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Effect of different rooting media and bioagents for rooting success in guava air layers

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Abstract

The simple air layering recorded significantly minimum days to root appearance (22.97 days), maximum success percentage (80.95%), maximum numbers of primary (23.14) and secondary roots (42.10), maximum length of primary (5.40 cm) and secondary roots (3.56 cm), maximum diameter of primary (1.72 mm) and secondary roots (0.54 mm), maximum fresh (0.94 g.) and dry weight of roots (0.53 g.). With respect to rooting media, sphagnum moss recorded significantly lowest days to root appearance (20.99 days), highest numbers of primary (29.83) and secondary roots (48.62), highest success percentage (58.83%), highest length of primary (6.08 cm) and secondary roots (4.03 cm), highest diameter of primary (1.84 cm) and secondary roots (0.60 mm), highest fresh (1.00 g.) and dry weight of roots (0.60 g.) Among the different biological agents, bio-mix recorded minimum days to root appearance (22.05 days), maximum success percentage (54.91%), maximum numbers of primary (23.80) and secondary (42.82) roots, maximum length of primary (5.55 cm) and secondary roots (3.68 cm), maximum diameter of primary (1.74 mm) and secondary roots (0.55 mm), maximum fresh (0.95g.) and dry weight of roots (0.54 g).

The treatment combination of L1M1B1(Simple air layering + Sphagnum moss + Bio-mix) was recorded significantly minimum days to root appearance(19.08 days), maximum success percentage (97.50%), maximum numbers of primary (31.65)and secondary roots (51.03), maximum length of primary (6.35 cm) and secondary roots (4.20 cm), maximum diameter of primary (1.87 mm) and secondary roots (0.62 mm), maximum fresh (1.03 g.) and dry weight of roots (0.63 g).

Keywords: Rooting media, bioagents, guava air layers

Introduction

Guava (*Psidium guajava* L.) is the native of Tropical America (from Mexico to Peru) and one of the most important fruits grown into the tropical, subtropical and some parts of arid regions of the India. It is popular fruit crop in India due to its wide climatic adaptability and availability of a fruits for long periods during the years. It belongs to the family Myrtaceae. It is the fourth most popular and common fruit of India in area and productions after the mango, citrus and banana.

The fruit plants are normally propagated by two methods i.e., sexual or by seeds and asexual or by vegetative methods. In vegetative method guava can be propagated by air layering, inarching, stooling, root cutting and budding. Budding has been used to limited extent. The survival percentage is low in cutting and rooting also. Layering and that too air layering is the most popular commercial method of propagation for this crop. This air layering was evaluated as the commercial method of vegetative propagation of a guava. Air layering is practiced during the month of June - July with a good success rate. The success in air layering of guava mainly depends on some factors such as the mother plants, rainfall, humidity, time of layering, temperature, rooting media, growth media, plant growth regulators and care during removals of the bark from the shoots.

In more of the previous studies guava air layering is done by using of growth regulators such as IAA, IBA, NAA, etc. But, in the present investigation we replaced these chemical growth regulators by using organic biofertilizers such as bio-mix, *Azotobacter* and PSB. Here we also used the modified method of air layering along with simple air layering in which plastic glasses were used for holding of growing media instead of polythene wrappers. Hence, the present investigation entitled “Studies on the effect of propagation methods, rooting media and biological agents on success and survival of air layering in guava (*Psidium guajava* L.) cv. L-49” was carried out to study the effect of different biological agents *viz.* are bio- mix, *Azotobacter* and PSB and propagation methods *i.e.*, simple and modified air layering in guava.

Material and Methods

The present investigation entitled "Studies on the effect of propagation methods, rooting media and biological agents on success and survival of air layering in guava (*Psidium guajava* L.) cv. L-49" was carried out during year 2020- 2021 on experimental farm, Department of Horticulture, VNMKV, Parbhani.

The Factorial Randomized block design (FRBD) was used to carried out the experiment. There were 18 treatments consisting of three different growing medias with the combination of three different biological agents with two replications.

One-year old branches about the pencil size thickness were selected. Layering operation was done on 30th July, 2021. A ring of bark of 2 cm was removed from just above the upper cut, to expose the fleshy tissues for absorption of applied biological agent"s formulations. The exposed region was immediately covered with a ball of moist, chopped sphagnum moss which was soaked into the prepared 1% solution of bio-mix. The same procedure was carried out for *Azotobacter* and PSB solutions, respectively. Such as sphagnum moss similar procedure was carried out for the coco peat and saw dust which was also used as the growing media. The growing media was covered with transparent polythene papers of 200-gauge thickness and both the ends were secured firmly using the jute string (sutali). In case of modified method of air layering the vertical cut is given to the plastic glasses up to middle of their base. These glasses are then set around the cut which is already taken on the branch. The growing media is then filled in these glasses and glasses were packed by using cello tape. Jute string also used to tie and secure these glasses to gives them additional support which helped them to stands erect. A small hole is also prepared at middle of this glasses base to drained out excess of water from them.

