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Minisett Technology and Yam Sprouting: A Comparative Study of Variety-specific Responses in Different Media

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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Abstract

Yam minisett technology is critical for addressing yam seed scarcity and improving tubers health and yields compared to traditional propagation methods. This study evaluated the effects of three growth media on three yam varieties using the minisett technique during the 2024 cropping season at the University for Development Studies, Nyankpala Campus, Ghana. The experimental design was replicated thrice per yam variety and growth media with sprouting parameters recorded at seven-day intervals for 35 days. Non- Sprouting setts and rots per basket were also recorded. Data

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were analyzed using Analysis of Variance (ANOVA) in GenStat with means separated by Fisher's protected method at p<0.05. The yam varieties -Chencito, Laribako, and Pona- were sourced from Savannah Region. Minisetts weighed from 25-30g were treated with fungicide for 5-10mins before planting in growth media which include; Groundnut Husk Biochar (GHB), Rice Husk Biochar (RHB) and Sawdust (SawD). The Biochars were prepared using the KUNTAN apparatus and all minisetts were nursed under Zanamat shade and watered every three days. Results showed no significant interactive effect between media and variety on sprouting (Day 35: p=0.873), but both factors individually had highly significant effects. Chenchito consistently produced the highest sprouts counts from Day 14 to Day 35. GHB supported the best sprouting, likely due to its nitrogen-fixing properties. Conversely, Pona recorded the highest rots, particularly in sawdust which retained excess moisture and favored fungal and bacterial growth.

Keywords: Yam minisett; media; groundnut husk; rice husk; biochar; Pona; Laribako.

1. Introduction

Yam (*Dioscorea* spp.) is also a critical staple crop in most of the subtropical and tropical areas (Andualem, 2022), especially in West and Central Africa, where about 30.1 million metric tonnes is produced annually (about 95% of the world) of this crop (Andualem, 2022). More than 60 million people in this sub-region depend on the yam as their food source and it is only second to cassava in terms of the magnitude of production (Nweke et al., 2013). In most of the producing communities, yam provides around 20 percent of the daily caloric/nutrition and is a key source of nutrition and energy to millions of people across the world (Ajieh, 2012). The historical system of yam production is very dependent on the use of whole tubers as planting material (Aighewi et al., 2020). This habit poses direct competition between yam to be consumed and yam to be seeded hence, limiting growth in production. In order to cope with this issue, a new propagation method called yam minisett technology has been created to enhance the availability and efficiency of seeds by specifically focusing on bettering seed availability (Ajieh, 2012; Aighewi et al., 2020).

The minisett technology implies the use of small tube cut pieces of disease-free yam tubers as a planting material, which makes it possible to grow a larger number of seed yams using fewer parent tubers (Aighewi et al., 2015; Aighewi et al., 2020). To achieve successful implementation of such technology, though, the planting media needs to be well prepared with sufficient moisture and nutrient availability to facilitate the sprouting and early establishment (Aighewi et al., 2020). Regardless of the significance of yam, farmers especially in West Africa have to deal with several production problems, such as the frequent lack of quality planting material, the invasion of seed yams by diseases, and high labor costs (Gbadamosi et al., 2019; Aighewi et al., 2020; Danquah et al., 2022). Such limitations have also led to the reduced productivity and deterred a number of farmers to engage in long-term farming of yams.

The technology has proven to be an innovative technology that has much potential to counter some of the shortcomings of the conventional yam propagation systems. The technology increases the supply of seeds by utilizing high-quality, disease-free planting material using fewer parent tubers, which lessens the demand on ware yam stock (Ikeorgu & Nwokocha, 2001; Gbadamosi et al., 2019; Sugihara et al., 2021). This is helping to boost production, food security, as well as economic stability of farmers in yam-producing areas (Ajieh, 2012). Moreover, the minisett technology opens up chances to innovate, research and develop the systems of production of yams thus contributing to sustainable agricultural development (Asante, 2014). Minisett technology is also very critical towards increasing the availability of the yam, enhancing the livelihood of the rural setting, and boosting the national and regional food security agenda (Andualem, 2022).

Consequently, smallholder farmers who lack sufficient capital will be able to farm yams (Ajieh, 2012; Kiba et al., 2020). The prolonged use of entire tubers to propagate yams has led to the constant shortage of seeds and high competition between planting material and food production (Aighewi et al., 2020). These challenges have added together with little education of the farmers, poor training, high labor and capital expenses, fluctuating output, and growing climatic variability, thus resulting in the limited production of yams over the years (Ajieh, 2012).

