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Economics of plant prepared through air layers of Kazi lime (*Citrus aurantifolia* Swingle) under rainfed conditions

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Abstract
The aim of this investigation was to assess economics of plant prepared through air layers of Kazi Lime (*Citrus aurantifolia* Swingle) under rainfed conditions. The study was conducted at the Rainfed Research Sub-Station for Sub-Tropical Fruits (RRSS) in Raya, SKUAST-Jammu during the rainy season of 2020-2021. Juvenile branches with a diameter ranging from 1.00 to 2.00 cm were selected and subjected to girdling. The girdled portions were treated with IBA at concentrations of 500 ppm, 1000 ppm, and 1500 ppm. Four different combinations of rooting media were used, including soil + sphagnum moss (2:1), soil + cocopeat + vermicompost (2:1:1), and soil + F.Y.M + sand (2:1:1), in addition to a control group using only soil. The results indicated that callus formation occurred in all air layers, regardless of the application of IBA. The highest cost of operation, amounting to ₹ 7500, was observed in the treatment using water + soil + sphagnum moss (T_2), while the lowest cost, ₹ 4650, was recorded in the control treatment using water + soil (T_1). Regarding gross income, the treatment with 1500 ppm IBA + soil + sphagnum moss (T_{14}) yielded the highest income (₹ 10170), while the control treatment (T_1) generated the lowest income (₹ 4950). Net profit varied among treatments, with the maximum (₹ 3320) observed in T_{14} and minimum (₹ 120) in T_{13}. The benefit-cost ratio (B:C) was influenced by the different treatments. The highest B:C ratio (1:4.8) was found in T_{14}, while the lowest (1:0.2) was observed in T_{13} (1500 ppm IBA + soil). In summary, the investigation demonstrated that the application of IBA and the choice of rooting media significantly affected the air layering of Kagzi lime under rainfed conditions. The treatment using 1500 ppm IBA, soil and sphagnum moss proved to be the most profitable, providing the highest net profit and B:C ratio.

Keywords: IBA, etiolation, layering, B:C ratio, net income

Introduction
Kagzi lime (*Citrus aurantifolia* Swingle) is one of the most important fruit crop in citrus family. It belongs to the family Rutaceae, sub family Aurantioideae with chromosome number (2n = 18) and is the third most vital species after mandarin and sweet orange. It is also known by various English names Pati lime, Spur lime, Acid lime and Mexican Lime. Kagzi lime is native to the tropical and sub- tropical regions of Asia and South East Asia including India and China and was latter spread to the regions of North Africa, Europe and other parts of world. In India, citrus fruits are successfully grown in states like Andhra Pradesh, Gujarat, Maharashtra, Karnataka, Uttrakhand, Bihar, Assam, Rajasthan, Madhya Pradesh and other states. Being bestowed with agro-climatic conditions of the Jammu and Kashmir (UT), Kagzi lime has got a tremendous potential in Jammu region for its cultivation in Jammu plains, Pir Panjal hills as well as foot hills in Himalayas. In these regions, lime generally propagated through sexual method (seeds) that takes long time to come into bearing. Also, there is a drag of no uniformity of progeny and high probability of viral diseases contamination by this method. To overcome this problem, the vegetative propagation is best method to produce true to type plants with desirable characters as that of mother plant. Among the various asexual methods, layering is one of the most common, cheaper and conventional method for the propagation of lime in both irrigated as well as rainfed areas. Air layering was first discovered by Chinese about 20 centuries ago and long known to horticulturists as a method of reproducing ornamental and cultivated plants (Mergen, 1953) [6]. In India, this method has been used on various fruit crops and in an appreciable scale for production of elite planting material. There are several vegetative methods for multiplication of the quality stock in fruit tree species but air layering is often used as a method of propagation where the formation of roots from cuttings is at slow