Result and Discussion

Days taken to root appearance Effect of propagation methods (L)

The minimum number of days taken to root appearance (22.97 days) was observed in treatment L1 (Simple air layering) and maximum (23.88 days) in treatment L2 (Modified air layering).

Effect of rooting media (M)

The minimum number of days taken to root appearance (20.99 days) was observed in treatment M1 (Sphagnum moss) and maximum (26.22 days) in treatment M2 (Coco peat). This might be due to the proper aeration and good water holding capacity of sphagnum moss which causes early root initiation. Similar results were reported by Maurya *et. al.* (2011) [3] in guava cv. Allahabad safeda.

Effect of biological agents (B)

The minimum number of days taken to root appearance (22.05 days) was observed in treatment B1 (Bio-mix) and maximum (24.75 days) in treatment B2 (*Azotobacter*). This might be due to the faster microbial activities of different bacteria present inthe bio-mix and maximum uptake of nitrogen, phosphorous and other nutrients and utilization of food materials under this bio-mix treatment resulted minimum numbers of days taken to root appearance. These results were in conformity with the Thakur *et al.* (2014) [7] in cuttings of olive

Interaction effects

All the interaction effects *i.e.*, interaction of propagation methods with rooting media (L X M), interaction of propagation methods with biological agents (L X B), interaction of rooting media with biological agents (M X B) and interaction of propagation methods, rooting media and biological agents (L X M X B) in case of days taken to root appearance was observed to be non- significant.

Success percentage (%)

Effect of propagation methods (L)

Maximum success percentage (80.95%) was observed in treatment L1 (Simple air layering) and minimum (16.83%) in treatment L2 (Modified air layering). This might be due to early root initiation causes highest success percentage in simple air layering than modified air layering.

Effect of rooting media (M)

Maximum success percentage (58.83%) per air layer was induced in treatment M1 (Sphagnum moss) and minimum (35.75%) in treatment M2 (Coco peat). The increased success percentage in sphagnum moss might have been due to better initiation of roots and increased amounts of the rooting co-factors, accumulation of the carbohydrates at the time of callus formation and root initiation. The similar results were also recorded by Rymbai and Reddy (2010) [6] in Guava cv. L-49.

Effect of biological agents (B)

Maximum success percentage (54.91%) was observed in treatment B1 (Bio- mix) and minimum (44.08%) in treatment B2 (*Azotobacter*). It might be due to the early and better initiation of roots and maximum utilization of nutrients, fastest microbial activities which were found in bio-mix. The bio- mix helped into synthesis of natural auxins which promotes production of the new cells and ultimately resulted highest success percentage under this treatment. The similar findings were recorded by Yasser (2015) [8] on pomegranate (*Punica granatum* L.) stem cuttings.

Interaction of propagation methods and rooting media (L X M)

Maximum success percentage (96.33%) was observed in treatment combination of L1M1 (Simple air layering + Sphagnum moss) which was significantly superior than the treatment combination of L1M3 (Simple air layering + Saw dust) (84.17%) and the other remaining treatments. Minimum success percentage (9.17%) was observed in treatment combination of L2M2 (Modified air layering + Coco peat). The combined effect of simple air layering and bio-mix resulted into the highest success percentage under these treatments.

Interaction of propagation methods and biological agents (L X B)

Maximum success percentage (84.83%) was observed in treatment combination of L1B1 (Simple air layering + Bio-mix) which was significantly superior than (80.00%) treatment combination of L1B3 (Simple air layering + PSB) and treatment L2B2 (78.00%). Minimum success percentage (10.17%) was observed in treatment combination of L2B2 (Modified air layering + *Azotobacter*). The interaction of simple air layering and bio-mix resulted into the highest success percentage under this treatment.

Interaction of rooting media and biological agents (M X B)

Maximum success percentage (64.50%) in treatment combination of M1B1 (Sphagnum moss + Bio-mix) which was significantly superior than the (58.00%) treatment combination of M1B3 (Sphagnum moss + PSB) and also the other remaining treatments. Minimum success percentage (30.75%) was observed in treatment combination of M2B2 (Coco peat+ *Azotobacter*). This might be due to the better aeration and water holding capacity of sphagnum moss, increased concentration of the bio-mix and favorable environmental conditions ultimately resulted into the maximum success percentage under this treatment.