Conventionally, the practices of producing yams can be described as a trial-and-error system, and some of the farmers may adopt a belief system as the basis of making production decisions instead of a scientifically proven one (Aighewi et al., 2020). The research is thus warranted in its attempt to assess the viability, value, and hurdles of incorporating minisett technology in the current farming systems (Aighewi et al., 2020). More specifically, it is essential to comprehend the varietal responses because genetic features, physical appearances, and adaptiveness to environmental factors play a pivotal role in determining the success of sprouting, regardless of the minisett procedure itself (Ajieh, 2012; Danquah et al., 2022). As an example, some of the varieties are reported to sprout early, perhaps because of some genetic characteristics, or because of increased levels of starch, which is more energy-giving and thus able to grow quickly (Otoo et al., 2016).

Moreover, growth medium is also a significant factor in the minisett performance. Earlier research has revealed that media that are rich in nutrients and have a high water-holding capacity lead to quicker sprouting and early development, and inappropriate media can give rise to the immobilization of nutrients, nitrogen deficiency, growth retardation, or death of plants (Aighewi et al., 2015; Aighewi et al., 2020; Sugihara et al., 2021). Such results highlight the importance of selecting both types of yams and cultivating medium in a way that would result in the highest effectiveness and effectiveness of minisett technology (Adeniji et al., 2019; Sugihara et al., 2021). The primary aim of the research was to evaluate how the various types of yams (*Dioscorea* spp.) respond to the various types of growth media to come up with evidence-based guidelines to farmers.

2. Material and Methods

2.1 Study Location and Sample Collection

The study was conducted in the 2024 cropping season at the Farming for the Future facility, located at the University for Development Studies (UDS), Nyankpala Campus, in the Northern region of Ghana. The yam varieties used for the study were; Chenchito, Labariko, and Pona which were obtained from Tenodo in the East Gonja Municipality of the Savannah Region of Ghana.

2.2 Nursery Preparation

A shade structure was constructed in which nursery beds were made. Construction materials included Zanamat, neem branches, ropes, healthy yam tubers sharp knife, basin, chemical for treatment (fungicide), water, weighing scale, paper/tags, sawdust and sacks. The neem branches were measured and cut at specific lengths. At the experimental site, holes were dug at specific depths and the sticks were placed into these holes to create a structure for the mounting of the Zanamat. Sticks were also placed on top of the structure and firmly tied with rope to ensure the structure was strong. The Zanamat was later covered around the sticks and on top and tied firmly to the sticks to create a rectangular room structure.

2.3 Sawdust Acquisition

Sawdust was acquired from the Tamale Timber market. The sawdust was packed into sacks and subsequently transported to the field of study. Nursery beds were created in the hut built using the Zanamat. The sawdust was poured onto the leveled area and raised to the required level. The sawdust was then thoroughly watered and left overnight to ensure it was moist and to maintain its moisture content.

2.4 Biochar Preparation for Planting Media

Biochar was prepared from collected rice husks and groundnut husks through a charring process. The apparatus used for preparing both the rice husk biochar and the groundnut husk biochar was the KUNTAN.

Below is the procedure used for the preparation of the biochar;

1. Dry rice husks and groundnut husks were collected in sacks, poured, gathered and cleaned to free them from contaminants such as stones or dirt.
2. The KUNTAN apparatus was positioned on a stable surface in a well-ventilated area to ensure effective operation.
3. A fire was initiated using small pieces of firewood underneath the metal drum and the fire intensity was gradually increased to heat the drum.
4. The collected rice husk or groundnut husk was then used to surround the metal drum of the KUNTAN apparatus, positioning it

against the direction of the wind to initiate charring.

5. Once the fire was well established, the entire drum was immediately surrounded with the respective husk (rice or groundnut) for the biochar process.
6. Loose positions were covered with a shovel of husks during burning to prevent the production of ashes, which results from burning in the presence of excess oxygen.
7. The color change of the flames was continuously observed; the flames turn colorless when the biochar is completely charred.
8. The darkening of the whole husk was monitored, and the pile was mixed evenly to ensure that the entire pile of husk was uniformly charred.
9. After the charring process was appropriately completed, the prepared biochar was spread out with a rake to facilitate cooling.
10. Once cooled, the biochar was collected using a shovel or a container and then stored in a cool, dry place.