rate (Hartmann & Kester, 1975) [3]. This is the method of reproducing plants by inducing roots to form a plant without cutting off the stem from the parent plant. It is an excellent way to replicate existing plant without disturbing the parent plant bearing fruit or flowering and produce larger plants which are readily mature, much faster than growing them from seed or cuttings as well as producing a new plant that is identical to the parent plant in all respects like fruit taste, colour and size. The new plant is formed while still attached to the parent plant which depends on it for water and nutrients until roots develop. It has evolved as a typical means of vegetative propagation utilized by horticulturists to propagate plants with desirable traits. Large number of plant can be developed in a relatively short period of time; it can be done during rainy season particularly in Jammu subtropical climatic conditions. The rainy (July) season was more favorable for rooting of air layers in lime due to the fact that constant moisture is one of the essential conditions for successful air layering as compared to summer and winter. Layering propagation techniques is an easy and inexpensive method. Moreover, air layering has an advantage over other methods, since reserve food of the parent branch induces the formation of well-developed root system. Also, the air layered branches in general, have balanced root system than cuttings and develop rapidly on planting out. Baghel *et al*. (2016) [1] achieved considerably higher success for rooted air layers during the month of August, number of primary and secondary roots, length of primary and secondary roots, fresh and dry weight of roots and survivability of the layers were also recorded high during the month. Rooting media is considered as an integral part of the propagation system, as percentage of rooting and root quality directly dependent upon the medium used (Loach, 1988) [5]. Usually substrates for rooting used are of organic or mineral origin. In addition to media and propagation method, success in rooting of layers has also been related to the specific location (Shanker *et al*., 2019) [8]. Moreover, root initiation can also be enhanced by the use of growth regulators, especially auxin. Root growth rates with IBA (4000 ppm) and moss grass (90.33% and 92.02%) treatment combination were reported to be the most promising in air layering (Devi and Singh, 2020) [2]. The growing media should be porous, uniform in texture, sufficiently moist and well ventilation (Sardoei *et al*., 2014) [7].

Material and Methods

The experiment took place during the rainy season of 2020-2021 at the Rainfed Research Sub-Station for Sub-Tropical fruits (RRSS) in Raya, Samba, SKUAST-Jammu, Jammu and Kashmir. It followed a Factorial Randomized Complete Block Design (RCBD) with sixteen treatment combinations replicated three times. Two factors were investigated: the growth regulator, Indole-3-butyric acid (IBA), which was applied in three different concentrations (500 ppm - I_1, 1000 ppm - I_2, 1500 ppm - I_3), along with a control using water. The second factor was the rooting media, consisting of three different combinations: soil + sphagnum moss (wet) in a ratio of 2:1 (RM_1), soil + cocopeat + vermicompost in a ratio of 2:1:1 (RM_2), and soil + FYM + sand in a ratio of 2:1:1 (RM_3), as well as a control using only soil.

For air layering process, healthy 1-2 year-old branches of uniform vigor from Kagzi lime trees were selected. Disease-free branches were carefully girdled with a 2-2.5 cm ring of bark just below the bud, without damaging the underlying wood, using two circular cuts about 45-60 cm below the top end of the selected shoot. The pre-prepared IBA formulation was evenly applied to all sides of the upper cut of the ringed portion. The cut area was then covered with the respective rooting media and wrapped with white polythene wrappers according to the treatment combinations.

Different observations were recorded after layering, including the success percentage of layering and various root parameters such as the number, length, fresh weight, and dry weight of primary and secondary roots. After that, the air layers were detached by making a cut just below the lowest end of the ringed surface using sharp secateurs. They were then transplanted in the fruit nursery at RRSS, Raya, SKUAST-Jammu and the survival percentage of the layered plants was calculated after 90 days of planting. Cost of production of layers was evaluated by evaluating common and variable expenditure cost as per treatment (Table 2 and Table 3). The economic analysis of different treatments on per hectare basis calculated by considering success and survival percentage of different layers.