Interaction of propagation methods, rooting media and biological agents (L X M X B)

Maximum success percentage (97.50%) in treatment combination of L1M1B1 (Simple air layering + Sphagnum moss + Bio-mix) which was statistically at par (96.50%) with treatment combination of L1M1B3 (Simple air layering + Sphagnum moss + PSB). Minimum success percentage (4.50%) was observed in treatment combination of L2M2B2 (Modified air layering + Coco peat+ *Azotobacter*). The combination of simple air layering, sphagnum moss and bio-mix and the favorable climatic conditions ultimately resulted into the maximum success percentage under this treatment.

Number of primary roots Effect of propagation methods (L)

Maximum number of primary roots (23.14) was observed in treatment L1(Simple air layering) and minimum (22.25) in treatment L2 (Modified air layering).

Effect of rooting media (M)

Maximum number of primary roots (29.83) per air layer was induced in treatment M1 (Sphagnum moss) and minimum (17.85) in treatment M2 (Coco peat). This might be due to the better water holding capacity of sphagnum moss resulted in more numbers of primary roots. The results are quite comparable with Kadman and Slor (1974) [2] who reported that the sphagnum moss as the best rooting medium for air layering in litchi.

Effect of biological agents (B)

Maximum number of primary roots (23.80) was observed in treatment B1 (Bio-mix) and minimum (21.65) in treatment B2 (*Azotobacter*). The increase in primary roots might be due to the more uptake and utilization of nitrogen, phosphorous and other nutrients by the air layers under bio- mix treatment and accumulation of rooting co-factors above the ringed portion as influenced of bio- mix. Similar findings were recorded by Thakur *et al.* (2014) [7] in cuttings of olive.

Interaction effects

All the interaction effects *i.e.*, interaction of propagation methods with rooting media (L X M), interaction of propagation methods with biological agents (L X B), interaction of rooting media with biological agents (M X B) and interaction of propagation methods, rooting media and biological agents (L X M X B) with respect to number of primary roots per air layer was observed to be non-significant.

Number of secondary roots Effect of propagation methods (L)

Maximum number of secondary roots (42.10) was observed in treatment L1 (Simple air layering) and minimum (40.96) in treatment L2 (Modified air layering). The maximum numbers of primary roots ultimately resulted in highest numbers of secondary roots under this treatment.

Effect of rooting media (M)

Maximum number of secondary roots (48.62) per air layer was induced in treatment M1 (Sphagnum moss) and minimum (36.72) in treatment M2 (Coco peat). The more numbers of secondary roots might be found due to more numbers of primary roots as well as maximum water holding capacity of sphagnum moss. The similar finding was recorded by Naithani *et. al.* (2018) [4] in Guava.

Effect of biological agents (B)

Maximum number of secondary roots (42.82) was observed in treatment B1 (Bio-mix) and minimum (40.25) in treatment B2 (*Azotobacter*). The increase in numbers of secondary roots might be due to the increase in numbers of primary roots and more uptakes of phosphorous, nitrogen and other nutrients by the air layers under bio-mix treatment. Similar findings were recorded by Thakur *et al.* (2014) [7] in cuttings of olive.

Interaction effects

All the interaction effects *i.e.*, interaction of propagation methods with rooting media (L X M), interaction of propagation methods with biological agents (L X B), interaction of rooting media with biological agents (M X B) and interaction of propagation methods, rooting media and biological agents (L X M X B) in case of number of secondary roots was found to be non-significant.

Length of primary roots (cm) Effect of propagation methods (L)

Effect of propagation methods (L) Maximum value was (5.40 cm) recorded in treatment L1 (Simple air layering) while minimum (5.30 cm.) into the treatment L2 (Modified air layering)

Effect of rooting media (M)

Maximum length of primary roots (6.08 cm) per air layer was induced in treatment M1 (Sphagnum moss) and minimum (5.23 cm) in treatment M2 (Coco peat). This might be due to the better water holding capacity of sphagnum moss which causes early root initiations, maximum rooting percentage, more numbers of roots and ultimately resulted the more length of primary roots. The results in respect to sphagnum moss are in conformity with the findings of Rymbai and Reddy (2010) [6] in guava air layering.

Effect of biological agents (B)

Length of primary roots per air layer influenced by biological agents was found to be non- significant. However, Maximum value was (5.55 cm) observed in treatment B1 (Bio-mix) while minimum (5.17 cm.) into the treatment B2 (*Azotobacter*).

