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Effect of Gibberellic Acid (GA) Different Concentrations at Different Time Intervals on Seed Germination and Seedling Growth of Rangpur Lime

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Abstract—*The present investigation was carried out to evaluate the "effect of Gibberellic Acid (GA) different concentrations at different time intervals on seed germination and seedling growth of Rangpur Lime" during the year 2010-2011 at the Department of Horticulture, SHUATS, Allahabad. The experiment was laid out in simple Randomized Block Design (RBD) with three replications and seven treatments. The results revealed that the maximum seed germination (90 %) was observed under the treatment at GA 80 ppm for 12 hours, rate of seed germination (25 Days), maximum height of plant (11.97 cm), number of leaves per plant (18.89) at 120 DAS, fresh and dry weight of shoot (13.65 g and 6.81 g), length of tap root (16.17 cm), number of secondary and fibrous roots(6.24 and 86.86), Fresh and dry weight of roots (5.92 g and 4.06 g) and survival percentage(82%) in the similar treatments. Therefore it may be concluded that the GA at 80 ppm has a significant effect on the seed germination and seedling growth of Rangpur Lime and can be recommended to the grower for obtaining better growth and yield.*

Keywords*: Germination, gibberellic acid, plant, root,*

1. INTRODUCTION

Citrus fruits have a prominent place among the people and extensively grown in tropical and sub-tropical regions. Citrus is often regarded as a 'queen of fruits'. It is one of the choicest fruit having high consumer's preference both as fresh fruit as well as for its Refreshing processed juice. 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. Internationally citrus plantation in the world is confined to 0-40° latitude from north to South, of the equator covering different regions having different soil and climatic conditions (Ghosh, 2000).

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. In India, citrus is third most important fruit crop, after banana and mango, with an estimated production of 3.80 million tones (Singh and Dohare,1963).

Rangpur lime *(Citrus limonia Osbeck*), a promising and recommended rootstock is used for the mandarins as well as sweet oranges in many other states. It is healthy, semi-vigorous, productive, tolerant to salt, greening diseases and resistant to tristiza. Rootstocks play an important role exclusion of toxic, which are important for deciding the life of orchard (Kadam and Pati1, 1985). In recent times the rootstock has assumed a greater importance in view of the role of dieback complex which is reduced to some extent by using rootstock like Rangpur lime. Trees on this stock are vigorous, precocious and prolific with quality produce. It makes a good union with a number of citrus species like Sweet orange, Mandarins and Pummelo.

Raising of healthy buddable rootstock, seedlings in the shortest possible time becomes imperative and is a primary concern of nurserymen and research workers all over the country. The rate and extent of seed germination and seedling growth in Rangpur are not satisfactory.

The seeds take about 20 to 40 days to germinate and the seedling growth in the nursery stage is also very slow,

therefore it takes 18-24 months to attain buddable size, slow growth of Rangpur lime seedlings. Thus, a lot of expenditure and time is spent for maintenance of root stock seedlings.

The seed treatment of citrus species with GA enhanced the germination of seeds. growth and uniformity of seedlings both in commercial and rootstock varieties (Srivastava and Singh, 1965, Burns and Coggins, 1969; Shant and Rao, 1973). The use of growth regulators in overcoming the inhibitory action of certain chemical substances that delay the germination (Chaudhari and Chakrawar, 1981) in Rangpur lime. In view of the above specific problems of Rangpur lime the present experiment were carried out to study the "Effect of Gibberellic acid (GA) of different concentrations at different time intervals on seed germination, seedling growth of Rangpur Lime".

