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Effect of different rooting media and bioagents on growth of air layering in guava (*Psidium guajava* L) Cv. L-49

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Abstract
The simple air layering recorded the maximum number of sprouts (16.50), length of sprouts (21.33 cm), diameter of sprouts (2.23 mm) and number of leaves (50.38), highest plant height (32.86 cm), girth of shoot (5.60 mm), fresh (15.22 g.) and dry weight of shoots (7.13 g.) at 90 DAT were observed better under this treatment at 90 DAT. With respect to rooting media, sphagnum moss recorded maximum shoot characters such as highest number of sprouts (17.30), highest length of sprouts (23.41cm), highest diameter of sprouts(2.30 mm), highest number of leaves (52.23), while highest plant height (33.12 cm), highest girth of shoot (6.00 mm), highest fresh (15.76 g) and dry weight of shoot (7.56 g) at 90 DAT. However, lowest values were found in the coco peat. Among the different biological agents, bio-mix recorded significantly maximum shoot characters such as number of sprouts (16.72), length of sprouts (21.78 cm), diameter of sprouts (2.26 mm), number of leaves (50.98), plant height (32.95 cm), girth of shoot (5.72 mm), fresh (15.36 g.) and dry weight of shoot (7.30 g.) at 90 DAT were also recorded maximum under this treatment. The treatment combination of L1M1B1(Simple air layering + Sphagnum moss + Bio- mix) was recorded significantly maximum shoot characters such as the maximum number of sprouts (17.78), maximum length of sprouts (23.97 cm), maximum diameter of sprouts (2.34 mm), maximum number of leaves(53.91) ,maximum plant height (33.28 cm), maximum girth of shoot (6.35 mm), maximum fresh (15.90 g.) and dry weight of shoot (7.68 g.) and the highest survival percentage (93.53%) at 90 DAT. However, minimum values were recorded in the treatment combination of L2M2B2 (Modified air layering + Coco peat+ *Azotobacter*).

Keywords: Rooting media, bioagents, growth, air layering, *Psidium guajava* L

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 celotape. 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

Number of sprouts

Effect of propagation methods (L)

Maximum number of sprouts (16.50) at 90 DAT was observed in treatment L1 (Simple air layering) and minimum (16.30) in treatment L2 (Modified air layering). Simple air layering was superior which causes a greater number of sprouts than modified air layering.

Effect of rooting media (M)

Maximum number of sprouts (17.31) at 90 DAT air layer was induced in treatment M1 (Sphagnum moss) and minimum (15.59) in treatment M2 (Coco peat). This might be due to the proper aeration and more water holding capacity of sphagnum moss resulted into the maximum primary and secondary roots and this ultimately causes maximum utilization and uptake of carbohydrates and food materials by plants resulted into the greater number of sprouts under this sphagnum moss treatment. The similar results were recorded by the Bhosale *et al.* (2010) [1] in pomegranate cv. Sindhuri.

Effect of biological agents (B)

Significantly maximum number of sprouts (16.72) 90 DAT was observed in treatment B1 (Bio-mix) and minimum (16.06) in treatment B2 (*Azotobacter*). The increase in number of sprouts might be due to the more uptake and utilization of nutrients by roots and faster microbial activities present in bio-mix which was ultimately resulted into the greater number of sprouts under this bio-mix treatment. The above findings were supported by Thakur *et al.* (2014) [8] in cuttings of olive.

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

At 90 DAT maximum numbers of sprouts per air layer (17.48) was observedin treatment combination of L1M1 (Simple air layering + Sphagnum moss) which was significantly superior the treatment L2M1 (17.14) and L1M3 (16.40). However, minimum (15.55) shown in treatment combination of L2M2 (Modified air layering + Coco peat). The interaction of these two factors *i.e.*, simple air layering and sphagnum moss increased numbers of sprouts under this treatment.

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

It was found non-significant at 90 DAT.

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

Interaction effect of rooting media and biological agents with respect to number of sprouts was found to be non- significant results recorded at 90 DAT.

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

Interaction effect of propagation methods, rooting media and biological agents with respect to number of sprouts per air layer shown non-significant at 90 days after transplanting respectively.

