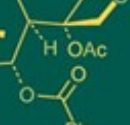
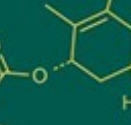
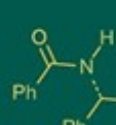


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Effect of different seed treatments on germination, seedling vigour and survival of Acid lime (*Citrus aurantifolia* Swingle) cv. Kagzi lime

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ABSTRACT

An investigation was carried out during the year 2025-26 at Pt. K.L.S. College of Horticulture and Research Station, Rajnandgaon, Chhattisgarh, to evaluate the effect of different seed treatments on germination, seedling vigour and survival of Acid lime (*Citrus aurantifolia* Swingle) cv. Kagzi lime. The experiment was laid out in a Completely Randomized Design with 13 treatments replicated thrice. The treatments comprising different concentrations of GA₃, Thiourea, KNO₃, Salicylic acid, Cow urine and Cow dung. Significant variations were observed among treatments for all germination indices, seedling vigour and survival parameters. GA₃ @ 200 ppm consistently outperformed other treatments, taking minimum days (20.40 days) to germinate and 23.20 days for 50% germination, along with the highest germination percentage (90.60%). It also recorded maximum seedling vigour index-I (4183.91), seedling vigour index-II (1253.90) and highest seedling survival percentage (87.43). Whereas, the untreated control exhibited delayed germination in 30.32 and 37.50 days, respectively and recorded lowest germination percentage (60.20). The results demonstrate that GA₃ @ 200 ppm is highly effective for improving germination and survival of Acid lime.

Keywords: Acid lime, seedling vigour index, germination, survival percentage, GA₃, salicylic acid, KNO₃, thiourea etc.

Introduction

Citrus is the third largest fruit industry in India, which ranks sixth globally in citrus production. The group includes mandarins, oranges, lemons, limes, grapefruits and hybrids, and the North Eastern Region is a major centre of origin and diversity (Ghosh, 2007) [2]. Citrus fruits are valued for flavour, colour and high vitamin-C content, and serve both as commercial crops and rootstocks. Seed propagation is widely adopted due to polyembryony, ensuring true-to-type and vigorous seedlings (Khatana et al., 2015) [6]. However, germination is slow and irregular (27–58%) with high early mortality due to seed-coat barriers and inhibitors (Jaiswal et al., 2018) [5]. Pre-sowing treatments can overcome these limitations: GA₃ enhances enzymatic mobilisation of reserves (Panda et al., 2018) [11], KNO₃ releases dormancy and improves seedling growth, and thiourea also breaks dormancy. Such treatments significantly improve germination, seedling vigour and stress tolerance in citrus (Krishnaveni et al., 2010) [7]. Salicylic acid (SA), a phenolic compound functioning as an endogenous growth regulator, has been demonstrated to mitigate oxidative stress and enhance seed germination under adverse conditions (Hernandez et al., 2017 and Mir et al., 2021) [3&10]. Cow urine contains bioactive compounds such as urea, uric acid, hormones and micronutrients, which stimulate physiological processes, improving seedling growth and vigour (Raj Joshi et al., 2019) [13]. Cow dung slurry, rich in microbial flora and growth-promoting substances like auxins, supplies essential nutrients (N, P, K) and improves seed coat permeability, thereby promoting better germination and root development (Raj et al., 2014) [14].

Materials and Methods

The investigation was carried out during the year 2025-26 at Pt. K.L.S. College of Horticulture and Research Station, Rajnandgaon (C.G.) The experiment was laid out in a Completely Randomized Design with 13 treatments replicated thrice. The treatments comprising different concentrations of GA₃, Thiourea, KNO₃, Salicylic acid, Cow urine and Cow dung, along with a control are T₀ – Control, T₁ – GA₃ @ 100 ppm, T₂ – GA₃ @ 200 ppm, T₃ – Thiourea @ 0.5%, T₄ – Thiourea @ 1%, T₅ – KNO₃ @ 2%, T₆ – KNO₃ @ 3%, T₇ – Salicylic acid @ 100 ppm, T₈ – Salicylic acid @ 200 ppm, T₉ – Cow urine @ 5%, T₁₀ – Cow urine @ 10%, T₁₁ – Cow dung @ 50 g L⁻¹ and T₁₂ – Cow dung @ 100 g L⁻¹. A potting mixture of soil, sand and FYM (1:1:1) was filled uniformly into perforated 6" × 12" polythene bags. Working solutions of GA₃, thiourea, KNO₃, salicylic acid, cow urine and cow dung were prepared as per standard procedures and uniform seeds

were soaked for 12 hours in their respective solutions, while control seeds were soaked in distilled water. Treated seeds were sown and the bags were arranged according to the layout. Uniform cultural practices— including irrigation, weeding, insecticidal sprays for caterpillar and leaf miner were followed throughout. Observations were recorded at regular intervals on germination parameters, viz. days taken to 1st seed germination, days taken to 50 percent germination, germination percentage and survival percentage. Seedling vigour indices (SVI-I and SVI-II) were computed as per standard procedures and the data were statistically analysed to determine significant differences among treatments.