2. MATERIALS AND METHODS

The present experiment entitled "Effect of Gibberellic acid (GA) of different concentrations at different time intervals on Seed Germination, seedling growth of Rangpur Lime" was carried out separately during the year 2010-2011 under the Allahabad agro-climatic conditions 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 Rangpur lime trees. The seeds were extracted carefully, washed with clean water and dried in shade for a day. Seeds were sowed in 25 x 15 cm size polythene bags. The polythene bags were punctured to improve the drainage and filled with the garden mixture which was prepared by well mixing of two parts of soil, 1 part of fine sand, and 1 part of well rotted FYM. The soaking of seeds was carried out for 06 hours and 12 hours for each as per treatment combinations. 1 g of GA3 was dissolved in few ml of ethyl alcohol and volume was made to one liter by adding distilled water to obtain a concentration of 1000 ppm. The normal and uniform sized 30 seeds of Rangpur lime were subjected to different treatments as per the study. For the soaking, the desired concentrations of GA were prepared from respective stock solutions by adding distilled water. 50 ml solution of each concentration was taken in 100 ml beaker and seeds were soaked thoroughly. Seeds of control treatment were soaked in distilled water. Then these seeds were taken out and washed with distilled water. Pre-treated seeds were sown at 9.00 AM in polythene bags which were properly filled, labeled with tags and placed as per design. The experiment was laid as per the Randomised block design and replicated thrice. Cultural operations like regular watering, weeding and plant protection measures like spraying of insecticides against caterpillar and leaf miner were taken (Table.1).

Table 1: Details of Treatments

Treatment	Chemical	Concentrations
T_1	GA_3	GA_3 @ 40ppm for 06 hrs
T_2	GA_3	GA_3 @ 40ppm for 12 hrs
T_3	GA_3	GA_3 @ 60ppm for 06hrs
T_4	GA_3	GA_3 @ 60ppm for 12hrs
T_5	GA_3	GA_3 @ 80ppm for 06 hrs
T_6	GA_3	GA_3 @ 80ppm for 12 hrs
T_7	GA_3	Distilled Water

The data were recorded for following traits:

3. 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 30DAS (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.

4. STATISTICAL ANALYSIS

The data recorded during the course of the investigation were subjected to statistical analysis as per the method of analysis of variance (Panse and Sukhatme, 1967).

5. METROLOGICAL DATA

The data and weather parameters during the period of field investigation recorded in SHUATS, Allahabad (Table.2).

6. RESULTS AND DISCUSSION

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

7. SEED GERMINATION

Seed germination Percentage

Data presented in the table. 3 in respect of seed germination percentage of Rangpur lime as affected by various seed treatments clearly indicated that the treatment differences were significant. Best germination percentage (90.00 per cent) was recorded in the treatment GA 80ppm for 12 hours, which was significantly superior to control and rest of the treatments under study. The next best treatment was T_4(80.00 per cent),which was statistically at par with the treatments T_5,T_3,T_2 and found significant over the treatments T_1, Less

seed germination percentage(40.00 per cent.) was recorded in the Treatment control (T_7).

8. RATE OF SEED GERMINATION

The perusal of data presented in table.4 with regard to the rate of seed germination in Rangpur lime, clearly indicated that there were significant differences in different concentrations of GA at different hours. The progressive increase was observed in the rate of seed germination up to 30 DAS.

Data presented in the table. 3 revealed that significantly more germination percentage (90.00 %) of Rangpur lime seeds was observed in the treatment GA 80 ppm for 12 hours and completed germination in less number of days (25 days). While significantly less germination percentage (40.00 %) was recorded in control (T_7) and took more number of days (40 days) for completion of germination.

The seeds treated with GA 60 ppm for 6 hours and GA 60 ppm for 12 hours concentration completed their germination within 30 days; while seeds treated with GA 40 ppm for 6 hours, GA 40 ppm for 12 hours required more number of days (35 days) for completion of their germination.

The seeds treated with higher concentration of GA at 12 hours germinated in 10 to 15 days earlier than control. However, the seeds treated with the lower concentration of GA at 6 hours took 5 to 10 days earlier than control for completion of germination. The accelerated and enhanced germination in Rangpur lime under GA might have been due to increased enzyme activities and better supply of nutrients. The property of GA to induce better and quicker germination has been already reported by various workers (Witter and Buckovac, 1958). Similar findings were reported Maurya and Lal (1969) in onion, Achituv and Mendal (1973) in sweet lime, and Chaudhari and Chakrawar (1981) in Rangpur lime which support the present findings.