Length of sprouts (cm)

Effect of propagation methods (L)

Length of sprouts per air layer as influenced by propagation methods observed non-significant at 90 DAT.

Effect of rooting media (M)

Maximum length of sprouts (23.41 cm) at 90 DAT air layer was induced in treatment M1 (Sphagnum moss) and minimum (19.39 cm) in treatment M2 (Coco peat). This might be due to the maximum aeration and water holding capacity of sphagnum moss, maximum numbers of roots, maximum utilization of water and nutrients stimulated the faster growth of roots resulting in the maximum length of newsprouts. The similar results were recorded by Tyagi and Patel (2004) of air layering inguava (*Punica granatum* L.) cv. Sardar.

Effect of biological agents (B)

Maximum length of sprouts (21.78 cm) at 90 DAT was observed in treatment B1 (Bio-mix) and minimum (20.61 cm) in treatment B2 (*Azotobacter*).

The probable reason behind this as bio-mix promotes synthesis of natural auxins which are helped into the cell division and elongation ultimately resulted into the increase in length of sprouts. The above findings were supported by Yasser (2015) [10] on pomegranate (*Punica granatum* L.) stem cuttings.

Interaction of propagation methods and rooting media (L X M)
The interaction effect of propagation methods and rooting media on length of sprouts per air layer non-significant at 90 DAT.

Interaction of propagation methods and biological agents (L X B)
Interaction effect of propagation methods and biological agents with respect to length of sprouts per air layer was observed to be non-significant at 90 days after transplanting.

Interaction of rooting media and biological agents (M X B)
Interaction effect of rooting media and biological agents with respect to lengthof sprouts was found to be non-significant results recorded at 90 DAT.

Interaction of propagation methods, rooting media and biological agents (L X M X B)
Interaction effect of propagation methods, rooting media and biological agentswith respect to number of sprouts per air layer shown non-significant variations at 90 DAT.

Diameter of sprouts (mm) Effect of propagation methods (L)
Maximum diameter of sprouts (2.23 mm) at 90 DAT was observed in treatment L1 (Simple air layering) and minimum (2.21 mm) in treatment L2 (Modified air layering). It might be due to those maximum numbers and length of sprouts under simpleair ultimately caused the maximum diameter of sprouts.

Effect of rooting media (M)
Maximum diameter of sprouts (2.31 mm) at90 DAT respectively per air layer was induced in treatment M1 (Sphagnum moss) and minimum (2.13 mm) in treatment M2 (Coco peat). The superiority of sphagnum moss over other rooting media might be owing toits unique ability such as the proper aeration and increased water holding capacity which in later stage helped into more numbers of roots, maximum root length, maximum nutrients and water uptake resulted into the maximum diameter of new sprouts. The similar results were recorded by Naithani *et. al.* (2018) [4] in Guava.

Effect of biological agents (B)
Maximum diameter of sprouts (2.26 mm) at 90 DAT was observed in treatment B1 (Bio-mix) and minimum (2.18 mm) in treatment B2 (*Azotobacter*). The proper reason behind this as bio-mix promotes synthesis of natural auxins which are helped into the cell division and elongation ultimately resulted into the increase in numbers, length of sprouts and simultaneously resulted into the more diameter of sprouts. The above findings were supported by Yasser (2015) [10] on pomegranate (*Punica granatum* L.) stem cuttings.

Interaction of propagation methods and rooting media (L X M)
Interaction effect of propagation methods and rooting media with respect to diameter of sprouts per air layer was observed to be non-significant at 90 days after transplanting.

Interaction of propagation methods and biological agents (L X B)
At 90 days after transplanting diameter of sprouts was found to be maximum (2.27 mm) in treatment combination of L1B1 (Simple air layering + Bio-mix) which was significantly superiors than the (2.25 mm) treatment combination of L2B1 (Modified air layering + Bio-mix) and the other remaining treatments and minimum value was resulted (2.17 mm) in treatment combination of L2B2 (Modified air layering+ *Azotobacter*). Interaction effect of propagation methods and rooting media resulted into the maximum diameter of sprouts under this treatment.