Interaction effects

All the interaction effects *i.e.*, interaction of propagation methods with rooting media (L X M), interaction of propagation methods with biological agents (L X B), interaction of rooting media with biological agents (M X B) and interaction of propagation methods, rooting media and biological agents (L X M X B) with respect to length of primary roots was observed to be non- significant.

Length of secondary roots (cm) Effect of propagation methods (L)

Length of secondary roots per air layer as influenced by propagation methods was found to be non-significant.

Effect of rooting media (M)

Effect of rooting media on length of secondary roots per air layer was found tobe significant. Maximum length of secondary roots (4.03 cm) per air layer was induced in treatment M1 (Sphagnum moss) and minimum (3.39 cm) in treatment M2 (Coco peat). The increased length of primary roots ultimately resulted the maximum length of secondary roots. The results are quite comparable with Kadman and Slor (1974) [2] who reported that sphagnum moss as the best rooting medium for air layering in litchi.

Effect of biological agents (B)

Length of secondary roots per air layer influenced by biological agents was found to be non- significant.

Interaction effects

All the interaction effects *i.e.*, interaction of propagation methods with rooting media (L X M), interaction of propagation methods with biological agents (L X B), interaction of rooting media with biological agents (M X B) and interaction of propagation methods, rooting media and biological agents (L X M X B) with respect to length of secondary roots per air layer was observed to be non-significant.

Diameter of primary roots (mm) Effect of propagation methods (L)

Maximum diameter of primary roots (1.72 mm) was observed in treatment L1 (Simple air layering) and minimum (1.70 mm) in treatment L2 (Modified air layering). This might be due to early root initiation and maximum numbers and length of roots ultimately causes maximum diameter of primary roots under simple air layering than modified air layering. The proper reason behind this as maximum diameter of primary roots ultimately resulted in the maximum diameter of secondary roots under this treatment.

Effect of rooting media (M)

Maximum diameter of primary roots (1.84 mm) per air layer was induced in treatment M1 (Sphagnum moss) and minimum (1.60 mm) in treatment M2 (Coco peat). The superiority of sphagnum moss over other rooting media might be owing to its unique ability such as the proper aeration and increased water holding capacity which in later stage helped into thicker root formations. Increase in root diameter may also be due to the early initiation of roots. The similar results were recorded by Naithani *et al.* (2018) [4] in Guava.

Effect of biological agents (B)

Maximum diameter of primary roots (1.74 mm) was observed in treatment B1 (Bio- mix) and minimum (1.69 mm) in treatment B2 (*Azotobacter*). The increase in root diameter might be due to the more utilization of food materials such as carbohydrates resulted into the maximum diameter of primary roots and favorably supported by moderate environmental conditions under bio-mix treatment. The above findings were supported by Pirlak (2000) [5] on hardwood cuttings of cornelian cherry (*Cronus mas* L.).

Interaction of propagation methods and rooting media (L X M)

Significant difference was not noticed among the interaction between propagation methods and rooting media.

Interaction of propagation methods and biological agents (L X B)

Diameter of primary roots was found to be maximum (1.75 mm) in treatment combination of L1B1 (Simple air layering + Bio-mix) which was significantly superior than the (1.73 mm) treatment combination of L2B1 (Modified air layering + Bio-mix). Minimum diameter of primary roots (1.67 mm) was observed in treatment combination of L2B2 (Modified air layering + *Azotobacter*). Interaction of simple air layering and bio-mix resulted into the maximum diameter of roots under these treatments. Interaction of simple air layering and bio-mix resulted into the maximum diameter of roots under these treatments.

Interaction of rooting media and biological agents (M X B)

Diameter of primary roots was found to be maximum (1.86 mm) in treatment combination of M1B1 (Sphagnum moss + Bio-mix) which was significantly superior than the (1.84 mm) treatment combination of M1B3 (Sphagnum moss + PSB). Minimum diameter of primary roots (1.58 mm) was observed in treatment combination of M2B2 (Coco peat+ *Azotobacter*). The favorable climatic conditions, increased concentration of bio-mix and sphagnum moss in this combination might be responsible for the increased diameter of the roots.

Interaction of propagation methods, rooting media and biological agents (L X M X B)

Diameter of primary roots was found to be maximum (1.87 mm) in treatment combination of L1M1B1 (Simple air layering + Sphagnum moss + Bio-mix) which was statistically at par (1.86 mm) with treatment combination of L2M1B1 (Modified air layering + Sphagnum moss + Bio-mix). Minimum diameter of primary roots (1.57 mm) was observed in treatment combination of L2M2B2 (Modified air layering + Coco peat+ *Azotobacter*). The combined effect of simple air layering, sphagnum moss and bio-mix and the favorable climatic conditions was responsible for increasing diameter of the primary roots.