9. PHYSICAL PARAMETERS OF GROWTH

Height of plant (cm)

The average height of the plant as influenced by the different concentration of GA plant growth regulator was recorded periodically at 30, 45, 75, 90, 105 and 120 DAS of Rangpur lime are presented in table. 5

In Rangpur lime (Table.5) it was observed that, at 30 DAS the treatment GA 80 ppm for 12 hours exhibited the significant increase in plant height (2.88 cm) over control and all other treatments, followed by treatment T_4 (2.73 cm), which was statistically at par with the treatment T_5. The treatments T_3 and T_2 were statistically at par with each other and significantly superior over rest of the treatments. The remaining treatments recorded intermediate effect on plant height. Significantly lowest plant height (1.34 cm) was observed in the treatment (T_7).

At 45 DAS, highest plant height (4.49 cm) was recorded in the treatment GA 80 ppm for 12 hours (T_6), which was significantly superior to control and remaining treatments under investigation, rest of the treatments showed an intermediate effect on plant height. In treatment control (T_7) plant height (2.16 cm) was recorded which was significantly at par with treatments T_1, T_2, T_3 and T_5.

After 60 days of sowing, maximum plant height (5.49 cm) was recorded in the treatment GA 80 ppm for 12 hours followed by the treatments T_4 (4.37 cm) and T_5 (4.36 cm) which were significantly superior over control and remaining treatments and were statistically at par with each other. Minimum plant height (2.51 cm) was recorded in the treatment control.

At 75 DAS, highest plant height (7.29 cm) was recorded in the treatment GA 80 ppm for 12 hours T_6 followed by T_4 (6.73 cm), T_5 (6.71 cm) and T_3 (6.36 cm) which were statistically similar to each other. The next best treatment in producing plant height was T_2 and T_1 which were statistically at par with each other. Minimum plant height (3.82cm) were recorded at the control. Similar trend was observed at 90 DAS. The treatment GA 80 ppm for 12 hours (T_6) exhibited significantly increase in plant height (8.42 cm) which was at par with T_4 (8.21 cm) remaining treatments showed an intermediate effect on producing plant height. The lowest plant height (5.03 cm) was observed in treatment control. At 105 DAS, maximum plant height (10.51 cm) was recorded in the treatment GA 80 ppm for 12 hours followed by T_4 and T_5 which was significantly similar to each other. The treatments T_3, T_2, and T_1 were statistically similar with each other and recorded next best plant height. Control recorded minimum plant height (6.91 cm).

At 120 DAS GA 80 ppm for 12 hours (T_6) produced significantly more plant height (11.97 cm), which was significantly superior to control and remaining treatments under investigation. The treatments T_4, T_5, and T_3 were found to be statistically similar to each other. Rest of the treatment showed intermediate effect on producing plant height. Treatment (T_7) recorded minimum plant height (7.92 cm) which was significantly at par with T_2 and T_1. More plant height in GA might have occurred due to cell division (Stowe and Yamaki, 1957) and cell elongation (Shanmugavalue, 1970) which in turn would have increased the internodal length.

The beneficial effects of GA_3 on seedlings height has also been reported in Oranges and Citrus. Sharma *et al*. (1999) reported an increase in plant height with pre-sowing treatments of GA in Kagzi lime which supports the present findings.

Initially, in Rangpur lime (Table.6) at 30 DAS, the treatment T_6 produced significantly more number of leaves per plant (8.31), which was statistically superior to control and all

other remaining treatments under study. It was followed by T_4 (6.46), which were statistically at par with the treatments T_5, T_3, T_2 and T_1. The minimum number of leaves per plant was obtained under the treatment control (4.29).

After 45 days of sowing, GA 80 ppm for 12 hours produced a more average number of leaves per plant (9.38) which was significantly maximum over control and rest of the treatment under investigation. The treatments T_4 and T_5 produced 7.89 and 7.29 number of leaves per plant respectively and were significantly superior to rest of the treatment. Significantly minimum number of leaves per plant (5.01) was produced under the treatment control (T_7).

At 60 days of sowing, the maximum number of leaves was produced by the treatment GA 80 ppm for 12 hours (10.30) and was significantly superior to control and rest of the treatment under study. The treatment T_4, T_5 and T_3 produced more number of leaves per plant respectively and were significantly superior over rest of the treatments, except T_7 and being statistically at par with each other. A minimum number of leaves was obtained under control treatment (6.11).

