Indian Journal of Agricultural Sciences **82** (7): 632–7, July 2012

Effect of plant growth regulators on growth, flowering and corm production of gladiolus cv. Snow Princess*

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Received: 5 January 2011; Revised accepted: 2 May 2012

Key words: Benzyl Adenine, Corm, Cormel, Flowering, Gibberellic acid, Gladiolus, Indole acetic acid, Soaking, Spraying

Gladiolus is one of the important flower crops in India as well as in the world and is referred to as the queen of bulbous flowers. The fascinating spikes bear a large number of florets in a variety of colours which exhibit varying sizes and forms, with smooth, ruffled, deeply crinkled or lacinated petals. An attempt was made to investigate the effect of gibberellic acid (GA_3), benzyl adenine (BA) and indole acetic acid (IAA) on growth, flowering and corm production of gladiolus cv. Snow Princess.

Healthy and uniform sized corms (8–10 cm) of gladiolus cv. Snow Princess were used for conducting the present investigations during 2006-07. Three chemicals GA_3 (200, 500 and 1 000 ppm), BA (25, 50 and 100 ppm) and IAA (100, 250 and 500 ppm) each at three levels were used as soaking (for 3 hr before planting), spraying (on 45th day after planting@ 50 ml/10 plants using an atomizer of 500 ml capacity) and combination of soaking and spraying. The experiment was laid out in a randomized block design with 28 treatments in three replications including an untreated control. The corms were planted at a spacing of 40 cm × 15 cm with three replications each consisting 10 corms. Data recorded on vegetative growth, flowering and corm production was subjected to analysis of variance (Gomez and Gomez 1984).

The study on the number of shoots/corm revealed that the treatment with BA (100 ppm) through soaking + spraying resulted in maximum number of shoots (4.20) followed by soaking alone in BA at 100 ppm (3.52). IAA (100 ppm) as a spray gave minimum number of shoots (1.81). This was in close conformity with the findings of Mahesh and Misra (1993) who reported that foliar application of BA at 50 ppm, 45 days after planting increased the number of shoots per corm from 2.05 to 2.28. IAA (100 ppm) as a spray gave minimum number of shoots (1.81). GA_3, however, had no significant effect on the number of shoots/plant. Among GA_3, NAA or CCC as dipping or spraying at 40 days after planting or both, Kirad *et al* (2001) reported that CCC 6000 ppm under the dipping and spraying treatment recorded maximum number of shoots than GA_3 or NAA.

The plant height was recorded maximum with IAA (250 ppm) as soaking + spraying (92.88 cm) followed by GA_3 at 500 ppm as soaking treatment (92.52 cm), the shortest plant being with the application of GA_3 at 1000 ppm as spraying alone (84.29 cm). Increase in plant height by GA_3 application was in accordance with the findings of Kirad *et al.* (2001) who reported that GA_3 at 100 ppm (dipping for 12 hr + spraying at 40 days after planting) resulted in maximum plant height and highest leaf number in gladiolus cv. White Prosperity. Among the modes of application, soaking + spraying treatment was the best, which supports the findings of Kirad *et al* (2001). Plant height is negatively correlated to peroxidase activity (Galston and Davies 1969) and probably due to these hormone treatments there is suppression of either peroxidase production or inactivation resulting in an increase in plant height.

The number of leaves/plant was not influenced by the treatment of growth regulators significantly. The growth regulators, however, were found to play a significant role in influencing the total leaf area (dm^2) of the plant. Maximum leaf area (4.57 dm^2) was recorded by using IAA (100 ppm) as spraying, followed by IAA (500 ppm) as soaking + spraying which showed 41% increase over the control (3.22 dm^2). The positive role of auxins in cell enlargement could be the reason for an increased leaf area in IAA treated plants. Mahesh and Misra (1993) also found that IAA 100 ppm (4.57 dm^2) as foliar sprays at 45 days after planting was effective in increasing the leaf area in gladiolus compared to control (3.22 dm^2).

Days to flowering were significantly reduced by GA_3 treatment. Contrary to that, BA increased it. IAA had no

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significant effect on the earliness (Table 1). The earliest flowering (100.19 days) occurred in plants treated with GA_3 at 1 000 ppm (soaking + spraying), followed by GA_3 at 500 ppm as soaking (102.62 days). The flowering was delayed by 11 days in plants treated with BA at 100 ppm (soaking + spraying). The delay in flowering by BA treatment could be attributed to the fact that BA treatment helps in the production of more corms and shoots thereby preventing the translocation of carbohydrates for the floral primordia to develop. Out of the two sinks, flower spike and corm and cormel production in gladiolus, BA treatment encourages the activity of the latter. Earliness due to GA_3 application was reported in gladiolus cv. Friendship by Ravidas *et al.* (1992) and Naveen Kumar *et al* (2008). The delay in flowering by BA application was contrary to the findings of Tawar *et al.* (2003) who reported that the number of days before emergence of spike, number of days before the opening of the first floret and number of days to flowering decreased with increasing dose of IAA, BA and GA_3.