Interaction of rooting media and biological agents (M X B)
Diameter of sprouts was found to be maximum (2.33 mm) in treatment combination of M1B1 (Sphagnum moss + Bio-mix) minimum diameter of sprouts (2.08 mm) was observed in treatment combination of M2B2 (Coco peat+ *Azotobacter*) at 90 DAT.
Sphagnum moss and bio-mix combinedly shown the positive effect which was resulted in highest diameter of sprouts under these treatments.

Interaction of propagation methods, rooting media and biological agents (L X M X B)
Significantly maximum (2.34 mm) diameter of sprouts was observed in treatment combination of L1M1B1 (Simple air layering + Sphagnum moss + Bio-mix) minimum diameter of sprouts (2.08 mm) was observed in treatment combination of L2M2B2 (Modified air layering + Coco peat+ *Azotobacter*) at 90 DAT. The increase in diameter of sprouts might be due to the increasing availability of water by sphagnum moss and maximum nutrition supply by bio-mix plays vital role in development of plants and the influenced physiological activities resulted more diameter of the sprouts under this treatment. But the result were non- significant.

Number of leaves
Effect of propagation methods (L)
Maximum number of leaves (50.38) at 90 days after transplanting was observed in treatment L1 (Simple air layering) and minimum (49.83) in treatment L2 (Modified air layering). In simple air layering maximum numbers of sprouts, length and diameter of sprouts, caused more accumulation of food materials which was ultimately resulted into the maximum numbers of leaves.

Effect of rooting media (M)
Maximum number of leaves (52.23) at 90 DAT per air layer was induced in treatment M1 (Sphagnum moss) and minimum (48.34) in treatment M2 (Coco peat). The increased in numbers of leaves it might be due to the availability of more mineral nutrients and water due to efficient absorption and by the vigorous root system. These results further get supports from the findings of Rymbai *et al.* (2010) [7].

Effect of biological agents (B)
Significantly maximum number of leaves (50.98) at 90 DAT was observed in treatment B1 (Bio- mix) and minimum (49.30) in treatment B2 (*Azotobacter*). The increased numbers of leaves might be due to the increased numbers of sprouts and increased cell division and elongation, more assimilation and accumulation of the food materials by the higher concentration of bio-mix and its possible reason for increase and activation of the shoot growth which probably increased the number of nodes that leads to developments of the more

numbers of leaves. The above findings were supported by the Damar *et al.* (2014) [2].

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 leaves per air layer was observed to be non-significant at 90 DAT.

Shoot girth (mm)

Effect of propagation methods (L)

Maximum shoot girth (5.60 mm) was observed in treatment L1 (Simple air layering) and minimum (5.49 mm) in treatment L2 (Modified air layering) at 90 DAT. Superiority of simple air layering caused more accumulation of food materials resulted into the maximum girth of shoots over modified air layering.

Effect of rooting media (M)

Effect of rooting media on girth of shoot per air layer was found to be significant. Maximum shoot girth (6.00 mm) per air layer was induced in treatment M1 (Sphagnum moss) and minimum (5.15 mm) in treatment M2 (Coco peat) at 90 DAT. It might be due to the higher water holding and aeration capacity of sphagnum moss stimulated early root initiation and faster root growth, more numbers of roots, longest roots, etc. which improved the absorption of water and nutrients and more accumulation of carbohydrates and nutrients resulted better girth of the shoots. The similar results were recorded by Tyagi and Patel (2004) of air layering in guava (*Punica granatum* L.) cv. Sardar.

Effect of biological agents (B)

Maximum shoot girth (5.72 mm) was observed in treatment B1 (Bio-mix) and minimum (5.37 mm) in treatment B2 (*Azotobacter*) at 90 DAT. The proper reason behind this as bio-mix promotes synthesis of natural auxins which are helped into the cell division and elongation ultimately resulted into the increase in numbers, length of sprouts and maximum accumulation and utilization of carbohydrates and other nutrients which simultaneously resulted into the more girth of shoots. The above findings were supported by Yasser (2015) [10] on pomegranate (*Punica granatum* L.) stem cuttings and Patil *et al.* (2000) [5].