After 75 days of sowing, more number of leaves per plant (12.41) was observed in the treatment GA 80 ppm for 12 hours, which was significantly superior over control and rest of the treatment under study. Remaining treatments were also produced significantly more number of leaves as compared to control. The plant in control produced less number of leaves per plant (7.30).

At 90 days of sowing, the treatment GA 80 ppm for 12 hours, produced significantly maximum number of leaves (16.62) followed by T_4, T_5 and T_3 which were statistically similar to each other. The remaining treatment was also produced significantly more number of leaves as compared to control. Significantly maximum number of leaves (9.15) was produced under the treatment control (T_7).

After 105 days of sowing, statistically more number of leaves was observed in the treatment GA 80 ppm for 12 hours (16.22). Rest of the treatments were also produced significantly more number of leaves as compared to control. The control (T_7) recorded less number of leaves per plant (10.41).

At the final stage of observation i.e. 120 days of sowing the maximum number of leaves per plant was obtained under the treatment GA 80 ppm for 12 hours (18.89), followed by T_4 (17.44) which were statistically similar to each other. The treatments T_5, T_3, T_2 and T_1 produced significantly more number of leaves than control and being statistically at par with each other. The minimum number of leaves per plant was obtained under the treatment control (11.27).

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 Rangpur lime and Kagzi lime (Table.6)

Increase in a number of leaves in GA 80 ppm for 12 hours might be due to the 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.* (1999).

10. FRESH AND DRY WEIGHT OF SHOOTS (G)

Data presented in the table. 7 clearly indicated that the responses to the application of various concentrations of Gibberellic acid at different hours regarding fresh and dry weight of shoots in Rangpur lime were highly significant. Increase in number of leaves in GA 80 ppm for 12 hours might be due to the 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.* (1999).

Data presented in table.7 of Rangpur lime clearly indicated that fresh and dry weights of shoots were significantly increased by all the treatments and their concentrations over control.

Regarding the fresh weight of shoots, the maximum weight was produced by the treatment GA 80 ppm for 12 hours (13.65 g), which was significantly superior to control and rest of the treatments under study, followed by the treatment T_4 (12.27 g). The next best treatment recorded maximum fresh weight of shoots was T_5, T_3 and T_2. Remaining treatments were also produced significantly maximum fresh weight of shoots than control except T_1. Significantly less fresh weight was observed under the treatment control (6.93 g). A similar trend was observed as regarding dry weight of shoots. More dry weight was produced by the treatment GA 80 ppm for 12 hours (6.81 g), which was significantly superior to control and rest of the treatments under study. In rest of the treatments also there was a significant increase in dry weight of shoots as compared to control. The next best treatment in producing dry weight was T_4, T_5, T_3, T_2 and T_1. Significantly less dry weight was recorded by the treatment control (3.74 g).

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 (Brain *et al.* 1959;Shenmugavelu, 1966). Similar results were obtained by Chourdhari and Chakrawar, (1981) in Rangpur lime, the length of tap root (cm) data regarding the length of tap root as affected by different growth regulators and chemical substance is presented in table.8 of Rangpur lime. The responses to the application of seed treatment regarding the length of tap root were highly significant.

Data presented in table.8 of Rangpur lime clearly indicated that the more length of tap root was recorded under

treatment GA 80 ppm for 12 hours (16.26 cm), which was significantly superior to control and rest of the treatments. It was followed by the treatments T_4 and T_5, which were significantly superior over rest of the treatments. The remaining treatments were also significantly produced more length of tap root over control. However, the treatments T_2 and T_1 were statistically similar with each other. Significantly less length of tap root was noticed under the treatment control (10.08 cm). 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 (1970). The application of GA increases the root growth of Jackfruit seedlings (Shanmugavelu, 1970). The results obtained in the present studies are in agreement with that reported by Choudhari and Chakrawar, (1981) in Rangpur lime.

