The Pharma Innovation Journal 2022; 11(12): 3056-3061

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(12): 3056-3061

www.thepharmajournal.com
Received: 07-10-2022
Accepted: 11-11-2022

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Effect of GA_3 and growing media on seed germination, growth and vigour of Rangpur lime (*Citrus limonia* Osbeck)

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Abstract
A field experiment was conducted at the Horticulture Research Farm, under Pt. K. L. Shukla College of Horticulture and Research Station Rajnandgaon (C.G.) during the year 2021-22, with a view to study the "Effect of GA_3 and growing media on seed germination, growth and vigour of Rangpur lime (*Citrus limonia* Osbeck)". The Rangpur lime crop was used to grown and treatment was replicated three times in Factorial Completely Randomized Design. In an investigation there were five growing media i.e., M_1: (Soil) Control, M_2: Soil: Sand: FYM (1:1:1) ratio, M_3 : Soil: Sand: FYM: Rice husk (1:1:1:1) ratio, M_4: Soil: Sand: FYM: Vermicompost (1:1:1:1) ratio and M_5: Soil: Sand: Rice husk: Vermicompost (1:1:1:1) ratio and Plant growth regulators i.e., G_1 : (Water) Control, G_2: GA_3 50 ppm, G_3: GA_3 100 ppm and G_4: GA_3 150 ppm were applied at different concentrations in rangpur lime in twenty treatments combinations. Treatment M_5G_4: - Soil: Sand: Rice husk: Vermicompost (1:1:1:1) + $GA_3$150 ppm. The germination parameters i.e., No. of days required for germination (DAS), No. of days required for 50 per cent germination (DAS), No. of days required for appearance of first true leaves, Germination percentage, Germination index and seedling growth parameters i.e., Seedling height (cm), Stem girth (mm), No. of leaves per seedling and Survival percentage were significantly superior in the treatment Soil: Sand: Rice husk: Vermicompost (1:1:1:1) + $GA_3$150 ppm (M_5G_4). Therefore, it may be recommended that treatment (M_5G_4) Soil: Sand: Rice husk: Vermicompost (1:1:1:1) + $GA_3$150 ppm was found most appropriate for raising of healthy seedlings of Rangpur lime.

Keywords: GA_3, growing media, seed germination, Rangpur lime, Plant growth regulators, FYM, rice husk, vermicompost and factorial completely randomized design

Introduction
Citrus fruits have a prominent place among popular and extensively grown tropical and subtropical fruits. Citrus is the world's leading tree fruit crop, it is a crop adaptable to a wide range of soils, terrain, planting and cultural arrangements and over 100 nations reported citrus in 1980. Citrus fruits contain high levels of vitamin A and vitamin C.

Among the citrus fruits cultivated in India, the Rangpur lime (*Citrus limonia* Osbeck.) is a natural hybrid exhibiting the characters of both acid limes (*Citrus aurantifolia* Swingle) and mandarins (*Citrus reticulate*, Blanco). It is a native of India. It is a prolific variety of citrus with well flavoured and highly acidic fruits. The variety has worldwide usage as a rootstock on account of its high resistance to tristeza virus and more tolerant to salts than others. It is a principal rootstock in Brazil and Argentina for sweet oranges, mandarins and grape fruits (Ahmad *et al.*, 2018) [3].

Rangpur lime is a prolific variety of citrus with well flavoured and highly acidic fruits mostly grown for purpose of rootstock production worldwide. Rangpur lime is a promising and recommended rootstock used for both mandarins as well sweet oranges in India as well as Maharashtra, Andhra Pradesh and some other states of India and also used in Argentina. 'Rangpur' lime is not unknown in the world scenes. Apparently originated in India (Webber and Walter, 1967) [22] and seedling plants can be found in almost every citrus-growing country. It is the most important rootstock of citrus in Brazil (Moreira, S. 1964) [13].

Media is a substrate that provides the required elements and physical support to the growing plant. Different growing media are used in raising horticultural plants in the nursery they are mostly organic or inorganic in nature. Growing media are as soil, sand, FYM, Rice husk, Vermicompost consist of mixtures of components that provide water, air, nutrients and mechanical support to the plants, FYM is partially composed of cow dung, urine, bedding and

straw. GA_3 compounds have now been applied to plant organs in several ways and it has been found to greatly enhance stem elongation as its most striking effect. Gibberellic acid is a plant growth hormone involved in various physiological activities such as growth, flowering and ion transport (Wareing and Phillips, 1981; Khan and Samiullah, 2003) [21, 11].