2.5 Preparation, Treatment and Nursery of Yam Minisetts

The minisetts were produced from a mother tuber which was confirmed to be clean, healthy and free from any form of diseases. The mother tuber was processed into minisetts after the yam sett went through dormancy. A weighing scale was used to measure and record the weight of the mother tuber. Each set of yam varieties was weighed accordingly and recorded. The mother tuber was then sliced into pieces using a sharp knife to obtain appropriate sizes for good and effective Yam minisett. The weight of each piece fell within the ranges of 25 to 30 grams. The number of the cuts for the minisetts was dependent on the size of the mother tuber, but approximately 7 to 10 cuts were obtained from each mother tuber.

2.6 Treatment

Sixty grams (60 grams) of fungicide were dissolved in 10 liters of water in a basin and stirred evenly to obtain a uniform solution. The purpose of the fungicide solution was to prevent the minisetts from rots and pest damage after planting. The cut minisetts were immersed into the basin containing the fungicide solution for about 5 to 10 minutes, and were dried on sacks afterwards.

The experiment was 3x3 factorial design and which was laid in completely randomized block design. Each treatment was replicated three times for each variety across each of the three media with total of Nine (9) treatments. The minisett of each variety were transferred into the growth media: groundnut husks biochar, rice husks biochar, and sawdust and then covered with just enough of each of the respective media to support the growth and sprouting of the Yam minisetts. Each variety planted in the different media was labeled to simplify data recording. The growth media containing the minisetts was watered at a three-day interval to maintain adequate moisture in all the media to support the growth and sprouting of the minisetts.

2.7 Data Collection and Analysis

The following parameters were recorded throughout the experimental period. Number of sprouts at a 7-day interval from day 14 to day 35, number of non-sprouted minisett and number of rots per nursery bed.

The data collected from the experiment were subjected to Two-way analysis of variance (ANOVA) using GenStat version 18. Means separation was performed using the Fisher protected method at a significance level of $p<0.05$.

3. Results and Discussion

3.1 Sprouts at Day 14

The insignificance of the interaction of the growth media and the yam varieties ($p = 0.643$) implies that the reaction of the varieties in the various media was the same. Nevertheless, the large primary influences of variety ($p = 0.004$) and growth media ($p = 0.004$) indicate that both of the factors had an independent effect on the measured variables, which is why the choice of varieties and growth media plays a crucial role in determining the performance of yams.

The non-significant growth media x yam varieties interaction in this research indicates that the varietal growth media responses were consistent between the various media tested. This means that the relative performance ranking of the yam varieties did not vary depending on the change in the growth media and therefore there was no difference sensitivity of the yam varieties to the types of media used. Other studies have reported similar results with yam and other crops covering genetically propagated crops; in which genotype x substrate interactions were low or not significant under controlled propagation conditions (Danquah *et al.,* 2022).

3.2 Number of Sprouts at Day 21

The 21 days following the planting shows that the interaction between growth media and the yam varieties were insignificant ($p = 0.360$), which shows that the varietal reactions were similar in the various media. This implies that, the type of growth media that was applied was not a determinant of the relative performance of the yam varieties. Conversely, the large main effects of variety ($p = 0.001$) and growth media ($p = 0.002$) show that the natural genetic variations between the varieties and the physical and chemical nature of the growth media alone had an impact on early growth and establishment.

These results emphasize the need to not only use appropriate types of yams, but also to use appropriate types of growth media to maximize progression, and also indicate that media management practices may be utilized in a general manner across different types of yams. Fig. 2 displays the number of sprouts at the end of twenty-one days.

The non-significant interaction between the growth media and the types of yams at 21 days after planting implies that the pattern of the response of the varieties was similar in the various media used to rate them. This implies that the growth media did not have a selective effect on the performance of the different yam varieties, and that the ranking of the varietal performance did not change regardless of the type of substrate utilised. Other vegetatively propagated crops have also been found to exhibit little genotype x substrate interactions in nursery or controlled propagation environments.

Contrastingly, the large principal impact of variety indicates the extent to which genetic distinctions determine early development and setting up. Differences in physiological properties of tuber reserves mobilization, bud viability and dormancy period are familiar to affect sprouting and early development in yam (Okpara et al., 2014). These inherent varietal differences were probably the cause of the revealed differences in varieties at 21 days after planting regardless of the growth media used. The strong influence of growth media is another factor which highlights the importance of substrate properties in the propagation of the yam. The growth media play an important role in determining the availability of moisture, movement, presence of nutrients and activity of microbes; these factors influence root initiation and development of the shoot (Mignouna et al., 2014; IITA, 2020-2021).