11. NUMBER OF SECONDARY AND FIBROUS ROOTS

As regards number of secondary roots in Rangpur lime (Table.9) a maximum number of secondary roots was obtained under treatment GA at 80 ppm for 12 hours (6.24), followed by the treatment T_4 (5.45) which were significantly superior over control and rest of the treatments under study. The remaining treatment produced intermediate number of secondary roots. The minimum number of secondary roots was produced under control (2.32), which was statistically similar to the treatment T_1.

A similar trend was observed for number of fibrous roots as affected by different treatments in Rangpur lime (Table.9). A maximum number of fibrous roots was obtained under treatment GA 80 ppm for 12 hours (86.86), followed by the treatment T_4 (82.22) were significantly superior to control and rest of the treatments under study. Rest of the treatment produced intermediate number of fibrous root, except treatment T_5 and T_3. The minimum number of fibrous roots was obtained under control (57.04) however, it was statistically similar with treatments T_2 and T_1.

In case of Rangpur lime more number of secondary and fibrous roots were 6.24 and 86.86 respectively. Bhambota and Kaul (1966) reported that the application of GA decreased the tap root length and number of secondary roots of rootstock seedlings of citrus. Similar results were reported by Chourdhari and Chakrawar (1981) in Rangpur lime .

12. FRESH AND DRY WEIGHT OF ROOTS (G)

In case of Rangpur lime (Table.10), a maximum fresh weight of roots was obtained in the treatment GA 80 ppm for 12 hours (5.92 g), which were significantly superior to control and rest of the treatments under study. All the treatments of GA increased the fresh weight of roots as compared to rest of the treatments. The minimum fresh weight of roots was obtained under the treatment control (2.93 g).The favorable effect of GA 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 are in accordance with findings of Chaudhari and Chakrawar, (1981) in Rangpur lime.

13. SURVIVAL PERCENTAGE

Data presented in the table.11 in respect of survival percentage of Rangpur lime as affected by various seed treatments clearly indicated that the treatment differences were significant. More survival percentage (82.00%) was recorded in the treatment (T_6) GA 80 ppm for 12 hours, which was significantly superior to control and rest of the treatments under study. The next best treatment was T_4 (75.00%), which was statistically at par with the treatments T_5, T_3 and T_2 and found significant over the treatments T_1 less seed survival percentage (30.00 %) was recorded in the treatment control (T_7).

14. CONCLUSION

On the basis of experimental findings it can be concluded that among the different concentration at different time interval on seed germination and seedling growth of Ranpur lime, seed treated with GA 80 ppm for 12 Hours was the most effective treatment for enhancing seed germination, height of the plant, number of leaves per plant, fresh and dry shoot weight, length of tap root, number of secondary and fibrous roots, fresh and dry root weight and survival percentage as compared to other treatments. Therefore, the present study will be helpful to the farmers for cultivation of this important fruit crop.

REFERENCES

[1] Achituv, M. and Mendel, K. (1973). Effect of certain treatments on the germination of sweet lime (*Citrus limonia*) seeds. *Plant Propogator*.19(4): 15-20.

[2] Bhambota, J.R. and Kaul, G.L. (1966). Studies on the effects of gibberellic acid on growth of seedlings of citrus rootstocks. *Indian J. Hort*. 23 (1 & 2):21-29.

[3] Brain, P.W. (1959). Effect of gibberellines on plant growth and development. *Biol. Rev*.34:37-84.

[4] Burns, R.M. and Coggins, C.W. Jr. (1969). Sweet orange germination and growth aided by water and GA seed soak. *Calif. Agril*. 23(12)118-19.

[5] Chaudhari, B.K. and Chakrawar, V.R. (1981). Note on the effect of some chemicals on the germination of Rangpur lime seeds. *Indian Agric. Sci*. 51(3):201-203.

[6] Ghosh, S.P. (2000).Nutrient management in fruit crops. *Fertilizer News*.45:71-76.

[7] Kadam, B.A. and Patil, V.K. (1985). Effect of different concentration chloride, bicarbonate and high ESP in soil on growth and chemical composition of citrus rootstocks. Ph.D.

Thesis (Ag.), Marathwada Agricultural University, Parbhani, M.S. (INDIA).

