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Effect of foliar spray of plant growth regulators on growth of potted hibiscus

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Abstract
Investigation was done to study the effect of foliar spray of plant growth regulators on growth and flowering of potted hibiscus plants grown in pot during 2017-18 and 2018-19. Application of gibberellic acid, benzyl adenine and salicylic acid at different concentrations found significant in influencing the vegetative growth, flowering parameters and plant pigments of *Hibiscus rosa- sinensis* plants during both the years as compared to untreated plants (control). Plants sprayed with 100 ppm gibberellic acid resulted in to maximum plant height (24.90, 26.77 and 28.93 cm), plant spread and leaf area (15.55, 16.17 and 16.48 cm^2) respectively at 30, 60 and 90 days after spraying (DAS). While, maximum number of branches (4.63, 5.45 and 6.02) and leaves (26.57, 31.33 and 35.65) was recorded in plants sprayed with 50 ppm gibberellic acid, respectively at 30, 60 and 90 days after spraying (DAS). Maximum number of flowers per plant, flowers per branch, flower diameter, flowering period and *in situ* flower longevity was observed in hibiscus plants sprayed with 100 ppm gibberellic acid. The plants receiving the same treatments also increased chlorophyll content in leaves (19.50, 20.37 and 20.85 mg/g) and anthocynin in flower (17.03, 18.65 and 20.20 mg/g), respectively at 30, 60 and 90 days after spraying (DAS).

Keywords: Hibiscus, gibberellic acid, benzyl adenine, salicylic acid, pigments

Introduction
Hibiscus rosa-sinensis (China rose, Chinese hibiscus, rose mallow and shoe black plant) belongs to Malvaceae family. This plant is native to tropical and south-eastern Asia (China). Tropical hibiscus grows in countries that have a warm weather all round the year. Hibiscus leaves are alternate often with lobed margins. It is also used for medicinal properties (Kumaraguru and Sethuram, 2015) [8]. This plant is highly popular in landscaping and is also now gaining impetus as flowering pot plant especially for Indian tropical and subtropical climate.

Plant growth regulators *viz.* Gibberellic acid (Bose *et al.*, 2013 and Zang *et al.*, 2016) [1, 23], 6-benzyl adenine (Soad, 2016 and Raifa *et al.*, 2005) [19, 15] and Salicylic acid (Saadawy and Abdel-Moniem, 2015 and Kapadia *et al.*, 2017) [16, 6] has been known to play important role in influencing branching and plant growth in plants. Therefore, this study was conducted to the effect of foliar spray of plant growth regulators on growth and flowering of potted hibiscus.

Materials and methods
The present study was carried out at the ATC of soilless systems, at the Department of Floriculture and Landscape Architecture, ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari-396450, Gujarat during 2017-18 and 2018-19. The experiment was laid out in Completely Randomized Design with three repetitions. Uniform plants of *Hibiscus rosa- sinensis* var. Red Double were exposed to foliar spray of different concentrations of gibberellic acid (50 and 100 ppm), benzyl adenine (25 and 50 ppm) and salicylic acid (25 and 50 ppm) and its combinations after 30 days of planting at 15 days interval twice. Each plant was sprayed with approximately 30 ml of freshly prepared solution. Plants considered as control were not exposed to foliar spray. The data on various vegetative, flowering and pigments were recorded at 30, 60 and 90 DAS. The total chlorophyll content was determined by DMSO (Dimethylsulphoxide) method of Wellburn (1994) [22] and expressed in mg/g of fresh weight. The statistical analysis of pooled data of two years was done by adopting pooled analysis with appropriate standard error (S.Em ±) method in each case as suggested by Panse and Sukhatme (1985) [14].

Results and Discussion

Vegetative growth parameters

Hibiscus rosa-sinensis plants sprayed with different growth regulators substances influenced vegetative growth parameters as compared to untreated (control) plants. Significantly maximum plant height at 30 DAS (24.90 cm), 60 DAS (26.77 cm) and 90 DAS (28.93 cm), plant spread North to South direction at 30 DAS (21.45 cm), 60 DAS (22.82 cm) and 90 DAS (23.52 cm) and in East to West direction at 30 DAS (20.00 cm), 60 DAS (21.77 cm) and 90 DAS (23.53 cm) as well as maximum leaf area at 30 DAS (15.55 cm^2), 60 DAS (16.17 cm^2) and 90 DAS (16.48 cm^2) was recorded with 100 ppm gibberellic acid (T_3) as per pooled analysis of two years. Increase in plant height was due to gibberellic acid, a plant hormone, that is known to trigger transition from meristem to shoot growth and from juvenile to adult leaf stage. The capacity of GA_3 to increase plant height has been attributed mainly to it's promotory effect on cell elongation and to a lesser extent due to increase in meristematic activity. It is as shown in the findings of Mohariya *et al.* (2003) [11] and Talukdar and Paswan (1998) [20] in chrysanthemum.

