L**: regenerated shoots from single node vines; **M**: roots and tuber formation from the nodal vine cuttings]

PercentageTuberization of Single Nodes at 6 Weeks After Planting

There was significant differenceamong the varieties and substrates for percentagetuberization of the nodal cuttings at 6 weeks after plating while the interaction effect was not statistically significant. Labakorecorded the highest tuberization of 87.9 %, followed by kpamyo with 75.4 %, and the lowest of 71.5 % for nyamenti (Figure 6N)

The positive control (cocopeat) had the highest of 88.2 % mean tuber formation, followed by FRBand CRH + top soil with 84.0 and 83.3 %, respectively (Figure 6O).The lowest tuberization(60.4%) of the nodal cuttings was observed in the aged rice husk treatment.

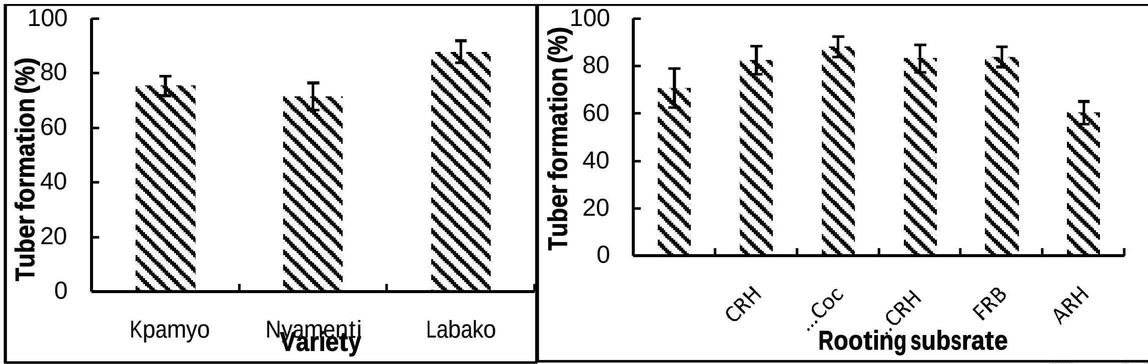

Figure 6N: Tuber initiation effect by variety**6O**: Tuber initiation effect by substrate

Number of Roots per Plant

Highly significant (P < 0.001) variability was observed for the main effects of variety and substrate as well as the interaction effects for number of roots. The highest number of roots for all the 3 white yam varieties was observed in the fermented rice bran treatment (Figure 7), outperforming both positive and negative controls.

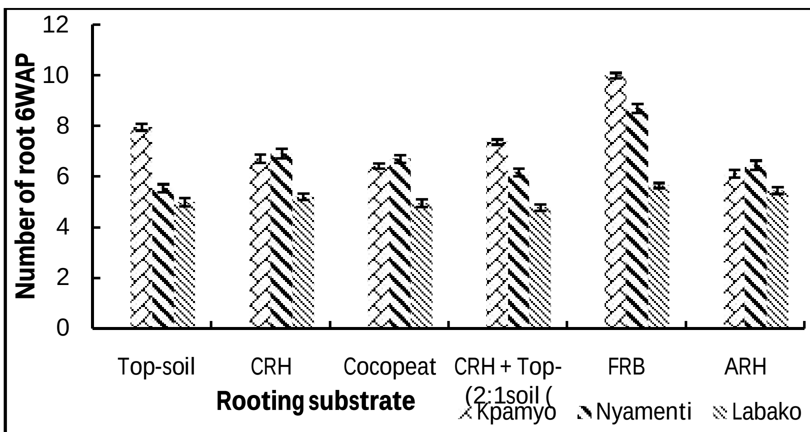

Figure 7: Number of roots per plant at 6 weeks after planting

Number of Shoots per Plant at 4 Weeks After Planting

Highly significant (*P*< 0.001) difference was found in major effect and the interaction effect for the mean number of shoot (Figure 8). Nyamenti produced 1.8 mean number of shoots per plant in CRHand 1.5 in top-soil and FRB, whiles the rest of the varieties produced less than 1.5 mean number of shoots per plant in the other rooting substrates.

