 Chilean J. Agric. Anim. Sci., (2023) 39(3):256-265.
https://doi.org/10.29393/CHJAA39-22PBTO20022

ISSN 0719-3890 online

PERFORMANCE OF BLACK PEPPER CUTTINGS AS INFLUENCED BY GROWING MEDIA

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ABSTRACT

Black pepper is a highly valued spice and an important ingredient in traditional medicine. The increase in black pepper cultivation to improve farmers' income in Nigeria is constrained by poor seedling survival from vine cuttings. Using imported media to reduce mortality is expensive for low-income farmers. The objective of this study was to evaluate the influence of local growing media (topsoil, sawdust, and fresh rice hull) on the establishment and growth of black pepper vine cuttings in the nursery under screenhouse conditions. A repeated pot experiment was conducted using a randomised completed block design, with 9 treatments and four replicates. The following treatments were used: 100% topsoil (T1), 100% sawdust (T2), 100% rice hull (T3), 50% topsoil+50% sawdust (T4), 50% topsoil+50% rice hull (T5), 75% topsoil+25% sawdust (T6), 25% topsoil+75% sawdust (T7), 75% topsoil+25% rice hull (T8), and 75% rice hull +25% topsoil (T9). Data on sprouting, mortality and growth were evaluated. The results showed that T2 and T4 significantly reduced the number of days to sprouting compared to T1, T5 and T9, while T6, T7 and T8 exhibited a similar behaviour in the two plantings. Vine mortality was significantly higher in T3 compared to the other treatments, except for T5 and T8 in the second planting. With respect to number of leaves and leaf area, T2 and T6 showed significantly higher values at 8 and 12 weeks after planting (WAP), respectively; whereas T1 had significantly higher values at 16 and 20 WAP compared to the other treatments in both plantings. The results indicated that the most appropriate growing media for early transplanting are 100% sawdust and 50% topsoil+50% sawdust, while 100% topsoil is the most suitable for delayed transplanting.

Keywords: Black pepper, growing media, growth, sprouting, vine mortality.

INTRODUCTION

Black pepper (*Piper nigrum* L) is referred to as black gold because of the colour of its peppercorn, being the most widely used spice crop in the world (Ravindran et al., 2000). The crop is considered as the "King of Spices" due to its high international trade market value (Hammouti et al., 2019). The plant is used in traditional medicine due to its medicinal properties and the seeds are used as spices (Srivastava and Singh, 2017). Black pepper is efficient in treating malaria, gastrointestinal disorders, and respiratory diseases, (Rai et al., 2018). In Nigeria, the spice is sold as a condiment (Olife and Onwualu, 2013).

The crop originated in the Western Ghats

Received: October 28, 2022 Accepted: October 23, 2023

of the Indian Peninsula and is now cultivated in the tropical regions of the world (Hao et al., 2012). The major producers of black pepper are India, Vietnam, Malaysia, Indonesia, China, and Brazil, followed by Sri Lanka and West Indies but on a smaller scale. The world production of black pepper is yet to meet the increasing demand for the crop and its products (Korah and Mohankumar, 2021). According to estimates by FAO (2020), the world cultivation of black pepper increased from 608,309 to 624,488 ha, while the yield was reduced from 764259 to 747644 tonnes of peppercorns in 2019 and 2020, respectively. Therefore, the world market trade provides black pepper growers the opportunity to earn more income from its cultivation. Black pepper is mostly produced by small farmers, and thus the reduction in yield, despite of the increase in the planted surface area, could be attributed to environmental challenges and lack of adequate inputs, including good planting materials. The production of pepper in Nigeria lacks documentation since the bulk of the production is from small-scale farmers. Although there is a huge local and international market for the crop, which can help improve the living standard of farmers in the country, an increase in production has been constrained by the lack of adequate planting materials at low cost for field establishment.