Plants treated with 50 ppm gibberellic acid (T_2) exhibited maximum number of branches per plant at 30 DAS (4.63), at 60 DAS (5.45) and at 90 DAS (6.02) with more number of leaves at 30 DAS (26.57), at 60 DAS (31.33) and at 90 DAS (35.65) which was at par with treatment T_3 during the experiment. Since, gibberellic acid (GA_3) has been to play important role in plant growth and development processes, as its exogenous application has been found to lead to bigger shoots, leaves and stem by stimulating cell growth and division in many plants (Bose *et al.*, 2013 and Zang *et al.*, 2016) [1, 23]. Besides, promotory effect of GA_3 on branches may be due to the abolition of apical dominance, as gibberellins have been categorically, shown to be instrumental in lifting apical dominance (Moond *et al.*, 2006) [13].

Flowering characters

Gibberellic acid showed significant effect on flowering parameters of *Hibiscus rosa –sinensis* plants. Foliar application of gibberellic acid at 100 ppm (T_3) recorded maximum number of flowers per plant at 30 DAS (4.78), 60 DAS (6.13) and 90 DAS (6.60), flower per branch at 30 DAS (2.83), 60 DAS (2.93) and 90 DAS (4.10) with maximum diameter of flower at 30 DAS (6.27 cm), 60 DAS (6.73 cm) and 90 DAS (6.97 cm) in pooled analysis. Gibberellic acid regulates flower initiation and its development and it is essential for male and female fertility (Griffiths *et al.*, 2006) [3]. Hormones play a major role in directing the movement of organic metabolites and in establishing sinks. Besides, increase in flower numbers by GA_3 might be due to indirest influence of increased leaf numbers and leaf area, which might have boosted the production and accumulation of assimilates that were translocated from source to sink for flowers production as also observed by other scientists (Carvalho *et al.*, 2006 and Sajid *et al.*, 2015) [2, 17]. Further, increase in flower diameter can be attributed to promotory effect of GA_3 on cell elonagation and cell division as also observed in english cape lily (Manimaran *et al.*, 2017) [10] and gerbera (Zosser *et al.*, 2017) [24].

Plants sprayed with gibberellic acid at 100 ppm (T_3) showed maximum flowering period (128.2 days) and *in situ* flower longevity at 30 DAS (3.87 days), 60 DAS (4.07 days) and 90 DAS (4.10 days) in pooled analysis. Gibberellic acid has been known to extend flowering period as well as flower longevity and shelf life with it's hydrolyzing effect on amylase enzyme that converts starch reserves to reducing sugar as reported earlier in chrysanthemum (Singh *et al.*, 2018) [18].

Pigments

Plants sprayed with gibberellic acid at 100 ppm (T_3) recorded significantly maximum chlorophyll content in the leaves at 30 DAS (19.50 mg/g), 60 DAS (20.37 mg/g) and 90 DAS (20.85 mg/g) with maximum anthocynin in flower at 30 DAS (17.03 mg/g), 60 DAS (18.65 mg/g) and 90 DAS (20.20 mg/g) in pooled analysis. Gibberellic acid inhibits degradation of the pigments by controlling the process of starch and sucrose hydrolysis into fructose and glucose, which indirectly affect the content of chlorophyll a and b in leaves (Khan and Chaudhry, 2006) [6]. Phenylalanine ammonia-lyase (PAL), one of the key enzymes in controlling anthocynin biosynthesis from phenylalanine has been reported to increase by GA_3 application (Tucker, 1993 and Khandaker *et al.*, 2015) [21]. Influence of gibberellic acid on anthocynins content has been earlier reported in flowers *viz. Hibiscus sabdariffa* (Hassanein *et al.*, 2005) [4] and *Ajuga reptans* (Kwack *et al.*, 1997) [9] and fruits like strawberry (Montero *et al.*, 1998) [12].