[8] Maurya, A.N. and Lal, S. (1968). Effect of plant growth regulators on the germination of onion (*Allium cepa* L.) seeds. *Punjab Hort. J*. 12(4):257-259.

[9] Panse, V.G. and Sukhatme, P.V. (1967). Statistical methods for agricultural worker, I.C.A.R., Publ. New Delhi.

[10] Shanmugavelu, K.G. (1966). A note on the effects of gibberellic acid on the root and shoot weights of some tree species. *Madras agric. J*. 54:44-45.

[11] Shanmugavelu, K.G. (1970). Effect of gibberellic acid on seed germination and development of seedlings of some tree species. *Madras. agric. J*. 57(6):311- 314.

[12] Shant, P.S. and Rao, S.N. (1973). Note on effect of gibberellic acid on seed germination and seedling growth of acid lime (*Citrus aurantifolia* Swingle). *Prog. Hort*. 5(3):63-65.

[13] Sharma, M.C., Ughreia, P.P.U. and Jambukia, T.K. (1999). Effect of some plant growth regulators, chemicals and organic waste on germination and subsequent seedling growth of Kagzi lime (*Citrus aurantifolia* Swingle). *Int Svm on citriculture*, (Abstracts), Nagpur, 51pp.

[14] Singh, K. and Dohare, S.R. (1963). Pre-sowing treatments with NAA in relation to growth and development of radish. *Punjab Hort.J*.4(38z4):160-164.

[15] Srivastava, R.P. and Singh, L. (1965). The influence of pre-sowing treatments with gibberellic acid on the germination and growth of fruit plants in Hill lemon and Malta. *The Punjab Hort. J*. 9(1 & 2):71-73.

[16] Stowe, B.B. and Yamaki, T. (1957). The history and physiological action of the gibberellins. *Ann. Rev. Plant Physio*. 8 : 181-216.

[17] Wittwer, S. H., and Bukovac, M. J. (1958). The effect of GA on economic crops. *Econ. Bot*. 12(3):213-255.

Table 2: Meteorological data during experimental period

(September 2010 to March 2011)

Standard Week/Month	Temperature (^{o}C) Max	Min	Relative humidity (%) Max	Min	Rainfall (mm)
September 2010					
1st Week	35.00	28.31	85.05	42.50	2.48
2nd week	34.80	28.17	84.55	43.80	2.85
3rd week	31.95	26.55	83.52	41.02	10.08
4th week	34.51	28.93	82.22	41.97	0.37
October 2010					
1st Week	35.20	23.60	78.00	30.40	Nil
2nd week	36.40	21.00	83.00	29.57	Nil
3rd week	36.60	21.8	95.00	29.12	Nil
4th week	34.80	15.00	81.00	31.52	Nil
November 2010					
1st week	32.60	16.40	82.50	38.42	Nil
2nd week	32.80	18.34	90.70	57.57	Nil
3rd week	28.00	12.00	90.00	54.14	1.40
4th week	29.40	10.08	91.14	45.57	Nil
December 2010					
1st week	27.40	10.88	87.42	47.28	21.6
2nd week	29.00	9.00	91.28	40.00	Nil
3rdweek	29.60	8.50	90.42	39.28	Nil
4th week	26.20	5.52	93.25	41.00	Nil
January 2011					
1st week	25.71	6.68	90.42	30.42	Nil
2nd week	25.62	5.51	95.00	49.00	Nil
3rd week	27.08	5.80	93.28	33.00	Nil
4th week	28.29	8.60	93.00	30.42	Nil
February 2011					
1st week	26.40	10.77	90.00	32.71	1.75
2nd week	28.60	1061	91.57	34.28	25.55
3rd week	28.60	11.84	87.28	31.42	Nil
4th week	31.85	17.14	87.85	24.71	Nil

Source:-Agro-meteorological observatory unit, College of Forestry, SHUATS, Allahabad-211007.

Table 3. Effect of seed treatment with Gibberellic acid on seed germination percentage with Rangpur lime.