Materials and Methods

The experiment was carried out in the Horticulture Research Farm, under Pt. K. L. Shukla College of Horticulture and Research Station Rajnandgaon (C.G.) during the year 2021-22. Rajnandgaon is located in central plane of Chhattisgarh at latitude 21.10° N, and longitude 81.03° E and an altitude of 330.70 meters above the mean sea level. Climatologically, Rajnandgaon witnesses normal tropical wet and dry climate. The experiment was laid out in Factorial Completely Randomized Design. With three replication there were twenty treatment combination. Growing media (M) as a factor A and GA_3 as a factor B.

The garden soil collected from the college nursery field this soil has been used as growing media. The texture of the soil is sandy loam type and pH is 5-6. FYM is partially composed of cow dung, urine, bedding and straw. FYM contains about 0.4-1.5% nitrogen, 0.3-0.9% phosphoric acid and 0.3-1.9% potash. Vermicompost is a peat-like nutrient-rich growing material that is a rich source of nitrogen 0.51-1.61%, phosphorous 0.19-1.02%, potassium 0.15- 0.73%, and calcium 1.18-7.61% with low C: N ratio (Adhikary, 2012). Rice husk contains Carbon (37%), ash (20%) and the main constituent of the ash is SiO2 (94%). It is acts as a sorbent for nutrients due to presence of high silica content (Radha *et al.* 2018). The stock solution (1000 ppm) of GA_3 was prepared by dissolving 1gm of GA_3 in 20 ml of acetone solution and after making a volume of one liter by adding pure distilled water. Five plants were randomly selected and labelled in each treatment for recording the observations. During the initial stage of the plant or before the 1st observation.

Results and Discussion

Data pertaining to germination parameters and growth seedling parameters influenced by various treatment has been given in Table 1.

No. of days required for germination (DAS)

The data collected during the experiment according to different treatment combinations has been shown in Table 1.

Among all the growing media, treatment M_5 [Soil: Sand: Rice husk: Vermicompost (1:1:1:1)] took the significantly minimum days (11.42 days) for seed germination. The maximum days (13.75 days) required for germination was recorded in M_1 (Control). The treatment of different concentrations of GA_3 and interaction between the growing media and GA_3 was found to be non-significant.

The most probable reason for minimizing the germination time in the media M_5 [Soil: Sand: Rice husk: Vermicompost (1:1:1:1)] is the presence of greater organic manures in this media, which contain organic acid with high accessible moisture and certain acids that may have aided in reducing the germination period. Similar finding was reported by Dayeswari *et al.* (2017) [7] in papaya CO-8.

No. of days required for 50 per cent germination (DAS)

The data collected during the experiment according to different treatment combinations have been shown in Table 1 along with graph for better understanding.

As regard to growing media treatment, M_5 [Soil: Sand: Rice husk: Vermicompost (1:1:1:1)] recorded the minimum no. of days (15.76 days) required for 50% germination. Whereas the maximum no. of days (22.59 days) required for 50% germination was observed in M_1 (Control). The growing media Soil: Sand: Rice husk: Vermicompost (1:1:1:1) promote early seed germination. This might be due to macro and micro nutrients present in this media and also the presence of nitrogen fixers, along with many growth hormones like gibberellins. The finding was closely in agreement with Arvind *et al.* (2015) [4].

The data pertaining to the days required for 50% germination was significantly influenced by the treatment of different GA_3 concentrations. The significantly minimum no. of days (17.54 days) required for 50% germination was found in GA_3 @150 ppm G_4. While the maximum no. of days (19.80 days) required for 50% germination was observed in Water (Control). The minimum time taken for 50% germination in GA_3 might be due to the participation of GA_3 in the activation of cytological enzymes together with the extended plasticity of the cell wall and the higher water uptake that can be the reason for the accelerated germination. Similar result was observed by Prajapati *et al.* (2017) [18] in Acid lime cv. Kagzi lime.

