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REGULAR ARTICLE

Influence of Gibberellic acid (GA_3) on seed germination and seedling growth of Kagzi Lime

W. S. Dilip[1], D. Singh[1], D. Moharana[1], S. Rout[2] and S. S. Patra[3*]

[1]Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture Technology & Sciences, Allahabad-211007, Uttar Pradesh, India.

[2]College of Forestry, Sam Higginbottom University of Agriculture Technology & Sciences, Allahabad-211007, Uttar Pradesh, India.

[3]Department of Meteorology & Oceanography, Andhra University, Visakhapatnam-530003, Andhra Pradesh, India.

Abstract

A study was conducted to estimate the influence of gibberellic acid (GA_3) at different concentrations in different time intervals on seed germination and seedling growth of kagzi lime. The results revealed that Maximum germination percentage (95%) was recorded under treatment with GA_3 80 ppm for 12 hours, rate of germination of seeds (25 days), height of plant (18.79 cm) at 120 DAS, number of leaves per plant (26.53), fresh and dry weight of shoot (25.84 g and 14.44 g), tap root (17.44 cm), secondary and fibrous roots (5.98 and 85.99), fresh as well as dry weight (7.04 and 4.95 g), survival percentage (85 percent) in similar treatment. Therefore, it may be concluded that the GA_3 at 80 ppm has a significant effect on the seed germination and seedling growth of Kagzi Lime and can be recommended to the grower for obtaining better growth and yield.

Key words: Germination, gibberellic acid, plant, roots

Introduction

Citrus is one among the most utilized fruits cultivating in tropical and sub-tropical regions. Citrus can be used for fresh as well as canned juice preparations. Genus citrus is unique in its diversity of forms and no other fruit a parallel to it. Citrus fruit possesses greater adoptability to different climatic conditions. Throughout the world, citrus is cultivated in different regions having different soil and climatic conditions [1].

Globally citrus is grown in 114 countries. The world citrus is dominated by sweet range with 71 percent contribution followed by mandarin 13 per cent, lime and lemon 10 percent and grape fruits and other species 6 percent. India is the sixth largest producer of citrus in the world contributing 4.8 per cent share in production. In India, citrus is grown in 26 states out of which 10 states cover more than 50 per cent of the area and 88 per cent of total country's production. Citrus comes third important fruit, after banana and mango in India, with a production of 3.80 million tonnes.

Kagzi lime (*Citrus aurantifolia* Swingle) is commercially propagated through seeds in India as it comes true to type, because of high

*Corresponding Author

S. S. Patra

Department of Meteorology & Oceanography, Andhra University, Visakhapatnam-530003, Andhra Pradesh, India

Email: mailsspatra@rediffmail.com

degree (39-60 per cent) of nucellar embryony. The resultant seedlings are known to be free from tristiza virus and thus perform better. In kagzi lime polyembryonic is 98 per cent and mostly two seedlings are generally obtained from the single seed [2]. They reported that the overall performance of Kagzi lime seedlings is better over budded plants.

In seed propagated plants better and quicker germination of seeds and production of the maximum number of the seedling is highly essential to meet the increasing demand of the cultivators in shortest possible time. But in Kagzi lime germination percentage is low and it varies between 27 to 58 per cent [3]. Kagzi lime takes about 3 weeks to germinate. The most serious problem in Kagzi lime propagation is heavy mortality with the seedlings in primary nursery stage [4]. The seed coat of lime acts as a barrier because it interferes with early germination of seed due to the presence of certain inhibitory substance. The growth of acid lime seedling is very slow in the nursery as well as in the field. In fact, many complaints from cultivators for the slow growth of seedling under field conditions are being reported [5].

It is highly essential to accelerate the seed germination and growth rate of citrus seedling by treating with growth substances to attain buddable size earlier, such forcing of growth may ultimately reduce the cost in raising budded citrus plants. In view of the above specific problems of Kagazi lime, the present experiment was carried out to study the effect of Gibberellic acid (GA_3) of different concentrations at different time intervals on seed germination and seedling growth of Kagazi lime.

