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Different levels of fertigation, growth regulators and their interaction effects on growth characters of rose cultivars under polyhouse condition

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Abstract
Increased concentration of gibberellic acid combined with 120 percent of recommended dose of fertilizers as fertigation significantly increased the plant height, mean number of branches per plant, number of leaves per plant and internodal length in both the seasons respectively. Though all the varieties positively responded for the treatments but variety Grand gala produced significantly superior quality of growth characters when plants were treated with 120 per cent of fertigation in combination with 300 ppm of GA_3.

Keywords: Fertigation, ppm

Introduction
The productivity and quality of a crop mainly depends on its genetic potential and its interaction with the environmental conditions in addition to its response to fertigation and exogenous application of growth substances. Balanced use of nutrients is known to result in the overall improvement of any crop in terms of growth, yield and quality. An interruption in the supply of plant nutrients even for a short period will have a negative effect on yield and quality. Many times, a portion of the recommended nutrients applied to the soil for taking up by the plant, go waste. Moreover, the amount of nutrients taken up also depends on the form of nutrients applied. It has also been observed that in many commercial flowers, the response of a crop to growth regulators were significant in achieving desirable characters.
Although, breeders have developed several rose cultivars having desirable characters, but all the characters could not be incorporated into a single variety. Hence, there is a great need to improve the quality of rose flowers to emulate the flowers of international standard. There are various ways by which quality of flowers can be improved and use of growth regulators combined with fertigation have played a vital role in retarding the senescence, improving the quality and prolonging the vase life of flowers (Bhattacharjee and Bose, 1978; Gowda, 1985) [3, 5]. Hence, studies were conducted to know the Effect of different levels of fertigation and growth regulators on growth, yield and quality of rose cultivars under polyhouse condition.

Material and Methods
Two years old healthy budded plants were pruned. The cut ends were treated with blitox (copper oxychloride) at the rate of 2 per cent. Channels were opened at the centre of each bed. They were filled with well decomposed FYM at the rate of 50 kg per bed (bed length 24 m). The beds were irrigated thoroughly to maintain the optimum soil moisture condition. Major nutrients (N, P & K) as per the recommendations were supplied by fertigation in the morning hours. Micronutrients (Multiplex) were supplied as foliar spray at 0.2 per cent at monthly intervals. The nutrients were given in splits at weekly intervals as per treatment.
Growth regulators at required concentrations were prepared. To prepare 200 ppm GA_3, 200 mg of GA_3 was dissolved in 1ml 0.1 N NaOH and volume was increased up to one liter using distilled water. Whereas, humic acid was directly dissolved in water and then applied to plants as foliar spray. The experiment was carried out in two seasons.

Results and Discussion
Treatments V_4 (75.46 cm & 73.48 cm), G_2 (69.21 cm & 68.28 cm) and F_2 (67.18 cm & 68.28 cm) produced plants of maximum height in the seasons 1 and 2 respectively. While, V_4 treated plants (4.54 & 4.61), G_2 (4.70 & 5.00) and F_2 (4.93 & 5.32) induced maximum number of branches in the seasons 1 and 2 respectively. Interestingly the same treatments produced

higher number of leaves per plant in the treatment V_4 (259.83 & 235.02), G_2 (206.86 & 205.08) and F_2 (206.86 & 230.88). Internodal length was also maximum in treatment V_4 (5.32 cm & 5.20 cm), G_2 (4.85 cm & 4.63 cm) and F_2 (4.78 cm & 4.59 cm) in the seasons 1 and 2 respectively (Table 1 & 2).

Interaction between V_4F_2 (82.29 cm & 80.54 cm) recorded maximum plant height, while G_2F_2 (74.57 cm & 72.29 cm) and G_1F_2 (73.06 cm & 74.31) were on par with each other for the character plant height. However, V_4G_2 (90.27 cm) interaction resulted in maximum plant height only in one season. Meanwhile, the interaction between V_4F_2 (5.90 & 5.98) and G_2F_2 (5.48 & 5.93) recorded the highest mean number of primary branches per plant respectively. Whereas, interaction between V_4G_2 (5.21) recorded maximum number of primary branches per plant only in first season and minimum branches were noticed in the interaction V_3G_4 (2.39) (Table 3 & 4).

