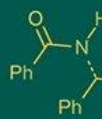


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Influence of leaf scrap amendments and humic acid seed priming on germination of acid lime (*Citrus aurantifolia* Swingle)

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Abstract

Acid lime (*Citrus aurantifolia* Swingle) is an economically important citrus fruit crop, but its commercial propagation is often constrained by slow and uneven seed germination during the nursery phase. The present investigation evaluated the combined effect of organic leaf scrap amendments and humic acid seed priming on the germination behaviour of acid lime. The experiment was conducted during 2024-2025 at the Fruit Research Station, Imaliya, Department of Horticulture, JNKVV, Jabalpur (M.P.), using a Randomised Block Design with thirteen treatments and three replications. Treatments consisted of soil amended with mango, sapota, or karonda leaf scrap (100 g or 200 g kg⁻¹ soil) along with seed soaking in humic acid solutions (1500 ppm and 2000 ppm). Observations were recorded for days to initial germination, days to 50% germination, and germination percentage. The results revealed significant differences among treatments. Seeds sown in soil amended with mango leaf scrap (100 g kg⁻¹ soil) and primed with humic acid at 2000 ppm recorded the earliest initiation of germination (11.00 days), minimum days to 50% germination (16.00 days), and the highest germination percentage (77.33%), compared to the control (19.00 days, 28.66 days, and 57.00%, respectively). The findings indicate that moderate incorporation of mango leaf scrap combined with higher humic acid concentration enhances germination efficiency in acid lime, offering a sustainable and cost-effective approach for improving nursery establishment.

Keywords: Acid lime, humic acid, leaf litter amendment, seed priming, germination behaviour, nursery media

1. Introduction

Acid lime (*Citrus aurantifolia* Swingle) is an economically important citrus crop widely cultivated in India for its high vitamin C content and year-round market demand. Successful orchard establishment depends largely on the availability of uniform and vigorous nursery seedlings; however, seed propagation of acid lime is often constrained by slow and irregular germination (Chadha, 2001; Hartmann *et al.*, 2011) [5, 9]. Suboptimal physical and biological properties of nursery growing media further aggravate this problem.

Incorporating organic amendments, such as leaf litter, can improve soil structure, moisture retention, and microbial activity, thereby creating a more favourable environment for seed germination. Leaf scraps from perennial fruit trees gradually decompose and contribute organic matter and nutrients to the growing medium (Swift *et al.*, 1979) [16]. In parallel, humic acid, a biologically active component of soil organic matter, has been reported to enhance seed germination by improving membrane permeability, water uptake, and early metabolic activity (Nardi *et al.*, 2002; Canellas *et al.*, 2002) [13, 4]. The present study was undertaken to evaluate the combined influence of different leaf scrap amendments and humic acid seed priming on the germination behaviour of acid lime, to identify an efficient and sustainable nursery practice.

2. Materials and Methods

2.1 Experimental Site and Duration

The experiment was conducted during the 2024-2025 season at the Fruit Research Station, Imaliya, Department of Horticulture, Jawaharlal Nehru Krishi Vishwa Vidyalaya (JNKVV),

Jabalpur, Madhya Pradesh. The region falls under a subtropical climatic zone.

2.2 Experimental Design and Treatments

The experiment was laid out in a Randomized Block Design (RBD) with thirteen treatments and three replications. Seeds of acid lime were subjected to different combinations of potting soil amendments and humic acid seed priming.

Treatments consisted of:

- Control: soil alone without humic acid
- Soil amended with mango, sapota, or karonda leaf scrap at 100 g or 200 g per kg of soil
- Seed soaking in humic acid solutions at 1500 ppm or 2000 ppm for 24 hours prior to sowing

2.3 Preparation of Media and Seed Treatment

Leaf scraps were air-dried, crushed, and incorporated thoroughly into the soil as per treatment specifications. Seeds were surface sterilised and soaked in the respective humic acid solutions for 24 hours, while control seeds were soaked in distilled water.

2.4 Observations Recorded

The following germination parameters were recorded:

- **Days to initial germination:** Number of days taken for the emergence of the first seedling
- **Days to 50% germination:** Number of days required for 50% of seeds to germinate
- **Germination percentage:** Calculated at 30 days after sowing (DAS)

2.5 Statistical Analysis

The recorded data were subjected to analysis of variance (ANOVA) as per the procedure described by Gomez and Gomez (1984) [6]. Treatment means were compared at the 5% level of significance.

