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Research Article

Effect of Substrates, Planting Period, Explants Nodal Level and Arbuscular Mycorrhizal Fungi on Sweetpotato Vine Cutting Production in Soil and Soilless Systems

Chukwunalu Okolie OSSAI[*1], Stephanie Clara AKPEJI[2], Elizabeth OBOH[3]
Sunday Ifeakachukwu ALAMA[4], Smart Augustine OJOBOR[5], Tina OJUEDERIE[6]

[1,3,6]Crop Protection and Environmental Biology Department, University of Ibadan, Nigeria
[2]Microbiology Department, Novena University, Ogume, Delta State, Nigeria
[1,3,6]International Institute of Tropical Agriculture, Nigeria
[4,5]Agronomy Department, Delta State University, Delta State, Nigeria

[1]https://orcid.org/0000-0002-1924-5855, [2]https://orcid.org/0000-0003-2191-8032, [3]https://orcid.org/0000-0001-8407-8742, [4]https://orcid.org/0000-0003-4968-686X, [5]https://orcid.org/0000-0002-6835-6797, [6]https://orcid.org/0000-0003-3322-2198

*Corresponding author e-mail: ossaichukwunalu1@gmail.com

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Abstract: In West Africa, little attention has been given to the rapid propagation of sweet potato with much dependence on the use of tuber part as seed. This study thus investigated the propagation and establishment of a different number of nodal segments of sweet potato vines in soil and soilless system under the influence of Arbuscular Mycorrhizal Fungi (AMF). Cut vines (double and single nodal explants) from growing sweet potato plants were planted in the following substrates; Topsoil, Cocopeat, and Cocopeat + 5 g AMF (4 kg each fertigated with 250 g poultry manure). The experiment was conducted twice (March to July and August to December 2021). The experiment was a 2 (nodal explants) x 3 (substrates) x 2 (periods) factorial arranged in a completely randomized design with three replicates. The agronomic and yield parameters were collected and analysed using Analysis of Variance (ANOVA), and means were separated using Duncan Multiple Range Test (DMRT) at 5% level of significance. At 4 Weeks after Planting (WAP), the number of new leaves produced by the nodal explants was insignificant. At 8 WAP, the number of nodes produced differed significantly among substrates and ranged from 17.67±0.42 (cocopeat) to 20.17±0.42 (cocopeat+5g AMF). Number of tubers produced differed significantly between planting periods and ranged from 3.28±0.41 (March to July) to 5.06±0.41 (August to December). For efficient vine rooting, planting of single node vines of sweetpotato in cocopeat substrate fertigated with poultry manure and AMF between the August to December period of the year is thus recommended.

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1. Introduction

Sweet potato (*Ipomea batatas*) is the second most cultivated tuber crop after cassava in the world predominantly due to its high dry matter and nutrient content (Nedunchezhiyan et al., 2012). The tuber part is consumed after boiling or fried as a source of carbohydrates, vitamins, and proteins, or it can be sold to other end users, making it a source of cash for the producer (Magagula et al., 2010). However, in West African countries, Sweet potato has received little attention in terms of production by the local farmers relative to other tuber crops like yam and cassava. This is probably due to the fact that the crop is largely considered as poor man's food and as a dessert to the rich rather than a staple for all and source of income to the farmers and gross domestic product to the nations (Essilfie et al., 2016). The above factors have contributed largely to the low production of sweet potato in West Africa, coupled with the production technique that is solely dependent on the use of tuber part, which is also the edible part.

Vine cutting technology is the propagation of crops through the nodal parts. This process increases the propagation ratio of clonally propagated crops against the sole use of tuber parts, as demonstrated in yam (Maroya et al., 2014) and sweet potato (Essilfie et al., 2016). However, the position of the shoot, number of nodes in the cut section, nutrient content of the rooting substrate, and the substrate type play an important role in the successful establishment of the technology (Nair, 2006). The younger shoots are normally considered a better option for the vine cutting establishment as the older shoots tend to lose totipotency easily over time (Balogun and Gueye, 2014). The higher the initial number of nodes in the establishing cutting, the faster rate of its establishment, but this reduces the propagation ratio obtainable from a growing plant. However, it is yet to be established the yield variability obtainable from the use of different explant numbers.