Result and Discussion

Days taken to 1st seed germination

The data regarding days taken to 1st seed germination is presented in Table 1. Minimum days taken to 1st seed germination was recorded under treatment T_2 (20.40) with GA_3 @ 200 ppm. The maximum days taken for initiation of germination was observed in treatment T_0 (30.32) with (control). The superiority of GA_3 @ 200 ppm in promoting early germination might be due to its role in enhancing hydrolytic enzyme activity, facilitating rapid mobilization of food reserves and promoting early radicle emergence. These findings align with earlier reports by Jadhav *et al.*, (2019) [4] in rangpur lime, Yadav *et al.*, (2020) [17] in rangpur lime.

Days taken to 50% seed germination

A significant variation was observed among the treatments for days required for 50% germination. The earliest 50% germination was recorded in T_2 (GA_3 @ 200 ppm) with 23.20 days, which was followed by T_1 (25.06 days). The maximum number of days for 50% germination (37.50 days) was observed in the control (T_0 – control), clearly indicating delayed germination in untreated seeds. The enhanced response of GA_3 , particularly at 200 ppm, might be associated with its role in stimulating hydrolytic enzyme activity, ensuring faster mobilization of stored reserves and promoting early radicle emergence. Similar results were reported by Yadav *et al.* (2020) [17] in rangpur lime and Aishwarya and Bahadur (2024) [1] in acid lime, supporting the superiority of GA_3 treatments for early germination.

Germination percentage

A significant influence of treatments on germination percentage was recorded under the different treatments. The highest germination (90.60%) was occurred in T_2 (GA_3 @ 200 ppm), which was statistically at par with T_1 (GA_3 @ 100 ppm) registering 87.21% germination. The minimum germination percentage (60.20%) was observed in the control (T_0 – control). The superior germination in GA_3 -treated seeds may be due to enhanced hydrolytic enzyme activity, especially α -amylase, which ensures rapid mobilization of stored carbohydrates and supports early embryo growth. Similar promotive effects of GA_3 on germination percentage have been reported by Patel *et al.* (2024) [12] in wood apple and Kumar *et al.* (2025) [9] in papaya.

Table 1. Effect of different seed treatments on days taken to 1st seed germination, 50 percent germination and germination percentage of Acid lime (*Citrus aurantifolia* Swingle) cv. Kagzi lime

Treatments	Days taken to 1st seed germination	Days taken to 50 percent seed germination	Germination percentage
T_0 -Control	30.32i	37.50k	60.20g
T_1 - GA_3 @ 100 ppm	22.74b	25.06b	87.21a
T_2 - GA_3 @ 200 ppm	20.40a	23.20a	90.60a
T_3 -Thiourea @ 0.5%	27.10e	32.72ef	71.11de
T_4 -Thiourea @ 1%	26.12d	31.90de	73.23cd
T_5 - KNO_3 @ 2%	25.27d	31.10cd	76.11c
T_6 - KNO_3 @ 3%	24.18c	30.15c	80.43b
T_7 -Salicylic acid @ 100 ppm	27.93ef	34.11g	69.31de
T_8 - Salicylic acid @ 200 ppm	27.34ef	33.75fg	70.75de
T_9 -Cow urine @ 5%	28.92gh	35.43hi	67.23ef
T_{10} -Cow urine @ 10%	28.13fg	34.90gh	68.11ef
T_{11} -Cow dung @ 50 gm L-1	29.40h	36.89jk	64.21f
T_{12} -Cow dung @100 gm L-1	29.10h	36.12ij	65.12f
SE(m) $\pm$	0.30	0.42	1.35
SE(d)	0.42	0.59	1.91
C.D.@ 5%	0.88	1.23	3.96
C.V	1.96	2.25	3.23

*The superscript letter indicates that the treatment means with same letters are at par at 5% level of significance, while the means with different letters are significantly different at 5% level of significance. These letters have been affixed based on CD-value comparison of treatment means.