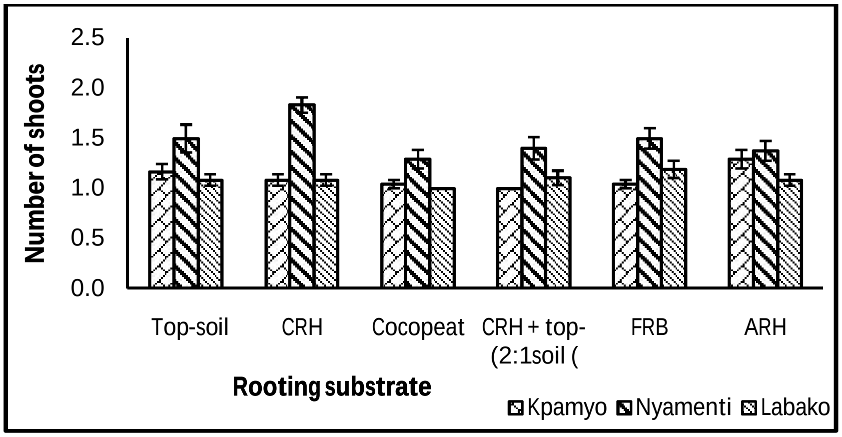

Figure 8: Number of shoots per plant, 4WAP

Height of Shoot at 6 Weeks After Planting

Highly significant (*P*< 0.001) variability existed in main factor and interaction effect for height of shoot per plant in 6 weeks after planting (Figure 9). Kpamyo had the longest shoot of 17.2cm in FRB whiles the shortest shoot length of 10.0cm was found in ARH at 6 weeks after planting. Nyamentiin the positive control (cocopeat), recorded highest shoot length of 21.7cm, followed by 17.1cm in CRH and 16.9cm in FRB. However, the least height of 10.8cm for nyamenti was observed in ARH. Labako had their shoot grew as high as 30.7 cm in CRH, which was more than twice the growth in the ARH.

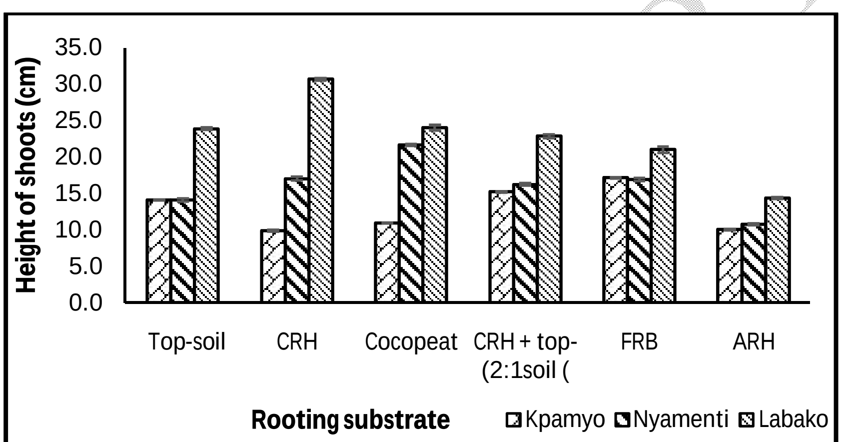

Figure 9: Height of shoot per plant in 6 weeks after planting

Numberof Nodes per Plant at 6 Weeks After Planting

Highly significant (*P*< 0.001) variability existed in main factors and interaction effect for number of nodes per plant (Figure 10). The highest number of 6 nodes per plant was recorded by nyamenti planted in carbonized rice husk, followed by labakoin the same substrate. The maximum number of nodes for kpamyo was found in the Fermented rice bran treatment whereas the lowest number of nodes for all the varieties was encountered when the nodal cuttings were planted in the aged rice husks.