The use of soil as an establishing substrate has the advantage as a cheap source, but it is usually constrained by disease transmission, and heterogeneity of the soil nutrient content has resulted in crops low productivity relative to substrate based hydroponics (Maboko et al., 2009). Substrates like cocopeat, usually deployed in a hydroponics system, is another good rooting source, but it is nutrient inert and expensive to source. Hence the use of the cocopeat substrate means it has to be fortified with an additional nutrient source which could be synthetic or organic (Ossai et al., 2020). While the organic requires the addition of microbes to aid the decomposition or left for a longer time to completely mineralize before its eventual use (Alaboz et al., 2022). Different beneficial bacteria like the AMF have been frequently deployed to aid mineralization (Bunn et al., 2019), but their mode of action in unlocking the nutrient contained in organic manure has not been so clear as researchers have considered their role as a symbiotic and catalytic relationship with other enterobacteria in the environment. But to which extent their role will be beneficial in the quick establishment of the sweet potato vine cutting over just the use of the manure alone is yet to be established.

This study thus investigated the propagation and establishment of a different number of nodal segments of sweet potato vines in soil and soilless system under the influence of AMF in unlocking the organic fortified nutrient status of the substrates.

2. Material and Methods

2.1. The experimental site and environmental location

The experiment was conducted in a greenhouse condition at Idi-Ose, opposite International Institute of Tropical Agriculture, IITA, Ibadan, located at Latitude 7.5014° N and longitude 3.9099° E.

2.2. Source of planting materials

Single and double node vines were cut from two months old orange sweet potato varieties growing at the Soilless FarmLab, Abeokuta, Ogun State, Nigeria. Buffered cocopeat blocks were purchased from the Afri-Agri Company, Lagos, Nigeria. Topsoil was collected from the Teaching and Research Farm, Faculty of Agriculture, University of Ibadan. The AMF was purchased from the Botany Department, University of Ibadan, Nigeria, while poultry manure was sourced from Ajayi Farm Limited.

2.3. Experimental procedure

The topsoil was sterilized using an autoclave at a temperature of 121^{o}C for 15 minutes and kept in a bowl overnight to cool. The cocopeat blocks were dissolved in water (30 litres per block). Both the sterilized soil and dissolved cocopeat were weighed into a hydroponics trough and arranged in the following treatment composition;

Treatment One (T1): 250 g Poultry manure + 4 kg Topsoil,
Treatment Two (T2): 250 g Poultry manure + 4 kg Cocopeat,
Treatment Three (T3): 250 g Poultry manure + 4 kg Cocopeat + 5 g AMF

The substrates were left for 2 weeks, and single node and double node cuttings, respectively, of the orange fleshed sweet potato variety were planted in the treatment arrangements. The experiment was conducted in two (2) periods: 1. March to July 2021 as cycle one and August to December 2021 as cycle two.

2.4. Experimental design and data collection

The experiment was a 2 (nodal cuttings) x 3 (substrates) x 2 (periods) factorial arranged in a completely randomized design with three replicates. The number of new leaves produced at 2 and 4 weeks old, plant height, number of nodes and internodes at 2, 4, 6, and 8 weeks old, days to flowering, number of tubers, and tuber weight were collected.

2.5. Data analysis

Data collected were analysed using Analysis of Variance (ANOVA) (SAS 9.3 version), and means were separated using Duncan Multiple Range Test (DMRT) at 5% level of significance.