3. Results and Discussion

3.1 Days to first germination

Leaf scrap and humic acid treatments significantly influenced the time taken for initial seedling emergence (Table 1; Fig. 1). The earliest germination (11.00 DAS) was recorded in Soil + mango leaf scrap 100 g + humic acid 2000 ppm (T₃), which was statistically comparable with Soil + sapota leaf scrap 100 g + humic acid 1500 ppm (T₆: 12.33

DAS), Soil + sapota leaf scrap 200 g + humic acid 2000 ppm (T₉: 12.33 DAS), and Soil + sapota leaf scrap 200 g + humic acid 1500 ppm (T₈: 13.33 DAS). The maximum delay in germination was observed in the control (T₁: 19.00 DAS). The enhanced early emergence under T₃ may be attributed to the biostimulant effect of humic acid on enzymatic hydrolysis of seed reserves and improved cell membrane permeability, which accelerates water uptake and metabolic processes [Nardi *et al.*, 2002] [13]. Similar reductions in days to germination due to humic substances have been reported in tomato and maize, supporting the present findings [Ampong *et al.*, 2022] [11].

3.2 Days to 50% germination

Significant differences among treatments were also observed for days taken to attain 50% germination (Table 1). Treatment T₃ recorded the minimum number of days (16.00 DAS), followed by T₆ (17.36 DAS) and T₉ (19.51 DAS), whereas the control (T₁) required the maximum time (28.66 DAS) to reach 50% germination. Faster achievement of 50% germination under T₃ indicates better synchronisation and uniformity of seedling emergence, which is desirable for nursery management and subsequent cultural operations. Improved germination performance in enriched organic substrates has also been reported for acid lime, suggesting that organic-humic amendments create a more favourable microenvironment for seed germination [Nainar and Muthulakshmi, 2021] [12].

3.3 Germination percentage

Germination percentage at 30 DAS varied significantly among treatments (Table 1). The highest germination percentage (77.33%) was recorded in T₃, which was significantly superior to all other treatments. Sapota-based treatments also showed comparatively higher germination, particularly T₆ (65.33%), while the lowest value (56.00%) was observed in T₄. The superior performance of T₃ can be attributed to enhanced soil microbial activity, improved nutrient release from decomposing mango leaf scrap, and the synergistic hormonal effects of humic acid on early seedling development. Previous work has highlighted the positive influence of decomposed leaf litter on soil fertility and germination in plantation crops, supporting the role of organic residues in improving germination [Guruprasad, 1992] [7] [Harishma, 2017] [8].

Table 1: Effect of leaf scrap and humic acid on Days to first germination, Days to 50% germination and germination percentage

Treatment	Days to first germination	Days to 50% germination	Germination percentage
T ₁ -Control	19.0	28.66	57.0
T ₂ -Soil + Mango leaf scrap 100 g + humic acid 1500 ppm	17.0	26.37	58.67
T ₃ -Soil + Mango leaf scrap 100 g + humic acid 2000 ppm	11.0	16.0	77.33
T ₄ -Soil + Mango leaf scrap 200 g + humic acid 1500 ppm	15.67	27.7	56.0
T ₅ -Soil + Mango leaf scrap 200 g + humic acid 2000 ppm	14.33	21.6	59.0
T ₆ -Soil + Sapota leaf scrap 100 g + humic acid 1500 ppm	12.33	17.36	65.33
T ₇ -Soil + Sapota leaf scrap 100 g + humic acid 2000 ppm	15.67	24.51	58.67
T ₈ -Soil + Sapota leaf scrap 200 g + humic acid 1500 ppm	13.33	23.41	56.33
T ₉ -Soil + Sapota leaf scrap 200 g + humic acid 2000 ppm	12.33	19.51	63.33
T ₁₀ -Soil + Karonda leaf scrap 100 g + humic acid 1500 ppm	16.67	25.07	57.33
T ₁₁ -Soil + Karonda leaf scrap 100 g + humic acid 2000 ppm	17.0	21.39	58.0
T ₁₂ -Soil + Karonda leaf scrap 200 g + humic acid 1500 ppm	16.1	23.93	59.33
T ₁₃ -Soil + Karonda leaf scrap 200 g + humic acid 2000 ppm	16.0	21.07	61.67
SEM±	0.98	1.60	1.05
CD @ 5%	2.86	4.66	3.07
CV	11.23	12.11	3.01

