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Modulating Adventitious Root Morphogenesis in Eriobotrya japonica Semi- Hardwood Cutting Through the Interaction of Plant Growth Regulator Application and Substrate Composition

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Research Article

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Abstract

The present study was conducted to evaluate the effect of plant growth regulators (PGRs) and rooting media on the rooting behavior of loquat (*Eriobotrya japonica* L.) cuttings under greenhouse conditions during 2021–2022 at Lovely Professional University,Punjab.The experiment was laid out in a factorial randomized block design with two factors comprising different concentrations of IBA (750 and 850 ppm) and paclobutrazol (80 and 100 ppm) along with three rooting media (soil, vermicompost, and cocopeat).Among the treatments, IBA at 850 ppm and PBZ at 80 ppm significantly reduced the number of days to bud emergence, sprouting, and rooting, while enhancing sprouting percentage, number of leaves, root length, and survival percentage. Cocopeat was found to be the most effective rooting medium, resulting in earlier sprouting and better root development compared to soil.The interaction effect revealed that IBA (850 ppm) combined with cocopeat recorded minimum days for bud emergence and sprouting, whereas PBZ (80 ppm) with vermicompost produced superior root length and survival percentage. Overall, treatment combination of PBZ @ 80 ppm with vermicompost was found most suitable for successful propagation of loquat through cuttings.

Introduction

Loquat (*Eriobotrya japonica*), commonly known as Japanese Medlar or Japanese Plum, is a subtropical fruit crop belonging to the family Rosaceae. This plant originated in China, where its cultivation has been documented for over 2,000 years (Lin et al., 2007). According to FAO, the world produced 1.58 million tons of loquat in 2019. In India, the National Horticultural Board (NHB) reports a total loquat production of 44,000 tons from an area of around 7,300 hectares. Among states, Jammu and Kashmir leads in loquat production, accounting for approximately 70% of the country's total production. Loquat cultivation in Himachal Pradesh is concentrated primarily in the districts of Shimla, Solan, and Sirmaur (NHB, 2021).Given its nutritional, commercial, and medicinal importance, the reliable large-scale production of genetically uniform, high-quality planting material is paramount.The loquat fruit and leaves arewell recognized for their significant phytochemical content and medicinal properties, historically utilized in traditional Chinese medicine for treating conditions like cough and asthma. Modern research confirms its rich profile of phenolic compounds (e.g., chlorogenic acid and neochlorogenic acid), carotenoids, and terpenoids (like ursolic and oleanolic acids), which confer potent antioxidant, anti-inflammatory, and anti-diabetic activities (Shi et al., 2025; Ziyat et al., 2025). Nutritionally, the fruit is known to contain various vitamins (A, B, and C), particularly vitamin B17, as well as high levels of minerals such as phosphorus and calcium, in addition to carbohydrates (Karadeniz, 2003).

Although *Eriobotrya japonica* is often propagated by seeds, this method is severely limited due to high genetic heterogeneity. As a result, offspring generated through seed propagation have a prolonged juvenile phase (Surya et al., 2021). Moreover, seed germination is low, irregular, and slow due to endogenous dormancy in loquat seed (El-dengawy., 2013). Therefore, vegetative propagation methods, such as stem cuttings, are necessary to ensures genetic uniformity (true to type) and early fruiting (precocity).Rooting of cutting is one of the most economical and easiest methods of

propagation;however, woody plants are often difficult to root and this difficulty remains one of the major obstacles to economic propagation (Monricelli, 1998). The rooting of stem cutting is primarily modulated by two key factors: the exogenous application of plant growth regulators (PGRs) and the physical and chemical properties of the rooting substrate.Auxin application, particularly Indole-3-Butyric Acid (IBA), helps to induce adventitious root morphogenesis in cuttings, which usually improvesthe quality and number of roots formed (Abd El Hameed., 2018). Moreover, the use of anti-gibberellin,i.e.Paclobutrazol (PBZ), is employed sometimes, as it plays a role in the inhibition of gibberellin biosynthesis, redirecting energy and metabolites towards the root development in the species that are difficult to root (Bueno et al., 2024). Likewise, a rooting medium with optimal aeration, water retention, and texture is critical for nutrient supply and mechanical support under protected cultivation system (Surya et al., 2021). Despite the general knowledge regarding these factors, there is a significant gap in existing literature specifically investigating the synergistic and dosage-dependent interaction between combined PGR regimes (IBA and PBZ) and different rooting media in semi- hardwood cuttings of *Eriobotrya japonica* under green net house conditions. This knowledge gap obstruct the establishment of a commercially viable clonal propagation protocol.Hence, the present study was carried out to refine the propagation methodology for loquat (*Eriobotrya japonica*) semi-hardwood cuttings. The specific objectives of the research were:

1. To evaluate the effect of various concentrations and combinations of Plant Growth Regulators (IBA and PBZ) on the rooting efficiency, root quality, and survival rate of semi-hardwood cuttings.
2. To determine the most suitable rooting substrate composition that promotes the highest rate of adventitious root morphogenesis and subsequent establishment under green net house conditions.

