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Different levels of fertigation, growth regulators and their interaction effects on floral 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 number of petals per flower, bud diameter, bud length and mean weight of flower respectively. Though all the varieties positively responded for the treatments but variety Grand gala produced significantly superior quality of flower when plants were treated with 120 per cent of fertigation in combination with 300 ppm of GA_3.

Keywords: Fertigation, ppm

Introduction
Floriculture is increasingly regarded as a viable diversification from the traditional field crops due to increased returns per unit and the increasing habit of "saying it with flowers" during all occasions. With the advent of Government of India's liberalization policies and floriculture development initiatives, several corporate houses have entered to set up 100 per cent export oriented units, since the implementation of the new policies during 1991. These 100 per cent export oriented units are supported with technology and marketing tie up with the collaborators from Netherland and Israel. These were setup in and around Bangalore, Pune, Hyderabad and Delhi, mainly for rose, carnation and anthurium. The area under environment controlled greenhouse is estimated to be around 500 ha. Of this, many have received very encouraging results in terms of acceptance of the quality in the major international markets.
In International floriculture trade, India ranks 198 in flower export. In India, area under floriculture is estimated at nearly 3, 24,000 ha. The total production of flowers in India is 1962 lakh MT of loose flowers and 823 lakh of cut flowers. The total export value of flowers in 2018-19 in India is 42967 lakhs. Among the flowers, rose alone contributes 51 per cent share in the world flower trade. Area under rose cultivation in India is more than 6000 ha. Karnataka is a leading state in rose production. In spite of long tradition of agriculture and floriculture, India's share in the International market for cut flowers is hardly 0.04 per cent of global trade. The most important cut flower traded in the market is rose.
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 floral characters, quality and prolonging the vase life of flowers (Bhattacharjee and Bose, 1978; Gowda, 1985) [5, 10]. 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".

Materials 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

Grand gala (3.07 cm) and Gold strike (3.08 cm) verities were on par with each other in the first season, whereas, in second season Grand gala (3.17 cm) significantly differed for the character bud diameter. The plants treated with 300 ppm GA_3 (3.08 cm & 2.98 cm) and 120 per cent fertigation (3.18 cm & 3.13 cm) recorded maximum bud diameter in both the seasons. (Table 1). The interactions between Grand gala x 120 per cent fertigation (3.3 cm & 3.32 cm) and Gold Strike x 120 per cent fertigation (3.31 cm & 3.20 cm) were on par with each other and were significantly differed compared to rest of the treatments (Table 2 and Table 3).

Bud length was significantly increased in Grand gala (5.05 cm & 3.40 cm) when plants were treated with 300 ppm GA_3 (3.74 cm & 3.38 cm) and 120 per cent fertigation (3.86 cm & 3.51 cm) in both the seasons respectively (Table 1). Interaction between Grand gala and 120 per cent fertigation significantly increased the bud length (3.30 cm & 3.32 cm) but interaction between varieties and growth regulators failed to impact on bud length significantly (Table 2 and table 3).

Even though, fertigation with 120 per cent RDF (3.86 cm, 3.51 cm and 3.18 cm, 3.13 cm) and GA_3 300 ppm (3.28 cm, 3.09 cm and 3.08 cm, 2.98 cm) induced buds of maximum length and diameter but var. Grand Gala (5.05 cm, 3.40 cm and 3.07 cm, 3.17 cm) responded significantly. But varied interaction response was observed. However, interaction between V_4G_2 (5.28 cm), V_4F_2 (5.55 cm), G_1F_2 (3.50 cm) and G_2F_2 (3.50 cm) recorded lengthy buds. While interaction between V_4F_2 (3.3 cm & 3.32 cm), V_3F_2 (3.31 cm & 3.20 cm), G_4F_2 (3.29 cm) and G_2F_2 (3.17 cm) recorded buds of higher diameter.

Increasing the supply of fertilizers to rose plant improved the length of flower bud as observed by Krishna (1999) [13] and Nagaraju *et al*. (2003) [15]. The above results were in accordance with the findings of Arun *et al*. (1999) [3], Sadanand *et al*. (2000) [18], observed higher bud length in gerbera and rose, respectively grown under low cost polyhouse. These results are also comparable with the findings of Dhekney *et al*. (2000) [9], Chakradhar *et al*. (2003) [7] where they observed the highest bud conditions which were attributed to the genetic response of the cultivars to the treatments.