The establishment of black pepper can be either through seeds or vegetative propagation. However, studies have shown that the propagation from seeds does not provide true-to-type and uniform seedlings for field establishment (Ravindran et al., 2000). Also, the seeds of black pepper have short viability. The vegetative method of propagation using the grafted method, or the biotechnology multiplication technique, is expensive for small-scale farmers (Hussain et al., 2011). Vine cutting is a preferred method of propagating black pepper, even for commercial cultivation (Ee and Shang, 2017). Establishing black pepper through vine cuttings in the nursery is difficult due to high mortality rate and failure in the establishment (Ee and Shang, 2017). In this sense, the establishment of black pepper using cheap and locally available growth media could increase the survival, early growth and establishment of black pepper vine cuttings in the nursery.

Growing media take on the role of soil in providing anchorage for the root system, while they also supply water and nutrients for the plant and guarantee adequate aeration in the root rhizosphere (Gruda et al., 2013). Therefore, growth, establishment and survival of seedlings depend on the quality of the growing medium (Landis et al., 2014). Although there are many commercial growing media used to raise seedlings, most of them are expensive and locally unavailable for small growers (Renuka et al., 2015). Consequently, there is a need to establish appropriate and low-cost growing media that will promote black pepper early seedling growth, establishment and survival. In Nigeria, commonly available and used growing media are sawdust and rice hull. Rice hull, which is a by-product of rice milling industry, is one of the important agricultural waste materials used as a planting medium in rice growing areas (Fuy, 2019). It is high in organic matter (Terzioglu, 2019), and thus effective in improving poor drainage soils and increasing root zone exchange activities for improved plant growth (Badar and Qureshi, 2014). It has been regarded as a good growth medium for carrots, chilli pepper and *Corchorus olitorius* (Jayawardana and Weerahewa, 2016; Jakpa et al., 2020). Sawdust is another substrate widely used as a growth medium component in areas with wood processing industries (Garner, 2014). The use of these waste materials provides environmental benefits and the impact of residue accumulation is minimized (Owoyemi et al., 2016). These locally available growing media could be used in the establishment of black pepper in Nigeria. Other studies have explored the potential of sawdust and rice hull as an alternative to commercial horticultural media (Atila et al., 2017). Furthermore, the addition of soil may be necessary to improve medium quality for black pepper vine establishment and survival. According to Alidoust et al. (2012), diversified medium composition alters the activities of micro-organisms and increases cation exchange capacity, thus providing an excellent condition for root development and plant growth. Hence, the objective of this study was to evaluate the rate of establishment and growth of black pepper vine cuttings as affected by different growing media in the nursery under screenhouse conditions.

MATERIALS AND METHODS

The experiment was carried out between 2020 and 2021 at the screenhouse of the Department of Crop and Horticultural Sciences, Faculty of Agriculture, University of Ibadan, Ibadan, Nigeria. The co-ordinate of the location was 7.34°N and 3.89°E with an altitude of 227 m.a.s.l.

Treatments and experiment design

Different growing media (sawdust, fresh rice hulls and topsoil) were used in different proportions by volume to obtain nine treatments: 100% topsoil (T1); 100% sawdust

(T2); 100% rice hull (T3); 50% topsoil+ 50% sawdust (T4); 50% topsoil+50% rice hull (T5); 75% topsoil+ 25% sawdust (T6); 25% topsoil+ 75% sawdust (T7); 75% topsoil+ 25% rice hull (T8); and 25% topsoil+75% rice hull (T9). The treatments were evaluated in a randomised complete block design with four replicates.

Experimental materials

The sawdust was collected at the Bodija Sawmill and fresh rice hull was obtained at the Bodija market in Ibadan, Oyo State, Nigeria. The topsoil was collected from Parry Road, at the experimental field of the Department of Crop and Horticultural Sciences, University of Ibadan. Vines cuttings of black pepper were obtained from the National Horticultural Research Institute (NIHORT), Ibadan, Nigeria.

The media mixtures were bagged into black polythene bags (27 x 25 cm in size and 0.01 cm thickness) with perforations to drain off excess water and placed on benches in the screenhouse. The filling of the nursery bags with the growth media was done with 1 litter beaker for accurate measurement. The growing media in the polythene bags were moistened and allowed to sit for two weeks before the vines were planted.