Treatments	Seed germination Percentage

T_1 GA_3@40ppm for 6hrs	55.00
T_2 GA_3 @40ppm for 12 hrs	60.00
T_3 GA_3@60ppm for 6 hrs	70.00
T_4 GA_3@60ppm for 12 hrs	80.00
T_5 GA_3@80ppm for 6hrs	75.00
T_6 GA_3@80ppm for 12 hrs	90.00
T_7 Control	40.00

Table 4; Effect of seed treatment with Gibberellic acid on Rate of seed germination of Rangpur lime.

Treatment	Number of seed germinated					
	15 DAS	20 DAS	25 DAS	30 DAS	35 DAS	40 DAS
T_1 GA_3@ 40 ppm for 6hrs	1.67	8.33	11	12.00	12.00	12.00
T_2 GA_3@ 40 ppm for 12 hrs	2.00	9.00	11.33	13.00	13.00	13.00
T_3GA_3@ 60 ppm for 6hrs	2.33	10.00	11.00	14.00	14.00	14.00
T_4 GA_3@ 60 ppm for 12 hrs	3.33	12.67	15.00	17.33	16.00	16.00
T_5 GA_3@ 80 ppm for 6 hrs	3.00	10.33	13.00	16.00	15.00	15.00
T_6 GA_3@ 80 ppm for 12 hrs	3.67	15.00	17.00	18.00	18.00	18.00
T_7 Control	0.00	0.00	3.00	7.00	8.00	8.00
F-test	S	S	S	S	S	S
S. Ed (±)	**0.47**	**0.67**	**0.93**	**0.67**	**0.60**	**1.11**
C.D (5%)	**1.04**	**1.47**	**2.03**	**1.45**	**1.32**	**2.42**

Table 5: Effect of seed treatment with Gibberellic acid on Height (cm) of seedling of Rangpur lime.

Treatment	**Number of days after sowing (Height of seedling in cm)**						
	30 DAS	**45 DAS**	**60 DAS**	**75 DAS**	**90 DAS**	**105 DAS**	**120 DAS**
T_1 GA_3@ 40 ppm for 6hrs	1.85	2.92	3.92	5.92	7.04	7.83	8.47
T_2 GA_3@40 ppm for 12 hrs	2.22	3.11	4.10	6.17	7.09	7.84	8.59
T_3 GA_3@60 ppm for 6hrs	2.29	3.15	4.15	6.36	7.26	8.6	9.93
T_4 GA_3@60ppm for 12 hrs	2.73	3.6	4.37	6.73	8.21	9.69	11.17
T_5 GA_3@80ppm for 6 hrs	2.54	3.38	4.36	6.71	7.81	8.9	9.99
T_6 GA_3@ 80ppm for 12 hrs	2.88	4.49	5.49	7.29	8.42	10.51	11.97
T_7 Control	1.34	2.16	2.51	3.82	5.03	6.91	7.92
F-test	**S**	**S**	**S**	**S**	**S**	**S**	**S**
S. Ed (±)	**0.20**	**0.09**	**0.18**	**0.02**	**0.12**	**0.03**	**0.07**
C.D (5%)	**0.45**	**0.21**	**0.40**	**0.05**	**0.27**	**0.07**	**0.17**

Table 6: Number of Leaves per Plant of Rangpur lime as affected by seed treatment with Gibberellic acid.

Treatment	**Average Number of leaves for Rangpur lime**						
	30 DAS	**45 DAS**	**60 DAS**	**75 DAS**	**90 DAS**	**105 DAS**	**120 DAS**
T_1 GA_3 @ 40ppm for 6hrs	5.64	6.06	6.7	8.21	10.05	11.25	13.33
T_2 GA_3 @40ppm for 12 hrs	5.65	6.13	6.97	8.35	10.29	11.25	13.81
T_3 GA_3 @ 60ppm for 6hrs	5.76	6.69	7.26	8.75	10.85	11.81	13.93
T_4 GA_3 @ 60ppm for 12 hrs	6.46	7.89	8.78	9.34	12.72	14.59	17.44
T_5 GA_3 @ 80ppm for 6 hrs	5.82	7.29	8.35	9.19	11.78	12.64	16.62
T_6 GA_3 @ 80ppm for 12 hrs	8.31	9.38	10.30	12.41	16.62	16.22	18.89
T_7 Control	4.29	5.01	6.11	7.3	9.15	10.41	11.27
F-test	**S**	**S**	**S**	**S**	**S**	**S**	**S**
S. Ed (±)	**0.19**	**0.03**	**0.02**	**0.01**	**0.89**	**0.05**	**0.11**
C.D (5%)	**0.43**	**0.07**	**0.05**	**0.02**	**1.94**	**0.10**	**0.24**

Table 7: Fresh and dry weight of shoots (g) of Rangpur lime as influenced by different seed treatment with Gibberellic acid.