Flowers belongs to Grand gala (39.95) and Noblesse (42.32) varieties when treated with 200 and 300 ppm GA_3 (38.72, 39.17) recorded on par results for the characters number of petals per flower in the first season. Where as in the second season Grand gala (39.91) and 300 ppm GA_3 (37.41 cm) recorded maximum number of petals per flower (Table 4). In the fertigation aspects, 120 per cent fertigation (38.23 & 39.14) recorded significantly higher number of petals per flower as compared to rest of the treatments (Table 5 and Table 6).

Higher number of petals per flower to be associated with var. Grand Gala (39.95) and Noblesse (42.32), GA_3 300 ppm (39.17) and GA_3 200 ppm (38.72) which were on par with each other and fertigation with 120 per cent recommended dose of fertilizers (38.23 & 39.14) recorded significantly higher number of petals per flower. Any of the interactions did not show much significant difference between them. The results were in accordance with Qasim *et al*., (2008) who noticed maximum number of petals per flower in rose with the application of 500 and 250 ml of NPK at 2, 4 and 6 days interval.

More number of petals per flower with GA due to high levels of endogenous gibberellins and auxins which contributed to the development of flower, more production of carbohydrate associated with existence of more leaf number and area per flowering shoot. Similar results regarding the number of petals were noted by Gowda (1998) who observed increased number of petals per flower in rose cv. American Heritage with GA, Chakradhar (2002) [2] in rose cultivar Gladiator and Horibe *et al*., 2010 in rose.

As far as number of petals per flower is concerned, results of interaction between factors, varieties, growth regulators and fertigation depicted that fertigation and growth regulator levels did not influence the varieties, thus giving way for the thought that it is more a varietal characteristic.

Based on the quality attributes it was observed that 120 per cent of recommended dose of nutrients in water soluble form resulted in better quality in terms of length and girth of stalk, length and thickness of flower bud and number of petals per flower as compared to 80 per cent and 100 per cent of recommended dosage. This takes anchorage form the lowest number of basal shoots recorded per plant, which received 120 per cent of recommended dose. The quantity of nutrients available over and above the optimum dose might have enhanced the quality of result of cut rose flowers.

Flowers harvested from Grand gala (5.81 g & 5.66 g) when treated with 300 ppm GA_3 (5.04 g & 4.94 g) and 120 per cent fertigation (5.55 g & 5.41 g) recorded maximum weight (Table 4). Among the interactions Grand gala x 120 per cent fertigation (6.06 g) and Grand gala x 200 ppm GA_3 (5.97 g) were on par with each other and recorded maximum flower weight (Table 5 and Table 6).

Application of 120 per cent (5.55 g & 5.41 g) of recommended dose as fertigation and GA_3 300 ppm (5.04 g & 4.94 g) resulted in flowers of maximum weight and var. Grand Gala (5.81 g & 5.66 g) responded significantly. The same results were reflected in the interaction between V_4G_2 (6.06 g), V_4G_1 (5.97 g), V_4F_2 (6.39 g), G_2F_2 (5.54 g) and G_1F_2 (5.51 g).

Increase in weight of flower by higher dose of fertigation may be due to the role of K_2O in plants which includes cation transport across membrane, water economy, energy metabolism and enzyme activity and consequently stimulates vegetative growth and decreases translocation of photo synthates into storage organs which resulted in increased in weight of flowers. Similar results were reported by Larikk, *et al.* (1999) [14] who studied the effect of N and K fertilization on quality, yield of Zinnia and observed maximum weight with application of optimum dose of N and K.

Increased weight of flower in relation to application of gibberellic acid may be due to production of larger flowers containing more number of petals, which in turn resulted from increased levels of gibberellins and auxins in plant and more biomass producing area. These findings are in conformity with the results obtained by Singh *et al.* (1991) who noticed significantly increased in flower weight in African marigold with GA_3 400 ppm. Dehale *et al*. (1993) [8] also found increased weight of flowers with GA_3 100 ppm in Chrysanthemum, Tiwari (2002) [19] in rose cv. Mercedes and Abadi (2010) [1] in rose.