Materials and methods

This investigation was carried out at Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture Technology & Sciences, Allahabad. Uniform sized, fully matured and true to type fruits were collected from Kagazi lime trees. The seed collection and germination were done as explained previously [15]. The experiment was laid in RBD with 3 replicates. The treatments were in seven sets, out of which 3 different concentrations of GA3 for 3 different durations (40ppm for 06 hrs, 40ppm for 12 hrs, 60ppm for 06hrs, 60ppm for 12hr, 80ppm for 06 hrs and 80ppm for 12 hrs) and distilled water as control.

Rate and percentage of seed germination

The Germination count was taken 15 days after sowing at an interval of five days. The seeds germinated were counted till completion of germination and the rate and percentage of seed germination were calculated. Physical Parameters of Growth of plant were recorded of five representative plants, height of Plant (cm) from 30 DAS (Days after sowing) up to 120 DAS at 15 days interval, Number of Leaves from 30 DAS to 120 DAS at 15 days interval, Fresh and dry weight of shoot (g) at 120 days, length of tap (Primary) root (cm), number of secondary (lateral) roots, number of fibrous roots, fresh and dry weight of root (g) at 120 DAS.

Statistical analysis

The data recorded during the course of the investigation were subjected to statistical analysis as per the method of analysis of variance [6].

Results and discussion

Data obtained in the present investigation in respect of seed germination, vegetative growth and root development of Kagazi lime were analyzed statistically

Seed germination percentage

Data presented in Table 1 in respect of seed germination percentage in Kagzi lime revealed that different concentrations of Gibberellic acid had significant effect for increasing the seed germination percentage over control. Highest germination percentage (95.00 per cent) was obtained in the treatment GA_3 80 ppm for 12 hours, which was significantly superior over control and rest of the treatments under investigation. It was followed by the treatment T_4 (85.00 per cent). The treatment T_5 and T_3 were statistically at par with each other and significant over the treatments T_2, T_1 and T_7. The treatments T_3, T_2 and T_1 were also statistically at par with each other and significant over the treatment control T_7. The promotive effect of GA_3 on seed germination might be due to its participation in the activity of alpha-amylase which catalyses the starch conversion into simple carbohydrates and chemical energy is liberated which is used in the activation of embryo. Similar results were reported by Choudhari and Chakrawar [7] in Kagzi lime. All the treatments of GA_3 significantly increase the percentage of seed germination from 65 to 75 per cent in case of Kagzi lime respectively over

control. The effectiveness of GA_3 might be due to stimulation of ethylene production as suggested by Singh *et al.* [8].

Table 1. Effect of seed treatment with Gibberellic acid on seed germination percentage with Kagzi lime.

Treatments	Seed Germination percentage (For Kagzi lime)
T_1 GA_3@40ppm for 6 hrs	65
T_2 GA_3@40ppm for 12 hrs	70
T_3 GA_3@60ppm for 6 hrs	75
T_4 GA_3@60ppm for 12 hrs	85
T_5GA_3@80PPM for 6 hrs	80
T_6 GA_3@80ppm for 12 hrs	95
T_7 Control	45

As regards the influence of GA_3 significant results were obtained for seed germination percentage in present study in both species. Significantly more germination percentage i.e. 50 to 60 per cent was observed in Kagzi lime respectively over control. The effectiveness of GA_3 might be due to phytochrome activity which improved membrane permeability facilitating movement which subsequently initiates germination. As regard the influence of GA_3, Negi (1970) [9] reported increased seed germination in strawberry. Similar results are obtained in present study. The results are in agreement with the finding of Rout *et al.* [10] in *Delonix regia*.

Rate of seed germination

The perusal of data presented in Table 2 with regard to rate of seed germination in Kagzi lime respectively clearly indicated that there were significant differences in different concentrations of GA_3 at different hours. The progressive increase was observed in the rate of seed germination up to 30 DAS.