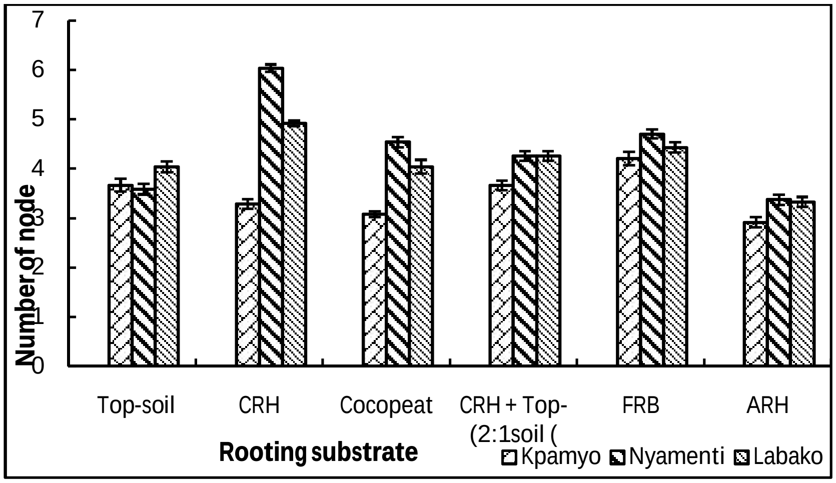

Figure 10: Number of nodes per plant of three yam varieties planted in different rooting substrates.

Number of Leaves per Plant at 6 Weeks After Planting

The number of leaves per plant of the nodal cuttings varied significant ($P < 0.001$) with variety, rooting substrate and their interaction effect. The highest number of leaves of 5.4 and 4.0 for nyamenti and labako, respectively, was observed in the carbonized rice husk treatment, while that of kpamyo occurred in the fermented rice bran substrate (Figure 11). Number of leaves was intermediate with the positive control (cocopeat) for all the three varieties. The lowest number of leaves per plant for kpamyo was in the carbonized rice husk, for nyamenti in top soil and labako in aged rice husk.

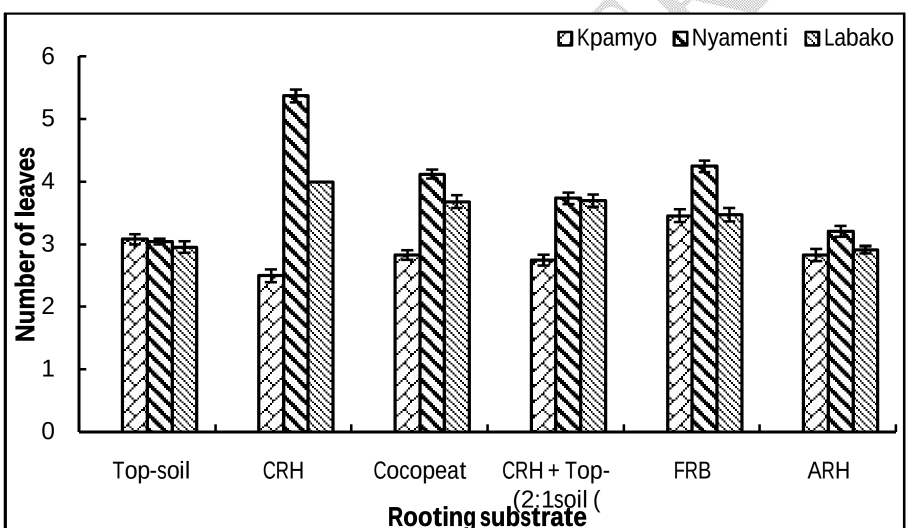

Figure 11: Number of leaves per plant of three white yam varieties established from single node vine cuttings in different growth substrates

DISCUSSION

Vine cutting approach, according to [14], offers an easy and quick alternative for a high-output seed yam production and can satisfy the demand for the speedy dissemination of planting materials of improved and clean varieties to a considerable number of yam growers.

The findings from this research are corroborated by [17], who indicated that the use of a single node was efficient in their study for convenience of planting as nodal propagation.

The response of all the elite landraces of white guinea yam to the vine cutting technique was high as the mean survival rate, ranged from 93-100 % in all the rooting substrates except the negative control and ARH for nyamenti. Also, these landraces had optimum regeneration in CRH whiles kpamyo attained highest regeneration in the positive control (cocopeat) and ARH, than any other substrate. The result suggests that the CRH has the potential of regenerating both landraces at a higher rate. This is consistwith the report that using clean, disease-free material resulted for good plantlet establishment, high survival rates (98 %) and high shoots development (96 %) in screenhouse-derived plants [18].

