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Effect of growing media and gibberellic acid on seedling growth of acid lime (*Citrus aurantifolia* Swingle.) cv. Kagzi lime

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Abstract
An investigation entitled "Effect of growing media and gibberellic acid on seedling growth of acid lime (*Citrus aurantifolia* Swingle) cv. Kagzi lime" was conducted during the year *Kharif*-2019 at Horticultural Research Farm, Department of Horticulture, B. A. College of Agriculture, Anand Agricultural University, Anand. Treatments were comprised five levels of growing media (M)*viz*.,M_1-Soil + FYM (1:1), M_2-Soil + Vermicompost (1:1), M_3-Soil + FYM + Vermiculite (1:1:1), M_4-Soil + Vermicompost + Vermiculite (1:1:1) and M_5-Soil + FYM + Vermicompost + Vermiculite (1:1:1:1) with four levels dipping of seeds of acid lime in gibberellic acid for 24 hrs before sowing in polythene bags *viz*.,G_1-GA_3 @ 50 mg/l,G_2-GA_3 @ 100 mg/l and G_3-GA_3 @ 150 mg/l with G_0-Control (Water). The experiment were laid out in a Completely Randomized Design (Factorial) with twenty treatment combinations and repeated thrice. Growing media of soil + FYM + vermicompost + vermiculite (1:1:1:1) recorded maximum height of seedling (38.71 cm), shoot length (14.15 cm), stem diameter (1.01 mm), number of leaves per plant (10.34), leaf area (5.75 cm^2), root length (25.71 cm), chlorophyll content (61.68), fresh weight of seedling (1.73 g) and dry weight of seedling (0.78 g) at 120 DAS respectively. Dipping of acid lime seeds for 24 hrs before sowing in GA_3 @ 150 mg/l recorded maximum height of seedling (38.96 cm), shoot length (14.22 cm), stem diameter (0.85 mm), number of leaves per seedling (10.25), leaf area (5.57 cm^2), root length (25.68 cm), chlorophyll content (62.20), fresh weight of seedling (1.58 g), dry weight of seedling (0.64 g) at 120 DAS respectively. Treatment combination of Growing media and GA_3 of soil + FYM + vermicompost + vermiculite (1:1:1:1) + Dipping of acid lime seeds before sowing in GA_3 @ 150 mg/l apparently recorded maximum shoot length (16.43 cm), stem diameter (1.15 mm), number of leaves per seedling (10.26), leaf area (6.60 cm^2), root length (30.83 cm) and chlorophyll content (70.12) at 120 DAS respectively.

Keywords: Kagzi lime, growing media, GA3, growth parameters

Introduction
Citrus is one of the largest and most important fruits of tropical and subtropical regions. It is a native to India and South Eastern China. It occupies 3rd ranks after mango and banana in India. It comprised two groups: Lime and Lemon. Citrus is a member of the family Rutaceae. Small, fruited acid limes are classified botanically under the *Citrus aurantifolia* (Swingle).

Acid lime is an important fruit crop which is propagated through seeds only. The quality of seedlings obtained from a nursery influences re-establishment in the field and the eventual productivity of an orchard. Seed germination is affected by many factors like type of substrate used, environmental factors etc. Some of the problems faced by acid lime growers are slow, erratic and incomplete germination, high initial seedling mortality and incidence of soil born diseases. In heavy soil without enough drainage, the development of root system is suppressed and plants are more susceptible to soil born diseases. The increasing germination percentage and producing healthier seedling is a major challenge for farmers. Hence, there is a need to standardize the growing media with using different concentration of GA3, which give better germination and growth of the plant.

Growing media play an important role in germination of seed and further growth and development of seedling. It is a substrate that provides the required elements and physical support to the growing plants and serves as a nutrient and water reservoir and permit gaseous exchange between roots and atmosphere. The role of GA3 in the induction of synthesis of α-amylase and other hydrolytic enzymes among monocots and certain dicots is well

documented. GA_3 appears mainly to induce the activity of the gluconeogenic enzymes during early stages of seed germinations and GA3 has proved to be the best for seedling growth.