Data presented in Table 2 clearly indicated that rate of seed germination in Kagzi lime seeds. Significantly more germination percentage (95.00 percent) was observed in the treatment GA_3 80ppm for 12 hours (T_6) and completed germination in less number of days (25 days). Less rate of seed germination (45.00 percent) was recorded in control (T_7) and required more number of days (25 days) for completion of germination. The seeds treated with GA_3 at 40 and 60 ppm (for 6 hours and 12 hours), concentrations took 30 days for completion of their germination. The accelerated and enhanced germination in Kagzi lime under GA_3 might be due to increased enzyme activities and better supply of nutrients. The property of GA_3 to induce better and quicker germination has been already reported by Singh *et al.* [8].

Morphological parameters

Height of plant (cm)

The average height of the plant as influenced by the different plant growth regulator was recorded periodically at 30, 45, 75, 90, 105 and 120 DAS of Kagzi lime and are presented in Table 3 respectively. Data presented in Table 3 of Kagzi lime clearly indicated that there was increase in the height of the plant due to seed treatment with Gibberellic acid with different concentrations at different hours.

Table 2. Rate of seed germination of Kagzi lime as influenced by seed treatment with Gibberellic acid.

Treatment	Number of seed germination for Kagazi lime					
	15 DAS	20 DAS	25 DAS	30 DAS	35 DAS	40 DAS
T_1 GA_3@ 40ppm for 6hrs	1.67	6.00	9.67	13.00	13.00	13.00
T_2 GA_3@40ppm for 12 hrs	2.00	10.00	12.00	14.00	14.00	14.00
T_3GA_3@60ppm for 6hrs	3.00	11.00	13.00	15.00	15.00	15.00
T_4 GA_3@60ppm for 12 hrs	3.67	13.00	16.00	17.00	17.00	17.00
T_5 GA_3@80ppm for 6 hrs	3.33	12.00	14.00	16.00	16.00	16.00
T_6 GA_3@80ppm for 12 hrs	4.00	16.00	18.67	19.00	19.00	19.00
T_7 Control	0.00	0.00	3.00	8.00	9.00	9.00
F-test	S	S	S	S	S	S
S.Ed(±)	0.56	0.89	6.93	0.79	0.87	0.87
C.D at (5%)	1.22	1.94	4.82	1.74	1.90	1.90

After 30 days of sowing, maximum plant height was obtained under the treatment GA_3 80 ppm for 12 hours T_6 (2.41 cm), followed by the treatment T_4 (2.21 cm), T_5 (2.18 cm) and T_3 (2.11 cm), which were significantly superior over rest of the treatments and statistically at par with each other. Significantly minimum plant height was obtained under treatment control (1.03 cm).

At 45 days of sowing, highest plant height (4.81 cm) was recorded in the treatment GA_3 80 ppm for 12 hours (T_6), which was significantly superior over control and remaining treatment under study. The treatments T_4, T_5, T_3,T_2, and T_1 were found to be statistically similar to each other. Lowest plant height was observed in the treatment control T_7 (2.89 cm). After 60 DAS, maximum plant height (5.82 cm) was observed under the treatment GA_3 80 ppm for 12 hours (T_6) which was significantly superior over rest of the treatments under study. The minimum plant height was recorded in the treatment control T_7 (3.70 cm).

At 75 days of sowing, significantly highest plant height (10.83 cm) was produced in the treatment GA_3 80 ppm for 12 hours (T_6) over control and rest of the treatment under investigation. The treatments T_4, T_5 and T_3 were found to be statistically at par with each other and significantly superior over rest of the treatments. The remaining treatment showed intermediate effect in producing plant height. Significantly lowest plant height (4.61 cm) was observed in the treatment control (T_7).

After 90 days of sowing, significantly more plant height (12.32 cm) was recorded in the treatment GA_3 80 ppm for 12 hours (T_6) over all other treatment under study, followed by the treatment T_4 (11.44 cm) and being statistically at par with the treatment T_5, the remaining treatments showed intermediate effect on plant height. Significantly less plant height (5.39 cm) was recorded in the treatment control (T_7).

At 105 days after sowing, GA_3 80 ppm for 12 hours produced significantly maximum plant height (15.79 cm) over control and all other treatments under investigation. The treatments T_4, T_5, T_3, T_2 and T_1 were statistically at par with each other. Rest of the treatment showed intermediate effect on plant height. Control recorded significantly minimum plant height (8.11 cm).