Planting

The vines were planted the same day at the screenhouse in the Department of crop and Horticultural Sciences, University of Ibadan. A black pepper vine with three nodes was planted in each of the polythene bags. The poly bags were irrigated until emergence, and then at two-day intervals until the completion of the study. The black pepper vine cuttings with three nodes were planted with one vine cutting per bag (Sharangi et al., 2010).

Second planting: The planting in the screenhouse was repeated after concluding and terminating the previous experiment to validate the observed results.

Data collection

The data were collected days to sprouting and the vine cutting mortality rate was determined. The number of leaves and leaf area were measured every four weeks for 20 weeks, while the final growth was measured 24 weeks after planting. The days to sprouting were days observed for the appearance of young leaves at the node of the vines. The number of leaves per plant was determined by manually counting every visible leaf on the plant, including the tips of new leaves that were just emerging. The leaf area was determined using the formula of Ibrahim et al. (1985):

$$Y = 0.61(L \times B)$$

Where Y = leaf area; L = length (measured from the leaf base to the tip of the leaves using a ruler); B = breadth (measured on the widest part of the leaf using a ruler).

The final vine length was measured from the base of the sprouted vine to the tip of the vine using a meter tape.

Statistical analysis

The collected data were subjected to a Two-way Analysis of Variance and significant means among the growing media were separated using Duncan's Multiple Range Test at a 95% confidence level. The relationship between the measured parameters at the early and late stages of the vine cutting establishment was measured using Pearson's correlation coefficient. Statistical Analysis System (SAS) 9.0 software was used for the statistical analysis.

RESULTS AND DISCUSSION

The pH of media

The pH of the growing media ranged from 5.4 (T3) to 7.2 (T7). Apart from T1, all media containing rice hall (T3, T5, T8 and T9) had a pH below 6, while media containing sawdust had a pH above 6. According to the USDA Natural Resources Conservation Service (1998), soils with pH ranges 6.5 to 7.5 are considered neutral; 6.1 to 6.5 are slightly acidic; 5.6 to 6.0 are moderately acidic; and 5.1 to 5.5 are considered strongly acidic. Accordingly, the T3 medium was strongly acidic; T1, T5, T6, T8 and T9 were moderately acidic; and T2, T4 and T7 were neutral. A strongly acidic condition is likely to impede or prevent root development, thereby limiting the establishment of the vine cuttings. Limiting root growth results in the reduction in plant access to nutrients required for growth. Furthermore, media pH affects microbial activity, and thus the bioavailability of macro- and micro-nutrients. Kumar et al. (2019) reported that soil microbes thrive better in a slightly acidic pH range (6-7) due to the high bioavailability of most nutrients. Plant nutrient uptakes are promoted by increased nutrient bioavailability from microbial activities (Singh et al. 2022).

Effect of growing media on the days to sprouting

The influence of growing media on the days to the sprouting of black pepper vine cuttings varied significantly among the treatments in the two plantings (Table 1). T5 had a significantly higher number of days to sprouting compared to

Table 1. Influence of growing media on the days to sprouting of black pepper vine cuttings in two plantings.

Media	pH of media	Days to sprouting		Vine cutting mortality	
		First planting	Second planting	First planting	Second planting
T1	5.62	51.00b	47.33b	0.00c	0.00b
T2	6.63	28.00c	25.67c	0.00c	0.00b
T3	5.40	0.00d	73.00a	100.00a	66.67a
T4	6.94	31.33c	27.33c	0.00c	0.00b
T5	5.70	81.00a	74.67a	66.67ab	33.33ab
T6	6.28	38.33bc	35.67bc	0.00c	0.00b
T7	7.20	37.00bc	35.00bc	0.00c	0.00b
T8	5.52	39.00bc	36.33bc	33.33bc	33.33ab
T9	5.83	51.00b	49.33b	0.00c	0.00b
SE	0.22	5.81	4.97	15.21	17.56

