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Effect of gibberellic (GA_3) acid on seed germination and growth of kagzi lime (*Citrus aurantifolia* Swingle)

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Abstract
The present experiment was carried out to find out the effect of gibberellic acid (GA_3) on germination, growth and survival of kagzi lime. The study revealed that gibberellic acid at 100 ppm (G_3) recorded minimum days taken to germination (26.00), germination percentage (55.24%), Seedling vigour index-I (1436.94 cm) and seedling vigour index-II (104.07 gm).
Significantly, highest survival percentage (63.85%), maximum shoot length (11.36 cm), number of leaves (19.26), seedling length (21.67 cm), root length (11.36 cm) and fresh weight of seedling (2.09%) were registered in G_3. However, maximum polyembryony was observed in G_1 (control). Hence, gibberellic acid at 100 ppm gives best result on germination, growth and survival of kagzi lime.

Keywords: Gibberellic (GA_3) acid, seed germination, growth, kagzi lime, *Citrus aurantifolia* Swingle

Introduction
Citrus is the most commercially important fruit crops of India as well as world and is grown in over 100 countries and it is often regarded as golden fruit. Kagzi limes (*Citrus aurantifolia* Swingle) are believed to have originated from south- East Asia. It belongs to family Rutaceae, is one of the most important citrus fruit as a major source of Vitamin C grown throughout the world. Among different citrus species, kagzi lime is commercially grown in tropical and subtropical regions of India and ranks third important fruit after mandarins and sweet oranges. In India, Citrus fruits are successfully grown in Andhra Pradesh, Gujarat, Maharashtra, Karnataka, Uttarakhand, Bihar, Assam, Rajasthan, Madhya Pradesh and other states. The area under kagzi lime fruit is on 3.16 lakh hector with annual production of 25.71 lakh tons with a productivity of 8.14 Mt. /ha (Anon., 2015) [1]. In Gujarat, area, production and productivity of acid lime is 40.80 thousand hectares, 433.12 thousand metric tons and 10.6 MT/ ha, respectively (Anon., 2015) [1]. Kagzi lime is usually propagated by seed while seed germination is slow and erratic. The possible reasons of slow germination are presence of growth inhibitors and physical resistance of seed coat to radical protrusion. Hence during germination gibberellic acid play an important role in conversion of carbohydrate to sugar which and synthesis of different hydrolytic enzymes such as amylase, protease etc. which degrade the stored food materials present in embryo and endosperm. Gibberellic acids play an important role in germination and growth of the seedlings. Hence at a given concentration germination of the seed is maximum. So, the present study was taken to find out the effect of Gibberlic acid on seed germination, growth and survival of kagzi lime.

Material and method
The present experiment entailed "effect of different concentration of gibberllic acid on germination, growth and survival of acid lime" was carried out at Hi-Tech Horticulture Park, Department of Horticulture, College of Agriculture, Junagadh Agricultural University, Junagadh during September, 2016 to March, 2017. It was laid out in completely Randomized Design (FCRD) with Factorial concept having three repetitions. The experiment was done to find out the influence of gibberlic acid on germination, growth and survival of acid lime. The experiment consist of four treatment i.e. G_0 (control), G_1 (50 ppm), G_3 (100 ppm) and G_4 (150 ppm). Fresh seed of acid lime was collected, extracted and sown immediately. 50 mg, 100 mg and 150 mg of gibberlic acid powder was weighed in an electrical weighing balance and each was dissolved in 10 ml. of 99% absolute ethyl alcohol to which distilled water was added to

make up the volume equal to one liter as a stock solution. Polybags having a length of 15 cm and diameter of 10 cm with 200 gauge thickness were used and filled with the media comprising of soil and FYM. Treated seed of acid lime were sown in polythene bags of 15 X 10 cm size filled in different mixture and its combinations on 17th July 2015. Watering was done using rose can regularly. Necessary plant protection measures were taken. Five representative plants from each treatment were selected and observed for different growth characters and physiological parameter.

Result and Discussion

The result indicated that when seeds treated with 100 ppm GA_3 (G_3) took minimum days (26.00) to start germination. While the highest days (29.00) were registered under control (G_1). The early germination might be due to involvement of GA_3 in the activation of cytological enzymes resulted into the production of energy and substrates, which in turn provide the structural components, essential for growth and emergence of the embryo along with increase in cell wall plasticity and better water absorption. The findings are supported by Burns and Coggnies (1969) who reported that the growth and uniformity of seedling of sweet orange were also enhanced by seed treatment with GA_3. Percentage of germination under gibberellic acid concentration showed significant effect**.** The data revealed that GA_3 at 100 ppm (G_3) recorded significantly the highest percentage (55.22%) of germination which was found at par with G_2 (52.24%). The lowest percentage of germination (48.97%) was recorded in control (G_1). These findings might be due to pre-soaking treatment of GA_3, which would have triggered the activity of specific enzymes that promoted early germination, such as α-amylase, which have brought an increase in availability of starch assimilation. This finding is supported Venkatarao and Reddy (2005) [12] as well as Kumar *et al*. (2008) [6] in mango and Patil *et al*. (2012) [8] in Rangpur lime.