At the final stage of the observation i.e. 120 days after sowing, more plant height (18.79 cm) was observed in the treatment GA_3 80 ppm for 12 hours, which was significantly superior over control and rest of the treatment under study. The treatment T_4 (16.14 cm), T_5 (15.41 cm) and T_3 (15.23 cm) were the next best treatment and being statistically at par. The remaining treatments produced intermediate effect on plant height except T_1 treatment. Significantly less plant height (9.75 cm) was produced under the treatment control (T_7). The results of present investigation in respect of plant height clearly revealed that seed treatment with Gibberellic acid with different concentrations at different hours increased the plant height at all stages of growth from 30 DAS to 120 DAS in Kagzi lime (Table 3). Results obtained in present study are also supported by Rout *et al.* [10] in *Delonix regia* and Sharma *et al.* [11] in Kagzi lime.

Table 3. Height (cm) of seedling of Kagzi lime as affected by seed treatments with Gibberellic acid.

Treatment	Height of seeding for Kagzi lime (cm)						
	30 DAS	45 DAS	60 DAS	75 DAS	90 DAS	105 DAS	120 DAS
T_1 GA_3@ 40ppm for 6hrs	1.30	3.16	4.20	5.54	7.83	10.19	12.19
T_2 GA_3@40ppm for 12 hrs	1.55	3.20	4.24	8.15	9.96	13.63	14.25
$T_3$$GA_3$@60ppm for 6hrs	2.11	3.24	4.44	8.84	10.89	13.37	15.23
T_4 GA_3@60ppm for 12 hrs	2.21	3.35	4.55	9.44	11.68	13.65	16.14
T_5 GA_3@80ppm for 6 hrs	2.18	3.44	4.22	9.24	11.44	13.64	15.41
T_6 GA_3@80ppm for 12 hrs	2.41	4.81	5.82	10.83	12.32	15.79	18.79
T_7 Control	1.03	2.89	3.70	4.61	5.39	8.11	9.75
F-test	S	S	S	S	S	S	S
S.Ed (±)	0.18	0.09	0.09	0.15	0.14	0.10	0.09
C.D at (5%)	0.39	0.21	0.19	0.35	0.29	0.22	0.19

Number of leaves per plant

Data presented in Table 4 of Kagzi lime clearly indicated that there was increase in average number of leaves per plant due to seed treatment with plant growth substances and claimed from 30 days to 120 days after sowing. After 30 days of sowing the maximum number of leaves per plant was produced under the treatment GA_3 80 ppm for 12 hours (8.53) followed by T_4 (7.26). Rest of the treatment was intermediate, except T_1. The minimum number of leaves per plant was obtained under the control (3.98).

At 45 days of sowing, significantly more number of leaves (12.05) was produced in GA_3 80 ppm for 12 hours followed by T_4 and T_5. Remaining treatments were also produced significantly more number of leaves as compared to control. The control (T_7) recorded less number of leaves per plant (5.89). After 60 days of the maximum number of leaves per plant were recorded under the treatment GA_3 80 ppm for 12 hours (14.52) over control and all other treatments under study. It was followed by the treatment T_4 (11.55), which were significantly superior over rest of the treatments. The remaining treatment recorded intermediate effect except T_1. The control (T_7) recorded less number of leaves per plant (7.22).

At 75 days of sowing, the treatment T_6 produced significantly more number of leaves per plant (16.04) over control and all other treatments under study. Remaining treatments were also produced significantly more number of leaves per plant than control. Significantly less number of leaves was obtained under control treatment (8.24). After 90 days of sowing, GA_3 80 ppm for 12 hours produced significantly maximum number of leaves (18.20). The next best treatment was T_4 (14.86). Rest of the treatment produced intermediate effect on producing leaves per plant; Control recorded minimum number of leaves (9.49).