Table 1: Flower bud diameter and bud length as influenced by varieties, growth regulators and levels of fertigation

Particulars	Mean bud diameter (cm)		Mean bud length (cm)	
Varieties	**Season 1**	**Season 2**	**Season 1**	**Season 2**
V_1-First Red	2.76	2.73	3.44	3.54
V_2-Noblesse	2.62	2.59	2.33	2.57
V_3-Gold Strike	3.08	2.81	3.32	3.29
V_4- Grand Gala	3.07	3.17	5.05	3.40
F-test	*	*	*	*
SEm ±	0.01	0.01	0.04	0.02
CD at 5%	0.04	0.05	0.15	0.07
Growth regulators				
G_1-200 ppm GA_3	2.83	2.74	3.72	3.19
G_2 -300 ppm GA_3	3.08	2.98	3.74	3.38
G_3 -0.2% Humic acid	2.67	2.71	3.28	3.09
G_{4} - 0.4% Humic acid	2.96	2.86	3.40	3.14
F-test	*	*	*	*
SEm ±	0.01	0.02	0.03	0.02
CD at 5%	0.06	0.07	0.12	0.08
Fertigation				
F_0-100% RDF Soil application	2.52	2.50	3.23	2.92
F_1- 80% Fertigation	2.95	2.83	3.52	3.17
F_2-120% Fertigation	3.18	3.13	3.86	3.51
F-test	*	*	*	*
SEm ±	0.09	0.08	0.18	0.10
CD at 5%	0.31	0.28	0.62	0.36

Table 2: Flower bud diameter and bud length as influenced by interaction between variety and growth regulators and variety and fertigation

Particulars	Mean flower bud diameter (cm)		Mean bud length (cm)	
V X G	**Season 1**	**Season 2**	**Season 1**	**Season 2**
V_1G_1	2.70	2.65	2.44	3.49
V_1G_2	2.93	2.87	2.57	3.65
V_1G_3	2.61	2.66	2.19	3.48
V_1G_4	2.10	2.05	1.58	2.67
V_2G_1	2.58	2.45	3.56	2.56
V_2G_2	2.85	2.81	3.57	2.70
V_2G_3	2.39	2.43	3.28	2.50
V_2G_4	2.68	2.66	3.37	2.51
V_3G_1	3.02	2.92	4.13	3.33
V_3G_2	3.27	2.94	3.55	3.53
V_3G_3	2.85	2.74	2.82	3.15
V_3G_4	2.39	2.12	2.38	2.38
V_4G_1	3.13	3.22	5.24	3.51
V_4G_2	3.27	3.31	5.28	3.66
V_4G_3	2.12	2.27	3.63	2.41
V_4G_4	2.38	2.41	3.71	2.49
F-test	NS	NS	*	NS
SEm ±	0.03	0.04	0.07	0.04
CD at 5%	-	-	0.25	-
V X F				
V_1F_0	2.35	2.36	2.26	3.30
V_1F_1	2.73	2.79	2.22	3.51
V_1F_2	3.21	3.03	2.51	3.83
V_2F_0	2.33	2.18	3.24	2.22
V_2F_1	2.65	2.61	3.42	2.50
V_2F_2	2.89	2.97	3.67	2.98
V_3F_0	2.71	2.53	2.67	3.05
V_3F_1	3.22	2.71	3.59	3.28
V_3F_2	3.31	3.20	3.70	3.53
V_4F_0	2.69	2.96	4.75	3.11
V_4F_1	3.21	3.21	4.85	3.39
V_4F_2	3.30	3.32	5.55	3.69
F-test	*	*	*	NS
SEm ±	0.04	0.04	0.09	0.05
CD at 5%	0.15	0.14	0.31	-

Table 3: Flower bud diameter and bud length as influenced by interaction between fertigation and growth regulators

Particulars	Mean flower bud diameter (cm)		Mean bud length (cm)	
G X F	Season 1	Season 2	Season 1	Season 2
G_1F_0	2.53	2.40	3.31	2.88
G_1F_1	2.90	2.74	3.60	3.19
G_1F_2	3.06	2.99	4.23	3.50
G_2F_0	2.68	2.64	3.41	3.02
G_2F_1	3.08	3.08	3.66	3.33
G_2F_2	3.31	3.14	3.92	3.59
G_3F_0	2.26	2.40	3.01	2.86
G_3F_1	2.87	2.77	3.37	3.07
G_3F_2	2.88	2.97	3.47	3.32
G_4F_0	2.62	2.58	3.19	2.92
G_4F_1	2.97	2.82	3.44	3.09
G_4F_2	3.29	3.17	3.57	3.41
F-test	*	NS	*	*
SEm ±	0.03	0.03	0.06	0.04
CD at 5%	0.11	-	0.22	0.14

Table 4: Flower weight and diameter of opened flower as influenced by varieties, growth regulators and levels of fertigation