Result was also found significant and the highest seedling vigour index-I (1436.94 cm) was recorded in G_3 (100 ppm). While, the lowest vigour index (1193.78 cm) was noted at G_4 (150 ppm). This result is supported by Suma and Balamurugan (2006) in custard apple and Patil *et al*. (2012) [8] in Rangpur lime. Likewise, highest seedling vigour index-II (104.07 g) was recorded at GA_3 100 ppm (G_3). While, the lowest vigour index (84.00 g) was noted at control (G_1). This finding is supported by Patil *et al*. (2012) [8] in Rangpur lime.

The results indicated that the significantly the highest numbers of leaves (19.26) were recorded at 100 ppm GA_3 (G_3) followed by treatment G_2 at 90 DAS. While, the lowest numbers of leaves (17.03) were noted in fresh seed (G_1). The more number of leaves under gibberellic acid treatment might be due to increases in cell division which enhance production of more number of leaves and also activity of GA_3 at the apical meristems resulting in more synthesis of nucleoprotein responsible for increasing leaf initiation. This result is similar with finding of Misra *et al*. (2000) in Malta common seedling and Kadam *et al*. (2010) [3] in kagzilime.

As regard to GA_3, significantly the shoot length (11.36 cm) was observed under GA_3 100 ppm (G_3) at 90 days after seed sowing and the minimum length of shoot (9.72 cm) was recorded under control (G_1). It might be due to additional gibberellic acid which activates the α- amylase which digested the available carbohydrate into simple sugar so that energy and nutrition were easily available to faster growing seedlings. The finding is supported by Kalabandi *et al*. (2003) [4] in kagzilime. Significantly the highest seedling length (21.67cm) was observed in GA_3 100 pm (G_3) which is at par with G_2 at 90 DAS. The lowest seedling length (19.24 cm) was noted in GA_3 150 ppm (G_4). Gibberellins are well known for inter nodal cell elongation, thereby increased the seedling length. The application of growth regulator increase the seedling height and such effect might be due to increase in photosynthetic activity, enhancement in the mobilization of photosynthates and change in membrane permeability (Shukla *et al*. 1997) [9].

Result was also found significant and the highest root lengths (11.36 cm) were recorded under G_1 and G_3 which was at par with G_2 (11.21) and treatment G_4 gave the lowest root length (10.35 cm) at 90 DAS. The increase in root length could be due to gibberellic acid which causes cell division and elongation of already existing cells by enlargement of the vacuoles which in turn increase the root length or it might be due to more production of photosynthates and their translocation through phloem to the root zone which responsible for improving root length. This finding is supported by findings of Ramteke *et al*. (2015) [11] in papaya.

GA_3 concentration had significant effect on fresh weight of seedling and the highest fresh weight (2.09 g) was recorded under GA_3 100 ppm (G_3). While, the lowest fresh weight (1.62 g) was recorded under control (G_1). More fresh weight might be due to influence of gibberellic acid to increase water uptake of seedling. This finding is supported by studies of Kadam *et al*. (2010) [3] and Khatana *et al*. (2011) [5] in kagzi lime. The data pertaining to the effect of GA_3 concentration was found non-significant for the dry weight of seedling at 90 DAS.

Significantly, highest survival percentage (63.85%) was recorded under treatment G_3 fallowed by G_2 (60.97%). The lowest survival percentage (58.30%) was found under treatment GA_3 150 ppm (G_4). This finding is supported by Khatana *et al*. (2011) [5] in kagzi lime and Ramteke *et al*. (2015) [11] in papaya. Significantly the highest polyembryony percentage (21.48%) was recorded under control (G_1) and lowest polyembryony percentage (16.93%) was recorded under treatment GA_3 150 ppm (G_4).

Table 1: Effect of gibberellic acid on germination, seedling vigour index and survival of Kagzi lime

Treatment	Days required to germination	Germination Percentage (%)	Seedling vigour index- I (cm)	Seedling vigour index-II (gm)	Survival percentage (%)	Polyembryony percentage (%)
G_1 (control)	29.58	48.97	1198.37	84.00	58.68	21.48
G_2 (50 ppm)	27.25	52.24	1258.20	90.80	60.97	18.53
G_3 (100 ppm)	26.00	55.22	1436.94	104.07	63.85	18.82
G_4 (150 ppm)	28.25	50.59	1193.78	86.68	58.30	16.93
S.Em.±	0.50	1.12	33.99	2.30	1.27	0.36
C.D. at 5%	1.45	3.23	97.93	6.03	3.68	1.04

Table 2: Effect of GA_3 on vegetative and root characters of kagzi lime

Treatment	Leaf number	Shoot length (cm)	Seedling length (cm)	Root length (cm)	Fresh weight of seedling (%)	Dry weight of seedlings (%)
G_1 (control)	17.03	9.72	19.69	11.36	1.78	1.37
G_2 (50 ppm)	18.35	10.44	20.85	11.21	1.83	1.34
G_3 (100 ppm)	19.26	11.36	21.67	11.36	2.09	1.43
G_4 (150 ppm)	17.24	10.28	19.24	10.35	1.62	1.32
S.Em.±	0.40	0.25	0.40	0.28	0.03	0.03
C.D. at 5%	1.17	0.74	1.12	0.80	0.11	NS

Conclusion

From the above experiment, it can be concluded that gibberellic acid at 100 ppm (G_3) gave better result on germination, growth and survival of kagzi lime seedling.

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