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Enhancing seedling growth of grafted lime through organic and inorganic fertilizers

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Abstract
The study was conducted at Rama University, Kanpur, Uttar Pradesh, during(2023-2024), to assess the impact of organic amendments and bio-agents on the growth of grafted lime) seedlings in a poly house. Treatments T_1 through T_8 were evaluated for their effects on seedling development at 60, 90, and 120 days after transplanting (DAT). Results show varied growth patterns across treatments, with T_5 consistently demonstrating the highest growth and leaf count. Notably, T_5 displayed significant enhancement in both height and leaf count compared to the control treatment (T_1). These findings highlight the potential of specific fertilizer combinations, such as the one used in T_5, to promote robust growth and leaf development in grafted lime seedlings.

Keywords: Arbuscular mycorrhiza fungi, Bio fertilizers, Grafted lime, Urea, Vermicompost

Introduction

Citrus trees (*Citrus* spp.), major fruits globally, face risks to human health and the environment from excessive synthetic fertilizer use. Integrated fertilizing systems in citrus orchards enhance crop production, eco-friendly nutrient supply, fruit quality, plant resilience to stresses, grower profits, and resource sustainability. Organic fertilizers like compost, vermicompost, and biochar, along with biofertilizers containing microorganisms such as *Azotobacter* and *Pseudomonas*, increase nutrient availability, tree productivity, and soil health. They also boost microflora, reduce pathogenic effects, and enhance stress tolerance. Combining organic, bio, and mineral fertilizers offers a significant environmental conservation impact, reducing excessive inorganic fertilizer use and promoting citrus orchard vitality.

Therefore, there is a need to expedite the growth of seedlings cultivated in poly bags by implementing necessary changes in the composition of potting media. This adjustment aims to reduce the time required for the seedlings to attain a saleable size, thus enhancing the efficiency of the production process. A potting medium is a blend of organic materials designed to meet the chemical and physical requirements necessary for a crop to achieve its full growth and development potential. Effective management of container media is fundamental to producing high-quality citrus nursery plants grown in containers.

Farmyard manure has traditionally served as the primary source of organic matter, supplying essential minerals required by the plants. Additionally, Azotobacter plays a crucial role not only in nitrogen fixation and improving plant nitrogen levels but also in supplying biologically active compounds such as vitamins and gibberellins. The symbiotic relationship between Arbuscular mycorrhiza (AM) and the roots of most terrestrial plants is well-documented, as it enhances plant growth and helps alleviate salt stress. AM fungi increase the surface area available for nutrient absorption and transport these nutrients back to the plant. They facilitate the absorption and mobilization of nutrients such as phosphorus, zinc, carbon, nitrogen, copper, and sulfur, which are then translocated to the host plant. Furthermore, AM fungi produce hormones like auxin, cytokinins, gibberellins, and vitamins, acting as supplements to root hairs in the nutrient absorption and mobilization process, thus aiding in the translocation of nutrients from the soil and root cortical parenchyma to the xylem elements of the host plant.

Research has indicated that organic fertilizers, such as bioorganic fertilizers and green manure, in combination with chemical urea, have a notable impact on the growth of citrus seedlings. The utilization of organic fertilizers not only enhances soil fertility, growth physiology, and citrus yield but also demonstrates that bioorganic fertilizers outperform other types, Khalid, (2023). It's suggested to employ natural organic fertilization methods like compost and manures to sustainably fulfill citrus plants' nutrient requirements Sutopo *et al.*, (2022) [11]. Moreover, integrating organic manure with a 30% reduction in chemical fertilizer has been found to mitigate N2O emissions while still maintaining optimal yields in citrus orchards, representing a promising approach for sustainable productivity and environmental conservation Aziz *et al.*, (2021) [3]. These discoveries underscore the significance of incorporating organic amendments to bolster citrus seedling growth while mitigating the environmental repercussions associated with excessive chemical fertilizer usage. Lian-Jie *et al.*, (2021) [7] and Hemma *et al.*, (2022) [4]

Materials and Methods

The experiment was conducted at, Department of Horticulture, Rama University, Kanpur, Uttar Pradesh, during the year 2022-23. The experiment was laid out in a Randomized Block Design (RBD) with three replications and 8 treatments. In this experiment, various treatments were applied to evaluate their effects on seedling growth. The treatments included T0, which served as the control treatment, while T_1 involved the application of 100 grams of vermicompost per seedling. T_2 consisted of 50 grams of Mycorrhizae per seedling. T3 applied a chemical urea fertilizer at a rate of 10 grams per seedling, divided into two equal batches of 5 grams each. T_4 combined 100 grams of vermicompost, 50 grams of Mycorrhizae, and 10 grams of chemical urea fertilizer per seedling, divided into two equal batches. T_5 utilized 100 grams of vermicompost and 50 grams of Mycorrhizae per seedling. T_6 applied 100 grams of vermicompost per seedling along with 10 grams of chemical urea fertilizer divided into two equal batches. Lastly, T_7 involved the application of 50 grams of Mycorrhizae per seedling along with 10 grams of chemical urea fertilizer divided into two equal batches. Each treatment combination aimed to assess its impact on seedling growth and development.