Materials and Methods

1.1 Experimental site and Duration

The experiment was laid out in a Factorial Randomized Block Design consisting of 15 treatments combinations replicated three times at the Horticulture Research Farm, Department of Agriculture, Lovely Professional University, Phagwara, Jalandhar, Punjab (India) during the academic year 2021–2022.The experiment consists of two factors: plant growth regulators (IBA at 750 and 800 ppm; paclobutrazol at 80 and 100 ppm) and rooting media (soil, vermicompost and cocopeat) along with control treatments. These substrates were filled into perforated polythene bags to ensure proper drainage and maintained under greenhouse conditions.For the hormonal treatment, stock solutions of Paclobutrazol and Indole-3-Butyric Acid (IBA) were prepared in the laboratory. The required concentrations were made by diluting the stock solutions. A total of 15 treatment combinations were evaluated. Disease-free, Healthy *Eriobotrya japonica* trees were selected as the mother plant. Semi-hardwood cuttings were prepared from current season's growth. The cuttings were 15–18 cm of length with a diameter of 0.8-1.0 cm (pencil thickness, each cutting retained at least 3–4 functional buds. To facilitate the orientation and rooting, a slant cut was made at the basal and distal end. The basal ends of 2–3 cm of the cuttings were dipped into the respective PGR solutions by the long dip method before

planting. Observations were recorded on parameters including days to bud emergence, days to sprouting, sprouting percentage, number of leaves at 30,60 and 90 days after planting (DAP), time taken for rooting, rooting length, rooting percentage and survival percentage.The data recorded during the experiment were analysed using SPSS(version 21.0) and OPSTAT software. The significance of variation among the treatments was observed by applying the Analysis of variance (ANOVA) for the F-RBD at a 5% level of significance ($p \leq 0.05$). General view of experiment has been represented in Fig. 1 and the data is depicted in Table 1.

Details of treatment combinations

Treatment code	Substrate	PGR Concentration (ppm)
T_1	Soil	IBA 750 ppm
T_2	Soil	IBA 850 ppm
T_3	Soil	Paclobutrazol 80 ppm
T_4	Soil	Paclobutrazol 100 ppm
T_5	Soil	Control (water)
T_6	Vermicompost	IBA 750 ppm
T_7	Vermicompost	IBA 850 ppm
T_8	Vermicompost	Paclobutrazol 80 ppm
T_9	Vermicompost	Paclobutrazol 100 ppm
T_{10}	Vermicompost	Control (water)
T_{11}	Cocopeat	IBA 750 ppm
T_{12}	Cocopeat	IBA 850 ppm
T_{13}	Cocopeat	Paclobutrazol 80 ppm
T_{14}	Cocopeat	Paclobutrazol 100 ppm
T_{15}	Cocopeat	Control (water)

Results and Discussion

Bud emergence and sprouting behaviour

The effect of plant growth regulators and rooting media on bud emergence and sprouting behaviour of loquat cuttings was found to be significant. Among the plant growth regulators, IBA at 850 ppm recorded the minimum days to bud emergence (17.13 days) and first sprouting (21.44 days), which was statistically at par with PBZ at 80 ppm. The control treatment recorded the maximum days for both parameters.Among the rooting media, cocopeat proved to be the most effective, recording minimum days to bud emergence (18.03 days) and sprouting (23.45 days), followed by vermicompost, whereas soil resulted in delayed sprouting.The interaction effect revealed that the combination of IBA at 850 ppm with cocopeat significantly reduced the days to bud emergence (14.33 days) and first sprouting (17.83 days), followed by PBZ at 80 ppm with cocopeat.The early bud emergence and sprouting observed under IBA treatments may be attributed to its role in stimulating cell division, elongation, and activation of dormant buds through enhanced auxin activity. Similarly, paclobutrazol may have influenced endogenous hormone balance, thereby promoting early physiological responses. The superior performance of cocopeat may be due to its high porosity, better aeration, and water holding capacity, which create favourable conditions for root and shoot initiation.These findings are in agreement with the results of Ercisli et al. (2003), who reported enhanced sprouting in cuttings under favourable media conditions, and Farooq et al. (2018), who observed improved vegetative growth in plants grown in cocopeat-based substrates. Similar results were also reported by Hartmann et al. (2002), emphasizing the role of auxins in promoting early root and shoot initiation in cuttings.