Diameter of secondary roots (mm) Effect of propagation methods (L)

Maximum diameter of secondary roots (0.54 mm) was observed in treatment L1 (Simple air layering) and minimum (1.70 mm) in treatment L2 (Modified air layering).

Effect of rooting media (M)

Maximum diameter of secondary roots (0.59 mm) per air layer was induced in treatment M1 (Sphagnum moss) and minimum (0.48 mm) in treatment M2 (Coco peat). This might be due to the maximum diameter of primary roots resulted into the maximum diameter of secondary roots as well as better aeration and water holding capacity of sphagnum moss. The similar results were recorded by Naithani *et. al.* 2018 [4] in Guava.

Effect of biological agents (B)
Maximum diameter of secondary roots (0.55 mm) was observed in treatment B1 (Bio-mix) and minimum (0. 52 mm) in treatment B2 (*Azotobacter*). The increase in diameter of primary roots ultimately resulted into the increase in diameter of secondary roots and more utilization of food materials also caused the maximum diameter of secondary roots under bio-mix treatment. The above findings were supported by Pirlak (2000) [5] on hardwood cuttings of cornelian cherry (*Cronus mas* L.).

Interaction effects
All the interaction effects *i.e.*, interaction of propagation methods with rooting media (L X M), interaction of propagation methods with biological agents (L X B), interaction of rooting media with biological agents (M X B) and interaction of propagation methods, rooting media and biological agents (L X M X B) with respect to diameter of secondary roots per air layer was observed to be non-significant.

Fresh weight of roots (g) Effect of propagation methods (L)
Maximum fresh weight of roots (0.94 g) was observed in treatment L1 (Simple air layering) and minimum (0.92 g) in treatment L2 (Modified air layering). It might be due to the maximum numbers, length and diameter of primary and secondary roots ultimately causes maximum fresh weight of roots under this treatment.

Effect of rooting media (M)
Maximum fresh weight of roots (1.00 g) per air layer was induced in treatmentM1 (Sphagnum moss) and minimum (0.87 g) in treatment M2 (Coco peat). This might be due to the maximum water holding capacity of sphagnum moss which is resulted in to the highest numbers of primary and secondary roots and hence ultimately shown the maximum fresh weight of roots. The results in respect to sphagnum moss are in conformity with the findings of Rymbai and Reddy (2010) [6] in guava air layerings.

Effect of biological agents (B)
Maximum fresh weight of roots (0.95 g) was observed in treatment B1 (Bio- mix) and minimum (0.91 g) in treatment B2 (*Azotobacter*). The probable reason for increase in fresh weight of roots might be the better utilization of nitrogen and other nutrients which has been aided by the bio-mix and more accumulation of carbohydrates and other food materials resulted into the maximum fresh weight of roots under this treatment. The above findings were supported by Yasser (2015) [8] on pomegranate (*Punica granatum* L.) stem cuttings.

Interaction effects
All the interaction effects *i.e.*, interaction of propagation methods with rooting media (L X M), interaction of propagation methods with biological agents (L X B), interaction of rooting media with biological agents (M X B) and interaction of propagation methods, rooting media and biological agents (L X M X B) with respect to fresh weight of roots was observed to be non- significant.

Dry weight of roots (g)
Effect of propagation methods (L)
Maximum dry weight of roots (0.53 g) was observed in treatment L1 (Simple air layering) and minimum (0.50 g) in treatment L2 (Modified air layering). The maximum fresh weight of roots ultimately resulted in the maximum dry weight of roots into the simple air layering.

Effect of rooting media (M)
Maximum dry weight of roots (0.60 g) per air layer was induced in treatment M1 (Sphagnum moss) and minimum (0.45 g) in treatment M2 (Coco peat). This might be due to the maximum fresh weight of roots resulted into the maximum dry weight of roots in sphagnum moss. The results are quite comparable with Kadman and Slor (1974) [2] who reported that sphagnum moss as the best rooting medium for air layering in litchi.

Effect of biological agents (B)
Maximum dry weight of roots (0.54 g) was observed in treatment B1 (Bio-mix)and minimum (0.49 g) in treatment B2 (*Azotobacter*). The maximum fresh weight of roots ultimately resulted into the maximum dry weight of roots and also the better utilization of the carbohydrates, nitrogen and other nutrients under the bio-mix treatment. The above findings were supported by Galavi *et al.* (2013) [1] on rooting of grape cuttings (*Vitis vinifera*).