The combination of growing media and GA_3 had a significant effect. The minimum no. of days (15.00 days) required for 50% germination was recorded in Soil: Sand: Rice husk: Vermicompost (1:1:1:1) + GA_3@150 ppm M_5G_4. While treatment Soil + Water M_1G_1 took the maximum no. of days (27.33 days) for 50% germination of Rangpur lime. The reason behind minimum time required for Rangpur lime seed germination in Soil: Sand: Rice husk: Vermicompost (1:1:1:1) + GA_3@150 ppm (M_5G_4) might be that vermicompost contains a high amount of organic matter, with sufficient amount of water and nutrients. It also contains bioactive principles which are beneficial for root growth, root initiation, germination and plant growth.

No. of days required for appearance of first true leaves (DAS)

Among various growing media, treatment M_5 [Soil: Sand: Rice husk: Vermicompost (1:1:1:1)] took the shortest time (25.13 days) to first true leaf appearance, which was found significantly superior to rest of the other treatments while the longest time (32.79 days) taken in treatment M_1 Soil (Control). The reason for improved germination in treatment M_5 [Soil: Sand: Rice husk: Vermicompost (1:1:1:1)] is probably because of the presence greater available potassium in the vermicompost, which is well decomposed by earth worms and pH turned neutral, which made the nutrients in a more readily available form for uptake by plants. Prajapati *et al.* (2017) [18] also observed a positive effect of vermicompost on true leaf appearance in Acid lime cv. Kagzi lime.

Different concentrations of GA_3 had a significant effect. The minimum time required for first true leaf appearance (27.99 days) was observed treatment G_4 (GA_3@150 ppm). While the maximum time (29.84 days) was observed in Water (Control). The minimum days required for first true leaf appearance was recorded in G_4 (GA_3 @150 ppm) the possible reason behind

this GA_3 @150ppm promotes seed germination by forming α amylase enzyme, which converts insoluble starch into soluble sugars and it also promotes radical growth by removing some metabolic impediments. Similar finding was also recorded by Choudhary and Chakrawar (1982) [6] in Rangpur lime and Misra *et al.* (1982) [12] in Acid lime.

The interaction between the growing media and GA_3 was found to be non- significant.

Germination percentage

Among the various growing media M_5 [Soil: Sand: Rice husk: Vermicompost (1:1:1:1)] showed significantly maximum germination percentage (89.21%), the minimum germination percentage (76.00%) was recorded in M_1 Soil (Control). The maximum germination in M_5 [Soil: Sand: Rice husk: Vermicompost (1:1:1:1)] might be due to vermicompost has a balanced composition of nutrients and was higher in organic matter, which increases the availability of nutrients and water holding capacity with suitable ratio of soil, sand and Rice husk. All these factors favor the germination and germination percentage. A similar result was also recorded by Dayeswari *et al.* (2017) [7] in papaya.

Different concentrations of GA_3 had a significant effect on germination percentage. The maximum germination percentage (83.80%) was recorded in G_4 (GA_3 @150 ppm), While the minimum germination percentage (81.41%) was observed in G_1 Water (Control). The increased germination percentage in seeds treated with GA_3 @150 ppm might be due to GA_3 involvement in activation of cytological enzymes and also increases cell wall plasticity and water absorption. A similar result was obtained by Veerugavathathan *et al.* (1980) [20] in papaya.

The interaction between growing media and GA_3 had a significant effect on germination percentage. The maximum germination percentage (90.00%) was recorded in M_5G_4 [Soil: Sand: Rice husk: Vermicompost (1:1:1:1) + GA_3@150 ppm]. While treatment M_1G_1 [Soil + Water] took the minimum germination percentage (74.00%). The reason behind the least days required for Rangpur lime seed germination in M_5G_4 [Soil: Sand: Rice husk: Vermicompost (1:1:1:1) + GA_3 @150 ppm] might be due to media contains a high amount of organic matter, which provides the media with a sufficient amount of water and nutrients. The results are in conformity with the findings of Farooqui *et al.* (1991) [9] in sapota.

Germination index

Observed with treatment M_5 [Soil: Sand: Rice husk: Vermicompost (1:1:1:1)] gave the significantly highest germination index (0.44). While the lowest germination index (0.31) was found in (Control). The reason behind the highest germination index in growing media M_5 [Soil: Sand: Rice husk: Vermicompost (1:1:1:1)] might be due to vermicompost is rich in organic matter, which acts as glue for soil aggregation and is a source of soil nutrients. Result was confirmed with the finding of Arvind *et al.* (2015) [4] in papaya and Abirami *et al.* (2010) [1] in Aonla.