3.4 Seedling vigour indices

Seedling vigour index I and II exhibited marked enhancement under treatments involving the combined application of leaf scrap and humic acid (Table 2). The maximum values for SVI I (2931.85) and SVI II (19096.23) were obtained in T₃, which were significantly higher than all other treatments; in contrast, the lowest vigour indices were recorded in the control (SVI I: 615.57; SVI II: 2399.40). Improved seedling vigour under T₃ is likely due to enhanced root growth, better nutrient and water uptake, and increased antioxidant activity induced by humic substances, which collectively promote more robust seedling growth [Ampong *et al.*, 2022] ^[1]. Similar positive effects of humic acid on seedling vigour have been documented in cereals and horticultural crops, emphasising its broad agronomic utility [Bag *et al.*, 2020] ^[2].

3.5 Survival percentage

Survival percentage at 150 DAS also differed significantly among treatments (Table 2). The highest survival (81.00%) was observed in T₃, followed by sapota-based treatments T₆ and T₉ (73.00%), while the control (T₁) recorded the lowest survival (58.33%). The higher survival under T₃ reflects the cumulative positive effects of improved vigour indices, better root-shoot balance, and enhanced stress tolerance, which enable seedlings to withstand environmental fluctuations. The results are in agreement with observations that organic-humic amendments improve seedling resilience and survival in nursery crops by improving physical, chemical, and biological properties of the growth medium [Prisa and Caro, 2023] ^[4].

Table 2: Effect of leaf scrap and humic acid on seedling vigour index I, seedling vigour index II and survival percentage

Treatment	SVI I	SVI II	Survival%
T ₁ -Control	615.57	2399.4	58.33
T ₂ -Soil + Mango leaf scrap 100 g + humic acid 1500 ppm	1899.09	7609.63	65.33
T ₃ -Soil + Mango leaf scrap 100 g + humic acid 2000 ppm	2931.85	19096.23	81.0
T ₄ -Soil + Mango leaf scrap 200 g + humic acid 1500 ppm	779.44	3861.93	64.67
T ₅ -Soil + Mango leaf scrap 200 g + humic acid 2000 ppm	777.58	4074.93	64.33
T ₆ -Soil + Sapota leaf scrap 100 g + humic acid 1500 ppm	1499.17	11431.93	73.0
T ₇ -Soil + Sapota leaf scrap 100 g + humic acid 2000 ppm	1182.37	4455.19	64.33
T ₈ -Soil + Sapota leaf scrap 200 g + humic acid 1500 ppm	752.7	6775.11	68.33
T ₉ -Soil + Sapota leaf scrap 200 g + humic acid 2000 ppm	1172.14	9295.36	73.0
T ₁₀ -Soil + Karonda leaf scrap 100 g + humic acid 1500 ppm	863.53	4353.91	65.33
T ₁₁ -Soil + Karonda leaf scrap 100 g + humic acid 2000 ppm	771.84	7249.0	64.67
T ₁₂ -Soil + Karonda leaf scrap 200 g + humic acid 1500 ppm	783.64	4333.91	66.67
T ₁₃ -Soil + Karonda leaf scrap 200 g + humic acid 2000 ppm	1011.6	6382.93	68.0
SEM±	50.68	47.04	2.96
CD @ 5%	147.91	137.30	8.65
CV	7.59	1.16	7.61

Conclusion

The study clearly indicated that the combined application of leaf scrap and humic acid significantly influences seed germination and seedling establishment of acid lime under nursery conditions. Among the tested treatments, Soil + mango leaf scrap 100 g + humic acid 2000 ppm (T₃) consistently outperformed other combinations by recording the earliest germination, shortest time to 50% germination, highest germination percentage, superior seedling vigour indices, and maximum survival percentage. These findings confirm the synergistic benefits of mango leaf scrap as an organic substrate and humic acid as a bio-stimulant in promoting early and vigorous growth of acid lime seedlings, and suggest that T₃ can be recommended as a practical and cost-effective nursery technology for improving the efficiency of acid lime propagation.

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