Interaction effects
All the interaction effects *i.e.*, interaction of propagation methods with rooting media (L X M), interaction of propagation methods with biological agents (L X B), interaction of rooting media with biological agents (M X B) and interaction of propagation methods, rooting media and biological agents (L X M X B) with respect to dry weight of roots was observed to be non- significant.

Table 1: Shows the factors days taken to root appearance and its success percentage

Factors	Days taken to root appearance	Success percentage (%)
Factor A	**Propagation methods**	**Propagation methods**
L1	22.97	80.90 *(64.12)
L2	23.88	16.80 (24.22)
S.E(m) ±	0.172	0.114
C.D. @ 5%	0.514	0.341
Factor B	**Rooting media**	**Rooting media**
M1	20.99	58.80 (50.08)
M2	26.22	35.70 (36.72)

M3	23.07	52.00 (46.19)
S.E(m) ±	0.211	0.140
C.D. @ 5%	0.630	0.418
Factor C	**Biological agents**	**Biological agents**
B1	22.05	54.90 (47.81)
B2	24.75	44.00 (41.60)
B3	23.47	47.60 (43.66)
S.E(m) ±	0.211	0.140
C.D. @ 5%	0.630	0.418
Interaction of AXB		
L1 M1	20.26	96.30 (78.95)
L1 M2	25.89	62.30 (52.13)
L1 M3	22.77	84.10 (66.55)
L2 M1	21.71	21.30 (27.50)
L2 M2	26.55	9.170 (17.62)
L2 M3	23.37	20 (26.56)
S.E(m) ±	0.299	0.198
C.D. @ 5%	N.S.	0.591
Interaction of AXC		
L1B1	21.67	84.80 (67.07)
L1B2	24.23	70 (62.02)
L1B3	23.03	80 (63.43)
L2B1	22.44	25 (25)
L2B2	25.28	10.10 (18.59)
L2B3	23.91	15.30 (23.05)
S.E(m) ±	0.299	0.198
C.D. @ 5%	N. S	0.724
Interaction of BXC		
M1 B1	19.48	64.50 (53.42)
M1 B2	22.36	54.50 (47.58)
M1 B3	21.12	50 (49.60)
M2 B1	24.55	42.20 (40.54)
M2 B2	27.75	30.70 (33.67)
M2 B3	26.37	34.20 (35.81)
M3B1	22.13	57.50 (49.31)
M3 B2	24.16	40 (43.28)
M3 B3	22.92	51.20 (45.71)
S.E(m) ±	0.366	0.243
C.D. @ 5%	N.S.	0.724
Interaction of AXBXC		
T1- L1 M1 B1	19.08	97.50 (80.90)
T2-L1 M1 B2	21.32	90 (77.07)
T3-L1 M1 B3	20.40	96.50 (79.21)
T4-L1 M2 B1	24.10	70.50 (57.10)
T5-L1 M2 B2	27.43	50 (49.02)
T6-L1 M2 B3	26.15	59.50 (50.47)
T7-L1 M3B1	21.82	86.50 (68.44)
T8-L1 M3 B2	23.96	80 (64.89)
T9-L1 M3 B3	22.54	80 (66.42)
T10-L2 M1 B1	19.89	31.50 (34.14)
T11-L2 M1 B2	23.41	10 (21.97)
T12-L2M1 B3	21.84	18.50 (25.47)
T13-L2 M2 B1	25.00	10 (21.97)
T14-L2 M2 B2	28.08	4.0 (12.24)
T15-L2 M2 B3	26.59	0 (17.45)
T16-L2 M3 B1	22.45	29.50 (32.89)
T17-L2 M3 B2	24.36	10 (20.26)
T18-L2 M3 B3	23.31	18.50 (25.47)
S.E(m) ±	0.517	0.343
C.D. @ 5%	N.S.	1.024

Value presented in parenthesis indicate the arc sine value

Table 2: Shows the treatments numbers of success of air layers and Success percentage of air layers