At 105 days after sowing, the treatment GA_3 80 ppm for 12 hours (T_6) produced significantly more number of leaves (22.22). The next best treatment in recording more number of leaves per plant was T_4, T_5 and T_3. The remaining treatment produced statistically similar number of leaves except T_1. Significantly less number of leaves (10.64) was observed in the treatment control (T_7). At final observation i.e. 120 days after sowing, treatment T_6 produced significantly more number of leaves per plant (26.53), which was superior over control and remaining treatment followed by the treatment T_4 (20.93). Remaining were also produced statistically similar number of leaves per plant except T_1. Significantly less number of leaves was obtained under treatment control (11.81). All the concentrations of Gibberellic acid at different hours produced more number of leaves per plant as compared to control at all stages of growth i.e. from 30 DAS to 120 DAS of seedling growth in Kagzi lime (Table 4). Increase in number of leaves in GA_3 80 ppm for 12 hours might be due to maximum height of seedlings under this treatment. This also helps in invigoration of physiological process of plant and stimulatory effect of chemicals to form new leaves at faster rate as suggested by Sharma *et al.* [11].

Table 4. Effect of seed treatment with Gibberellic acid on Number of leaves per plant of Kagzi lime.

Treatment	Average Number of leaves for Kagzi lime (No. of days after sowing)						
	30 DAS	45 DAS	60 DAS	75 DAS	90 DAS	105 DAS	120 DAS
T_1 GA_3@ 40ppm for 6hrs	4.79	5.89	7.90	9.17	11.38	12.04	14.41
T_2 GA_3@40ppm for 12 hrs	6.23	8.12	9.72	11.16	12.52	14.09	15.366
$T_3$$GA_3$@60ppm for 6hrs	6.33	8.20	9.96	11.55	13.17	15.36	18.53
T_4 GA_3@60ppm for 12 hrs	7.26	9.65	11.55	12.96	14.86	16.27	20.93
T_5 GA_3@80ppm for 6 hrs	7.04	8.79	10.57	11.89	13.30	15.83	18.71
T_6 GA_3@80ppm for 12 hrs	8.53	12.05	14.52	16.04	18.20	22.22	26.53
T_7 Control	3.98	5.34	7.22	8.24	9.49	10.64	11.81
F-test	S	S	S	S	S	S	S
S.Ed(±)	0.39	0.07	0.54	0.08	0.09	0.09	0.09
C.D at (5%)	0.96	0.16	1.19	0.18	0.22	0.19	0.21

Fresh and dry weight of shoots (g)

Data presented in Table 5 of Kagzi lime clearly indicated that different plant growth regulators and chemical substance significantly affected fresh and dry weight of shoots. The treatment GA_3 80 ppm for 12 hours produced more fresh weight of shoots (25.84 g), which was significantly superior over control and remaining treatments. It was followed by the treatments T_4 (19.70 g) and T_5 (18.33 g), which were also statistically superior over remaining treatments. The rest of the treatments were also recorded significantly more fresh weight over control. Significantly less fresh weight of shoots was observed under the treatment control (11.36 g).

Similar trend was observed as regarding the dry weight of shoots. The maximum dry weight of shoots was recorded in treatment GA 80 ppm for 12 hours (14.44g), which was significantly superior over control and rest of the treatments under study. It was followed by the treatments GA_3 60 ppm for 12 hours (8.31 g) and GA_3 80 ppm for 6 hours (6.51 g), which were also significantly superior over rest of the treatments. Remaining treatment produced statistically similar dry weight, except T). Significantly minimum dry weight of shoots was obtained under the treatment control (4.34 g). The fresh and dry weight of shoots was significantly increased with increase in concentrations by all the treatments of GA_3 at different hours over control in Kagzi lime (Table 5). The application of GA_3 at 80 ppm for 12 hours was found more beneficial in increasing the fresh and dry weight of shoots as compared to other treatments. This seems to be the effect of mobilization of water and nutrients transported at higher rate which might have promoted more production of photosynthetic product and translocated them to various plant parts which might have resulted in better growth of the seedlings and hence more fresh and dry weight [12,13]. Thus, it is seen that due to pre-sowing seed treatments to Kagzi lime the seedlings become ready for sale within 6 to 7 months.