Materials and Methods

The experiment was conducted in the Net House at the Horticultural Research Farm, Department of Horticulture, B. A. College of Agriculture, Anand Agricultural University, Anand during the year kharif-2019. The experiment was laid out in Completely Randomized Design (Factorial) with twenty treatment combinations and repeated thrice. Seeds were carefully extracted from uniform size fully ripened and healthy fruits of acid lime. Extracted seeds were washed in running water and dried under shade for 1 hour. Seeds were soaked in 50, 100 and 150 mg/l GA_3 solution for 24 hours which was prepared by dissolving 50, 100 and 150 mg GA_3, respectively (GA_3 was completely dissolved by addition of small quantity of NaoH) in 1 liter of water. Various growing media *viz*., soil, FYM, vermicompost and vermiculite were used in 1:1 proportion as a different combination or mixture used for sowing seeds. Black polythene bags of 7" × 5" size were filled with (1:1) proportion for different mixture of growing media according to the treatments. One seed of the acid lime was dibbled at about 2 to 3 cm depth in each polythene bag. For each replication and for each treatment 75 polythene bags were filled and kept in net house having 75% green shed net. Data on height of seedling, shoot length, stem diameter, number of leaves per seedling, leaf area, root length, chlorophyll content, fresh weight and dry weight.

Results and Discussion

Effect of growing media

Growing media showed the significant effect on growth parameters. Growing media of soil + FYM + vermicompost + vermiculite (1:1:1:1) recorded maximum height of seedling (22.26, 28.93 and 38.71 cm), shoot length (7.08, 10.14 and 14.15 cm), stem diameter (0.89, 0.97 and 1.01 mm), number of leaves per seedling (7.90, 9.51 and 10.34), leaf area (3.51, 4.68 and 5.75 cm^2) and root length (15.04, 20.35 and 25.71 cm) at 60, 90 and 120 DAS. This might be due to facts that at initial stage soil provide natural support; vermiculite improved soil texture, porosity, retention property and Later on FYM added humus, activity of useful soil micro fauna and flora which maintained soil temperature and improved soil health and nutrient status of medium (Hartmann and Kester, 1997) [5]. While, at latter stage vermicompost which contained plant growth regulating materials, such as humic acid and plant growth regulators like auxin, gibberellins and cytokinins, might be responsible for increasing growth parameters (Atiyeh *et al.*, 2002) [2] Similar results were also reported by Ramteke *et al.* (2015) [12], Nelson *et al.* (2008) [11] in arnotta plant (*Bixaorellana*), Yadav *et al.* (2012) [13] in acid lime and Abirami *et al.* (2010) [1] in nutmeg. Growing media also observed significant effect on physiological parameters. Growing media of soil + FYM + vermicompost + vermiculite (1:1:1:1) recorded maximum chlorophyll content (56.63, 60.20 and 61.68), fresh weight of seedling (1.17, 1.59 and 1.73g), dry weight of seedling (0.35, 0.57 and 0.78 g) at 60, 90 and 120 DAS. This might be due to combination of growing media stimulated nutrient uptake specially nitrogen and synthesis of chlorophyll which have role in the assimilation of numerous amino acids that are subsequently incorporated in proteins and nucleic acid, which provide framework for chloroplast result into better chlorophyll content in leaves (Awasthi *et al.*, 1996) [3]. Similar results were obtained by Yadav *et al.* (2012) [13] in acid lime.

Effect of gibberellic acid

Gibberellic acid showed significant effect on growth attributes. While gibberellic acid of GA_3 @ 150 mg/l recorded maximum height of seedling (21.78, 29.78 and 38.96 cm), shoot length (6.81, 9.66 and 14.22 cm), stem diameter (0.76, 0.79 and 0.85 mm), number of leaves per seedling (7.60, 8.44 and 10.25), leaf area (2.94, 4.07 and 5.57 cm^2) and root length (14.60, 20.64 and 25.68 cm) at 60, 90 and 120 DAS. This might be due to GA_3 effect on elongation of internodes, as GA_3 is known to enhance cell elongation (Krishnamoorthy and Sandooja, 1981) [9]. Similar results were found by Chiranjeevi *et al.* (2017) [4] in aonla and Jaiswal *et al.* (2018) [7] in kagzi lime. Gibberellic acid also exhibited significant effect on physiological parameters such as chlorophyll content (54.20, 57.28 and 62. 20), fresh weight of seedling (0.92, 1.35 and 1.58 g) and dry weight of seedling (0.30, 0.50 and 0.64 g). It might be due to GA_3 treated plant may be indication of increased rate of photosynthesis (Kanjilal and Singh, 1998) [8] and the increase in total chlorophyll content can also be attributed to involvement of growth regulators in promoting the synthesis of chlorophyll as well as development of chloroplast. These results were in accordance with (Kanjilal and Singh, 1998) [8]. Similar results were also reported by Hota *et al.* (2018) [6] in Jamun.