Table 1: Details of treatments

Treatments	Combination
T_1	control treatment
T_2	100 g of vermicompost per seedling
T_3	50 g *Mycorrhizae* per seedling
T_4	10 g seedlings^{-1} of the chemical urea fertilizer was divided into two batches, each batch of 5g
T_5	100 g of vermicompost per seedling + 50 g *Mycorrhizae* per seedling + 10g seedlings^{-1} of the chemical urea fertilizer was divided into two batches, each batch of 5g
T_6	100 g of vermicompost per seedling + 50 g *Mycorrhizae* per seedling
T_7	100 g of vermicompost per seedling + 10g seedlings^{-1} of the chemical urea fertilizer was divided into two batches, each batch of 5 g
T_8	50 g *Mycorrhizae* per seedling + 10g seedlings^{-1} of the chemical urea fertilizer was divided into two batches, each batch of 5g

Fully matured acid lime fruits were manually harvested from trees, and the seeds were carefully extracted by cutting the fruits and squeezing out the seeds. The extracted seeds underwent thorough washing with clean water and were then spread out in a thin layer on a clean floor under shade for 2 to 3 days to dry. Once thoroughly dried, the seeds were used for sowing on raised nursery beds. Prior to sowing, the seeds were treated with Diathane M-45 at a rate of 3 grams per kilogram of seed and then shade dried for 2 hours. Black polyethylene bags, with a gauge of 100 microns and dimensions of 6×8 inches, were filled with a potting media mixture consisting of soil, sand, vermicompost, cocopeat, and farmyard manure in different proportions (1:1:1 v/v). Healthy seedlings with vigorous growth and uniform height were transplanted at 2 months, 3 months, and 4 months of age into the poly bags containing media with various combinations. Before transplanting, the seedling roots were washed under running water, and then dipped in a fungicidal solution (Diathane M-45 at a rate of 3 grams per liter of water) for 2 minutes as a preventive measure against soil-borne pathogens.

Results and Discussion

Table 2: Effect of Organic, Bio-fertilizers, and Chemical Fertilizers Combination on Grafted Lime Seedling Growth (cm) at 2 Month Olds

Treatments	60 DAT	90 DAT	120 DAT
T_1	3.11	7.00	9.17
T_2	3.60	8.17	10.45
T_3	3.91	8.60	10.80
T_4	4.30	8.80	11.00
T_5	4.72	11.13	13.23
T_6	5.42	8.83	10.93
T_7	4.30	9.83	11.93
T_8	5.55	10.16	12.26
C.D.	0.407	0.955	0.86
SE(m)	0.133	0.312	0.281
SE(d)	0.188	0.441	0.397
C.V.	5.272	5.956	4.335

The (Table 3 and Fig 1) presents the results of an experiment examining the effects of various combinations of organic, bio-fertilizers, and chemical fertilizers on the growth(cm) of grafted lime seedlings at 60, 90, and 120 days after transplanting (DAT). The treatments, labeled T_1(Control) through T_8, were evaluated for their impact on seedling growth over time. At 60 DAT, the seedlings exhibited varying levels of growth across the treatments, with T_1 (Control) showing the lowest growth at 3.11 and T_8 displaying the highest growth at 5.55. As the seedlings continued to develop, significant differences in growth were observed at 90 and 120 DAT. By 90 DAT, the seedlings in T_5 had experienced substantial growth, recording a height of 11.13, the highest among all treatments. This trend continued at 120 DAT, with T_5 exhibiting the highest growth at 13.23, indicating the positive impact of the specific fertilizer combination used in T_5 on seedling development. Overall, the results highlight the varying effects of different fertilizer combinations on grafted lime seedling growth over time. The data suggests that certain combinations, such as the one used in T_5, can significantly promote seedling growth.

