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Studies on the effect of different rooting media on survival and success of air layering in acid lime (*Citrus aurantifolia* Swingle) under Chhattisgarh plain

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Abstract
The experiment was conducted in randomized block design (RBD) with three replications. One year old branches of "seedless lime'' cultivar of about 60 cm length having diameter of about pencil thickness, were selected for this experiment. Barks of the branches are removed at 5 cm width of uniform twigs having pencil thickness evenly. Air layering in acid lime is done with the application of respective rooting media around the ringed out portion with help of the hand followed by wrapping portion with polythene film tied with jute rope. Application of Vermicompost + FYM + Sand (1:1:1) yielded the maximum root parameters, such as rooting percentage (94.33%), number of primary roots (34.40), maximum and minimum root length (10.60 cm and 0.95 cm), root fresh and dry weight (0.93 and 0.16 g), survival percentage (82%), plant height (44 cm), number of branches (8.27), and number of leaves (48.20) was significantly recorded best under the treatment combination (T_9) of vermicompost + FYM + sand (1:1:1) as compared to control. In case of soil alone (T_0) these favourable conditions were not available as per requirement of the air layers. The media having sand in mixtures proved the best because of the proper aeration available to the rooting of air layer.

Keywords: Seedless lime, air layering, vermicompost, primary roots and rooting percentage

Introduction
Acid lime (*Citrus aurantifolia* Swingle) is an important sub- tropical fruit crop of the world. It belongs to family Rutaceae and originated probably in southern slope of Himalayan region, the entire north-eastern region of India and then spread to the Middle East and other tropical and subtropical countries.

It has very wide distribution in all parts of India and is the most important acid fruit for multipurpose uses. Acid lime is available all year long and can be grown in a variety of soil types and climates. They are primarily utilized as fresh fruits for eating at tables or making beverages. On the digestive system, they have a laxative effect. Vitamins A, B, and C, minerals, alkaloids, and salts are all abundant in kagzi lime. In addition to being used to make pickles, acid lime fruits are also used to make juice that is added to dals (cooked pulses).

Acid limes can be sprouted, grown from seeds, or stacked in a Marcotte. Usually, seeds are spread out across the country and grown. To proliferate fruit plants, especially those that are challenging to propagate through cutting, air layering is a straightforward method of vegetative propagation (developing roots on stem). While the shoots are still attached to the mother plant during layering, the roots are induced on them. The stem is chopped off and changed into a new plant that can spread its own roots after developing roots appropriately. Since it directly impacts the percentage of rooting and the quality of the roots that are generated, the rooting media should be viewed as a vital part of the propagation system. The choice of medium is dependent on the species, the type of cutting, the season, the type of propagation technique used, as well as the cost and accessibility of the medium's component parts, claim Macdonald (1986) [28] and Hartmann *et al*. (2002) [16]. It's also crucial to handle water effectively. Soil is the most common rooting medium.

Method and Materials
The present investigation was carried out during the year 2020-2021 at the PFDC (Precision farming development center, college of agriculture, Indira Gandhi Krishi Vishwavidyalaya Raipur, Chhattisgarh. Raipur is situated in mid-eastern part of Chhattisgarh state and lies at 21◦16' N latitude 81◦36' E longitude with an attitude of 298.56 metre above mean sea level.

The maximum and minimum temperature, rainfall, humidity percentage and number of rainy days for the experimental period from August 2021 to December 2021. Raipur, the place of investigation comes under dry- moist, sub-humid region. It has an annual rainfall of 1200-1400 mm, out of which 80-90 per cent is received during third week of June to mid-September and very little during October to February. The rainfall pattern has great variation during rainy season from year to year. May is the hottest and December is the coolest month of the year. The maximum temperature during the summer months reaches as high as 46 and the mercury drops to as 6 during December to January. The atmospheric humidity is high from June to October.

Table 1: Treatments and their symbols

S.no	Notations	Treatments
1.	T_0	Soil (control)
2.	T_1	Soil + FYM (1:1)
3.	T_2	Cocopeat + FYM (1:1)
4.	T_3	Sphagnum moss + FYM (1:1)
5.	T_4	Vermicompost + FYM (1:1)
6.	T_5	Saw dust + FYM (1:1)
7.	T_6	Soil + Sand + FYM (1:1:1)
8.	T_7	Cocopeat + Sand + FYM (1:1:1)
9.	T_8	Sphagnum moss +FYM+ Sand (1:1:1)
10.	T_9	Vermicompost +FYM+ Sand (1:1:1)
11.	T_{10}	Saw dust +FYM + Sand (1:1:1)

Source, selection of plants and their branches

For this trial, 11 acid lime plants of uniform size and vigor were selected. The mother plant selected was grown under similar soil and environment conditions and approximately similar in growth vigour and maturity. On these plants are selected which are well matured and healthy branches of pencil thickness. The average length of branches was 60 cm for each treatment. For each replication eleven plants were selected and three samples air-layers were randomly selected on each branch for each treatment combination. As such 25 shoots were layered in three replications and a total number of 825 air layered plants, we obtained in all the treatment combinations.