Treatments	Fresh weight(g)	Dry Weight(g)
T_1 GA_3 @ 400 ppm for 6hrs	9.72	5.68
T_2 GA_3@ 40oom for 12 hrs	10.56	5.77
T_3 GA_3@ 60ppm for 6 hrs	10.87	5.97
T_4 GA_3@ 60ppm for 12 hrs	12.27	6.43
T_5 GA_3@ 80 ppm for 6 hrs	11.28	6.33
T_6 GA_3@80 ppm for 12 hrs	13.65	6.81
T_7 Control	6.93	3.74
F-test	**S**	**S**
S. Ed (+)	**0.11**	**0.58**
C.D (5%)	**0.24**	**1.27**

Table 8: Length of tap root (cm) of Rangpur lime as influenced by different seed treatments with Gibberellic acid.

Treatments	Length of tap roots
T_1 GA3 @ 400 ppm for 6hrs	12.22
T_2 GA3@ 40oom for 12 hrs	13.66
T_3 GA3@ 60ppm for 6 hrs	14.82
T_4 GA3@ 60ppm for 12 hrs	16.17
T_5 GA3@ 80 ppm for 6 hrs	15.18
T_6 GA3@80 ppm for 12 hrs	16.26
T_7 Control	10.08
F-test	**S**
S. Ed (+)	**0.11**
C.D (5%)	**0.25**

Table 9: Average number of Secondary roots and fibrous roots of Rangpur lime as influenced by different seed treatments with Gibberellic acid.

Treatments	Average number of Secondary roots	Average number of Fibrous roots
T_1 GA_3 @ 400 ppm for 6hrs	2.54	61.5
T_2 GA_3@ 40oom for 12 hrs	3.46	72.90
T_3 GA_3@ 60ppm for 6 hrs	4.42	76.72
T_4 GA_3@ 60ppm for 12 hrs	6.24	82.22
T_5 GA_3@ 80 ppm for 6 hrs	4.91	78.00
T_6 GA_3@80 ppm for 12 hrs	5.45	86.86
T_7 Control	2.32	57.04
F-test	**S**	**S**
S.Ed (+)	**0.11**	**0.15**
C.D (5%)	**0.24**	**0.32**

Table 10: Fresh Weight and Dry Weight (g) of roots of Rampur lime as affected by Gibberellic acid with different seed treatment.

Treatments	Fresh weight(g)	Dry weight (g)
T_1 GA_3 @ 40 ppm for 6hrs	3.19	2.12
T_2 GA_3 @ 40 ppm for 12 hrs	3.26	2.54
T_3 GA_3 @ 60ppm for 6 hrs	3.45	2.59
T_4 GA_3 @ 60ppm for 12 hrs	4.06	2.80
T_5 GA_3 @ 80 ppm for 6 hrs	3.68	2.63
T_6 GA_3 @80 ppm for 12 hrs	5.92	4.06
T_7 Control	2.93	1.87
F-test	**S**	**S**

S.Ed (±)	**0.027**	**0.04**
C.D (5%)	**0.06**	**0.09**

Table 11: Effect of seed treatment with Gibberellic acid on survival percentage with Rangpur lime.

Treatments	Survival percentage
T_1 GA_3 @ 40 ppm for 6 hrs.	52.00
T_2 GA_3 @ 40 ppm for 12 hrs	55.00
T_3 GA_3 @ 60 ppm for 6 hrs	60.00
T_4 GA_3 @ 60 ppm for 12 hrs	75.00
T_5 GA_3 @ 80 ppm for 6 hrs	70.00
T_6 GA_3 @ 80 ppm for 12 hrs	82.00
T_7 Control	30.00