Growth media having the best physical arrangement and water retention are good at establishment and early vigor, which cause minimal stress at the sensitive phase of early growth. This observation of independent effect of growth media is consistent with the other studies that have been conducted on the topic and found that proper choice of the substrate improves sprouting and survival of the yam minisets and seedlings (Aighewi et al., 2015). On the whole, these findings suggest that early yam establishment depends on varietal performance and selection of growth media, but the effects of these two factors are mostly independent. This has practical consequences on the culture and management of nurseries in the propagation of yams and the management of nurseries, since this implies that the application of appropriate growth media can be used across the various types of yams, without necessarily requiring highly variable specific substrate formulations, which will enhance the scalability of the use of better yam propagation methods.

3.3 Sprouts at Day 28

The interaction between the growth media and the yam varieties became not statistically significant at 28 days after planting ($p = 0.765$). Nonetheless, the main effects were significant in terms of variety ($p = 0.013$) and the growth media ($p = 0.001$) meaning that the two factors alone had effects on the measured parameters (Fig. 3).

The fact that there was no substantial interaction between growth media and the types of yam at 28 days after the planting is an indication that the performance of the yam varieties was similar in all the growth media that were tested. This indicates that there was no special preference or differentiation of any of the varieties to a certain growth media, and that their relative growth behavior was not affected by the type of substrate used. This has been observed in yam propagation work, where the interaction between genotype and media was not significant, both in nursery and controlled settings.