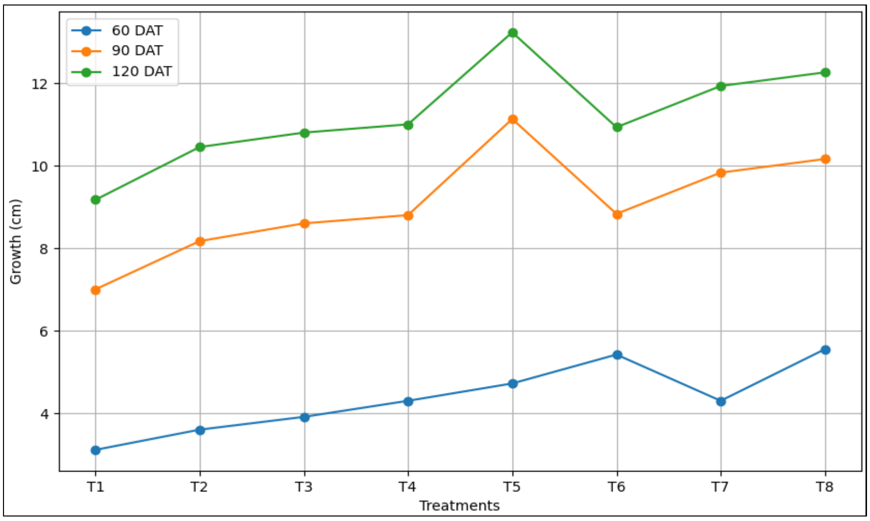

Fig 1: Effect of fertilizers on lime seeding growth at 2 months

Table 3: Effect of Organic, Bio-fertilizers, and Chemical Fertilizers Combination on Grafted Lime Seedling Growth (cm) at 3 Month Olds

Treatments	60 DAT	90 DAT	120 DAT
T_1	7.33	9.10	10.30
T_2	8.50	10.27	12.27
T_3	8.93	10.70	12.75
T_4	9.13	10.92	12.90
T_5	11.53	13.24	15.23
T_6	9.40	10.93	12.69
T_7	10.40	11.93	13.91
T_8	11.19	12.26	14.21
C.D.	0.853	1.83	1.692
SE(m)	0.279	0.598	0.553
SE(d)	0.394	0.845	0.781
C.V.	5.05	9.271	7.433