Results

The cost of operation per treatment of Kagzi lime, considering different levels of the growth regulator (IBA) and growing media, is presented in Table 1. The data demonstrates that the maximum cost of operation (₹ 7500) was recorded in treatment (T_2) with water + soil + sphagnum moss (2:1) combination, while the minimum cost (₹ 4650) was observed in treatment (T_1) with water + soil (control) combination.

The gross income data presented in the table shows that levels of treatments had an influence on the total income generated. The treatment (T_{14}) with 1500 ppm (IBA) + soil + sphagnum moss (2:1) combination yielded the highest gross income (₹ 10170), whereas the treatment (T_1) with water + soil (control) combination yielded the lowest gross income (₹ 4950).

Similarly, the net profit data reveals that the different treatment levels played a role in determining the net profit. The treatment (T_{14}) with 1500 ppm (IBA) + soil + sphagnum moss (2:1) combination resulted in the maximum net profit (₹ 3320), while the treatment (T_{13}) with 1500 ppm(IBA) + soil (control) combination resulted in the minimum net profit (₹ 120).

Analyzing the benefit-cost ratio presented in Table 1, it becomes evident that the B:C ratio is influenced by the various treatment combinations. The treatment (T_{14}) with 1500 ppm (IBA) + soil + sphagnum moss (2:1) combination achieved the highest B:C ratio of 1:4.8, indicating a favorable economic outcome. On the other hand, the treatment (T_{13}) with 1500 ppm (IBA) + soil (control) combination had the lowest B:C ratio of 1:0.2, suggesting a less favorable economic return.

In summary, the cost of operation, gross income, net profit, and benefit-cost ratio of Kagzi lime cultivation were significantly affected by the different levels of growth regulator (IBA) and growing media employed in the treatments.

Table 1: Economics analysis of different treatments of air layered Kagzi lime (*Citrus aurantifolia* Swingle) on per hectare basis

Treatments Combinations	Success (%) of layered plants at 90 DAL	Survival (%) at 90 DAP	No. of plant survived	Rate at which sold (per plant)	Gross income (Rs)	Total Cost (Rs)	Net Profit (Rs)	B:C ratio
T_1-I_0 RM_0 (Water+Soil)	62.69	65.00	110	45	4950	4650	300	1:0.6
T_2- I_0 RM_1 (Water +Soil+Sphagnum moss)	94.81	96.72	211	45	9495	7500	1995	1:2.7
T_3- I_0 RM_2 (Water +Cocopeat+Vermicompost)	87.47	85.45	165	45	7425	6500	925	1:1.4
T_4-I_0 RM_3 (Water+Soil+FYM+Sand)	92.86	91.96	175	45	7875	6000	1875	1:3.1
T_5-I_1 RM_0 (500 ppm (IBA)+Soil)	63.35	64.31	118	45	5310	4955	355	1:0.7
T_6-I_1 RM_1 (500 ppm (IBA)+Soil+Sphagnum moss)	94.80	98.39	222	45	9990	7000	2990	1:4.3
T_7-I_1 RM_2 (500 ppm (IBA)+Cocopeat+Vermicompost)	87.92	85.49	168	45	7560	6555	1005	1:1.5
T_8-I_1 RM_3 (500 ppm (IBA)+ Soil+ FYM+ Sand)	91.79	92.80	178	45	8010	6200	1810	1:2.9
T_9-I_2 RM_0 (1000 ppm (IBA)+Soil)	66.30	67.29	120	45	5400	5000	400	1:0.8
T_{10}-I_2 RM_1 (1000 ppm (IBA)+Soil + Sphagnum moss)	94.20	98.40	225	45	10125	6900	3225	1:4.7
T_{11}-I_2 RM_2 (1000 ppm (IBA) +Soil+ Cocopeat+Vermicompost)	90.99	85.93	170	45	7650	6560	1090	1:1.6
T_{12}-I_2 RM_3 (1000 ppm (IBA)+ Soil+ FYM + Sand)	93.86	93.70	185	45	8325	6250	2075	1:3.3
T_{13}-I_3 RM_0 (1500 ppm (IBA)+ Soil)	68.96	71.63	126	45	5670	5550	120	1:0.2
T_{14}-I_3 RM_1 (1500 ppm (IBA)+ Soil+ Sphagnum moss)	95.99	98.68	226	45	10170	6850	3320	1:4.8
T_{15}-I_3 RM_2 (1500 ppm (IBA)+ Soil+Cocopeat+Vermicompost)	93.66	88.10	177	45	7965	6750	1215	1:1.8
T_{16}-I_3 RM_3 (1500 ppm (IBA)+ Soil+FYM+ Sand)	92.03	93.74	186	45	8370	6000	2370	1:3.9