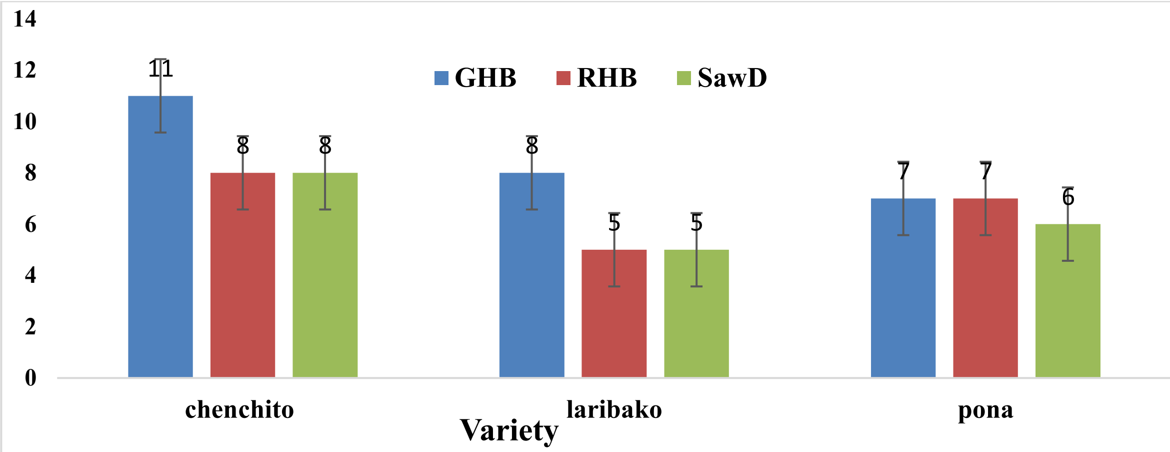

Fig. 1. Shows the number of sprouts after 14 days

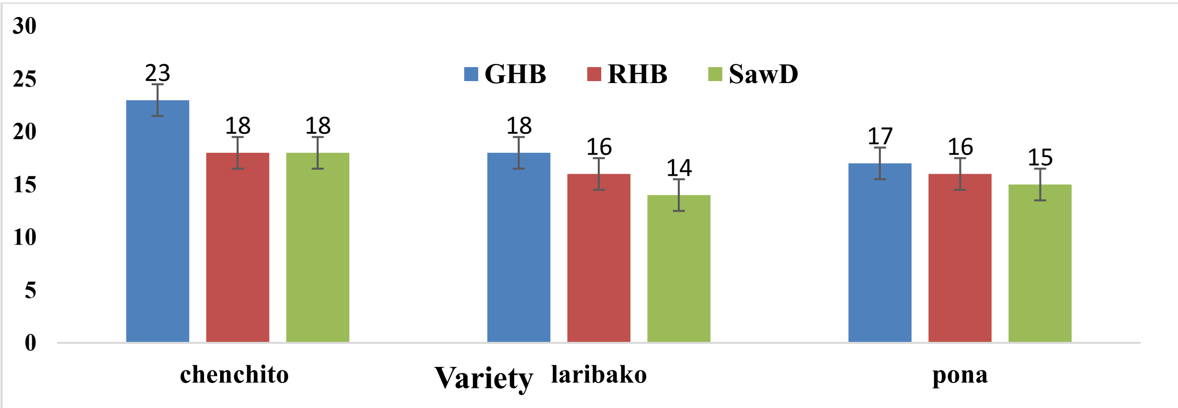

Fig. 2. Shows the number of sprouts after 21 days

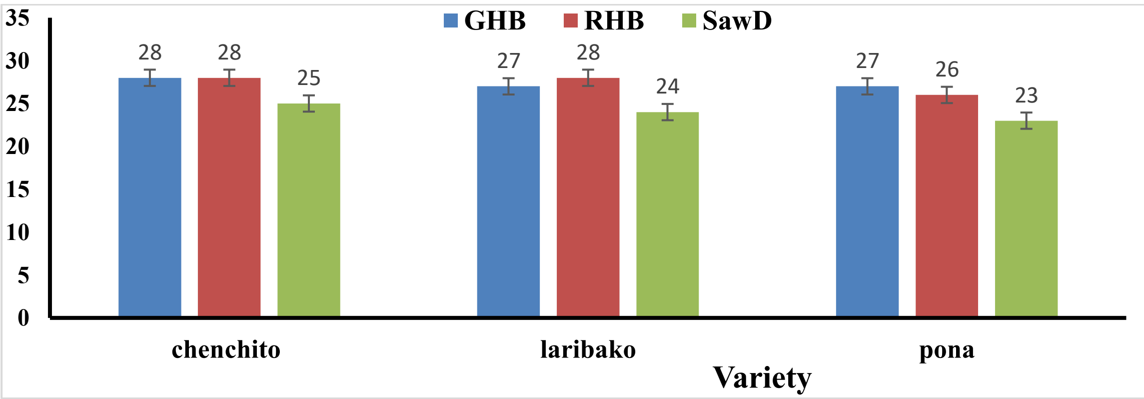

Fig. 3. Number of sprouts after 28

The main effect of variety that is very high at this stage relates to the existing genetic variation between the different yam varieties in the realization of growth vigor, mobilization of reserves and the establishment capacity. The differences in sprouting behavior and early growth have been reported in Dioscorea species and commonly explained by the variations in the physiology of tuber, bud activity, and dormancy (Okpara et al., 2014).

With respect to growth media, the groundnut husk biochar supported the highest number of sprouts at days 14 and 21 while sawdust recorded the least for days 14, 21 and 28. The superior performance of the groundnut husk biochar may be linked to its nitrogen fixation characteristics. This attracts beneficial microbial association with plant roots (Abdul-Aziz et al., 2025).

These inherent characteristics were very probable reasons why there was a difference in performance of different varieties after 28 days of planting. In the same way, the huge impact of growth media indicates the importance of substrate characteristics to the establishment and early development of yam. Media of growth are very crucial in controlling the availability of water, aeration, and nutrients, which are needed to continue the growth of root and shoot past the initial stage of sprouting (Mignouna et al., 2014; IITA, 2020-2021).

Medias with good physical structure and ability to retain water enhance better plant vigor and minimize stress and hence overall performance is improved. The combination of these findings shows that varietal selection and selection of the growth media are both relevant factors of yam performance, but their impacts are independent of each other. This has a practical use in the area of yam propagation and nursery management since it implies that the optimal growth media can be used across a broad range of yam varieties without having to formulate specialized substrates based on the particular variety which simplifies management and promotes the increased use of improved yam propagation technologies.

3.4 Sprouts at Day 35

The growth media-yam varieties interaction was not statistically significant at 35 days after planting ($p = 0.873$). Nevertheless, there were large main effects of variety ($p = 0.041$) and growth media ($p = 0.001$), and thus each of the independent variables had an individual impact on the measured outcomes (Fig. 4).

However, observations made on day 35 show a change where rice husk biochar records the highest number of sprouts followed by groundnut husk biochar and then sawdust (Fig. 4). The sawdust was likely undergoing decomposition, a process that can deplete nutrients, eventually leading to lower sprouts (Kumar et al., 2024).