3. Results

3.1. Effect of substrate type on the growth and yield of vine cutting established sweet potato

Results obtained showed a gradual increase in the number of new leaves produced by the vine cutting established sweet potato from two (2) Weeks After Planting (WAP) to 4WAP, where the vines established in the cocopeat substrate mixed with 5 g AMF (4.42±0.26) was significantly higher than the rest substrates (Table 1). The number of nodes produced also increased from 2WAP to 8WAP, where the number of nodes produced by the vines established in cocopeat substrate mixed with 5 g AMF (20.17±0.42) was significantly higher than the rest substrates. Table 2 shows a gradual increase in the height of the established vines in the substrates from 2WAP to 8WAP. At 8WAP, the height of the plants in the cocopeat substrate mixed with 5 g AMF (26.00±0.42) was significantly higher than the cocopeat substrate alone (23.17±0.42). However, the internodes at 2WAP were highest in soil (0.99±0.06) which was significantly higher than the vines grown in the mixture of cocopeat and 5 g AMF (0.78±0.06). The sweet potato plants grown in the mixture of cocopeat and 5 g AMF took the shortest number of days (71.25±0.69) to produce flowers, and this was significantly lower than the 74.00±0.69 it took for the plants grown in soil (Table 3). The substrate effect was insignificant in the number of tubers produced and the tuber weight, respectively.

3.2. Effect of planting period on the growth and yield of vine cutting established sweet potato

At 4WAP, the number of new leaves produced by the established vines within the period of March to July (3.83±0.22) was significantly higher than the ones established between August and December (3.06±0.22). Also, the number of nodes produced at 4WAP (5.33±0.22) and 6WAP (13.44±0.23) in the March to July planting period was significantly higher than in August to December planting period. The effect of the planting period on the plant height and internode length was insignificant. However, the number of days taken by the plants grown in the August to December planting period to produce flowers (70.56±0.56) was significantly shorter than the ones planted in the March to July planting season (75.00±0.56), and the number of tubers produced in the August to December planting period (5.06±0.41) was significantly higher than the March to July planting period (3.28±0.41).

3.3. Effect of planting explant's nodal level on the growth and yield of vine cutting established sweet potato

The number of new leaves produced by the established vines also increased from 2WAP to 4WAP where the new leaves produced by the double nodes explants had 4.11±0.22 which was significantly higher than the single node planting explants (2.78±0.22). Also, the number of nodes produced after establishment increased gradually from 2WAP to 8WAP. However, at 6WAP the number of nodes produced by the double node explant (14.11±0.22) was significantly higher than the single node explant (11.89±0.22). At 8WAP, the height of the plants produced by the double node planting explant (25.78±0.34) was significantly taller than the single node planting explant (23.11±0.34). Also, at 2WAP the internode length of the plants raised through the double node explant (0.94±0.05) was significantly longer than the single node planting explant (0.79±0.05). However, the number of nodes in the planting explant was insignificant in the days to flowering, number of tubers, and tuber weight, respectively.

3.4 Interactions between substrate types, period of establishment and explants nodal level on the growth and yield parameters of vine cutting established sweet potato

At 8 WAP, the interaction between substrate and explant nodal level on the number of nodes produced and plant height was significant. On the number of days to flowering, the interaction between substrate and explant nodal level, and between substrate and period of planting were significant, while the interaction between substrate and period of planting was significant on the number of tubers produced by the sweet potato plant.

Table 1. Effects of substrates, period of establishment, and explants node on the production of leaves and nodes by vine cutting established sweet potato

SUBSTRATES	Number of new leaves		Number of nodes			
	WEEK2	WEEK4	WEEK2	WEEK4	WEEK6	WEEK8
Cocopeat	1.00b	2.67b	2.00b	4.17b	12.17b	17.67b
Cocopeat+AMF	1.58a	4.42a	2.58a	5.92a	13.92a	20.17a
Soil	1.08b	3.25b	2.17ab	4.75b	12.92a	18.67b
SE	0.17	0.26	0.15	0.26	0.28	0.42
PERIOD						
MAR - JUL	1.39a	3.83a	2.39a	5.33a	13.44a	19.22a
AUG - DEC	1.06a	3.06b	2.11a	4.56b	12.56b	18.44a
SE	0.14	0.22	0.12	0.22	0.23	0.35
NODES						
DN	1.44a	4.11a	2.50a	6.11a	14.11a	20.72a
SN	1.00b	2.78b	2.00b	3.78b	11.89b	16.94a
SE	0.14	0.22	0.12	0.22	0.22	0.35
INTERACTIONS						
SUB*Period	NS	NS	NS	NS	NS	NS
SUB*Nodes	NS	NS	NS	NS	NS	**
SUB*Period*Nodes	NS	NS	NS	NS	NS	NS