All the local yam varieties studied showed tremendous rooting, with a mean number of roots per plant ranging from 5.7 -10.0 in FRB, higher than that of 5.0-6.7 root per plant in the positive control (cocopeat), whiles the minimum of 4.8 mean number of roots was obtained in CRH + top-soil; (2:1). Furthermore, kpamyo had maximum shoot growth in FRB with 17.2 cm, higher than 11.0 cm in the positive control (cocopeat) within 6 weeks.

Nyamenti however produced thelongest shoots in the positive control (cocopeat) with 21.7 cm. The shoot lengthheight of Nyamenti and Kpamyo in CRHand FRBwas statistically similar. However, the minimum shoot height for Nyamenti was obtained in ARH. Labako as well had optimum shoot height of 30.7 cm in CRH. These suggested that, CRH, FRB and the positive control (cocopeat) are suitable for seedling production of the local varieties using single nodes. The result wassupported bythe study of[18]which demonstrated that growing seed yam tubers from vine cuttings without the use of hormones wasachievable and couldbe a viable method of accomplishing this at a minimal production cost.

Additionally, at 4 weeks after planting, virtually all of the vine cuttings planted in nursery bags had successfully rooted (98 %) and more than 95 % of the rooted vines had produced fresh shoots and developed into full plants with new leaves [19], as observed in this study where regenerated vines of kpamyo developed 4.2 and 3.3 nodes per plant in FRB and CRHrespectively. Whereas Nyamenti had twice the average number of nodes of Kpamyoin the same medium (CRH).Labako as well produced 4.9 nodes in CRH. Due to the high C: N ratio of 85:1 and abundance in lignin and silica in fresh rice husk, it is difficult to decompose. They degrade quite slowly and have been demonstrated to be less effective for plant production than other forms of husks [20]. As observed in this study, where carbonized rice husk and fermented rice bran outperformed the aged rice husk which was left exposed to decompose naturally.

The positive control (cocopeat) exhibitedhad the highest of 88.2 % mean tuber formation, followed by FRBwith 84.0 %, and 83.0 % in CRH and CRH + top-soil; (2:1). This implies, the by-products of rice (carbonized rice husk and fermented rice bran) can be used efficiently for seed tuber production with the single node vine cutting approach. This was in line with the findings from [18] that revealed that (95 %) of thescreenhouse-derived plant tubers were initiated. [21]alsoobtained 30 % and 20 % of the tubers to be initiated from hormone treatment and hormone-free, respectively. [22], also reported that vine cuttings technique with *Dioscorearotundata* was used and generated small tubers at 100-120 days that might be used for germplasm exchange and for the propagation of seed tubers.

CONCLUSION

Through single node vine cutting, these local varieties were efficiently regenerated.

Following the research's findings, vines cut from 12 weeks old plants successfully regenerated (87.5 to 89.6%) within 4 weeks after planting in different rooting media.

The study indicated that, the regenerated plants of the various cultivars developed in different rooting media in diverse ways. Nyamenti produced shoots length of 21.7 cm in cocopeat with 6.6 nodes in CRH, whereas labako produced shoots length of 30.7 cm in CRH with an average of 4.9 nodes. Therefore, adopting single node cuttings technique to propagate nyamenti, kpamyo and labako cultivars, and the use of CRH, FRB, and cocopeat rooting media have proved to be favourable for plant establishment and growth.

For the three cultivars, the rooting media performed differently in terms of development of the mini-tubers. The best results were obtained with cocopeat (88.2%), then FRB (84.0%), CRH, and CRH + top-soil; (2:1) (83.0%).

Generally, all the studied varieties responded well to the single node vine cutting technique by producing healthy seedlings with mini tubers for healthy seedlings and mini tubers, indicating the potential to addressing the issue of insufficient planting materials and to facilitate the rapid dissemination of planting materials of these cherished local cultivars to numerous yam growers.

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