100% topsoil= T1, 100% sawdust = T2, 100% rice hull = T3, 50% topsoil+ 50% sawdust = T4, 50% topsoil+50% rice hull = T5, 75% topsoil+ 25% sawdust = T6, 75% sawdust + 25% topsoil= T7, 75% topsoil+ 25% rice hull = T8, 75% rice hull +25% topsoil= T9, Mean values within the same column, followed by similar letter(s) are not significantly different at $P< 0.05$ according to Duncan's Multiple Range Test.

the other growing media, while T3 did not sprout in the first planting. In the second planting, T3 and T5 had a significantly higher number of days to sprouting compared to the other treatments. Days to sprouting in black pepper vine cuttings were significantly reduced by using T2 and T4 compared to T1, T3, T5 and T9, but were similar to T6, T7 and T8 in the two plantings. The days to early sprouting were in the order of T2<T4<T7<T6<T8 for the first 5 treatments in the first and second plantings. Good cutting media can easily enhance the rooting of vine cutting and supply nutrients to the emerging seedling (Landis et al., 2014). Sprouting of vine cutting is achievable under conditions that promote media porosity, preventing water logging and providing aeration to ensure root formation (Landis et al., 2014). The early sprouting with the use of T2 indicated that this treatment had better conditions for the sprouting of black pepper compared to the other media. However, this media only differed from T4 by 2 and 3 days in the first and second plantings, respectively. This finding agrees with those of Famuwagun and Agele (2019), who reported that the use of sawdust and loamy soil resulted in excellent seed germination, seedling vigour and root development. Thus, sawdust provided better conditions for black pepper vine cutting establishment with respect to the soil or rice hull alone or in mixtures. Furthermore, it should be noted that the sawdust was obtained from sawmill from assorted wood that may contain antimicrobial properties, which probably help to preserve the cuttings before sprouting (Landis et al., 2014). This is further ascertained by the fact that the mixtures with different percentages of sawdust sprouted relatively earlier than the others containing rice hull in the two plantings. In this sense, it has been reported that the mixture of topsoil with other growing media promotes media porosity and enhance root development (Landis et al., 2014). The delay in sprouting observed in T1 could be attributed to the poor physical attributes of 100% soil as a rooting media for crops. Soil as growing media is more likely to have poor water drainage, nutrient immobilization, variability, and weeds as well as imbalance of soil microorganisms. These conditions are unfavourable for healthy plant root growth development in the nursery (Landis et al., 2014). Although the rice hull had similar physical properties to the sawdust, the relatively delayed number of days to sprouting could be attributed to the condition of the media before planting. The two weeks of water application, which was an attempt to stabilize the media before planting, could be inadequate. However, the result of this study is consistent with Zu et al. (2014), who reported that black pepper root development was inhibited at pH below 5.5.

Influence of growing media on the mortality of vine cuttings

The mortality of vine cuttings ranged from 0 to 100% and 0 to 66.67% in the first and second plantings, respectively (Table 2), being significantly higher in T3 with respect to the other treatments, except for T5 in the first planting and T5 and T8 in both plantings. The rest of the media did not show cutting mortality. This parameter is generally the result of unfavourable conditions for development. These conditions may be

Table 2. Effect of growing media on the number of leaves per plant in two plantings of black pepper vine cuttings at different weeks after planting.

Media	First planting					Second planting				
	8	12	16	20	24	8	12	16	20	24
T1	0.67	1.00a-c	3.67a	5.67a	8.00a	0.67bc	2.00ab	4.00a	6.33a	8.00a
T2	1.00	1.67ab	2.33ab	2.33a-c	2.33bd	1.67a	2.00ab	2.33b	2.67a-c	2.67a-c
T3	0.00	0.00c	0.00c	0.00c	0.00d	0.00c	0.00c	0.33c	0.33c	0.33c
T4	0.67	1.00a-c	1.67a-c	2.00a-c	2.00bd	1.67a	3.00a	3.00ab	3.00a-c	3.00a-c
T5	0.00	0.00c	0.33bc	0.67bc	0.67cd	0.00c	0.00c	0.67c	1.00bc	1.00bc
T6	0.33	2.00a	2.67a	4.33ab	5.67a-c	1.67a	2.00ab	3.00ab	4.33ab	5.67a-c
T7	1.00	1.00a-c	2.00a-c	2.00a-c	2.33bd	1.33ab	2.00ab	2.67ab	2.67a-c	2.67a-c
T8	0.67	0.67bc	3.00a	4.67ab	6.33ab	1.00ab	1.33b	2.33b	4.67ab	6.33ab
T9	0.67	1.00ac	3.33a	5.00a	6.33ab	0.67bc	1.33b	3.33ab	5.33a	6.33ab
SE	0.37	0.36	0.76	1.41	1.79	0.26	0.34	0.49	1.32	1.79