Means with the same letter down the column are not significantly different from each other at 5% significance level. SE: Standard error, SUB: Substrate, DN: Double nodes, SN: Single nodes, NS: Not significant, * and **: Significant at 5% and 1% levels of significance. AMF: Arbuscular Mycorrhizal Fungi.

Table 2: Effects of substrates, period of establishment and explants node on plant height and internode length of vine cutting established sweet potato

SUBSTRATES	PH2	PH4	PH6	PH8	INTER2	INTER4	INTER6	INTER8
Cocopeat	2.16b	4.67b	14.73b	23.17b	0.84ab	1.28a	1.27a	1.68a
Cocopeat+AMF	2.85a	5.92a	16.37a	26.00a	0.78b	1.21a	1.25a	1.77a
Soil	2.56ab	5.17ab	15.48ab	24.17b	0.99a	1.40a	1.31a	1.56a
SE	0.2	0.28	0.42	0.42	0.06	0.07	0.07	0.09
PERIOD								
MAR - JUL	2.72a	5.72a	15.87a	24.94a	0.86a	1.29a	1.32a	1.72a
AUG - DEC	2.32a	4.78a	15.18a	23.94a	0.88a	1.31a	1.23a	1.61a
SE	0.16	0.23	0.35	0.34	0.05	0.06	0.06	0.08
NODES								
DN	2.99a	5.89a	16.23a	25.78a	0.94a	1.37a	1.29a	1.72a
SN	2.05b	4.61b	14.82b	23.11b	0.79b	1.22a	1.26a	1.61a
SE	0.16	0.20	0.35	0.34	0.05	0.06	0.06	0.08
INTERACTIONS								
SUB*Period	NS	NS	NS	NS	NS	NS	NS	NS
SUB*Nodes	NS	NS	NS	*	NS	NS	NS	NS
SUB*Period*Nodes	NS	NS	NS	NS	NS	NS	NS	NS

Means with the same letter down the column are not significantly different from each other at 5% significance level. SE: Standard error, SUB: Substrate, DN: Double nodes, SN: Single nodes, NS: Not significant, * and **: Significant at 5% and 1% level of significance, PH2, PH4, PH6, and PH8 represents plant height at 2, 4, 6 and 8 weeks after planting, respectively. INTER2, INTER4, INTER6, and INTER8 represent Internodes at 2, 4, 6, and 8 weeks after planting, respectively. AMF: Arbuscular Mycorrhizal Fungi. PH and INTER were measured in cm.

Table 3: Effects of substrates, period of establishment and explants node on days to flowering and yield of vine cutting established sweet potato

SUBSTRATES	D2F	NOT	TW (g)
Cocopeat	73.08ab	4.25a	2.78a
Cocopeat+AMF	71.25b	4.83a	3.78a
Soil	74.00a	3.42a	3.50a
SE	0.69	0.5	0.25
PERIOD			
MAR - JUL	75.00a	3.28b	3.09a
AUG - DEC	70.56b	5.06a	3.34a
SE	0.56	0.41	0.2
NODES			
DN	72.5a	4.39a	3.27a
SN	73.06a	3.94a	3.17a
SE	0.56	0.41	0.2
INTERACTIONS			
SUB*Period	**	**	NS
SUB*Nodes	**	NS	NS
SUB*Period*Nodes	NS	NS	NS

Means with the same letter down the column are not significantly different from each other at 5% significance level. SE: Standard error, SUB: Substrate, DN: Double nodes, SN: Single nodes, NS: Not significant, * and **: Significant at 5% and 1% levels of significance. D2F: Days to flowering, NOT: Number of tubers and TW: Tuber weight. AMF: Arbuscular Mycorrhizal Fungi.