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

Maximum shoot girth (6.10 mm) was noticed in treatment combination of L1M1 (Simple air layering + Sphagnum moss) which was significantly superior than the treatment combination of L2M1 (Modified air layering + Sphagnum moss) (5.91 mm.) and the other remaining treatments. Minimum shoot girth (5.12 mm) was found in treatment combination of L2M2 (Modified air layering + Coco peat). It might be due to combination effect of both factors increased the girth of shoots under these treatments.

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

Interaction effect of propagation methods and biological agents with respect to girth of shoot was observed to be non-significant. However, the maximum value was observed in treatment L1B1 (5.76 mm.) and minimum observed into the treatment L2B2 (5.33 mm.).

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

Girth of shoot found to be maximum (6.26 mm) in treatment combination of M1B1 (Sphagnum moss + Bio-mix) which was significantly superior than (5.94 mm) the treatment combination of M1B3 (Sphagnum moss + PSB) and the other remaining treatments. Minimum shoot girth (5.02 mm) was observed in treatment combination of M2B2 (Coco peat+ *Azotobacter*).

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

Maximum shoot girth (6.35 mm) in treatment combination of L1M1B1 (Simple air layering + Sphagnum moss + Bio-mix) which was significantly superior than (6.17mm.) the treatment combination of L2M1B1 (Modified air layering + Sphagnum moss + Bio-mix) and the other remaining treatments. Minimum shoot girth (5.00 mm) was observed in treatment combination of L2M2B2 (Modified air layering + Coco peat+ *Azotobacter*).

The combined effect of sphagnum moss and bio-mix in simple air layering play's important role to increase the girth of shoots.

Plant height (cm)

Effect of propagation methods (L)

Maximum plant height (32.86 cm) was observed in treatment L1 (Simple air layering) and minimum (32.79 cm) in treatment L2 (Modified air layering) at 90 DAT.

This might be due to the more numbers of sprouts; more numbers of leaves were responsible for maximum rate of photosynthesis due to maximum chlorophyll contents in leaves and accumulation and utilization of more carbohydrates and other food materials ultimately resulted into the maximum plant height in simple air layering.

Effect of rooting media (M)

Maximum plant height (33.12 cm) per air layer was induced in treatment M1 (Sphagnum moss) and minimum (32.55 cm) in treatment M2 (Coco peat) at 90 DAT. It might be due to the higher water holding and aeration capacity of sphagnum moss stimulated early root initiation and faster root growth, more numbers of roots, longest roots, etc. which improved the absorption of water and nutrients resulted better shoot growth or plant height. The similar results were recorded by Tyagi and Patel (2004) of air layering in guava (*Punica granatum* L.) cv. Sardar.

Effect of biological agents (B)

Maximum plant height (32.95 cm) was observed in treatment B1 (Bio-mix) and minimum (32.72 cm) in treatment B2 (*Azotobacter*) at 90 DAT.

This increase of plant height could be attributed to the increased availability of nutrients such as nitrogen, phosphorous and their stimulated uptake and the production of phytohormones by the different bacteria present into the bio-mix. Similar findings were recorded by the Montero-Calasanz *et al.* (2013) and Vafadar *et. al.* (2014) [9].

Interaction effects

Interaction of propagation methods, rooting media and biological agents (L X M X B) with respect to plant height was observed to be significant. However, interaction of propagation methods with rooting media (L X M), interaction of propagation methods with biological agents (L X B) and interaction of rooting media with biological agents (M X B) was found to be non-significant. Significantly highest plant height (33.28 cm) was observed in treatment combination of L1M1B1 (Simple air layering + Sphagnum moss + Bio-mix) and minimum height of plant (32.33 cm) was observed in treatment combination of L2M2B2 (Modified air layering + Coco peat+ *Azotobacter*) at 90 DAT. The combined effect of sphagnum moss and bio-mix in simple air layering and favorable climatic conditions caused maximum nutrient uptakes ultimately resulted into the highest plant height under this treatment.

Fresh weight of shoot (g)

Effect of propagation methods (L)

Maximum fresh weight of shoot (15.22 g) was observed in treatment L1 (Simple air layering) and minimum (15.14 g) in treatment L2 (Modified air layering) at 90 DAT.

The probable reason behind this as maximum number of sprouts, length and diameter of sprouts in simple air layering ultimately resulted in the highest fresh weight of shoots under this treatment.