Result and Discussion

Successful rooting of acid lime air layers has been measured in the form of percentage of rooting, number of primary and secondary root, fresh and dry weight of root, number of leaves, length of shoot, number of branches and survival percentage of rooted air layers. In the present experiment, among all rooting media vermicompost with combination of sand and FYM have given better results.

Rooting percentage (%)

The success in rooting of air layer of acid lime was served under different rooting media at 45 days after layering. It was found significant. The 88.83 to 94.33% success in rooting was noted in case of vermicompost + FYM (1:1) as well as vermicompost + FYM + sand (1:1:1) rooting media i.e., T4 and T9. This was followed by 82.0% in case of sphagnum moss+ FYM+ sand (1:1:1) i.e., (T8) and then 80.30% in case of sphagnum moss + FYM (1:1) i.e., (T3) rooting media. When soil alone (control) was used as rooting media, the success in rooting percentage was lowest (58%).

Similar results were reported by Mishra (2014) [26] in kagzi lime, Duarte and Freundt (1991) [11] in Ficus elastica, Hore and Sen (1994) [29], and Tomar *et al*. (1999) [30] in kagzi lime also observed higher rooting percentage in air layers by using different rooting media. The result in respect to Vermicompost + Sand + FYM also in conformity in dragon fruit air layering highest rooting percentage and other root parameters observed with Vermicompost combined with different combinations of rooting media.

Number of primary roots

The number of primary roots was counted for each air layer under each treatment at 45 and 105 Days after layering (DAL) and the data so obtained were statistically computed as revealed from appendix. The mean data are highlighted in table 2.

Rooting media *viz*. Vermicompost +FYM +Sand (T9) and vermicompost +FYM (T4) formed the equally highest number of primary roots in layer of acid lime (23.00 to 27.25 roots at 45 DAL and roots 23.50 to 31.40 at 105 DAL). Both these rooting media were found significantly higher than the remaining media under use at 45 and 105 days after layering. On the other hand, the significantly lower roots were formed when soil alone or soil+ FYM rooting media were applied on the air layer (13.83 to 14.0 roots at 45 DAL). The remaining rooting media were found intermediate in their effect.

Some of the similar results which support the present investigation are Mishra (2014) [26], Singh *et al*. (2005) [27].

Maximum Root Length (cm)

The maximum length of roots of air layer was measured for each layer under each rooting media treatment at 45 and 105 DAL stages. The data recorded were subjected to statistical calculation. The best rooting media was Vermicompost +FYM +Sand (T9) as well as Saw dust+ FYM+ Sand (T10) which resulted in equally higher length of roots (7.55 to 7.80 cm at 45 DAL and 9.75 to 10.60 cm at 105 DAL) over rest of the rooting media. Both these rooting media were found significantly superior to most of the other media under test. On the other hand, the significantly lower root length (4.80 to 5.45 cm at 45 DAL and 6.30 to 7.17 cm at 105 DAL) was noted in the case of soil alone (T0) and Soil+ FYM (T1) rooting media.

The overall picture indicates that rooting media having sand resulted in better performance as compared to those having no sand.

Minimum Root Length (cm)

The minimum length of roots of air layer was measured for each layer under each rooting media treatment at 45 and 105 DAL stages. The data so recorded were statistically computed.

The significantly higher root length (0.50 to 0.85 cm at 45 DAL and 0.75 to 0.95 cm at 105 DAL) was noted in case of Vermicompost + FYM +Sand (T9) and Soil+ Sand +FYM (T6) rooting media over others. In contrast to these treatments, significantly lowest root length (0.20cm at 45 DAL and 0.30 at 105 DAL) was recorded in case of soil alone rooting media (T0). This was followed by Cocopeat +FYM + Sand (T7) and then Sphagnum moss + FYM + Sand (T8). Soil + FYM (T1) was found significantly was found superior to soil alone at both the stages of observation.

The agreement of the increase in minimum root length was also proved by Mishra (2014) [26] also shown in present

investigation.

Fresh weight of roots (g)

The fresh weight of roots of air layer was recorded in each rooting media treatment and the data were subjected to statistical computation.

The different rooting media showed significant influence upon this parameter only at 45 DAL stage. Accordingly, the rooting media having Soil + Sand + FYM (T6) and Vermicompost + FYM + Sand (T9) as well as Saw dust + FYM + Sand (T10) brought about equally significantly higher fresh weight of roots (0.50 to 0.51 g) over rest of the rooting media treatments. On the other hand, significantly lower fresh weight of roots (0.30 to 0.32) is recorded in case of Soil alone(T0) and Soil +FYM(T1) rooting media. Almost the same trend was noted at 105 DAL stages but, differences among the effect of rooting media was non-significant.

Dry weight of roots (g)

The dry weights of roots of air layer were recorded in each rooting media treatment and the data were subjected to statistical computation.