100% topsoil= T1, 100% sawdust = T2, 100% rice hull = T3, 50% topsoil+ 50% sawdust = T4, 50% topsoil+50% rice hull = T5, 75% topsoil+ 25% sawdust = T6, 75% sawdust + 25% topsoil= T7, 75% topsoil+ 25% rice hull = T8, 75% rice hull +25% topsoil= T9, Mean values within the same column, followed by similar letter(s) are not significantly different at $P< 0.05$ according to Duncan's Multiple Range Test.

environmental (weather conditions at the time of planting) or inherent to the growing media. In the present study, the cuttings were raised under similar conditions, and thus mortality could only be attributed to the media used. The significantly higher mortality in the 100% rice hull medium could be attributed to the strongly acidic condition of rice hull, which did not favour rooting in black pepper vine cutting, thus limiting the ability of the cutting to meet the water lost to the atmosphere through the vascular systems of plants by transpiration. The high mortality observed in the rice hull compared to that with the use of the sawdust, except for the mixture with topsoil, may be explained by the high level of acidity of the medium, thereby killing the vine cuttings. However, the mixture of rice hull and topsoil resulted in a reduction in vine cutting mortality. This implies that the acidity of rice hull decreased by the addition of topsoil as observed in T5, T8 and T9, indicating that an alkaline condition tends to promote rooting in black pepper vine cutting. Furthermore, an incomplete stage of decomposition may also account for the high mortality observed with the use of rice hull. This suggests that the decomposition leading to the generated heat from rice hull was reduced by the addition of topsoil (Thiyageshwari et al., 2018).

Influence of growing media on the number of leaves

The increase in the number of leaves per plant during the period of observation varied significantly among the growing media in the two plantings, except at 8 weeks after planting (WAP) in the first planting (Table 3). For the first planting, T6 had a significantly higher number of leaves compared to T5 and T8 but was similar to the other treatments at 12 WAP. At 16 WAP, the treatments T1, T6, T8 and T9 had a significantly higher number of leaves with respect to T5 and T8. The observed number of leaves for T1 and T9 was significantly higher with respect to T5 but similar to the other treatments at 20 WAP. No leaf growth was observed in T3 during the first planting. In the second planting, a significant increase in the number of leaves was observed in T2, T4 and T6 compared to T5 and T9 at 8 WAP, while the other treatments did not differ significantly. The number of black pepper leaves ranged from 0.33 (T3) to 4.0 (T1) at 16 WAP, with a significant increase in T4 compared to T5 and T9. Likewise, a significantly higher number of leaves was observed in T1 and T9 compared to T3 and T5 at 20 WAP. At 24 WAP, the number of leaves varied significantly among the treatments and ranged from 2.33 (T2) to 8.00 (T1) in the first planting and 2.67 (T2 and T7) to 8.00 (T1) in the second planting. The number of leaves per plant is an important indicator of the ability of the plant to accumulate assimilates for development and it can be used to determine the physiological age of the plant (Weraduwage et al., 2015). This was evident when the vines that sprouted earlier had higher number of leaves compared to those with a delayed sprouting. However, the subsequent increase in the number of leaves is dictated by the ability of the plant to acquire nutrients needed for improvement from the media. The media that sprouted earlier (T2, T4, T6, T7, T8 and T9) had higher number of leaves at the 8 WAP but

Table 3. Influence of growing media on leaf area (cm²) in two plantings of black pepper vine cuttings at different weeks after planting.