4. Discussion

4.1. Effect of substrate type on the growth and yield of vine cutting established sweet potato

The emergence of new leaves by the rooted vine seedlings of sweet potato showed that the vines were successfully established in the three substrate types (Maroya et al., 2014). However, the variation in the number of new leaves is as a result of differences in the establishment rate in the substrates, as the substrate in which a higher number of new leaves was observed was where the vines established faster. In this case, it was the addition of 5 g AMF to the cocopeat, which contained 250 g poultry manure, that was the better substrate. This could be that within the two weeks period the substrates were kept before planting, the AMF along with the environmental biota acted on the poultry manure to aid mineralization, thereby making nutrients more available for the early formed roots to assimilate adequate nutrients for the continued crop growth (Kumar et al., 2019). Due to the adequate nutrient available for the rooted vines in the AMF fortified cocopeat, the growth and development of the rooted vines in the substrate were faster than the ones grown in the soil or cocopeat substrate alone despite the insignificant differences in their internode lengths. Due to the fastened physiological development, the plants in the AMF fortified cocopeat substrate developed flowers within a shorter day interval as the plants rooted in the soil developed flowers late. This could also be attributed to the delay in the plants access to the nutrients locked in the poultry manure (Akpeji et al., 2021).

4.2. Effect of planting period on the growth and yield of vine cutting established sweet potato

Vines established in the first half of the year developed faster than the ones set up in the 2nd half. This could be because before the emergence of new shoots and root development, the harsh weather condition has started to disappear gradually, allowing the plants to thrive in a considerably cool atmosphere (Kipkori, 2016). Whereas, the ones established in the second half enjoyed cool weather at the establishment stage but the atmosphere gradually became hotter towards the end of the year. However, in terms of the reproductive and yield parameters, the plants established in the second half of the year produced flowers faster, and the number of tubers produced was superior to the ones established in the 1st half of the year. This could be because the considerable cool environmental condition they enjoyed earlier pave the way for their early physiological development, and before the emergence of harsh weather conditions, the root of the plants had already bulked (Egbe, 2012).

4.3 Effect of planting explant's nodal level on the growth and yield of vine cutting established sweet potato

The rate of establishment and agronomic performance of the double node planting explants was faster than the single node planting explants. This is as a result of the additional node advantage in the double node allowing for double point of contact with the substrate allowing for more points of root formation and shoot emergence. This finding agrees with that of Dumbuya et al. (2017), who stated that the longer the cut explant, the faster the rate of establishment and yield. However, in this study, the higher number of nodal point in the planting explant only favored the fast establishment and agronomic performance but the yield relative to the single node cuttings were the same, which is contrary to the findings of Essilfie et al. (2016) who stated that the explants with a higher number of nodes produced longer tubers compared to the ones with smaller nodal points.

4.4 Interactions between substrate types, period of establishment and explants nodal level on the growth and yield parameters of vine cutting established sweet potato

The significant effect of the interaction between substrate and explant nodal level on the agronomic and yield parameters show that the type of substrate and availability of nutrient is an essential factor to be considered in establishing sweet potato vine cutting in order to improve the propagation ratio.

Conclusion

Sweetpotato is an important tuber crop and staple worldwide. However, the low propagation ratio relative to cereals like maize has constrained the full realization of the economic importance. Rooted vine cutting technology has been deployed in improving the propagation ratio of different clonally propagated crops, as successfully demonstrated in this study. However, although the number of nodal points in the planting explants played a significant role in the agronomic parameters, the yield compared with the explants with single nodal points was statistically the same, with the latter having a higher propagation ratio considered more beneficial. But the substrate type is an important factor to consider in the establishment as the use of a hydroponics system with cocopeat substrate fertigated with poultry manure adequate for the production in the presence of AMF that act on the manure with the help of other biotas to aid the release of the minerals locked in the manure.

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