However, interaction between GA_3 and growing media was found non-significant with regards to germination index of Rangpur lime.

Seedling height (cm)

The significant impact of different growing media on seedling height was observed in treatment M_5 [Soil: Sand: Rice husk: Vermicompost (1:1:1:1)] gave the significantly maximum height (4.95, 6.20, 7.85 and 9.51 cm) at 30, 60, 90 & 120 DAS, respectively. While treatment M_1 (Soil) produced the lowest seedling height (3.01, 3.62, 4.47 and 5.28 cm) at each observation, *i.e.*, 30, 60, 90 and 120 DAS, respectively. The Maximum seedling height was observed in media containing vermicompost and Rice husk because they included nutrients that improved nutritional status, pH levels and organic carbon content. A similar result was obtained by Yadav *et al.* (2012) [23] in Acid lime.

The maximum seedling height (4.34, 5.23, 6.68 and 8.15 cm) was obtained in seeds treated with G_4 (GA_3 @ 150 ppm) at 30, 60, 90 and 120 DAS, respectively. While treatment G_1 (Water) produced the lowest seedling height (4.04, 4.86, 6.05 and 7.40 cm) at each observation, *i.e.*, 30, 60, 90 and 120 DAS respectively. Seedlings have sufficient number of endogenous levels GA_3, and external treatment of GA_3 improved with sufficient amount of growth by promoting cell multiplication and cell elongation, leading to greater plant development. A similar finding was reported by Patel *et al.* (2013) reported that the Acid lime cv. Kagzi lime.

The combined effect of GA_3 and growing media was found to be non-significant at 30, 60 and 90 DAS. The interaction effect of GA_3 and growing media resulted in a significantly increase in seedling height at 120 DAS, whereas. At 120 DAS maximum height (9.79 cm) of seedling was observed in treatment combination of M_5G_4 [Soil: Sand: Rice husk: Vermicompost (1:1:1:1) + GA_3@150 ppm], while the treatment combination M_1G_1 (Soil + Water) gave minimum seedling height (4.91 cm) at 120 DAS. This result was obtained may be due to the vermicompost and Rice husk both improve soil properties by adding organic carbon, which increases nutrient and water availability to plants and significantly increases the growth of seedlings. These results were in accordance with the findings of Parasanna and Ray (2013) [15] and Prajapati *et al.* (2017) [18] in Acid lime cv. Kagzi lime.

Stem girth (mm)

Treatment M_5 [Soil: Sand: Rice husk: Vermicompost (1:1:1:1)] was noted significantly highest stem girth (1.11, 1.47, 2.01 and 2.45mm) at 30, 60, 90 and 120 DAS, respectively, while media M_1 (Control) produced the lowest stem girth (0.89, 1.13, 1.32 and 1.45 mm) at each observation, *i.e.*, 30, 60, 90 and 120 DAS, respectively. The possible reason may be the sufficient availability of plant nutrients in available form during different growth period, which ultimately leads to promote seedling girth of Rangpur lime. A similar result was obtained by Bhardwaj *et al.* (2008) [5] in seedling growth of papaya.

The Rangpur lime seeds treated with different concentrations of GA_3 and the interaction between GA_3 and growing media had a non-significant impact on stem girth at each observation, *i.e.*, 30, 60, 90 and 120 DAS, respectively.

No. of leaves per seedling

Among various growing media was noted with treatment M_5 [Soil: Sand: Rice husk: Vermicompost (1:1:1:1)] significantly maximum number of leaves (4.47, 7.28, 10.80 and 14.30 per seedling) at 30, 60, 90 and 120 DAS respectively. While treatment M_1 (Soil) produced the minimum no. of leaves (3.49, 5.03, 6.15 and 7.94 per seedling) per seedling each observation, *i.e.*, 30, 60, 90, and 120 DAS, respectively. This

was due to the gradual decomposition of organic components such as cellulose and lignin, which eventually released humic acid material in vermicompost and led to a high silicon concentration in rice husk with suitable ratio. Similar finding was recorded by Prajapati *et al.* (2017)) [18] in Acid lime cv. Kagzi lime.