Rooting Behaviour and Survival of Loquat cuttings

The rooting behaviour and survival of loquat cuttings were significantly influenced by plant growth regulators and rooting media. Among the treatments, IBA at 850 ppm and PBZ at 80 ppm exhibited superior performance by reducing the time taken for root initiation and enhancing root development parameters.Cuttings treated with PBZ at 80 ppm recorded maximum root length and improved root system development, while IBA at 850 ppm resulted in earlier root initiation. The control treatment showed delayed rooting and poor root growth.Among the different rooting media, vermicompost proved to be the most effective for root development, producing longer roots and better root proliferation, followed by cocopeat. Soil was found to be least effective for rooting parameters.The interaction effect revealed that PBZ at 80 ppm combined with vermicompost recorded superior root length and survival percentage, whereas IBA at 850 ppm with cocopeat resulted in earlier root initiation. The highest rooting and survival percentage were observed under treatments involving PBZ at 80 ppm and vermicompost.The enhanced rooting observed under IBA treatments may be attributed to its role in promoting adventitious root formation through stimulation of cell division and differentiation at the basal portion of cuttings. Auxins are known to increase the accumulation of carbohydrates and other metabolites required for root initiation. Paclobutrazol, on the other hand, may have improved rooting by altering endogenous hormonal balance, reducing gibberellin activity, and enhancing assimilate partitioning towards root development.The superior performance of vermicompost may be due to its rich nutrient content, improved microbial activity, and better moisture retention, which collectively create a favourable environment for root growth and survival. These findings are in accordance with the results of Qadri et al. (2018), who reported enhanced root development under PBZ treatments, and Singh et al.

(2018), who observed better rooting and survival in vermicompost-based media. Similar results were also reported by Hartmann et al. (2002), highlighting the role of auxins in root initiation, and Netam et al. (2020), who emphasized the importance of nutrient-rich media for improved rooting and survival.

Table 1
Effect of plant growth regulators and rooting media on sprouting, rooting and survival percentage of loquat (*Eriobotrya japonica* L.) cuttings.

Treatment	Days to sprouting	Sprouting %	RootLength (cm)	Rooting (%)	Survival (%)
T_1(Soil + IBA 750 ppm)	29.17	56.67	1.92	43.33	6.67
T_2 (Soil + IBA 850 ppm)	24.60	66.67	2.08	46.67	6.67
T_3 (Soil + PBZ 80 ppm)	24.80	80.00	4.31	60.00	33.33
T_4(Soil + PBZ 100 ppm)	28.83	73.33	3.26	53.33	20.00
T_5(Vermicompost + IBA 750 ppm)	25.87	70.00	2.82	53.33	20.00
T_6(Vermicompost + IBA 850 ppm)	21.90	73.33	3.05	50.00	23.33
T_7(Vermicompost + PBZ 80 ppm)	20.83	83.33	5.04	63.33	53.33
T_8(Vermicompost + PBZ 100 ppm)	25.00	86.67	3.67	53.33	36.67
T_9(Cocopeat + IBA 750 ppm)	26.20	76.67	2.65	50.00	16.67
T_{10}(Cocopeat + IBA 850 ppm	17.83	73.33	4.15	56.67	43.33
T_{11}(Cocopeat + PBZ 80 ppm)	19.00	93.33	4.13	56.67	26.67
T_{12}(Cocopeat + PBZ 100 ppm)	20.33	83.33	2.56	46.67	16.67
T_{13}(Vermicompost + Water)	30.17	83.33	1.20	40.00	13.33
T_{14}(Cocopeat + Water)	33.90	63.33	1.53	40.00	0.00
T_{15}(Control - Soil)	31.17	66.67	0.87	36.67	0.00
S.Em(±):					
PGR concentration = 3.48, Growing media = 2.69					
CD (P = 0.05):					
PGR concentration = 10.13, Growing media = 7.84					

Conclusion

Based on the results of the present investigation, it can be concluded that plant growth regulators and rooting media significantly influence the rooting and growth of loquat cuttings. Among the treatments, IBA at 850 ppm and PBZ at 80 ppm showed superior performance in improving sprouting, rooting, and survival parameters.Cocopeat was found to be the most suitable medium for early sprouting, while vermicompost proved best for root development and survival. The interaction of PBZ at 80 ppm with vermicompost was identified as the most effective treatment combination for successful propagation of loquat through cuttings.Therefore, the use of PBZ @ 80 ppm in vermicompost medium can be recommended for efficient and economical propagation of loquat under similar conditions.

Declarations

Conflict of interest and Data availability: Not Applicable.

Ethics declaration: Not applicable.

Funding Declaration: No Funding

Author Contribution

Chander kant, Niharika and Suddhasuchi Das conceived of the presented idea. Chander kant, Niharika, Sovan Debnath and Feroze Hasan Rahman developed the theory and performed the computations. Feroze Hasan Rahman, Suddhasuchi Das verified the manuscript and methods. Sovan Debnath encouraged Chander kant and Niharika to investigate the proper review work and supervised the findings of this work. All authors discussed the results and contributed to the final manuscript.

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Figures



Figure 1

General view and layout of experiment