Effect of rooting media (M)

Maximum fresh weight of shoot (15.76 g) per air layer was induced in treatment M1 (Sphagnum moss) and minimum (14.65 g) in treatment M2 (Coco peat) at 90 DAT.

It might be due to the maximum numbers of new branches, longer branches and more numbers of leaves recorded under the sphagnum moss treatment. Sphagnum moss promotes luxurious growth of roots as well as shoots which may have been resulted into the maximum fresh weight of shoots. The similar results were obtained by the Reddy *et al.* (2014) [6].

Effect of biological agents (B)

Maximum fresh weight of shoot (15.36 g) was observed in treatment B1 (Bio-mix) and minimum (15.00 g) in treatment B2 (*Azotobacter*) at 90 DAT.The probable reason for increase in fresh weight of shoots 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 shoots under this treatment. The above findings were supported by Yasser (2015) [10] on pomegranate (*Punica granatum* L.) stem cuttings and Galavi *et al.* (2013) [3] on rooting of grape cuttings (*Vitis vinifera*).

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

Significant difference was not noticed among the interaction between propagation methods and rooting media with respect to fresh weight of shoot at 90 DAT.

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

fresh weight of shoot was observed to be significant at 90 days after transplanting. Fresh weight of shoot was found to be maximum (15.38 g) in treatment combination of L1B1 (Simple air layering + Bio- mix) which was significantly superiors than (15.33 g) the treatment combination of L2B1 (Modified air layering + Bio-mix) and the other remaining treatments. Minimum fresh weight of shoot (14.93 g) was observed in treatment combination of L2B2 (Modified air layering + *Azotobacter*). Interaction of simple air layering with bio-mix recorded maximum fresh weight of shoots while minimum was recorded into the modified air layering with *Azotobacter*.

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

Fresh weight of shoot was found to be significant at 90 days after transplanting. Fresh weight of shoot found to be maximum (15.89 g) in treatment combination of M1B1 (Sphagnum moss + Bio-mix) which was significantly superior than the treatment combination of M1B3 (Sphagnum moss + PSB) (15.73 g.) and the other remaining treatments.

Minimum fresh weight of shoot (14.40 g) was observed in treatment combination of M2B2 (Coco peat+ *Azotobacter*). This might be due to sphagnum moss helped in proper aeration and water holding and bio- mix shown the fastest microbial activities and nutrient utilizations which was resulted in maximum fresh weight of shoots under this treatment.

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

Fresh weight of shoot was observed to be significant at 90 days after transplanting.

Maximum fresh weight (15.90 g) in treatment combination of L1M1B1 (Simple air layering + Sphagnum moss + Bio-mix) which was statistically at par (15.88 g) with treatment combination of L2M1B1 (Modified air layering + Sphagnum moss + Bio-mix). Minimum fresh weight of shoot (14.37 g) 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 ultimately resulted in maximum fresh weight of shoots under this treatment.

Dry weight of shoot (g.)

Effect of propagation methods (L) Maximum dry weight of shoot (7.13 g) was observed in treatment L1 (Simple air layering) and minimum (7.05 g) in treatment L2 (Modified air layering) at 90 DAT. The maximum fresh weight of shoots ultimately resulted in the maximum dry weight of shoots in simple air layering.

Effect of rooting media (M)

Maximum dry weight of shoot (7.56 g) per air layer was induced in treatment M1 (Sphagnum moss) and minimum (6.58 g) in treatment M2 (Coco peat) at 90 DAT. The maximum fresh weight of shoots ultimately resulted into the maximum dry weight of shoots. It might be due to the maximum numbers of new branches, longer branches and more numbers of leaves recorded under the sphagnum moss treatment. Sphagnum moss promotes luxurious growth of roots as well as shoots which may have been resulted into the maximum dry weight of the shoots. The similar results were obtained by the Reddy *et al.* (2014) [6].

Effect of biological agents (B)

Maximum dry weight of shoot (7.30 g) was observed in treatment B1 (Bio- mix) and minimum (6.90 g) in treatment B2 (*Azotobacter*) at 90 DAT. The maximum fresh weight of shoots ultimately resulted into the maximum dry weight of shoots and also the better utilization of carbohydrates, nitrogen and other nutrients under the bio-mix treatment. The above findings were supported by Yasser (2015) [10] on pomegranate (*Punica granatum* L.) stem cuttings and Galavi *et al.* (2013) [3] on rooting of grape cuttings (*Vitis vinifera*).