The Rangpur lime seeds treated with different concentrations of GA_3 had a non- significant increase in the no. of leaves at 30 DAS and had a significant increase in the no. of leaves at 60, 90, and 120 DAS per seedling. The maximum no. of leaves (4.07, 6.52, 9.59 and 12.71 per seedling) was recorded in seeds treated with G_4 (GA_3 @150 ppm) at 60, 90, and 120 DAS, while treatment G_1 (Control)) produced the lowest no. of leaves (3.81, 6.11, 8.69 and 11.61) at 30, 60, 90, and 120 DAS, respectively. The possible reason might be GA_3 may have aided in the invigoration of plant physiological processes and the stimulatory action of chemicals to develop new leaves at a faster rate, resulting in an increase in the no. of leaves per seedling. A similar finding was reported by Choudhary and Chakrawar (1982) [6] in Rangpur lime.

The interaction between growing media and GA_3 effect on no. of leaves of Rangpur lime per seedling was found to be non-significant at 30 and 60 DAS. The significantly maximum no. of leaves (11.47 and 15.33) was observed in treatment M_5G_4 [Soil: Sand: Rice husk: Vermicompost (1:1:1:1) + GA_3 @150 ppm], While M_1G_1 [Soil + Water] recorded minimum leaves (5.60 and 7.53) at 90 and 120 DAS, respectively. The possible reason behind this the combination favors the physiological process and chemical stimulation by adding nutrients in the media, leading to the formation of new leaves. Similar result was obtained by Choudhary and Chakrawar (1982) [6] in Rangpur lime.

Survival percentage

Among all the growing media treatment M_5 [Soil: Sand: Rice husk: Vermicompost (1:1:1:1)] noted significantly higher survival percentage of Rangpur lime seedling treatments (88.88%), While the lower survival per cent (73.00%) observed with the treatment M_1 (Control). Possible reason behind this might be that they improve physical and biological conditions and maintain proper aeration as well as permeability, which promotes better shoot and root growth which leads better survival of Rangpur lime. Similar result obtained by Nagar *et al*. (2011) in Acid lime cv. Kagzi.

Different concentrations of GA_3 had a significant effect on the survival percentage. The significantly maximum survival (83.90%) was noted when the seeds were treated with G_4 (GA_3 @150 ppm), While the minimum survival (80.70%) was found in G_1 (Control). This might be due to the treatment of GA_3 increases the root and shoot growth by stimulating the cell elongation and cell expansion process, which leads better survival of seedlings. Similar result was obtained by Prajapati (2013) [17].

The analysis of the data indicated that interaction between growing media and GA_3 had a significant effect. The significantly maximum survival percentage (90.00) of Rangpur lime was observed with (M_5G_4) [Soil: Sand: Rice husk: Vermicompost (1:1:1:1) + GA_3 @150 ppm], whereas significantly minimum survival percentage (70.00%) of Rangpur lime seedling was noted with M_1G_1 (Soil + Water). The ideal combination of FYM, Rice husk and vermicompost gave a start for seedling development, which was then boosted with plant growth regulators. Similar result obtained by Joshi *et al.* (2015) [10] in Acid lime and Dilip *et al.* (2017) [8] in Rangpur lime.

Table 1: Effect of GA_3 and growing media on germination parameters and growth seedling of Rangpur lime.