The absence of a meaningful interaction between growth media and yam varieties 35 days after their planting implies that the reaction of the yam varieties was similar within the media that was tested. This indicates that there was no difference between the effects of the growth media on the performance of the plants across the varieties and that the ranking of the varieties would not be any different regardless of the nature of the substrate. The same trends have been listed in the yam propagation research, where the interactions of genotypes with the media were generally low in the controlled or nursery conditions.

The huge principal effect of diversity realized at this stage is as such that is characteristic of inherent genetic variation among the yam varieties in terms of their growth and establishment capabilities. The differences in this case are usually ascribed to the difference in physiological characteristics, such as reserve mobilization, bud activity, and growth vigor, which persist in affecting plant development after the initial sprouting stage (Okpara et al., 2014). The fact that the varietal influences are still visible at 35 days post-planting is evidence that the genetic influences are significant in the establishment of early growth performance in yam. On the whole, these results indicate that although the choice of the varietal differences and the growth media are the key factors influencing the performance of the yams, the effects of both are independent of each other. It has practical implications in terms of yam propagation and nursery management because it means that the correct growth media can be imposed on all types of yams without the necessity of formulating special substrates to each type of yam and therefore makes the management easier and the improved systems of yam propagation much more manageable.

At days, 28 and 35, the Chenchito variety maintained the highest number of sprouts with mean values of 26.83 and 27.63 respectively while Pona recorded the least number of sprouts with mean values of 24.17 and 26.33 respectively. This difference could be attributed to factors such as the growth hormones of each variety, starch contents, moisture contents (Messadia *et al.,* 2026).

3.5 Non-Sprouted Minisett

The non-sprouting results showed that there was a significant interaction of growth media and yam varieties ($p = 0.003$). Besides this, yam varieties ($p = 0.001$) and growth media ($p = 0.002$) had significant main effects, indicating that the two factors, along with their interaction, had an effect on non-sprouting behavior (Fig. 5).