Interaction between V_4G_2 (238.89) and V_2G_2 (248.21), G_2F_2 (242.24) and G_1F_2 (231.09) were on par with each other and recorded maximum number of leaves per plant. Meanwhile, interaction between V_2F_2 (291.13) resulted in plants that of higher number of leaves. Interaction between V_4G_2 (5.98 cm & 5.75 cm) and V_4G_1 (5.89 cm & 5.63 cm) were on par with each other and produced shoots of maximum length (Table 5 & 6).

Increased concentration of gibberellic acid combined with 120 percent of recommended dose of fertilizers as fertigation significantly increased the internodal length and in turn plant height respectively. When varieties were compared, it was found that Grand Gala showed a tendency of vigorous growth. The results obtained were in accordance with (Palai *et al*., 2002) [10] who noticed increased plant height with the application of 400:300:200ppm NPK per plant per week in rose cv. Montezuma, Suganya *et al*, 2007 and (Qasim *et al*., 2008) [12] who stated that NPK at 500 ml applied at 2 days interval in rose was optimum for vegetative growth. However humic acid reduced the plant height drastically in all the varieties. These results are in accordance with the findings (Meybodi *et al*., 2012) [7] who stated that, an increase in humic acid concentration caused a reduction in the height of the plants.

The increment in plant height with the application of GA is primarily due to cell division and cell elongation resulting in increase in internodal distance and number of internodes there by the mean plant height was increased. The steep increase in plant height with GA was also in conformity with Bankar and Mukhopadhyay (1982) [2] who found that GA_3 at 100 to 250 ppm increased the stem length and internodal length in rose Cv. Queen Elizabeth. Padmapriya and Chezhiyan (2003) [9] studied morphological characters of 4 cultivars of chrysanthemum as influenced by GA_3 and reported that plant height was increased drastically with increase in concentration of GA_3. These results are in accordance with the findings of Gowda (1980) [4] in rose Cv. Super Star, Gowda (1988) [6] in rose Cv. American Heritage, Sadanand *et al*. (2000) [14] in rose Cv. First Red, Ramesh and Singh (2003) [13] in Carnation.

Grand Gala produced plants with maximum number of branches as compared to other varieties. The productivity of the crop depends primarily on the framework and cultural operations. This could be the reason why varieties differed significantly with each other with respect to number of primary branches produced. However, fertigation with 120 percent of recommended dose (4.93 and 5.32) and Gibberellic acid at 300 ppm (4.70 & 5.00) concentration produced significantly higher number of primary branches per plant. This could probably due to application of optimum level of nutrients in a readily available form. Similar views were expressed by Anwar *et al*, (1999) [3] who studied the effect of N, K fertilizers on vegetative growth of Rose, Vidhya Sankar and Bhattacharjee (2000) [17] who obtained increased number of basal shoots with optimum level of nitrogen in roses and (Qasim *et al*., 2008) [12] who stated that NPK at 500 ml applied at 2 days interval in rose was optimum for vegetative growth.

Increase in the number of branches per plant as a result of GA_3 application can be explained in the light of the fact that GA_3 interacts with auxins thus reducing the apical dominance and thereby results in the increased number of axillary branches. Similar results have been reported by Prabhat Kumar *et al*. (2003) [11] in China Aster.

Meanwhile, more leaves appeared by application of GA attributed to increased shoot length, more nodes as well as the physiological role played by GA in increasing the area of photosynthesis to produce more carbohydrate. These results are in conformity with the results of Nanjan and Muthuswamy (1975) [8] who noted increase in number of leaves with increased shoot length by the application of GA_3 at 300 ppm in Edward rose.

Table 1: Plant height and number of branches per plant as influenced by varieties, growth regulators and levels of fertigation

Treatment	Mean plant height (cm)		Mean no. of branches per plant	
Variety	**Season 1**	**Season 2**	**Season 1**	**Season 2**
V_1-First Red	62.60	63.57	4.41	4.43
V_2-Noblesse	60.22	61.09	3.79	4.07
V_3-Gold Strike	46.54	47.89	3.47	4.00
V_4- Grand Gala	75.46	73.48	4.54	4.61
F-test	*	*	*	*
SEm ±	0.29	0.64	0.04	0.06
CD at 5%	1.02	2.24	0.13	0.24
Growth regulator				
G_1-200 ppm GA_3	64.54	66.01	4.27	4.35
G_2 -300 ppm GA_3	69.21	68.28	4.70	5.00
G_3 -0.2% Humic acid	56.06	57.07	3.63	3.79
G_4 - 0.4% Humic acid	55.02	54.66	3.63	3.96
F-test	*	*	*	*
SEm ±	0.25	0.40	0.03	0.06
CD at 5%	0.87	1.40	0.12	0.22
Fertigation				
F_0-100% RDF Soil application	55.97	54.85	3.30	3.44