Interaction effects

Interaction of rooting media with biological agents (M X B) with respect to dry weight of shoot was observed to be significant. However, interaction of propagation methods with rooting media (L X M), interaction of propagation methods with biological agents (L X B) and Interaction of propagation methods, rooting media and biological agents (L X M X B) was found to be non-significant at 90 days after transplanting. Significantly highest dry weight of shoot was observed (7.66 g) in treatment combination of M1B1 (Sphagnum moss + Bio-mix) which was statistically at par (7.55 g) with treatment combination of M1B3 (Sphagnum moss + PSB) and lowest dry weight of shoot (6.26 g) was observed in treatment combination of M2B2 (Coco peat+ *Azotobacter*) at 90 DAT. The interaction of sphagnum moss and bio- mix shown superior results with respect to dry weight of the shoots under this treatment.

Table 1: Shows the factors number of sprouts Length of sprouts (cm) and Diameter of sprouts (mm)

Factors	Number of sprouts	Length of sprouts (cm)	Diameter of sprouts (mm)
Factor A	90 DAT	90 DAT	90 DAT
L1	16.50	21.33	2.23
L2	16.30	21.09	2.21
S.E. (m) ±	0.028	0.099	0.001
C.D. @ 5%	0.083	N.S.	0.003
Factor B	**Rooting media**	**Rooting media**	**Rooting media**
M1	17.31	23.41	2.31
M2	15.59	19.39	2.13
M3	16.29	20.83	2.23
S.E. (m) ±	0.034	0.122	0.001
C.D. @ 5%	0.101	0.363	0.004
Factor C	**Biological agents**	**Biological agents**	**Biological agents**
B1	16.72	21.78	2.26
B2	16.06	20.61	2.18
B3	16.41	21.24	2.22
S.E. (m) ±	0.034	0.122	0.001
C.D. @ 5%	0.101	0.363	0.004
Interaction of AXB			
L1 M1	17.48	23.57	2.32
L1 M2	15.63	19.43	2.14
L1 M3	16.40	20.99	2.24
L2 M1	17.14	23.25	2.30
L2 M2	15.55	19.34	2.12
L2 M3	16.17	20.67	2.21
S.E. (m) ±	0.048	0.172	0.002
C.D. @ 5%	0.143	N.S.	N.S.
Interaction of AXC			
L1B1	16.80	21.83	2.27
L1B2	16.22	20.78	2.20
L1B3	16.50	21.38	2.23
L2B1	16.65	21.72	2.25
L2B2	15.90	20.44	2.17
L2B3	16.33	21.10	2.21
S.E. (m) ±	0.048	0.172	0.002
C.D. @ 5%	N.S.	N.S.	0.005
Interaction of BXC			
M1 B1	17.64	23.88	2.33
M1 B2	17.02	23.04	2.28
M1 B3	17.28	23.32	2.30
M2 B1	15.98	19.86	2.18
M2 B2	15.19	18.82	2.08
M2 B3	15.60	19.48	2.13
M3B 1	16.54	21.59	2.26
M3 B2	15.97	19.97	2.19
M3 B3	16.35	20.92	2.23

S.E. (m) ±	0.059	0.211	0.002
C.D. @ 5%	N.S.	N.S.	0.007
Interaction of AXBXC			
T1- L1 M1 B1	17.78	23.97	2.34
T2-L1 M1 B2	17.23	23.14	2.30
T3-L1 M1 B3	17.45	23.62	2.32
T4-L1 M2 B1	16.01	19.89	2.19
T5-L1 M2 B2	15.25	18.87	2.09
T6-L1 M2 B3	15.63	19.54	2.14
T7-L1 M3B1	16.60	21.64	2.27
T8-L1 M3 B2	16.19	20.34	2.21
T9-L1 M3 B3	16.40	20.99	2.24
T10-L2 M1 B1	17.50	23.78	2.33
T11-L2 M1 B2	16.81	22.94	2.28
T12-L2M1 B3	17.10	23.03	2.29
T13-L2 M2 B1	15.95	19.83	2.18
T14-L2 M2 B2	15.13	18.78	2.08
T15-L2 M2 B3	15.58	19.42	2.12
T16-L2 M3 B1	16.48	21.55	2.26
T17-L2 M3 B2	15.74	19.61	2.17
T18-L2 M3 B3	16.30	20.86	2.22
S.E. (m) ±	0.083	0.298	0.003
C.D. @ 5%	N.S.	N.S.	0.009
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	