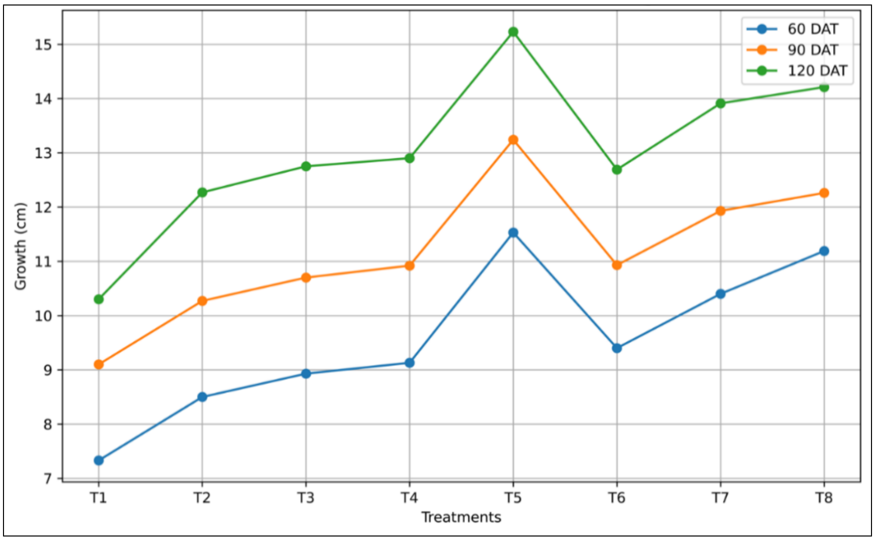

Fig 2: Effect of various fertilizers on Grafted Lime seeding growth

The experiment explored the influence of various combinations of organic, bio-fertilizers, and chemical fertilizers on the growth(cm) of grafted lime seedlings at 60, 90, and 120 days after transplanting (DAT) represented in (Table 4 and Fig. 3), specifically focusing on seedlings aged 3 months after transplanting. Treatments T_1 (Control) through T_8 were assessed for their effects on seedling growth over time. At 60 DAT, seedlings across treatments exhibited diverse growth patterns, with T_1 (Control) registering the lowest growth at 7.33 and T_5 showcasing the highest growth at 11.53. As the seedlings matured, notable differences in growth became apparent at 90 and 120 DAT. By 90 DAT, T_5 demonstrated significant growth, reaching 13.24 in height, the highest among all treatments. This trend persisted at 120 DAT, with T_5 recording the highest growth at 15.23, indicating the efficacy of the fertilizer combination employed in T_5 in promoting seedling development. The findings underscore the varied impacts of different fertilizer combinations on grafted lime seedling growth as they age. Notably, certain combinations, exemplified by T_5, show substantial potential in enhancing seedling growth. Similar findings were also reported by Patil (2013) [9] in papaya, Patil *et al.*, (2013) [9] in Rangpur lime seedlings, Kamble *et al.*, (2010) [5] in mango seedlings. These results are also supported with those of Mohdilyas *et al.*, (2015) [8] in Kinnow plants, Patil *et al.*, (2013) [9] in Rangpur lime seedlings and Aseri *et al.*, (2009) [2] in Aonla seedlings

Table 4: Impact of organic, bio-fertilizers, and chemical fertilizers combination on number of leaves in grafted lime seedlings at 2 months olds

Treatments	60 DAT	90 DAT	120 DAT
T_1	5.60	10.74	15.62
T_2	7.77	12.28	17.70
T_3	8.20	13.82	18.20
T_4	8.40	13.41	18.33
T_5	10.73	15.38	22.49
T_6	8.19	13.20	17.99
T_7	9.41	14.27	19.41
T_8	9.71	14.71	19.84
C.D.	1.138	1.137	1.887
SE(m)	0.371	0.371	0.616
SE(d)	0.525	0.525	0.871
C.V.	7.568	4.765	5.707

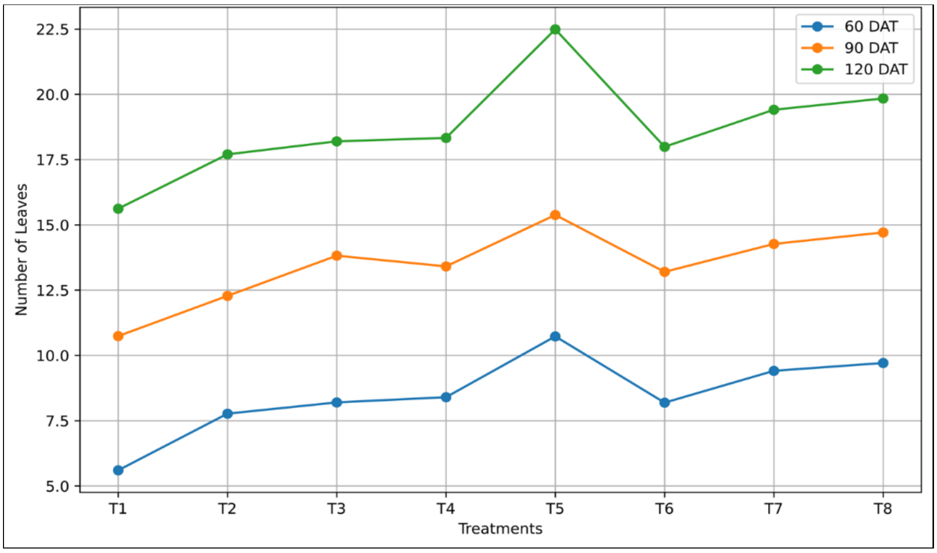

Fig 3: Impact of various fertilizers on number of leaves in grafted lime seeding

In this study, the effect of various combinations of organic, bio-fertilizers, and chemical fertilizers on the number of leaves in grafted lime seedlings was investigated at 60, 90, and 120 days after transplanting (DAT) when the seedlings were 2 months old. The treatments, denoted in (Table 4 and Fig. 3) as T_1 through T_8, were evaluated for their influence on leaf count over time. At 60 DAT, the seedlings displayed differing leaf counts across treatments, ranging from 5.60 leaves in T_1 (Control) to 10.73 leaves in T_5. As the seedlings progressed in age, notable variations in leaf count were observed at 90 and 120 DAT. By 90 DAT, T_5 exhibited the highest leaf count at 15.38, suggesting a positive impact of the fertilizer combination used in T_5 on leaf development. This trend continued at 120 DAT, with T_5 recording the highest leaf count at 22.49, indicating sustained growth enhancement over time. The findings underscore the diverse effects of different fertilizer combinations on the number of leaves in grafted lime seedlings. Specifically, certain combinations, exemplified by T_5, demonstrate significant potential in promoting leaf growth. These insights may inform the optimization of fertilizer strategies to enhance leaf development and overall seedling vigour, contributing to improved agricultural practices. Further research and experimentation could provide deeper insights into these dynamics, aiding in the refinement of cultivation techniques for grafted lime seedlings.