Treatments	No. of days required for seed germination	No. of days required for 50 per cent germination	No. of days required for appearance of first true leave	Germination percentage	Germination index	Seedling height (cm)			
						30 DAS	60 DAS	90 DAS	120 DAS
Growing media (M)									
M_1	13.75	22.59	32.79	76.00 (8.75)	0.31	3.01	3.62	4.47	5.28
M_2	13.07	18.92	29.25	79.46 (8.94)	0.35	3.89	4.53	5.80	7.21
M_3	12.59	18.02	28.78	82.67 (9.12)	0.38	4.40	5.14	6.57	8.08
M_4	12.19	17.01	27.92	86.17 (9.31)	0.41	4.65	5.57	7.19	8.93
M_5	11.42	15.76	25.13	89.21 (9.47)	0.44	4.95	6.20	7.85	9.51
C.D. at 5%	1.040	0.940	0.826	0.709	0.035	0.215	0.254	0.209	0.196
SE(m)	0.364	0.329	0.289	0.248	0.012	0.075	0.089	0.073	0.068
GA_3 (G)									
G_1	12.85	19.80	29.84	81.41 (9.05)	0.37	4.04	4.86	6.05	7.40
G_2	12.72	18.82	29.02	82.28 (9.10)	0.37	4.11	4.96	6.27	7.73
G_3	12.46	17.68	28.23	83.31 (9.15)	0.38	4.23	4.99	6.51	7.92
G_4	12.37	17.54	27.99	83.80 (9.18)	0.39	4.34	5.23	6.68	8.15
C.D. at 5%	NS	0.841	0.739	0.634	NS	0.193	0.228	0.187	0.175
SE(m)	0.326	0.294	0.259	0.222	0.011	0.067	0.080	0.065	0.061
Interaction (M × G)									
M_1G_1	14.00	27.33	34.73	74.00	0.30	2.92	3.49	4.09	4.91
M_1G_2	13.67	23.67	34.13	75.00	0.31	2.92	3.53	4.09	5.02
M_1G_3	13.66	19.70	31.27	77.00	0.31	3.01	3.57	4.63	5.29
M_1G_4	13.65	19.67	31.03	78.00	0.32	3.19	3.89	5.07	5.89
M_2G_1	13.62	19.33	29.43	78.50	0.33	3.59	4.39	5.19	6.41
M_2G_2	13.33	19.00	29.33	79.33	0.34	3.74	4.45	5.89	7.31
M_2G_3	12.67	18.68	29.20	80.00	0.35	4.08	4.45	5.99	7.57
M_2G_4	12.65	18.67	29.03	80.00	0.36	4.14	4.83	6.14	7.53
M_3G_1	12.61	18.33	29.90	81.07	0.37	4.27	4.95	6.24	7.79
M_3G_2	12.60	18.07	28.43	82.50	0.37	4.43	5.06	6.50	8.08
M_3G_3	12.58	18.00	28.40	84.12	0.38	4.43	5.13	6.72	8.10

M_3G_4	12.55	17.67	28.37	83.00	0.39	4.47	5.40	6.83	8.35
M_4G_1	12.34	17.33	28.33	85.00	0.40	4.58	5.44	6.99	8.60
M_4G_2	12.33	17.04	28.30	85.25	0.40	4.60	5.59	7.15	8.93
M_4G_3	12.07	17.00	27.70	86.42	0.41	4.64	5.62	7.27	9.02
M_4G_4	12.00	16.67	27.33	88.00	0.41	4.76	5.63	7.35	9.17
M_5G_1	11.68	16.66	26.80	88.50	0.43	4.83	6.05	7.73	9.30
M_5G_2	11.67	16.33	24.93	89.33	0.42	4.86	6.17	7.74	9.32
M_5G_3	11.33	15.04	24.60	89.00	0.44	5.01	6.19	7.93	9.62
M_5G_4	11.00	15.00	24.20	90.00	0.45	5.11	6.40	7.99	9.79
C.D. at 5%	NS	1.880	NS	1.418	NS	NS	NS	NS	0.391
SE(m)	0.728	0.658	0.578	0.496	0.024	0.151	0.178	0.146	0.137
CV %	10.006	6.172	3.481	1.039	11.228	6.248	6.154	3.974	3.038