Table 2: Shows the factors of Number of leaves Shoot girth (cm) and Plant height (cm)

Factors	Number of leaves	Shoot girth (cm)	Plant height (cm)
Factor A	**90 DAT**	**Propagation methods**	**Propagation methods**
L1	50.38	5.60	32.86
L2	49.83	5.49	32.79
S.E. (m) ±	0.162	0.007	0.022
C.D. @ 5%	0.483	0.022	0.065
Factor B	**Rooting media**	**Rooting media**	**Rooting media**
M1	52.23	6.00	33.12
M2	48.34	5.15	32.55
M3	49.74	5.47	32.81
S.E. (m) ±	0.198	0.009	0.027
C.D. @ 5%	0.592	0.027	0.079
Factor C	**Biological agents**	**Biological agents**	**Biological agents**
B1	50.98	5.72	32.95
B2	49.30	5.37	32.72
B3	50.03	5.53	32.82
S.E. (m) ±	0.198	0.009	0.027
C.D. @ 5%	0.592	0.027	0.079
Interaction of AXB			
L1 M1	52.76	6.10	33.17
L1 M2	48.49	5.17	32.57
L1 M3	49.89	5.51	32.85
L2 M1	51.70	5.91	33.07
L2 M2	48.20	5.12	32.53
L2 M3	49.60	5.43	32.77
S.E. (m) ±	0.281	0.013	0.038
C.D. @ 5%	N.S.	0.038	N.S.
Interaction of AXC			
L1B1	51.20	5.76	32.97
L1B2	49.58	5.42	32.77
L1B3	50.35	5.60	32.85
L2B1	50.76	5.68	32.92
L2B2	49.02	5.33	32.67

L2B3	49.72	5.47	32.78
S.E. (m) ±	0.281	0.013	0.038
C.D. @ 5%	N.S.	N.S.	N.S.
Interaction of BXC			
M1 B1	53.44	6.26	33.25
M1 B2	51.24	5.82	33.04
M1 B3	52.02	5.94	33.08
M2 B1	49.17	5.28	32.66
M2 B2	47.60	5.02	32.45
M2 B3	48.27	5.13	32.54
M3B 1	50.33	5.61	32.93
M3 B2	49.08	5.28	32.68
M3 B3	49.82	5.23	32.83
S.E. (m) ±	0.344	0.016	0.046
C.D. @ 5%	N.S.	0.046	N.S.
Interaction of AXBXC			
T1- L1 M1 B1	53.91	6.35	33.28
T2-L1 M1 B2	51.72	5.87	33.09
T3-L1 M1 B3	52.66	6.07	33.13
T4-L1 M2 B1	49.21	5.30	32.68
T5-L1 M2 B2	47.83	5.04	32.47
T6-L1 M2 B3	48.43	5.18	32.57
T7-L1 M3B1	50.48	5.63	32.95
T8-L1 M3 B2	49.21	5.34	32.76
T9-L1 M3 B3	49.97	5.56	32.85
T10-L2 M1 B1	52.98	6.17	33.21
T11-L2 M1 B2	50.76	5.76	32.99
T12-L2M1 B3	51.39	5.81	33.03
T13-L2 M2 B1	49.13	5.27	32.65
T14-L2 M2 B2	47.37	5.00	32.43
T15-L2 M2 B3	48.11	5.10	32.51
T16-L2 M3 B1	50.18	5.60	32.90
T17-L2 M3 B2	48.95	5.22	32.60
T18-L2 M3 B3	49.67	5.49	32.81
S.E. (m) ±	0.486	0.022	0.022
C.D. @ 5%	N.S.	0.065	0.065
Treatment details			
L_1- Simple air layering	M_1- Sphagnum moss	B_1- Bio-mix	
L_2- Modified air layering	M_2- Coco peat	B_2- *Azotobacter*	
	M_3- Saw dust	B_3- PSB	