Treatments	Numbers of success of air layers	Success percentage of air layers
T1	97.50	97.50%
T2	95.00	95.00%
T3	96.50	96.50%
T4	70.50	70.50%
T5	57.00	57.00%
T6	59.50	59.50%
T7	86.50	86.50%
T9	84.00	84.00%
T10	31.50	31.50%
T11	14.00	14.00%
T12	18.50	18.50%
T13	14.00	14.00%
T14	4.50	4.50%
T15	9.00	9.00%
T16	29.50	29.50%
T17	12.00	12.00%
T18	18.50	18.50%
Factors	**Number of primary roots**	**Number of secondary roots**
Factor A	**Propagation methods**	**Propagation methods**
L1	23.14	42.10
L2	22.25	40.96
S.E(m) ±	0.128	0.214
C.D. @ 5%	0.381	0.639
Factor B	**Rooting media**	**Rooting media**
M1	29.83	48.62
M2	17.85	36.72
M3	20.40	39.27
S.E(m) ±	0.157	0.262
C.D. @ 5%	0.467	0.782
Factor C	**Biological agents**	**Biological agents**
B1	23.80	42.82
B2	21.65	40.25
B3	22.63	41.53
S.E(m) ±	0.157	0.262
C.D. @ 5%	0.467	0.782
Interaction of AXB		
L1 M1	30.31	49.35
L1 M2	18.37	37.20
L1 M3	20.75	39.77
L2 M1	29.35	47.88
L2 M2	17.35	36.23
L2 M3	20.03	38.78
S.E(m) ±	0.221	0.371
C.D. @ 5%	N.S.	N.S.
Interaction of AXC		
L1B1	24.19	43.36
L1B2	22.19	41.01
L1B3	23.05	41.95
L2B1	23.43	42.28
L2B2	21.09	39.48
L2B3	22.21	41.13
S.E(m) ±	0.221	0.371
C.D. @ 5%	N.S.	N.S.
Interaction of BXC		
M1 B1	31.11	50.13
M1 B2	28.83	47.43
M1 B3	29.55	48.28
M2 B1	18.55	37.87
M2 B2	17.20	35.46
M2 B3	17.83	36.82
M3B1	21.78	40.46
M3 B2	18.90	37.85
M3 B3	20.50	39.50
S.E(m) ±	0.271	0.454

C.D. @ 5%	N.S.	N.S.
Interaction of AXBXC		
T1- L1 M1 B1	31.65	51.04
T2-L1 M1 B2	29.35	48.20
T3-L1 M1 B3	29.93	48.81
T4-L1 M2 B1	18.81	38.13
T5-L1 M2 B2	17.99	36.17
T6-L1 M2 B3	18.31	37.30
T7-L1 M3B1	22.11	40.90
T8-L1 M3 B2	19.23	38.69
T9-L1 M3 B3	20.91	39.71
T10-L2 M1 B1	30.58	49.22
T11-L2 M1 B2	28.30	46.67
T12-L2M1 B3	29.17	47.75
T13-L2 M2 B1	18.28	37.60
T14-L2 M2 B2	16.40	34.76
T15-L2 M2 B3	17.37	36.33
T16-L2 M3 B1	21.44	40.03
T17-L2 M3 B2	18.57	37.02
T18-L2 M3 B3	20.10	39.29
S.E(m) ±	0.383	0.642
C.D. @ 5%	N.S.	N.S.

Table 3: Show the Interaction of AXBXC

M3B1	5.40	3.50	1.73
M3 B2	5.01	3.27	1.67
M3 B3	5.26	3.40	1.70
S.E(m) ±	0.183	0.167	0.002
C.D. @ 5%	N.S.	N.S.	0.007
Interaction of AXBXC			
T1- L1 M1 B1	6.35	4.21	1.87
T2-L1 M1 B2	6.03	3.99	1.84
T3-L1 M1 B3	6.13	4.07	1.85
T4-L1 M2 B1	4.96	3.38	1.66
T5-L1 M2 B2	4.62	2.98	1.59
T6-L1 M2 B3	4.76	3.22	1.60
T7-L1 M3B1	5.44	3.53	1.74
T8-L1 M3 B2	5.09	3.28	1.69
T9-L1 M3 B3	5.28	3.42	1.71
T10-L2 M1 B1	6.29	4.14	1.86
T11-L2 M1 B2	5.76	3.83	1.82
T12-L2M1 B3	5.96	3.93	1.83
T13-L2 M2 B1	4.92	3.35	1.61
T14-L2 M2 B2	4.59	2.95	1.57
T15-L2 M2 B3	4.73	3.19	1.59
T16-L2 M3 B1	5.38	3.47	1.72
T17-L2 M3 B2	4.95	3.27	1.64
T18-L2 M3 B3	5.24	3.40	1.70
S.E(m) ±	0.258	0.237	0.003
C.D. @ 5%	N.S.	N.S.	0.010

Table 4: Shows the factors Diameter of secondary roots (mm) Fresh weight of roots (g) and its Dry weight of roots (g)