Seedling vigour index-I

Seedling vigour index-I varied significantly among the treatments. The maximum seedling vigour index-I (4183.91 cm) was recorded under the treatment T_2 – GA_3 @ 200 ppm, which was significantly followed by T_1 – GA_3 @ 100 ppm (3650.61 cm) and T_6 – KNO_3 @ 3% (3183.22 cm). However, the minimum seedling vigour index-I (1424.93 cm) was recorded under T_0 – control. The marked improvement under GA_3 treatments, indicates its positive role in enhancing physiological vigour through accelerated enzymatic activity, efficient

mobilization of stored reserves and rapid elongation of root and shoot during germination. Similar results were also reported by Solanki *et al.* (2018) [16] in papaya.

Seedling vigour index-II

The highest value of seedling vigour index-II (1253.90 g) was obtained under the treatment T_2 – GA_3 @ 200 ppm, which was significantly followed by T_1 – GA_3 @ 100 ppm (1100.59) at 5% level of significance. However, the minimum seedling vigour index-II (447.29 g) was recorded under T_0 – control. Overall, seeds treated with GA_3 exhibited

markedly higher seedling vigour index-II, reflecting enhanced physiological strength and improved seedling establishment. The promotive effect of GA₃ may be attributed to its ability to activate hydrolytic enzymes, improve reserve mobilization and facilitate cell elongation and division during early seedling development. These results corroborate earlier findings by Shivare *et al.* (2023) [15] in acid lime, who also reported significant improvement in vigour with GA₃ application.

Survival percentage

The maximum survival percentage (87.43) was obtained the treatment T₂- GA₃ @ 200 ppm, which was superior over all other treatments and significantly followed by treatment T₁ - GA₃ @ 100 ppm

(83.29%) and T₆ - KNO₃ @ 3% (78.33%) at 5% level of significance. However, the minimum survival percentage (49.26) was recorded under T₀- control. The maximum survival percentage was observed under GA₃ treated seeds, which might be due to its role in stimulating early germination, rapid reserve mobilization, and vigorous root-shoot development that help seedlings establish more efficiently and withstand environmental stress. Similar findings were also reported by Yadav *et al.* (2018) [18] in Papaya and Kumar *et al.* (2024) [8] in Dragon fruit seedlings.

Table 2. Effect of different seed treatments on seedling vigour index-I, seedling vigour index- II and survival of Acid lime (*Citrus aurantifolia* Swingle) cv. Kagzi lime

Treatments	Seedling vigour index-I	Seedling vigour index-II	Survival percentage
T ₀ -Control	1424.93k	447.29j	49.26k
T ₁ -GA ₃ @ 100 ppm	3650.61b	1100.59b	83.29b
T ₂ -GA ₃ @ 200 ppm	4183.91a	1253.90a	87.43a
T ₃ -Thiourea @ 0.5%	2468.46f	735.28e	69.25ef
T ₄ -Thiourea @ 1%	2682.41e	787.22e	71.91de
T ₅ -KNO ₃ @ 2%	2867.46d	859.04d	73.16d
T ₆ -KNO ₃ @ 3%	3183.22c	956.31c	78.33c
T ₇ -Salicylic acid @ 100 ppm	2281.49g	679.94f	65.42gh
T ₈ - Salicylic acid @ 200 ppm	2430.97g	715.28f	67.89fg
T ₉ -Cow urine @ 5%	1970.72hi	605.14gh	61.27ij
T ₁₀ -Cow urine @ 10%	2034.13h	642.96fg	62.85hi
T ₁₁ -Cow dung @ 50 gm L-1	1754.22j	536.15i	58.92j
T ₁₂ -Cow dung @100 gm L-1	1848.11ij	568.50hi	60.46ij
SE(m) ±	58.592	17.947	1.17
SE(d)	82.861	25.381	1.66
C.D.@ 5%	171.26	52.46	3.44
C.V	4.027	4.087	2.98

*The superscript letter indicates that the treatment means with same letters are at par at 5% level of significance, while the means with different letters are significantly different at 5% level of significance. These letters have been affixed based on CD-value comparison of treatment means.

Conclusion

It can be inferred from the present investigation that different seed treatments had a clear influence on the germination, seedling vigour and survival of acid lime (*Citrus aurantifolia* Swingle) cv. Kagzi lime. Among all treatments, GA₃ @ 200 ppm proved most effective, consistently promoting germination, superior seedling vigour and better survival. Overall, GA₃ @ 200 ppm was found suitable for achieving healthy, vigorous and uniform seedling establishment in acid lime

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