In conclusion, foliar application of 100 ppm GA_3 at 30 days after planting in hibiscus plants, at 15 days interval can be effectively used to develop improved plant growth with regard to more branching, leaves and flower parameters in *Hibiscus rosa-sinensis* as a pot plant.

Table 1: Effect of foliar spray of plant growth regulators on vegetative growth parameters of potted hibiscus

Treatments	Plant height (cm)			Plant spread (cm) (N-S)			Plant spread (cm) (E-W)			Leaf area (cm^2)		
	Pooled			Pooled						Pooled		
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
T_1–Control (water)	18.50	19.65	21.82	16.13	16.97	18.40	14.42	15.90	17.93	11.48	12.50	12.98
T_2–GA_3 50 ppm	22.83	24.93	26.85	19.77	20.67	21.60	18.18	19.78	21.03	14.63	15.65	15.87
T_3–GA_3 100 ppm	24.90	26.77	28.93	21.45	22.82	23.52	20.00	21.77	23.53	15.55	16.17	16.48
T_4–BA 25 ppm	19.20	20.55	22.73	17.47	18.50	18.97	15.52	17.03	18.48	12.35	13.62	13.73
T_5–BA 50 ppm	19.37	20.65	22.93	17.66	18.58	19.10	15.67	17.12	18.63	12.73	13.90	14.27
T_6 – SA 25 ppm	19.50	20.85	23.10	17.78	18.73	19.25	15.78	17.32	18.70	13.15	14.17	14.70
T_7 – SA 50 ppm	20.28	21.25	23.17	18.10	18.97	19.43	15.95	17.68	18.75	13.30	14.32	14.82
T_8 – BA (25) + GA_3 (50) ppm	21.12	21.78	23.87	18.57	19.30	20.02	16.45	18.11	19.47	13.48	14.53	14.82
T_9 – BA (25) + GA_3 (50) + SA (25) ppm	21.90	23.07	25.10	19.15	19.92	20.67	17.00	18.75	20.23	13.92	15.35	15.65
S.Em.±	0.29	0.13	0.14	0.18	0.16	0.11	0.19	0.38	0.51	0.19	0.45	0.39
C.D. at 5 %	0.94	0.42	0.44	0.60	0.51	0.31	0.63	1.24	1.66	0.64	1.47	1.26
C.V. %	0.77	0.67	0.60	0.89	1.26	1.30	1.06	1.17	0.92	2.01	2.73	1.54
Year (Mean)												
Y x T S.Em.±	0.09	0.08	0.08	0.09	0.14	0.15	0.10	0.12	0.10	0.15	0.22	0.13
Y x T C.D. at 5 %	0.26	0.24	0.23	0.27	0.41	NS	0.29	0.35	0.29	0.46	0.65	0.37

Table 2: Effect of foliar spray of plant growth regulators on vegetative growth parameters of potted hibiscus

Treatments	Number of branches per plant			Number of leaves per plant		
	Pooled			Pooled		
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
T_1–Control (water)	2.37	2.67	2.77	11.80	13.60	15.02
T_2–GA_3 50 ppm	4.63	5.45	6.02	26.57	31.33	35.65
T_3–GA_3 100 ppm	4.42	4.82	5.27	25.10	29.82	35.00
T_4–BA 25 ppm	3.07	3.27	3.30	18.50	21.55	22.97
T_5–BA 50 ppm	3.63	3.77	3.87	19.52	22.22	24.38
T_6 – SA 25 ppm	3.17	3.30	3.43	20.25	22.95	24.88
T_7 – SA 50 ppm	3.73	3.87	4.03	20.87	24.00	26.82
T_8 – BA (25) + GA_3 (50) ppm	4.00	4.10	4.40	22.83	26.17	29.17
T_9 – BA (25) + GA_3 (50) + SA (25) ppm	4.23	4.43	4.73	24.32	27.85	30.82
S.Em.±	0.08	0.08	0.14	0.20	0.40	0.46
C.D. at 5 %	0.23	0.23	0.47	0.58	1.30	1.49
C.V. %	4.94	4.82	5.43	2.20	1.24	1.38
Year (Mean)						
Y x T S.Em.±	0.10	0.11	0.13	0.26	0.17	0.21
Y x T C.D. at 5 %	NS	NS	0.37	NS	0.51	0.64