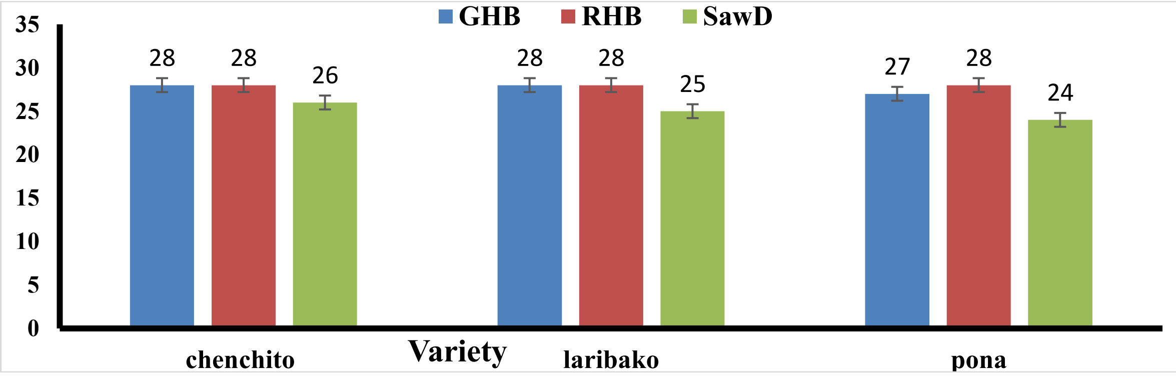

Fig. 4. Number of sprouts after 35 days

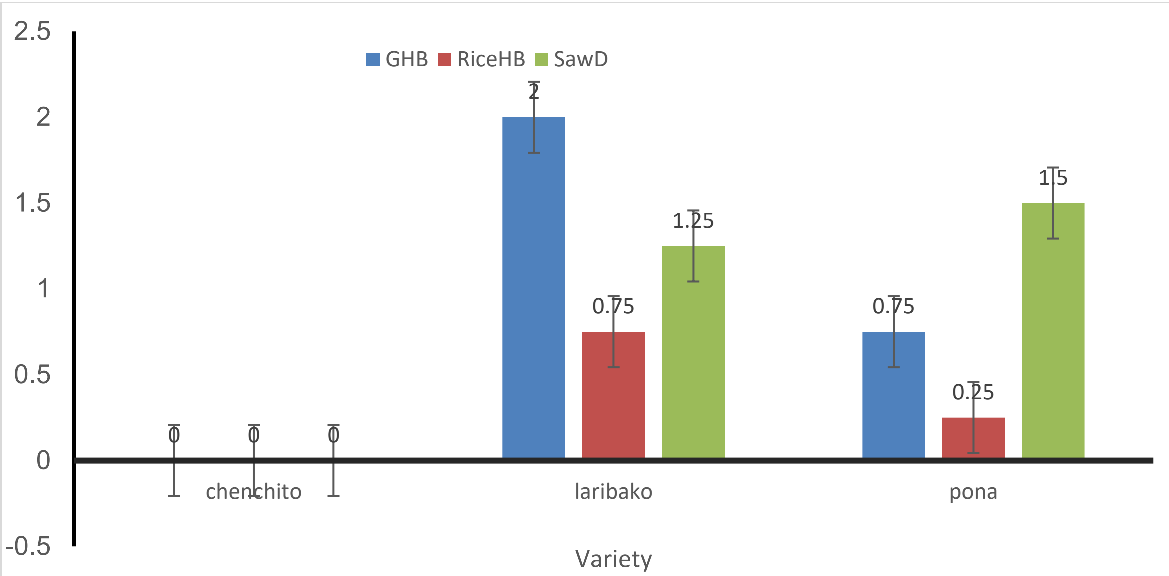

Fig. 5. Non-sprouting setts

The Chenchito variety showed no number of non-sprouted minisett in all of the three media, confirming its superior sprouting abilities compared to the other two varieties. The Laribako variety recorded the highest number of non-sprouting across all three media. This could be due to a variety of factors, including environmental conditions, physical nature and the genetic traces of these varieties.

The high degree of interaction between the growth media and yam varieties on non-sprouting to the fact that the degree of non-sprouting varied with the particular combination of the medium and type of the variety. This implies that some of the yam varieties were more susceptible to some media conditions, hence they failed to sprout differently in the treatment. These genotype x environmental interactions are typical of vegetatively-propagated crops, where varietal physiological characteristics are interacting with substrate characteristics to affect bud viability and sprouting effectiveness.

The large main effect of variety on non-sprouting further demonstrates that there are inherent differences among the yam varieties in terms of whether they can sprout or not. Different mobilization of carbohydrate reserves and duration of dormancy, as well as viability of buds have been found to influence sprouting in Dioscorea (Okpara et al., 2014). Types that have longer period of dormancy or reduced bud activity are more likely to be non-superfluous especially when propagation conditions are unfavorable. Likewise, the high influence of growth media also indicates the value of substrate attributes in determining the sprouting behaviour. The growth media influence moisture availability, aeration, microbial activity, and pressure of pathogens that may either stimulate or inhibit sprouting (Mignouna et al., 2014; IITA, 2020-2021).

Poor drainage or high load of pathogens in the media used may enhance rotting and inhibit sprout emergence hence, high non-sprouting rates. In general, this interaction between the forms of variety and growth media on the non-sprouting behavior highlights the importance of close correspondence between the yam varieties and the appropriate propagation substrates. This evidence indicates that, when compared to general growth performance, where the effects can be independent, non-sprouting is very sensitive to certain variety-media interactions. Significant implications of this on practice include nursery-based and miniset-based yam propagation systems, whereby both varietal and media choice of growth media are essential to reduce losses incurred when planting and enhance the success of plant establishments.

3.6 Rots Per Nursery Bed

The rots per Nursery bed had a significant interaction between the growth media and the yam varieties (p = 0.021). Moreover, the main effects were significant with respect to the yam varieties (p = 0.001) and growth media (p = 0.001), which reveals that the two factors along with their interaction affected the incidence of rot (Fig. 6).

The Pona variety had the highest number of rots across all three media. Related studies suggest that the Pona variety is more sensitive to environmental conditions and is highly susceptible to diseases and other pests (Otoo et al., 2016). The Laribako recorded the least number of rots.

Regarding the growth media, sawdust media recorded the highest number of rots among the varieties. This is potentially because sawdust has a very high moisture retention capacity, which creates a choked environment where fungi and other bacteria can thrive, leading to diseases and rot which is confirmed in (Gbadamosi et al., 2019).