F_1- 80% Fertigation	60.46	61.39	3.94	4.06
F_2-120% Fertigation	67.18	68.28	4.93	5.32
F-test	*	*	*	*
SEm ±	0.83	1.93	0.13	0.29
CD at 5%	2.87	6.69	0.45	1.00

* Significant at 5% level

Table 2: Number of leaves per plant and internodal length as influenced by varieties, growth regulators and levels of fertigation

Treatment	Mean number of leaves per plant		Mean internodal length (cm)	
Variety	**Season 1**	**Season 2**	**Season 1**	**Season 2**
V_1-First Red	158.38	156.48	4.57	4.32
V_2-Noblesse	191.75	216.99	3.43	3.38
V_3-Gold Strike	145.69	154.22	3.34	3.29
V_4- Grand Gala	259.83	235.02	5.32	5.20
F-test	*	*	*	*
SEm ±	17.12	2.02	0.01	0.04
CD at 5%	59.26	7.01	0.04	0.14
Growth regulator				
G_1-200 ppm GA_3	191.54	188.21	4.54	4.35
G_2 -300 ppm GA_3	206.86	205.08	4.85	4.63
G_3 -0.2% Humic acid	176.71	182.53	3.82	3.75
G_4 - 0.4% Humic acid	180.54	186.89	3.45	3.47
F-test	*	*	*	*
SEm ±	5.16	1.65	0.02	0.03
CD at 5%	17.84	5.72	0.07	0.12
Fertigation				
F_0-100% RDF Soil application	176.71	153.71	3.63	3.53
F_1- 80% Fertigation	191.54	187.43	4.09	4.03
F_2-120% Fertigation	206.86	230.88	4.78	4.59
F-test	*	*	*	*
SEm ±	6.97	7.78	0.06	0.15
CD at 5%	27.92	26.92	0.24	0.53

* Significant at 5% level

Table 3: Plant height and number of branches per plant as influenced by interaction between variety, growth regulators and fertigation

Particulars	Mean plant height (cm)		Mean no. of branches per plant	
V X G	**Season 1**	**Season 2**	**Season 1**	**Season 2**
V_1G_1	66.59	68.20	4.71	4.69
V_1G_2	67.83	69.47	5.09	5.02
V_1G_3	58.99	59.59	3.88	3.92
V_1G_4	42.74	42.75	2.96	3.06
V_2G_1	62.94	65.60	4.10	4.13
V_2G_2	65.34	67.83	5.09	4.83
V_2G_3	56.13	56.27	3.22	3.43
V_2G_4	56.47	54.66	3.29	3.61
V_3G_1	60.04	59.27	3.86	4.25
V_3G_2	53.38	55.57	3.92	4.81
V_3G_3	42.16	42.88	3.12	3.64
V_3G_4	30.51	31.08	2.39	2.88
V_4G_1	81.73	80.21	4.67	4.94
V_4G_2	90.27	80.25	5.21	5.34
V_4G_3	50.19	52.15	3.20	3.15
V_4G_4	49.43	49.17	3.07	3.21
F-test	*	NS	*	NS
SEm ±	0.50	0.81	0.06	0.13
CD at 5%	1.74	-	0.24	-
V X F				
V_1F_0	56.57	56.70	3.69	3.79
V_1F_1	59.03	61.17	4.46	4.41
V_1F_2	72.25	72.83	5.07	5.09
V_2F_0	56.17	57.88	3.33	3.31
V_2F_1	61.00	60.27	3.60	3.74
V_2F_2	63.49	65.12	4.44	4.94
V_3F_0	42.80	39.35	2.77	3.21
V_3F_1	46.07	49.66	3.34	3.70
V_3F_2	50.74	54.65	4.29	5.30
V_4F_0	68.33	65.47	3.4	3.44
V_4F_1	75.76	74.45	4.33	4.41

V_4F_2	82.29	80.54	5.9	5.98
F-test	*	*	*	*
SEm ±	0.41	0.96	0.06	0.14
CD at 5%	1.43	3.34	0.22	0.50