Media	First planting					Second planting				
	8	12	16	20	24	8	12	16	20	24
T1	2.72b	21.94ab	97.71a	191.44a	277.09a	4.61bd	26.50a	100.20a	230.84a	270.97a
T2	7.36ab	12.73ab	31.52ab	35.87b	36.16bc	8.89ab	19.50a	31.09ab	41.83b	44.88bc
T3	0.00b	0.00b	0.00b	0.00b	0.00c	0.00d	0.00b	3.31b	4.34b	4.77c
T4	3.22b	7.12ab	9.30b	36.31b	38.61c	7.93a-c	12.95ab	14.59b	38.40b	43.28bc
T5	0.00b	0.00b	4.26b	10.30b	17.60c	0.00d	0.00b	8.07b	17.33b	22.49bc
T6	13.43a	33.53a	66.29ab	103.24ab	140.34a-c	10.35a	26.88a	63.99ab	128.48ab	131.15a-c
T7	7.98ab	11.91ab	28.04b	39.26b	41.31bc	8.30ab	14.15ab	27.06b	40.98b	46.80bc
T8	2.34b	12.43ab	48.87ab	130.62ab	201.67ab	4.22bd	16.51a	47.17ab	155.68ab	196.24ab
T9	3.42ab	9.60ab	52.94ab	119.75ab	160.12ac	3.40cd	11.96ab	51.09ab	142.13ab	156.41a-c
SE	3.38	8.94	22.39	43.96	58.13	1.56	5.32	23.50	60.02	63.72

100% topsoil= T1, 100% sawdust = T2, 100% rice hull = T3, 50% topsoil+ 50% sawdust = T4, 50% topsoil+50% rice hull = T5, 75% topsoil+ 25% sawdust = T6, 75% sawdust + 25% topsoil= T7, 75% topsoil+ 25% rice hull = T8, and 75% rice hull +25% topsoil= T9. Mean values within the same column followed by similar letter(s) are not significantly different at $P<0.05$ according to Duncan's Multiple Range Test.

was unable to sustain the increase compared to the other treatments. This could be attributed to the inadequate supply of nutrients required for photosynthate accumulation. Given the fact that nitrogen is required for photosynthesis and cell multiplication, the use of sawdust, which is basically organic matter with almost no nitrogen, probably explains the lower performance in the treatments with larger percentages of this medium (T2, T4 and T7). However, T6 with a low sawdust percentage (25%) and higher topsoil performed consistently better than T2 after 8 WAP by helping improve the physical properties of the media in the two plantings. This means that sawdust acted as an amendment and improved soil physical characteristics. The decrease in the number of leaves observed in T2 agrees with the findings of Ismail-Embong et al. (2021), who conducted a study on *Clinacanthus nutans* and reported that fewer leaves are produced under nutrient deficient conditions, resulting in a decrease in net photosynthesis.

Influence of growing media on leaf area

In both plantings, T6 had a significantly higher leaf area compared to the other treatments, except for T2 and T7 at 8 WAP (Table 4). At 12 WAP, the leaf area in T6 was significantly higher with respect to T3 and T5, while the other treatments were similar in the first planting. Although T1, T2, T6, and T8 were similar, T6 had the highest leaf area and was significantly different from T3 and T6 in the second planting. At 16 and 20 WAP, T1 had significantly higher leaf area compared to T2, T3, T4, T5 and T7, while the lowest area was observed in T3 at the two plantings. The T1 treatment had significantly higher leaf area compared to the other treatments in both plantings. However, T8 and T9 were similar to T1 in both plantings. The leaf area of a plant is important in determining its ability to accumulate photosynthate for development. Although the ability of the plant to accumulate photosynthetic materials depends on many factors, leaf size is crucial to plant development (Ayalew et al., 2022). Except where there was complete mortality of the cuttings, leaf area increased with the age of the plant. The media with early sprouting had higher leaf area than those that sprouted later (T2, T6 and T7). However, the continued growth of the seedlings in the media indicated that T1 had the highest leaf area among the treatments in the two plantings. Leaf area is key determinant of light interception and resource use efficiency of crops (Weraduwage et al., 2015). The wider the leaf area the larger the exposed surface to incident light. This finding suggests that T1 was able to promote greater efficiency of the photosynthetic apparatus of the seedling through the supply of nutrients compared to the other media. The inability of 100% sawdust (T2) to promote seedling growth has been explained by the lack of nutrients required for continued growth. This agrees with Ismail-Embong et al. (2021), who found that growing media with higher nutrient content resulted in the best growth performance. They also reported that the growth rate in the growing media with a low nutrient content was slower. To overcome this challenge, Famuwagun and Agele (2019) suggested the inclusion of manure to increase plant growth in cocoa seedlings. Furthermore, the role of topsoil in improving the