The high degree of interaction on the number of rots per Nursery bed between the growth media and the types of yams suggests that the incidence of the rot was also dependent on the unique interaction between the type of variety and growth media. It indicates that some species of yams were more prone to rotting under a specific media condition which indicated the difference in genotypes to physical, chemical and biological characteristics of the propagation substrates. Much the same genotype x environment interactions have been observed with disease and rot occurrence in yam and other crops that are propagated vegetatively. The large principal effect of yam variety also emphasizes the genetic differences in rot susceptibility. Discriminatory variations in the skin thickness of the tuber, tissue structure, dormant behavior and resistance to fungal pathogens have been determined to vary rot development in yam (Okpara et al., 2014).

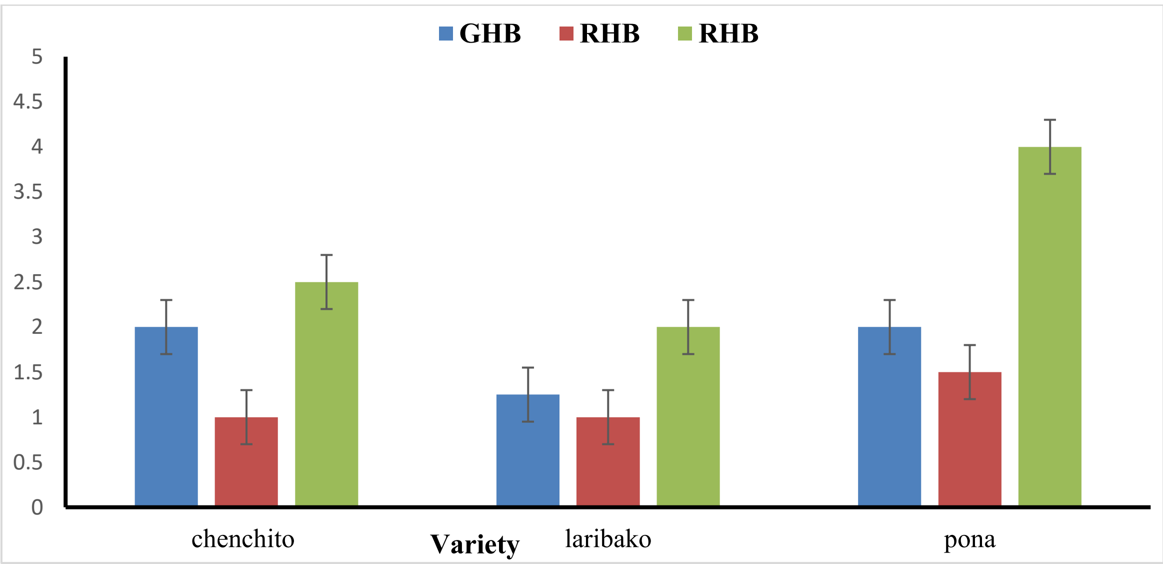

Fig. 6. Number of rots per basket

The ones having weak resistance or elevated moisture content might be more vulnerable to infection and tissue degradation especially in the initial phases of establishment. Equally, the substantial impact of growth media demonstrates the importance of substrate properties in the evolution of the disease. Growth media control moisture retention, aeration, drainage, and microbial activity, which impact on the growth and survival of rot-causing fungi, including Fusarium, Aspergillus and Penicillium species (Mignouna et al., 2014; IITA, 2020-2021). Poorly drained or elevated organic media media can provide good conditions in which the pathogens will grow, hence augmenting incidence of rot. All in all, the results suggest that it is important to optimize the choice of varietal and growth media to reduce rot loss in yam propagation systems.

A high interaction effect indicates that the generalized recommendations could be unsuitable in propagation systems using nursery and minisetts and that special combinations of variety-media are worth examination. Using proper growth media with disease-tolerant varieties and effective pre-planting treatments would play a major role in reducing the occurrence of rot and enhancing the establishment success.

4. Conclusion

The study concluded that the minisett technology was effective in enhancing yam sprouting, positioning it as a preferred alternative for addressing the challenges associated with sprouting in traditional yam farming methods. All three yam varieties tested Chenchito, Laribako and Pona demonstrated significant sprouting across the three experimental media: groundnut husk biochar, rice husk biochar and sawdust.

Based on the results spanning from day 14 to day 35, the Chenchito variety emerged as the best variety in terms of sprouting performance, followed by the Laribako and Pona varieties. Furthermore, groundnut husks biochar (GHB) proved to be the most effective growth media in supporting sprouting from day 14 up to day 35, attributed to its advantageous nitrogen fixing properties that provided superior support compared to rice husk biochar and sawdust.

Disclaimer (Artificial Intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

Competing Interests

Authors have declared that they have no known competing financial interests or non-financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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