Table 2: Cost of variable expenditure as per treatments on per hectare area basis for air layering of Kagzi lime (*Citrus aurantifolia* Swingle)

S.No.	Particulars	Rates
1.	FYM	Rs 2400
2.	Vermicompost	Rs 3000
3.	Coco peat	Rs 4540
4.	Sphagnum moss	Rs 3200
5.	Sand	Rs 1600
6.	Growth regulators	Rs 1196
7.	Urea	Rs 5000 /ha.
8.	DAP	Rs 3600 /ha.
9.	MOP	Rs 3200/ha.
10.	Polythene sheet	Rs 3300
11.	Poly bags	Rs 3500
12.	Miscellaneous	Rs 10000
	Total	Rs 44536

Table 3: Cost of common expenditure for all treatments on per hectare area basis for air layering of Kagzi lime (*Citrus aurantifolia* Swingle)

S. No.	Particulars	Cost (Rs/ha.)
1.	Training and Pruning (Tree maintenance)	12500
2.	Hoeing and Weeding	8119
3.	Cost of irrigation	6000
4.	Plant protection	9500
5.	Transport and marketing	5665
6.	Labour wages	3500
7.	Miscellaneous	10000
	Total	Rs 55284

Discussion

Regarding economics, the data on the cost of operation per treatment of Kagzi lime with different levels of growth regulator (IBA) and growing media presented in the Table 1, revealed that maximum (₹ 7500) cost of operation was incurred in treatment, T_2 (water + soil + sphagnum moss) whereas, the minimum was recorded (₹ 4650) in treatment, T_1 (water + soil (control)). Similarly, the maximum gross income (₹ 10170) was recorded in the treatment, T_{14} (1500 ppm (IBA) + soil + sphagnum moss) and the minimum (₹ 4950) was recorded in the treatment, T_1 (water + soil (control)).The data on the net profit presented in the Table 1 revealed that it is influenced by the different levels of the treatments under consideration. The maximum net (₹ 3320) profit was recorded in the treatment,(T_{14}) (1500 ppm (IBA) + soil + sphagnum moss) whereas, the minimum (₹ 120) was recorded in the treatment, (T_{13}) (1500 ppm (IBA) + soil (control)). The data on the benefit cost ratio presented, reported that B:C influenced by the different levels of the treatments under consideration i.e. three different concentration of IBA along with three different growing media. The maximum (1:4.8) B:C ratio was recorded in the treatment, T_{14} (1500 ppm (IBA) + soil + sphagnum moss) while the minimum (1:0.2) was recorded in the treatment, T_{13} (1500 ppm (IBA) + soil (control)). Similar, finding has been reported recently by Devi and Singh, (2020) [2] in Kagzi lime and Kumari and Prakash, (2017) [4].

Conclusion

Based on the findings of the present investigation, it can be concluded that plant growth regulator IBA@1500 ppm and rooting media soil+ sphagnum moss (wet) (2:1) treatment combination was found superior in achieving maximum success percentage of layered plants and survival percentage of layered plants after planting under rainfed conditions with high B:C ratio (1:4.8). Moreover, the above mentioned treatment combination also provides true to type and elite planting material of acid lime to the fruit growers.

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