chemical and physical condition of the sawdust and rice hull media was evident in the increase in leaf areas from different mixtures.

Influence of growing media on the final vine length of black pepper

The growth components of black pepper vine cuttings as influenced by growing media at the completion of the experiment are shown in Fig. 1. T1 had a significantly higher number of leaves and leaf area compared to the other treatments in both plantings, while T8 and T9 were similar to T1. There was a total stand loss for T3 in the first planting. T5 and T3 had the lowest values for the parameters observed at the first and second plantings, respectively. The improvement in vine length observed in T1 compared to the other treatments can be substantiated by the fact that, apart from the physical condition of the media, the supply of nutrients is crucial for seedling growth. According to Bijeta et al. (2018), the availability of nutrients in the growing media for nursery plant uptake through the roots is a major determinant of development. The acquired nutrients enable the plant to effectively accumulate photosynthates, which are utilized for cell multiplication and elongation, and thus growth. The increment in vine length observed in T1 compared to the other media was in conformity with the findings of Ismail-Embong et al. (2021). They reported that the media with more nutrients produce plants with better performance. The general poor performance of rice hull with respect to topsoil and sawdust can be attributed to the lower bulk and particle density and higher porosity in rice hull media (Jakpa et al., 2020). This suggests a greater efficiency of the photosynthetic apparatus of T1 with respect to the other media considered in the study.

Correlation coefficient among parameters at early and late plantings

Days to sprouting of black pepper vine cuttings and vine mortality had negative correlations with the number of leaves and leaf area at the early stage of black pepper establishment in the two plantings (Table 4). These comparisons were not significant, except for the relationship between mortality and the number of leaves in the first planting. For the second planting, the correlations among the parameters were highly significant ($P<0.01$) and had similar trends as observed in the first planting. There was a highly significant positive correlation coefficient observed between leaf area and the number of leaves in both plantings.

The comparison of the degree of association among vine cutting sprouting and the parameters observed at 24 weeks after planting are indicated in Table 5. Days to sprouting of the vine had no significant correlation with the final growth of the vine cuttings in the two plantings. However,