Interaction effect of Growing media and Gibberellic acid

Interaction effect of growing media and gibberellic acid showed the significant effect on growth attributes. Treatment combination of soil + FYM + vermicompost + vermiculite (1:1:1:1) + GA_3 @ 150 mg/l recorded maximum height of seedling (35.00 cm) at 90 DAS, shoot length (11.56 and 16.43 cm) at 90 and 120 DAS, stem diameter (1.05, 1.11 and 1.15 mm) at 60, 90 and 120 DAS, number of leaves per seedling (9.06 and 10.26) at 60 and 120 DAS, leaf area (4.54, 5.35 and 6.60 cm^2) and root length (16.56, 23.73 and 30.83 cm) at 60, 90 and 120 DAS, respectively. This might be due to availability of sufficient nutrient content in Fym with regard to physical parameters of soil, retention property of vermiculite and later on vermicompost which contained plant growth regulating materials which promotes better growth and GA_3 increases somatic uptake of nutrients, causing cell elongation. Similar result was reported by Mishra *et al.* (2017) [10] in papaya. While treatment combination of soil + FYM + vermicompost + vermiculite (1:1:1:1) + GA_3 @ 150 mg/l recorded significant effect on physiological attributes such as maximum chlorophyll content (61.77, 69.15 and 70.12) at 60, 90 and 120 DAS and dry weight of seedling (0.67 g) at 90 DAS respectively. This might be due to combination of growing media and GA_3 nutrient uptake specially nitrogen and Synthesis chlorophyll as well as development of chloroplast increases the chlorophyll content. Similar result was reported by Yadav *et al.* (2012) [13] in acid lime.

Table 1: Effect of growing media and GA_3 on growth of acid lime cv. Kagzi lime

Treatments	Height of seedling (cm)			Shoot length (cm)			Stem diameter (mm)			Number of leaves per seedling			Leaf area (cm^2)			Root length (cm)		
DAYS	60 DAS	90 DAS	120 DAS	60 DAS	90 DAS	120 DAS	60 DAS	90 DAS	120 DAS	60 DAS	90 DAS	120 DAS	60 DAS	90 DAS	120 DAS	60 DAS	90 DAS	120 DAS
Growing media (M)																		
M_1: Soil + FYM	19.40	25.41	34.27	6.08	8.70	12.80	0.63	0.67	0.73	6.65	8.14	9.45	2.32	3.50	4.92	13.07	18.00	20.85
M_2: Soil + Vermicompost	17.25	22.61	27.94	5.85	8.46	11.57	0.60	0.62	0.65	6.31	8.050	8.55	1.97	2.87	4.55	12.50	15.59	17.83
M_3: Soil + FYM + Vermiculite	19.94	27.75	37.00	6.21	9.30	13.03	0.76	0.77	0.79	7.17	7.44	10.00	2.42	3.69	5.33	13.66	19.61	25.40
M_4: Soil + Vermicompost + Vermiculite	19.08	24.98	33.50	6.06	8.72	12.11	0.63	0.68	0.70	6.65	7.20	8.78	2.09	3.25	4.69	12.52	16.76	19.55
M_5: Soil + FYM + Vermicompost + Vermiculite	22.26	28.93	38.71	7.08	10.14	14.15	0.89	0.97	1.01	7.90	9.51	10.34	3.51	4.68	5.75	15.04	20.35	25.71
S. Em±	0.34	0.39	0.60	0.11	0.18	0.19	0.01	0.01	0.01	0.10	0.08	0.12	0.05	0.04	0.10	0.17	0.29	0.37
C.D. at 5%	0.97	1.11	1.73	0.33	0.53	0.54	0.03	0.02	0.03	0.31	0.24	0.36	0.14	0.12	0.30	0.50	0.83	1.06
Gibberellic acid (G)																		
G_0: Control (Water)	16.88	21.77	28.70	5.52	8.21	11.32	0.63	0.68	0.70	6.44	7.85	8.60	1.92	3.11	4.41	12.21	15.30	18.42
G_1: GA_3 50 mg/l	18.97	24.46	33.21	6.16	9.04	12.22	0.69	0.71	0.74	6.68	8.01	9.11	2.33	3.47	5.04	12.94	17.62	20.88
G_2: GA_3 100 mg/l	20.70	27.74	36.25	6.52	9.35	13.18	0.72	0.78	0.81	7.04	7.97	9.74	2.66	3.78	5.18	13.68	18.70	22.48
G_3: GA_3 150 mg/l	21.78	29.78	38.96	6.81	9.66	14.22	0.76	0.79	0.85	7.60	8.44	10.25	2.94	4.07	5.57	14.60	20.64	25.68
S. Em±	0.30	0.35	0.54	0.10	0.16	0.17	0.01	0.009	0.01	0.09	0.07	0.11	0.04	0.03	0.09	0.15	0.15	0.33
C.D. at 5%	0.68	0.99	1.54	0.29	0.47	0.48	0.02	0.02	0.02	0.27	0.21	0.32	0.12	0.11	0.27	0.45	0.45	0.95
Interaction (M × G)	NS.	Sig.	NS.	NS	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	NS	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
C.V.%	6.06	5.22	6.12	6.39	7.15	5.17	4.53	4.67	4.10	5.44	3.66	4.66	7.08	4.22	7.40	4.57	5.60	5.89