Length of taproot (cm)

Data presented in Table 6 in Kagzi lime clearly revealed that more length of tap root was observed in the treatment GA_3 80 ppm for 12 hours (17.81 cm), followed by the treatments T_4, T_5, and T_3, which were significantly similar with each other and significantly superior over control and rest of the treatments under study. The next best treatment recorded maximum taproot length was in T_2 and T_1 which were at par with each other. The remaining treatments were also found significantly superior over control. Significantly less length of tap root was noticed under treatment control (11.18 cm).

Table 5. Effect of seed treatment with Gibberelic acid on fresh and dry weight of shoots (g) of Kagzi lime.

Treatments	Fresh weight(g)	Dry Weight(g)
T_1 GA_3@ 40ppm for 6hrs	15.25	6.46
T_2 GA_3@40ppm for 12 hrs	16.85	6.85
T_3GA_3@60ppm for 6hrs	18.25	7.55
T_4 GA_3@60ppm for 12 hrs	19.70	8.31
T_5 GA_3@80ppm for 6 hrs	18.33	6.51
T_6 GA_3@80ppm for 12 hrs	25.84	14.44
T_7 Control	11.36	4.34
F-test	S	S
S.Ed (±)	0.06	0.08
C.D at (5%)	0.14	0.17

The highest concentration of GA_3 at 12 hours showed more length of tap root than control in Kagzi lime. The application of GA_3 at 80 ppm for 12 hours as pre-sowing treatment was found beneficial in increasing the length of tap root as compared to the remaining concentrations of GA_3 at different hours. The more length of tap root in GA might be due to restorer of apical dominance which promotes root initiation, more nutrient uptake and root cell elongation as suggested by Shanmugavelu [14].

Number of secondary and fibrous roots

Data presented in Table 7 of Kagzi lime in respect of number of secondary roots clearly indicated that various pre-sowing seed treatments affected the number of secondary roots and number of fibrous roots significantly. Maximum number of secondary roots was obtained under the treatment GA_3 80 ppm for 12 hours (5.98) followed by GA_3 60 ppm for 12 hours (5.73), which were statistically similar to each other and significantly superior over control and rest of the treatments under investigation.

Results regarding the number of fibrous roots in Kagzi lime (Table 7) showed that more number of fibrous roots was produced under the treatment GA_3 80 ppm for 12 hours (85.99), except treatment T_4, T_5 and T_3 which were at par to each other. Rest of the treatments under study were also produced more number of fibrous roots over control. The

minimum number of fibrous roots was obtained under the treatment control (58.99), however, it was statistically similar to rest of the treatment, except T_2 and T_1. All the pre-sowing treatments of GA_3 at different hours with different concentrations produced more number of secondary and fibrous roots at 120 DAS as compared to control. Data presented in Table 7 revealed that GA_3 80 ppm for 12 hours produced significantly more number of secondary and fibrous roots over control in Kagzi lime respectively, followed by the treatments T_2 and T_1. Sharma *et al.* [11] reported that the application of GA_3 decreased the tap root length and number of secondary roots of rootstock seedlings of Kagazi lime.

Fresh and dry weight of roots (g)

The results pertaining to fresh and dry weight of roots as affected by seed treatment with GA_3 at different concentrations were presented in Table 8 of Kagzi lime. The results obtained in this regards were significant. Significant differences were obtained as regards to fresh and dry weight of roots in Kagzi lime (Table 8). Maximum fresh weights of roots were obtained in the treatment T_6 (7.04 g), which were significantly superior over control and rest of the treatments under study. The treatments T_4, T_5 and T_3 were also produced significantly more fresh weight of roots over control. The minimum fresh weight was recorded under the treatment control (3.34 g), however, it was statistically at par with the treatments T_3, T_2 and T_1.