Table 5: Influence of organic, bio-fertilizers, and chemical fertilizers combination on number of leaves grafted lime seedling at 3 month olds

Treatments	60 DAT	90 DAT	120 DAT
T_1	9.11	14.10	17.83
T_2	11.25	17.27	21.07
T_3	11.35	17.70	21.50
T_4	11.55	17.90	21.70
T_5	13.88	20.39	24.19
T_6	11.34	17.69	21.48
T_7	12.56	18.57	22.37
T_8	12.86	18.97	22.77
C.D.	1.125	1.382	1.441
SE(m)	0.367	0.451	0.47
SE(d)	0.52	0.638	0.665
C.V.	5.422	4.386	3.77

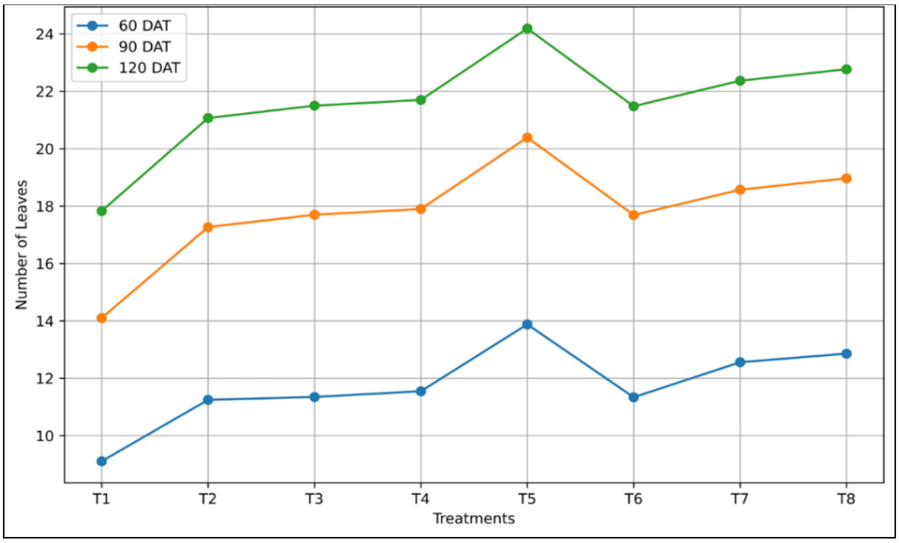

Fig 4: Influence of fertilizers on number of leaves in grafted lime Seeding's at 3 months

The impact of various combinations of organic, bio-fertilizers, and chemical fertilizers on the number of leaves in grafted lime seedlings aged 3 months represented in (Table 5 and Fig. 4). The treatments, T_1 (Control) through T_8, were compared to the control treatment (T_1) to evaluate their effectiveness in promoting leaf growth over time. At 60 days after transplanting (DAT), the seedlings exhibited diverse leaf counts across treatments, with T_1 serving as the control treatment at 9.11 leaves. Notably, T_5 showed the highest leaf count at 13.88. As the seedlings progressed in age, significant variations in leaf count were observed at 90 and 120 DAT. By 90 DAT, T_5 displayed the highest leaf count at 20.39, indicating substantial growth enhancement compared to the control treatment. This trend continued at 120 DAT, with T_5 recording the highest leaf count at 24.19, further highlighting its effectiveness in promoting leaf development compared to T_1.The findings underscore the positive effects of certain fertilizer combinations, such as the one used in T_5, in promoting leaf growth in grafted lime seedlings. These insights may aid in optimizing fertilizer strategies to enhance leaf development. These finding close conformity with those of Rakesh *et al.*, (2012) [10] in acid lime seedlings and Sharma (2009) [12] in citrus seedlings.

Conclusion

In conclusion, the optimal combination for promoting seeding height and leaf count in grafted lime seedlings cultivated in a poly house was determined to be a potting mixture comprising 100 grams of vermicompost and 50 grams of Mycorrhizae per seedling, supplemented with 10 grams of chemical urea fertilizer per seedling. This mixture was divided into two batches, with each batch containing 5 grams per bag. This balanced formulation yielded the best results in terms of both seedling height and leaf number, highlighting its efficacy in fostering healthy growth and development in the controlled environment of a poly house.

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