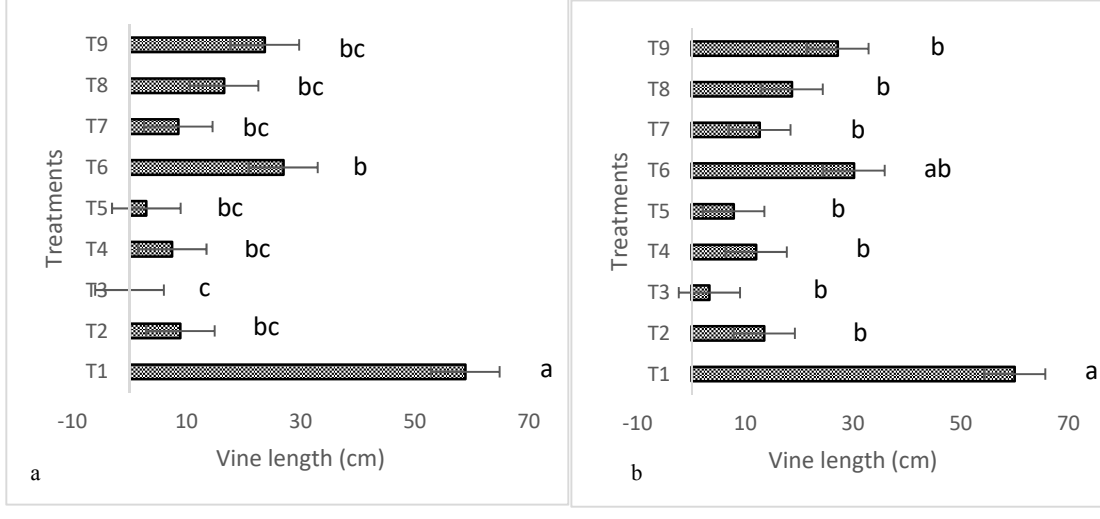

Fig. 1. Vine length of black pepper as influenced by growing media in two plantings (a = first planting; b, second planting). 100% topsoil= T1, 100% sawdust = T2, 100% rice hull = T3, 50% topsoil+ 50% sawdust = T4, 50% topsoil+50% rice hull = T5, 75% topsoil+ 25% sawdust = T6, 75% sawdust + 25% topsoil= T7, 75% topsoil+ 25% rice hull = T8, and 75% rice hull +25% topsoil= T9. Bars with similar letter(s) are not significantly different at *P*< 0.05 according to Duncan's Multiple Range Test.

Table 4. Pearson's correlation coefficient among parameters as affected by growing media at 8 weeks after planting.

	First planting			Second planting		
	Days to sprouting	Mortality	Number of leaves	Days to sprouting	Mortality	Number of leaves
Mortality	0.15			0.42*		
Number of leaves	-0.22	-0.43*		-0.82**	-0.51**	
Leaf area	-0.16	-0.37	0.55**	-0.77**	-0.51**	0.91**

*, ** = Correlation is significant at the 0.05 and 0.01 levels respectively (2-tailed).

Table 5. Pearson's correlation coefficient among parameters as influenced by growing media at 24 weeks after planting.

	First planting			Second planting		
	Days to sprouting	Number of leaves	Leaf area	Days to sprouting	Number of leaves	Leaf area
Number of leaves	0.13			0.29		
Leaf area	0.08	0.72**		0.19	0.97**	
Vine length	0.10	0.49**	0.89**	0.14	0.86**	0.88**

** = Correlation is significant at the 0.01 level (2-tailed).

the number of leaves, leaf area and vine length were significantly (P<0.01) correlated in both plantings. The significant correlation between the number of leaves and leaf area at the early and late periods in the two plantings agrees with Hu et al. (2020), who reported that the increase in leaf area is directly proportional to the number of leaves due to their contribution to improved net photosynthesis rate, which in turn determines growth.

CONCLUSIONS

The results of this study indicate that black pepper vine cuttings grown in 100% sawdust and 50% topsoil + 50% sawdust sprouted earlier compared to the rest of the treatments in the first and second plantings. Vine mortality was in the order of 100% rice hull > 50% topsoil + 50% rice hull > 75% topsoil + 25% rice hull, while vine mortality was minimal in the other treatments. The 100% sawdust (T2), 50% topsoil + 50% sawdust (T4) and 75% topsoil + 25% sawdust (T6) promoted vine growth at the initial stage (8 and 12 WAP) of development in the nursery. However, 100% topsoil (T1) consistently had the highest values for most of the growth parameters considered after 12 WAP. Consequently, 100% sawdust and 50% topsoil + 50% sawdust are the most appropriate media for short duration nursery management, while 100% topsoil is better for delayed transplanting.

ACKNOWLEDGMENTS

The authors acknowledge and appreciate Mr. Alabi, aka Prof. (National Horticultural Research Institute (NIHORT), Ibadan, Nigeria) for supplying the vine cuttings used in this study. The management of the seedlings by Mr. T. I. Ogiaga (Department of Crop and Horticultural Sciences, University of Ibadan, Ibadan) is greatly appreciated.

Conflict of interest

The authors declare that their no known competing financial interests is personal relationships that could have influenced this study.

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