Table 3: Shows the factors Fresh weight of shoot (g) and Dry weight of shoot (g)

Factors	**Fresh weight of shoot (g)**	**Dry weight of shoot (g)**
Factor A	Propagation methods	Propagation methods
L1	15.22	7.13
L2	15.14	7.05
S.E. (m) ±	0.007	0.026
C.D. @ 5%	0.020	0.077
Factor B	**Rooting media**	**Rooting media**
M1	15.76	7.56
M2	14.65	6.58
M3	15.13	7.14
S.E. (m) ±	0.008	0.032
C.D. @ 5%	0.024	0.094
Factor C	**Biological agents**	**Biological agents**
B1	15.36	7.30
B2	15.00	6.90
B3	15.18	7.09

S.E. (m) ±	0.008	0.032
C.D. @ 5%	0.024	0.094
Interaction of AXB		
L1 M1	15.79	7.60
L1 M2	14.69	6.61
L1 M3	15.19	7.19
L2 M1	15.73	7.53
L2 M2	14.62	6.55
L2 M3	15.07	7.09
S.E. (m) ±	0.012	0.045
C.D. @ 5%	N.S.	N.S.
Interaction of AXC		
L1B1	15.38	7.32
L1B2	15.08	6.96
L1B3	15.21	7.12
L2B1	15.33	7.27
L2B2	14.93	6.84
L2B3	15.15	7.05
S.E. (m) ±	0.012	0.045
C.D. @ 5%	0.035	N.S.
Interaction of BXC		
M1 B1	15.89	7.66
M1 B2	15.66	7.48
M1 B3	15.73	7.55
M2 B1	14.88	6.90
M2 B2	14.40	6.26
M2 B3	14.67	6.57
M3B 1	15.30	7.32
M3 B2	14.95	6.95
M3 B3	15.13	7.15
S.E. (m) ±	0.014	0.055
C.D. @ 5%	0.042	0.163
Interaction of AXBXC		
T1- L1 M1 B1	15.90	7.68
T2-L1 M1 B2	15.71	7.54
T3-L1 M1 B3	15.77	7.60
T4-L1 M2 B1	14.91	6.94
T5-L1 M2 B2	14.45	6.28
T6-L1 M2 B3	14.71	6.62
T7-L1 M3B1	15.33	7.35
T8-L1 M3 B2	15.09	7.08
T9-L1 M3 B3	15.14	7.16
T10-L2 M1 B1	15.88	7.65
T11-L2 M1 B2	15.61	7.43
T12-L2M1 B3	15.69	7.50
T13-L2 M2 B1	14.86	6.88
T14-L2 M2 B2	14.37	6.25
T15-L2 M2 B3	14.63	6.53
T16-L2 M3 B1	15.28	7.30
T17-L2 M3 B2	14.80	6.84
T18-L2 M3 B3	15.12	7.13
S.E. (m) ±	0.020	0.077
C.D. @ 5%	0.060	N. S.

Conclusion

The simple air layering recorded the maximum number of sprouts, length of sprouts, diameter of sprouts, and number of leaves, while highest plant height, girth of shoot, fresh and dry weight of shoots, were observed better under this treatment. With respect to rooting media, sphagnum moss recorded shoot characters such as highest number of sprouts, highest length of sprouts, highest diameter of sprouts, highest number of leaves, while highest plant height, highest girth of shoot, highest fresh and dry weight of shoot. Among the different biological agents, bio-mix recorded significant shoot characters such as number of sprouts, length of sprouts,

diameter of sprouts, number of leaves, while plant height, girth of shoot, fresh and dry weight of shoot were also recorded maximum under this treatment. The treatment combination of L1M1B1(Simple air layering + Sphagnum moss + Bio-mix) was recorded significant shoot characters such as the maximum number of sprouts, maximum length of sprouts, maximum diameter of sprouts, maximum number of leaves, while maximum plant height, maximum girth of shoot, maximum fresh and dry weight of shoot.

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