Similar pattern exhibited in case of dry weight of roots. GA_3 80 ppm for 12 hours recorded maximum dry weight of roots (4.95 g), which was significantly superior over control and rest of the treatments under study. The next best treatment produced drier weight was T_4 and T_5. The minimum dry weight was obtained under the treatment control (2.12 g), which was similar to rest of the treatment, except T_2 and T_1. The observations recorded in respect of fresh and dry weight of roots clearly indicated that significant differences were observed amongst different concentrations of GA_3 at different hours in Kagzi lime (Table 8). All the pre-sowing treatments with GA_3 at different hours significantly increased the fresh and dry weight of roots, however, the effect of higher concentration of GA_3 at 12 hours was more pronounced to the fresh and dry weight of roots. The favourable effect of GA_3 might be due to increased Auxin level in the roots which stimulated more root initiation, more nutrient uptake and root cell elongation, thus resulting into increased tap root length and number of secondary and fibrous roots and in return increased the fresh and dry weight. The results of present study are in accordance with findings of Dilip *et al.* [15] in Rangpur lime.

Table 6. Effect of seed treatments with Gibberellic acid on Length of tap root (cm) of Kagzi lime.

Treatments	Length of rap roots for Kagzi lime
T_1 GA_3@ 40ppm for 6hrs	12.29
T_2 GA_3@40ppm for 12 hrs	14.53
T_3GA_3@60ppm for 6hrs	16.36
T_4 GA_3@60ppm for 12 hrs	17.44
T_5 GA_3@80ppm for 6 hrs	16.79
T_6 GA_3@80ppm for 12 hrs	17.81
T_7 Control	11.18
F-test	S
S.Ed (±)	0.07
C.D at (5%)	0.16

Table 7. Effect of seed treatment with Gibberellic acid on Average number of Secondary and fibrous roots of Kagzi lime.

Treatments	Average no. of	
	Secondary roots	Fibrous roots
T_1GA_3@ 40ppm for 6hrs	3.58	76.77
T_2 GA_3@40ppm for 12 hrs	3.63	78.67
T_3 GA_3@60ppm for 6hrs	4.47	81.63
T_4 GA_3@60ppm for 12 hrs	5.98	85.60
T_5 GA_3@80ppm for 6 hrs	5.03	83.22
T_6GA_3@80ppm for 12 hrs	5.73	85.99
T_7 Control	2.69	58.99
F-test	S	S
S.Ed (±)	0.15	0.05
C.D at (5%)	0.32	0.11

Table 8. Effect of seed treatment with Gibberellic acid on fresh weight and Dry weight of roots (g) of Kagzi lime.

Treatments	Fresh weight(g)	Dry weight(g)
T_1GA_3@ 40ppm for 6hrs	3.48	2.41
T_2 GA_3@40ppm for 12 hrs	4.02	3.13
T_3 GA_3@60ppm for 6hrs	5.24	3.25
T_4 GA_3@60ppm for 12 hrs	6.00	4.20
T_5 GA_3@80ppm for 6 hrs	5.49	4.01
T_6GA_3@80ppm for 12 hrs	7.04	4.95
T_7 Control	3.34	2.12
F-test	S	S
S.Ed (±)	0.39	0.41
C.D at (5%)		

Table 9. Effect of seed treatment with Gibberellic acid on survival percentage with Kagzi lime.

Treatments	Survival percentage
T_1GA_3@ 40ppm for 6hrs	56
T_2 GA_3@40ppm for 12 hrs	60
T_3 GA_3@60ppm for 6hrs	65
T_4 GA_3@60ppm for 12 hrs	78
T_5 GA_3@80ppm for 6 hrs	73
T_6GA_3@80ppm for 12 hrs	85
T_7 Control	40

Survival percentage

Data presented in Table 9 in respect of survival percentage in Kagzi lime revealed that different concentrations of Gibberellic acid had significant effect for increasing the survival percentage over control. Highest survival percentage (85.00 per cent) was obtained in the treatment (T_6) GA_3 80 ppm for 12 hours, which was significantly superior over control and rest of the treatments under investigation. It was followed by the treatment T_4, (78.00 per cent). The treatments T_5 and T_3 were statistically at par with each other and significant over the treatments T_2, T_1 and T_7. The treatments T_3, T_2 and T_1 were also statistically similar with each other and significant over the treatment control. Significantly lowest germination percentage (40.00 per cent) was recorded in the treatment control (T_7).

On the basis of present investigation, it is concluded that seed treatment of Kagzi lime by soaking in GA_3 @ 80 ppm for 12 hours results in quicker germination, faster vegetative growth and better survival percentage of seedlings.

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