Treatments	Chlorophyll content			Fresh weight of seedling (g)			Dry weight of seedling (g)		
DAYS	60 DAS	90 DAS	120 DAS	60 DAS	90 DAS	120 DAS	60 DAS	90 DAS	120 DAS
M_1: Soil + FYM	49.80	52.41	58.71	0.84	1.28	1.51	0.23	0.44	0.53
M_2: Soil + Vermicompost	47.39	53.09	56.63	0.46	0.78	1.12	0.15	0.29	0.40
M_3: Soil + FYM + Vermiculite	53.08	54.68	59.26	1.03	1.45	1.54	0.31	0.45	0.58
M_4: Soil + Vermicompost + Vermiculite	50.18	53.57	59.00	0.57	1.11	1.29	0.17	0.34	0.46
M_5: Soil + FYM + Vermicompost + Vermiculite	56.63	60.20	61.68	1.17	1.59	1.73	0.35	0.57	0.78
S. Em±	0.72	0.97	1.01	0.01	0.01	0.02	0.008	0.01	0.01
C.D. at 5%	2.06	2.79	2.92	0.03	0.04	0.05	0.02	0.02	0.03
G_0: Control (Water)	49.00	51.40	54.43	0.72	1.13	1.31	0.19	0.34	0.49
G_1: GA_3 50 mg/l	50.52	53.30	58.85	0.78	1.21	1.39	0.21	0.39	0.52
G_2: GA_3 100 mg/l	51.94	57.19	60.74	0.84	1.27	1.47	0.26	0.44	0.55
G_3: GA_3 150 mg/l	54.20	57.28	62.20	0.92	1.35	1.58	0.30	0.50	0.64
S. Em±	0.64	0.87	0.91	0.01	0.01	0.01	0.007	0.009	0.01
C.D. at 5%	1.84	2.50	2.61	0.03	0.04	0.05	0.02	0.02	0.03
Interaction (M × G)	Sig.	Sig.	Sig.	NS.	NS.	NS.	NS.	Sig.	NS.
C.V.%	3.95	6.19	4.87	5.23	4.75	4.94	9.74	7.96	6.67

Table 1: Interaction effect of growing media and GA_3 on growth of acid lime cv. Kagzi lime

G M	Height of seedling (cm)				Shoot length (cm)								Stem diameter (mm)							
	90 DAS				90 DAS				120 DAS				60 DAS				90 DAS			
	G_0	G_1	G_2	G_3	G_0	G_1	G_2	G_3	G_0	G_1	G_2	G_3	G_0	G_1	G_2	G_3	G_0	G_1	G_2	G_3
M_1	22.03	24.93	27.03	27.64	8.03	8.73	9.26	9.36	11.43	12.16	13.33	14.30	0.56	0.63	0.67	0.68	0.65	0.66	0.71	0.68
M_2	18.46	22.30	23.90	25.80	7.46	8.56	8.59	8.66	10.08	11.20	12.13	12.87	0.57	0.59	0.61	0.62	0.60	0.61	0.65	0.63
M_3	22.90	25.10	30.60	32.43	8.93	9.03	9.06	10.20	11.90	13.00	12.56	14.66	0.72	0.74	0.76	0.81	0.72	0.76	0.78	0.82
M_4	21.06	24.16	26.63	28.06	8.13	9.10	9.12	8.53	11.43	11.98	12.20	12.83	0.59	0.63	0.65	0.67	0.61	0.66	0.72	0.72
M_5	24.39	25.80	30.53	35.00	8.48	9.80	10.72	11.56	11.76	12.74	15.66	16.43	0.74	0.84	0.93	1.05	0.83	0.89	1.05	1.11
S.Em±	0.78				0.37				0.38				0.02				0.02			
C.D. at 5%	2.23				1.07				1.08				0.06				0.05			