Factors	Diameter of secondary roots (mm)	Fresh weight of roots (g)	Dry weight of roots (g)
Factor A	**Propagation methods**	**Propagation methods**	**Propagation methods**
L1	0.54	0.94	0.53
L2	0.52	0.92	0.50
S.E(m) ±	0.002	0.001	0.002
C.D. @ 5%	0.006	0.004	0.006
Factor B	**Rooting media**	**Rooting media**	**Rooting media**
M1	0.59	1.00	0.60
M2	0.48	0.87	0.45
M3	0.52	0.92	0.51
S.E(m) ±	0.003	0.002	0.003

C.D. @ 5%	0.008	0.005	0.008
Factor C	**Biological agents**	**Biological agents**	**Biological agents**
B1	0.55	0.95	0.54
B2	0.52	0.91	0.49
B3	0.53	0.93	0.52
S.E(m) ±	0.003	0.002	0.003
C.D. @ 5%	0.008	0.005	0.008
Interaction of AXB			
L1 M1	0.60	1.01	0.61
L1 M2	0.49	0.87	0.46
L1 M3	0.53	0.94	0.52
L2 M1	0.59	0.99	0.59
L2 M2	0.47	0.86	0.43
L2 M3	0.52	0.91	0.50
S.E(m) ±	0.004	0.003	0.004
C.D. @ 5%	N.S.	N.S.	N.S.
Interaction of AXC			
L1B1	0.55	0.96	0.56
L1B2	0.53	0.92	0.51
L1B3	0.54	0.94	0.53
L2B1	0.54	0.94	0.54
L2B2	0.51	0.90	0.48
L2B3	0.52	0.92	0.51
S.E(m) ±	0.004	0.003	0.004
C.D. @ 5%	N.S.	N.S.	N.S.
Interaction of BXC			
M1 B1	0.61	1.03	0.63
M1 B2	0.58	0.98	0.58
M1 B3	0.59	1.00	0.59
M2 B1	0.49	0.89	0.47
M2 B2	0.47	0.85	0.42
M2 B3	0.48	0.86	0.45
M3B1	0.54	0.94	0.54
M3 B2	0.51	0.90	0.48
M3 B3	0.53	0.93	0.51
S.E(m) ±	0.005	0.003	0.004
C.D. @ 5%	N.S.	N.S.	N.S.
Interaction of AXBXC			
T1- L1 M1 B1	0.62	1.03	0.63
T2-L1 M1 B2	0.59	1.00	0.59
T3-L1 M1 B3	0.60	1.01	0.61
T4-L1 M2 B1	0.50	0.90	0.48
T5-L1 M2 B2	0.48	0.86	0.44
T6-L1 M2 B3	0.49	0.87	0.47
T7-L1 M3B1	0.55	0.96	0.56
T8-L1 M3 B2	0.52	0.92	0.49
T9-L1 M3 B3	0.54	0.93	0.52
T10-L2 M1 B1	0.61	1.02	0.62
T11-L2 M1 B2	0.57	0.97	0.57
T12-L2M1 B3	0.58	0.99	0.58
T13-L2 M2 B1	0.49	0.88	0.46
T14-L2 M2 B2	0.46	0.84	0.40
T15-L2 M2 B3	0.48	0.86	0.44
T16-L2 M3 B1	0.54	0.93	0.53
T17-L2 M3 B2	0.50	0.89	0.47
T18-L2 M3 B3	0.52	0.92	0.50
S.E(m) ±	0.006	0.004	0.006
C.D. @ 5%	N.S.	N.S.	N. S.
Treatment details			
L1- Simple air layering	M1- Sphagnum moss	B1- Bio-mix	
L2- Modified air layering	M2- Coco peat	B2- *Azotobacter*	
	M3- Saw dust	B3- PSB	

Conclusion
The simple air layering recorded significantly minimum days to root appearance, maximum success percentage, maximum numbers of primary and secondary roots, maximum length of primary and secondary roots, maximum diameter of primary and secondary roots and maximum fresh and dry weight of roots. With respect to rooting media, sphagnum moss recorded significantly lowest days to root appearance, highest

success percentage, highest numbers of primary and secondary roots, highest length of primary and secondary roots, highest diameter of primary and secondary roots, highest fresh and dry weight of roots. Among the different biological agents, bio- mix recorded significantly minimum days to root appearance, maximum success percentage, maximum numbers of primary and secondary roots, maximum length of primary and secondary roots, maximum diameter of primary and secondary roots and maximum fresh and dry weight of roots.

The treatment combination of L1M1B1(Simple air layering + Sphagnum moss + Bio- mix) was recorded significantly minimum days to root appearance, maximum success percentage, maximum numbers of primary and secondary roots, maximum length of primary and secondary roots, maximum diameter of primary and secondary roots, maximum fresh and dry weight of roots.

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