The different rooting media brought different impact upon dry weight of roots also at both stages. the dry weight was calculated at both 45 DAL and 105 DAL. the rooting media having Vermicompost + FYM + Sand(T9) and Soil + Sand + FYM (T6) as well as Saw dust + FYM + Sand (T10) registered equally higher dry weight of roots (0.10 to 0.10 g at 45 DAL and 0.16 to 0.16 g at 105 DAL) as compared to remaining rooting media treatments. On the other hand, significantly lower dry weight values (0.05 to 0.07 g at 45 DAL and 0.06 to 0.11 g at 105 DAL) were recorded in case of soil alone (T0) and soil + FYM (T1) rooting media. The differences among the treatments are found non-significant at both the stages.

The increase in fresh weight and dry weight of root due to application of rooting media are in agreement in fig, Kashyap *et al*. (2016) [31] in pomegranate, and Tani *et al*. in dragon fruit.

Survival percentage (%)

The survival percentage of planted air layering of kagzi lime was observed under each rooting media after 30 to 60 days of planting. The parameter was found to differ significantly due to rooting media at both the stages. At both the stages of planting, Vermicompost + FYM + Sand (T_9) indicated maximum survival percentage of planted air layering upto 77.0% to 82.0%. This was followed by Sphagnum moss + FYM + Sand (T_8) upto 75.0% to 77.0%. The third best rooting media was Soil + FYM + Sand (T_6) gave upto 71.70% to 76.60% survival after planting. On the other hand, soil alone gave poor performance (50.0% at 30 DAP and 55% at 60 DAP). This was followed by Soil + FYM (60.80% at 30 DAP and 69.50% at 60 DAP). The rooting media treatment (T_2) and (T_3) also gave lower survival percentage.

The results of Modi *et al*. (2012) [24] support of the findings of present investigation.

Plant height (cm)

The plant height of planted air layer was measured under different rooting media treatments at 30 DAP and 60 DAP (Days After Planting). The plant height was influenced significantly due to different rooting media at both the stages of observation. The best rooting media was Vermicompost +FYM+ Sand (T_9) (40 cm at 30 DAP and 44 cm at 60 DAP) being significant higher to T_0, T_1, T_2, and T_5 media. This was followed by T_4, T_6, T_8 and T_{10} found equally effective. the significantly lowest plant height was observed with soil alone rooting media treatment (19.50cm at 30 DAP and 24.70 cm at 60 DAP). Thereafter the lowest effective rooting media was Cocopeat + FYM (25.0 cm at 30 DAP and 32.20 cm at 60 DAP).

The same results were observed in Mishra (2014) [26] showed similar observations as in present investigation.

Number of branches

The number of branches of planted air layer was counted under each treatment at both the stages of observations. The data recorded were computed statistically. The formation of branches in planted air layer was deviated significantly due to different rooting media at both the stages. The rooting media Vermicompost + FYM+ Soil (T9) and Sphagnum moss + FYM+ Sand (T8) brought equally higher number of branches in planted air layer (4.10 to 9.85 at 30 DAP and 7.95 to 6.20 at 60 DAP) over rest of the rooting media. Both these rooting media are found superior to the most of the remaining treatments at both the stages. This was followed by treatment T3 and T6 4.25 to (4.87 at 30 DAP and 6.00 to 8.27 at 60 DAP). On the other hand, the significantly lowest number of branches (2.15 to 2.90 at 30 DAP and 4.20 to 5.25 at 60 DAP) was recorded in case of Soil alone (T_0) and Soil+ FYM (T_1).

The result was supported by Mishra (2014) [26] in kagzi lime, Tayade (2017) in pomegranate, Singh *et al*. (2005) [27] in guava, as in present investigation.

Number of leaves

The number of leaves of planted air layer was counted treatment wise at 30 DAP and 60 DAP stages and the data so obtained were subjected to statistical analysis. The number of leaves was influenced was influenced significantly due to different rooting media at both the stages of observation. Amongst the rooting media Vermicompost + FYM + Sand (T9), Saw dust + FYM + Sand (T_{10}) and Soil +FYM+ Sand (T_5) performed equally well producing maximum (22.80 to 22.30 at 30 DAP and 40.00 to 45.00 at 60 DAP). This was followed by Vermicompost + FYM (T_4) and Saw dust + FYM (T_5) producing (20.20 to 21.20 leaves at 30 DAP and 30.00 to 40.30 leaves at 60 DAP) being significantly lower. On the other hand, Soil alone and Soil + FYM did not prove their suitability upto that extend.

These results further get support from the findings of Rymbai *et al*. (2012) [21] and Mayura *et al*. (2012) [22] in guava and Patel *et al*. (2012) [23] in guava and Patel *et al*. (2012) [23] in pomegranate.

Conclusions

As per above findings, it can be concluded that acid lime can be commercially propagated by air layering by applying rooting media.

Among all the rooting media vermicompost in combination with FYM and sand taken in ratio of 1:1:1 was significantly proven best among all other rooting media taken in this experiment. For maximum success and survival in air layering of acid lime rooting media vermicompost was found best as compared to saw dust and sphagnum moss taken in this experiment.

All the observation taken under this experiment was proved to be maximum success with rooting media vermicompost in combination to FYM and Sand. The results were best with these media as compared to other rooting media taken under this experiment.

Overall, it may be concluded that vermicompost + FYM + sand (1:1:1 ratio) proved to be the best rooting media for the air layer of Acid lime under Chhattisgarh plain.

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