G M	Stem diameter (mm)				Number of leaves per seedling (cm)								Leaf area (cm)							
	120 DAS				60 DAS				90 DAS				60 DAS				90 DAS			
	G_0	G_1	G_2	G_3	G_0	G_1	G_2	G_3	G_0	G_1	G_2	G_3	G_0	G_1	G_2	G_3	G_0	G_1	G_2	G_3
M_1	0.65	0.71	0.75	0.83	6.26	6.53	6.80	7.03	7.73	6.73	7.33	8.90	1.89	2.28	2.52	2.58	2.83	3.13	3.83	4.21
M_2	0.62	0.64	0.68	0.67	6.00	6.20	6.13	6.93	7.83	8.46	7.90	8.00	1.56	1.67	2.23	2.41	2.55	2.87	2.92	3.14
M_3	0.75	0.76	0.80	0.85	6.73	6.96	7.13	7.86	7.20	6.73	7.96	7.86	1.88	2.26	2.71	2.86	3.35	3.72	3.82	3.88
M_4	0.65	0.68	0.73	0.74	6.33	6.50	6.70	7.10	7.60	7.13	6.90	7.16	1.87	2.15	2.05	2.31	3.00	3.09	3.15	3.77
M_5	0.85	0.94	1.10	1.15	6.90	7.20	8.46	9.06	8.90	9.13	9.76	10.26	2.42	3.29	3.79	4.54	3.84	4.55	4.99	5.35
S.Em±	0.02				0.21				0.17				0.10				0.08			
C.D. at 5%	0.06				0.62				0.48				0.28				0.25			

G M	Leaf area (mm)				Root length (cm)											
	120 DAS				60 DAS				90 DAS				120 DAS			
	G_0	G_1	G_2	G_3	G_0	G_1	G_2	G_3	G_0	G_1	G_2	G_3	G_0	G_1	G_2	G_3
M_1	4.60	4.68	4.98	5.50	12.30	12.86	13.46	13.66	16.40	17.53	18.86	19.20	16.63	20.30	22.10	24.40
M_2	3.57	4.98	4.55	5.11	11.22	11.71	12.48	14.62	11.40	15.93	16.26	18.76	14.56	18.36	18.63	19.76
M_3	5.15	5.29	5.15	5.73	11.96	13.76	14.33	14.60	17.66	18.33	20.06	22.40	23.60	23.93	25.33	28.73
M_4	3.95	4.80	5.09	4.94	11.66	12.26	12.60	13.56	13.80	16.60	17.53	19.13	15.56	18.33	19.60	24.70
M_5	4.81	5.46	6.14	6.60	13.93	14.13	15.53	16.56	17.23	19.70	20.76	23.73	21.76	23.50	26.74	30.83
S.Em±	0.21				0.35				0.58				0.74			
C.D. at 5%	0.61				1.00				1.66				2.12			

G M	Chlorophyll content (mm)												Dry weight of seedling			
	60 DAS				90 DAS				120 DAS							
	G_0	G_1	G_2	G_3	G_0	G_1	G_2	G_3	G_0	G_1	G_2	G_3	G_0	G_1	G_2	G_3
M_1	45.37	48.26	49.45	56.12	46.56	48.92	56.33	57.85	55.78	59.11	56.93	63.01	0.35	0.41	0.47	0.51
M_2	45.42	47.81	48.34	48.00	53.02	56.87	48.57	53.92	54.56	57.45	58.73	55.78	0.26	0.28	0.27	0.37
M_3	53.78	54.92	51.44	52.17	54.08	56.12	56.18	52.34	55.16	61.04	61.94	58.89	0.34	0.43	0.50	0.54
M_4	47.98	48.46	51.34	52.93	50.41	48.49	62.42	52.96	52.34	57.94	62.53	63.19	0.31	0.30	0.34	0.41
M_5	52.44	53.15	59.15	61.77	52.94	56.09	62.45	69.15	54.33	58.72	63.55	70.12	0.45	0.54	0.62	0.67
S.Em±	1.44				1.95				2.03				0.01			
C.D. at 5%	4.13				5.59				5.84				0.05			

Conclusion

In light of the results obtained from this investigation, it can be concluded that combined effect of soil + FYM + vermicompost + vermiculite (1:1:1:1) + GA_3 @ 150 mg/l showed significant effect on growth parameters and physiological parameters like chlorophyll content and dry weight of seedling.

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