Treatments	**Stem girth (mm)**				**No. of leaves**				**survival percentage**
	30 DAS	**60 DAS**	**90 DAS**	**120 DAS**	**30 DAS**	**60 DAS**	**90 DAS**	**120 DAS**	
Growing media (M)									
M_1	0.89	1.13	1.32	1.45	3.49	5.03	6.15	7.94	73.00 (8.57)
M_2	0.94	1.29	1.67	1.96	3.69	6.07	8.87	12.05	80.38 (8.99)
M_3	0.99	1.36	1.80	2.15	3.97	6.50	9.82	13.02	83.56 (9.17)
M_4	1.04	1.40	1.84	2.25	4.22	6.68	10.03	13.35	86.00 (9.30)
M_5	1.11	1.47	2.01	2.45	4.47	7.28	10.80	14.30	88.88 (9.45)
C.D. at 5%	0.150	0.101	0.228	0.197	0.262	0.215	0.257	0.229	0.890
SE(m)	0.053	0.035	0.080	0.069	0.092	0.075	0.090	0.080	0.311
GA_3 (G)									
G_1	0.97	1.30	1.67	1.99	3.81	6.11	8.69	11.61	80.70 (9.01)
G_2	0.98	1.32	1.72	2.03	3.96	6.28	8.99	12.03	82.00 (9.08)
G_3	1.00	1.34	1.75	2.07	4.01	6.35	9.27	12.18	82.85 (9.13)
G_4	1.02	1.36	1.78	2.12	4.07	6.52	9.59	12.71	83.90 (9.19)
C.D. at 5%	NS	NS	NS	NS	NS	0.192	0.229	0.205	0.796
SE(m)	0.047	0.032	0.071	0.062	0.082	0.067	0.080	0.072	0.278
Interaction (M × G)									
M_1G_1	0.87	1.06	1.21	1.36	3.00	4.73	5.60	7.53	70.00
M_1G_2	0.88	1.11	1.34	1.44	3.60	5.00	5.67	7.67	72.00
M_1G_3	0.89	1.17	1.36	1.49	3.67	5.13	6.33	7.87	74.00
M_1G_4	0.91	1.19	1.37	1.50	3.67	5.27	7.00	8.67	76.00
M_2G_1	0.91	1.27	1.61	1.88	3.67	5.87	8.00	10.60	78.00
M_2G_2	0.95	1.28	1.67	1.98	3.67	6.00	8.80	12.33	80.00
M_2G_3	0.95	1.29	1.67	1.99	3.67	6.07	9.20	12.47	81.00
M_2G_4	0.96	1.33	1.73	2.00	3.73	6.33	9.47	12.80	82.50
M_3G_1	0.96	1.34	1.76	2.13	3.93	6.40	9.73	12.93	83.00
M_3G_2	0.97	1.35	1.80	2.14	3.93	6.47	9.80	12.93	83.50
M_3G_3	1.01	1.37	1.82	2.15	4.00	6.60	9.87	13.07	83.75
M_3G_4	1.02	1.38	1.82	2.16	4.00	6.53	9.87	13.13	84.00
M_4G_1	1.02	1.39	1.82	2.16	4.07	6.53	9.93	13.20	84.50
M_4G_2	1.03	1.39	1.82	2.19	4.20	6.73	10.00	13.20	86.00
M_4G_3	1.04	1.40	1.83	2.29	4.27	6.73	10.07	13.40	86.50
M_4G_4	1.07	1.42	1.91	2.37	4.33	6.73	10.13	13.60	87.00
M_5G_1	1.09	1.42	1.94	2.41	4.40	7.00	10.20	13.80	88.00
M_5G_2	1.09	1.47	1.97	2.41	4.40	7.20	10.67	14.00	88.50
M_5G_3	1.11	1.49	2.05	2.42	4.47	7.20	10.87	14.07	89.00
M_5G_4	1.13	1.50	2.08	2.56	4.60	7.73	11.47	15.33	90.00
C.D. at 5%	NS	NS	NS	NS	NS	NS	0.513	0.458	1.779
SE(m)	0.105	0.071	0.160	0.138	0.183	0.150	0.180	0.160	0.623
CV %	18.373	9.218	16.007	11.659	8.017	4.122	3.404	2.287	1.309

M1=Soil (Control) G1= Water (control)
M2=Soil: Sand: FYM (1:1:1) G2= GA3 50 ppm
M3=Soil: Sand: FYM: Rice husk (1:1:1:1) G3= GA3 100 ppm
M4=Soil: Sand: FYM: Vermicompost (1:1:1:1) G4=GA3 150 ppm
M5=Soil: Sand: Rice husk: Vermicompost (1:1:1:1)

Conclusion

According to the research findings, germination parameters *like*, no. of days required for germination, no. of days required for 50% germination, no. of days required for the appearance of first true leaves, maximum germination percentage and germination index and Seedling growth parameters like seedling height, stem girth, no. of leaves and survival percentage were noted in M_5 [Soil: Sand: Rice husk: Vermicompost (1:1:1:1)].

GA_3 had a positive effect shown in both germination and seedling parameters. G_4 (GA_3 @150 ppm) was found to be the most appropriate for germination parameters; followed by G_3 (GA_3 @100 ppm).

Thus, on the basis of present investigation it may be recommended that treatment of M_5G_4 [Soil: Sand: Rice husk: Vermicompost (1:1:1:1) + GA_3 @ 150 ppm] was found appropriate for raising healthy seedlings of Rangpur lime.

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