Table 3: Effect of foliar spray of plant growth regulators on flowering characters of potted hibiscus

Treatments	Number of flowers per plant			Number of flowers per branch			Flower diameter (cm)			Flowering period (days)	*In situ* flower longevity (days)		
	Pooled			Pooled			Pooled			Pooled	Pooled		
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS		30 DAS	60 DAS	90 DAS
T_1–Control (water)	2.40	2.67	2.77	0.87	1.07	1.97	4.18	4.55	4.97	102.3	2.33	2.43	2.50
T_2–GA_3 50 ppm	4.53	4.92	5.27	2.55	2.72	3.85	6.07	6.23	6.45	125.2	3.67	3.83	4.00
T_3–GA_3 100 ppm	4.78	6.13	6.60	2.83	2.93	4.10	6.27	6.73	6.97	128.2	3.87	4.07	4.10
T_4–BA 25 ppm	3.07	3.27	3.30	1.25	1.45	2.42	4.77	4.83	5.18	107.8	2.73	2.80	2.87
T_5–BA 50 ppm	3.63	3.76	3.87	1.35	1.58	2.72	4.88	4.93	5.22	110.2	3.03	3.13	3.23
T_6 – SA 25 ppm	3.17	3.30	3.43	1.42	1.67	2.52	5.00	5.03	5.23	111.8	2.77	2.87	2.97
T_7 – SA 50 ppm	3.73	3.87	4.03	1.48	1.73	2.83	5.05	5.10	5.35	113.3	3.10	3.20	3.46
T_8 – BA (25) + GA_3 (50) ppm	4.00	4.10	4.40	2.15	2.28	3.25	5.12	5.18	5.45	119.9	3.33	3.47	3.63
T_9 – BA (25) + GA_3 (50) + SA (25) ppm	4.23	4.43	4.73	2.35	2.45	3.50	5.33	5.43	5.65	123.2	3.50	3.67	3.77
S.Em.±	0.12	0.15	0.12	0.05	0.04	0.09	0.07	0.08	0.09	1.93	0.13	0.14	0.12
C.D. at 5 %	0.34	0.44	0.36	0.14	0.12	0.25	0.19	0.22	0.27	0.28	0.36	0.40	0.35
C.V. %	7.74	9.16	7.15	6.70	5.30	6.84	3.14	3.71	4.26	0.15	10.19	10.74	8.38
Year (Mean)													
Y x T S.Em.±	0.16	0.21	0.17	0.06	0.06	0.11	0.09	0.11	0.14	0.10	0.18	0.20	0.16
Y x T C.D. at 5 %	NS	NS	NS	NS	NS	NS	NS	NS	NS	0.29	NS	NS	NS

Table 4: Effect of foliar spray of plant growth regulators on plant pigments of potted hibiscus

Treatments	Chlorophyll content in leaves (mg/g)			Anthocynin in flower (mg/g)		
	Pooled			Pooled		
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
T_1–Control (water)	14.85	15.12	15.60	12.65	12.78	13.20
T_2–GA_3 50 ppm	18.05	19.12	19.52	16.25	17.65	18.90
T_3–GA_3 100 ppm	19.50	20.37	20.85	17.03	18.65	20.20
T_4–BA 25 ppm	15.50	15.77	16.50	13.33	13.52	13.73
T_5–BA 50 ppm	15.58	15.85	16.62	14.03	14.37	14.52
T_6 – SA 25 ppm	15.72	15.98	16.73	13.45	13.60	13.80
T_7 – SA 50 ppm	15.95	16.10	16.83	14.32	14.73	14.87
T_8 – BA (25) + GA_3 (50) ppm	16.32	17.00	17.53	14.93	15.33	15.48
T_9 – BA (25) + GA_3 (50) + SA (25) ppm	16.80	17.30	18.37	15.43	16.27	17.33
S.Em.±	0.15	0.17	0.29	0.30	0.12	0.21
C.D. at 5 %	0.50	0.56	0.96	0.98	0.34	0.69
C.V. %	1.07	1.11	1.18	2.35	1.87	1.89
Year (Mean)						
Y x T S.Em.±	0.10	0.11	0.12	0.20	0.16	0.17
Y x T C.D. at 5 %	0.30	0.31	0.34	0.57	NS	0.49

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