Table 4: Plant height and number of branches per plant as influenced by interaction between growth regulators and fertigation

Particulars	**Mean plant height (cm)**		**Mean no. of branches per plant**	
G X F	**Season 1**	**Season 2**	**Season 1**	**Season 2**
G_1F_0	57.09	59.06	3.26	3.37
G_1F_1	63.49	64.65	4.05	4.08
G_1F_2	73.06	74.31	5.45	5.61
G_2F_0	64.21	60.12	3.56	3.80
G_2F_1	65.31	66.70	4.56	4.61
G_2F_2	74.57	72.29	5.48	5.93
G_3F_0	52.64	51.66	3.17	3.19
G_3F_1	56.32	58.24	3.48	3.75
G_3F_2	59.20	61.31	4.19	4.44
G_4F_0	49.93	48.56	3.20	3.38
G_4F_1	56.74	55.96	3.64	3.82
G_4F_2	58.37	59.47	4.08	4.66
F-test	*	*	*	*
SEm ±	0.43	0.70	0.06	0.11
CD at 5%	1.51	2.43	0.20	0.39

* Significant at 5% level

Table 5: Number of leaves per plant and internodal length as influenced by interaction between variety, growth regulators and fertigation

Particulars	**Mean number of leaves**		**Mean internodal length (cm)**	
V X G	**Season 1**	**Season 2**	**Season 1**	**Season 2**
V_1G_1	157.66	149.49	5.00	4.72
V_1G_2	174.44	173.76	5.58	5.15
V_1G_3	152.55	151.75	3.93	3.85
V_1G_4	111.66	113.20	2.82	2.68
V_2G_1	191.11	234.84	3.85	3.65
V_2G_2	212.11	248.21	4.03	3.93
V_2G_3	183.11	226.10	3.10	3.12
V_2G_4	180.66	230.91	2.75	2.83
V_3G_1	190.03	172.40	4.28	4.26
V_3G_2	154.91	159.48	3.83	3.68
V_3G_3	136.71	151.49	3.21	3.08
V_3G_4	106.67	116.62	2.05	2.14
V_4G_1	270.24	226.61	5.89	5.63
V_4G_2	286.00	238.89	5.98	5.75
V_4G_3	175.85	150.57	3.78	3.70
V_4G_4	187.80	157.68	3.41	3.47
F-test	NS	*	*	*
SEm ±	10.31	3.30	0.04	0.07
CD at 5%	-	11.44	0.14	0.25
V X F				
V_1F_0	130.91	124.96	3.97	3.81
V_1F_1	157.25	153.02	4.47	4.19
V_1F_2	187.00	191.47	5.26	4.97
V_2F_0	158.41	181.11	2.95	2.95
V_2F_1	192.75	232.81	3.27	3.30
V_2F_2	224.08	291.13	4.08	3.89
V_3F_0	137.12	144.67	3.02	2.98
V_3F_1	146.27	147.21	3.36	3.25
V_3F_2	153.70	170.79	3.65	3.66
V_4F_0	226.94	164.12	4.60	4.36
V_4F_1	275.59	216.70	5.25	5.39
V_4F_2	276.90	270.15	6.12	5.84
F-test	NS	*	*	*
SEm ±	18.48	3.89	0.03	0.07
CD at 5%	-	13.46	0.12	0.26

* Significant at 5% level

Table 6: Number of leaves per plant and internodal length as influenced by interaction between fertigation and growth regulators

Particulars	Mean number of leaves		Mean internodal length (cm)	
G X F	**Season 1**	**Season 2**	**Season 1**	**Season 2**
G_1F_0	164.75	148.11	3.97	3.81
G_1F_1	190.12	185.42	4.41	4.30
G_1F_2	219.76	231.09	5.25	4.93
G_2F_0	177.16	161.80	4.08	3.90
G_2F_1	212.91	202.80	4.72	4.55
G_2F_2	225.08	242.24	5.51	5.07
G_3F_0	147.81	149.75	3.42	3.28
G_3F_1	185.88	180.05	3.76	3.80
G_3F_2	196.44	217.78	4.28	4.16
G_4F_0	163.66	155.20	3.07	3.11
G_4F_1	182.94	181.47	3.46	3.48
G_4F_2	195.03	224.01	3.81	3.83
F-test	NS	*	*	*
SEm ±	8.93	2.86	0.03	0.06
CD at 5%	-	9.91	0.12	0.22

* Significant at 5% level

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