Particulars	Mean flower weight (g)		Mean number of petals per flower	
Varieties	**Season 1**	**Season 1**	**Season 1**	**Season 2**
V_1-First Red	4.95	31.02	31.02	33.37
V_2-Noblesse	4.38	42.32	42.32	35.76
V_3-Gold Strike	3.70	36.96	36.96	35.44
V_4- Grand Gala	5.81	39.95	39.95	39.91
F-test	*	*	*	*
SEm ±	0.04	0.82	0.82	0.30
CD at 5%	0.14	2.84	2.84	1.04
Growth regulators				
G_1-200 ppm GA_3	4.74	38.72	38.72	36.01
G_2 -300 ppm GA_3	5.04	39.17	39.17	37.41
G_3 -0.2% Humic acid	4.52	36.01	36.01	35.25
G_4 - 0.4% Humic acid	4.55	36.35	36.35	35.81
F-test	*	*	*	*
SEm ±	0.03	0.63	0.63	0.24
CD at 5%	0.12	2.20	2.20	0.86
Fertigation				
F_0-100% RDF Soil application	3.99	36.50	36.50	33.96
F_1- 80% Fertigation	4.59	37.96	37.96	35.26
F_2-120% Fertigation	5.55	38.23	38.23	39.14
F-test	*	*	*	*
SEm ±	0.18	3.25	3.25	1.20
CD at 5%	0.64	11.26	11.26	4.17

Table 5: Flower weight and diameter of opened flower as influenced by interaction between variety and growth regulators and variety and fertigation

Particulars	Mean flower weight (g)		Mean number of petals per flower	
V X G	Season 1	Season 2	Season 1	Season 2
V_1G_1	5.11	5.02	31.81	33.33
V_1G_2	5.34	5.26	32.51	34.74
V_1G_3	4.85	4.63	29.62	32.27
V_1G_4	3.39	3.56	22.61	24.88
V_2G_1	4.42	4.29	42.63	35.47
V_2G_2	4.77	4.64	43.15	36.53
V_2G_3	4.13	4.16	41.67	35.11
V_2G_4	4.22	4.24	41.85	35.92
V_3G_1	4.47	4.30	41.41	37.10
V_3G_2	3.97	3.89	40.03	37.02
V_3G_3	3.46	3.43	34.12	34.32
V_3G_4	2.72	2.71	25.69	26.19
V_4G_1	5.97	5.81	41.22	40.83
V_4G_2	6.06	5.97	41.00	41.37
V_4G_3	4.24	4.10	28.97	29.46
V_4G_4	4.36	4.19	29.38	29.41
F-test	*	NS	NS	NS
SEm ±	0.07	3.89	1.27	0.49

CD at 5%	0.25		-	-
V X F				
V_1F_0	4.29	4.26	29.83	30.82
V_1F_1	4.86	4.80	30.74	32.50
V_1F_2	5.70	5.68	32.50	36.80
V_2F_0	3.42	3.45	42.22	33.01
V_2F_1	4.20	4.26	42.07	34.96
V_2F_2	5.54	5.29	42.68	39.30
V_3F_0	3.00	3.04	34.27	33.60
V_3F_1	3.51	3.52	39.37	34.34
V_3F_2	4.59	4.41	37.24	38.37
V_4F_0	5.25	5.25	39.70	38.40
V_4F_1	5.80	5.49	39.66	39.25
V_4F_2	6.39	6.26	40.49	42.09
F-test	*	NS	NS	NS
SEm ±	0.09	4.49	1.62	0.60
CD at 5%	0.32		-	-

Table 6: Flower weight and diameter of opened flower as influenced by interaction between fertigation and growth regulators

Particulars	Mean flower weight (g)		Mean number of petals per flower	
G X F	Season 1	Season 2	Season 1	Season 2
G_1F_0	4.02	3.98	39.90	33.96
G_1F_1	4.70	4.58	36.97	35.17
G_1F_2	5.51	5.43	39.29	38.90
G_2F_0	4.29	4.23	40.63	34.73
G_2F_1	4.79	4.76	36.96	36.24
G_2F_2	5.54	5.39	41.77	39.59
G_3F_0	3.77	3.81	35.40	33.17
G_3F_1	4.42	4.32	36.12	34.63
G_3F_2	5.37	5.13	36.50	37.94
G_4F_0	3.87	3.97	35.92	33.97
G_4F_1	4.46	4.42	35.98	35.01
G_4F_2	5.31	5.24	37.17	38.43
F-test	*	NS	NS	NS
SEm ±	0.06	0.07	1.10	0.43
CD at 5%	0.21	-	-	-

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