The spike length was recorded maximum in case of IAA 500 ppm (soaking + spraying) (67.47 cm), followed by IAA at 250 ppm as soaking (66.12 cm) and GA_3 at 500 ppm as soaking and minimum in the case of plants sprayed with GA_3 at 1 000 ppm (60.61 cm). The increase in length of the spike due to IAA application is in confirmation with the findings of Tawar *et al.* (2003) in gladiolus cv. Jester. GA_3 at 500 ppm as soaking increased the rachis length (43.02 cm) significantly as compared to the control. It was followed by soaking treatment of GA_3 at 200 ppm (42.59 cm). The smallest rachis length was recorded in plants sprayed with GA_3 at 500 ppm (37.17 cm), followed by spraying with BA at 25 ppm (38.26 cm). Foliar application of GA_3 at lower concentration (200 ppm) increased the rachis length significantly over higher levels (500 or 1000 ppm). Also, plants dipped in GA_3 at 500 ppm showed 12% increase in the number of florets/spike and maximum diameter of the floret (12.00 cm). Increase in rachis length by GA_3 application was in accordance with the findings of Rajivkumar *et al.* (2002).

The maximum number of florets/spike was recorded in plants treated with GA_3 at 500 ppm as soaking + spraying (12.14), followed by GA_3 at 1 000 ppm as soaking + spraying (11.95). The lowest number of florets (9.57) was observed when the plants were dipped in IAA at 100 ppm for three hours. Contrary to this Tawar *et al* (2003) reported increase in spike length, rachis length, number of florets/spike, spike weight and vase life with increasing dose of IAA, BA and GA_3 up to 250 ppm in gladiolus cv. Jester. The number of florets/spike depends on the number of flower bud initials which varies from genotype to genotype. In this study, increase in the number of flowers has been observed which could be due to change in the bud initials, probably, some vegetative buds may have been changed to floral buds. On the other hand, it may be due to the fact that the increased spike length accommodates more number of florets. Prakash and Jha (1998) and Rajivkumar *et al* (2002) also observed the significant role of GA_3 in increasing the floret number. The decrease in the number of florets as observed in the study due to IAA application lends support from the findings of and Bhattacharjee (1984) in gladiolus cv. Friendship.

Spike durability (field life) was significantly affected by growth regulator treatments. The spike longevity was highest in case of soaking + spraying treatments with either GA_3 at 500 ppm or 1 000 ppm, which gave 36% increase over the control. Spike longevity was the lowest in plants subjected to soaking in BA (100 ppm). The maximum field life in GA_3 treatments could be due to the fact that GA_3 induced early flowering helped the spikes in avoiding the higher temperature during the early summer. In case of BA treatment, flowering was significantly delayed to coincide with higher day temperatures of early summer. Therefore the florets might have dried very quickly and durability was reduced in BA treated plants.

Floret diameter was significantly affected by the growth regulator treatments. The diameter of the flower was maximum (12.00 cm) with soaking treatment of GA_3 (500 ppm) and least (10.85 cm) with spraying of GA_3 at 1000 ppm followed by soaking in BA at 25 ppm (10.94 cm). The length of floret was recorded maximum with BA 100 ppm (soaking + spraying) (10.22 cm), while the lowest (9.53 cm) was obtained by soaking in GA_3 at 1000 ppm. Increase in diameter due to low concentrations of GA_3 application and decrease due to higher concentration as observed in the present study is in conformity with the findings of Bhattacharjee (1984) who observed that concentrations of GA_3 as it increased from 10 to 1 000 ppm decreased the flower diameter correspondingly. Increase in flower diameter by GA_3 application was also reported by Prakash and Jha (1998) in gladiolus cv. Friendship.

It was interesting to note that all the growth regulators exhibited highly significant role in the characters pertaining to corm production (Table 2). BA (100 ppm) given as soaking + spraying recorded maximum number of corms (4.67) as compared to the control (2.13). In general, all the BA treatments increased the number of corms. The lowest number of corms (2.00) was produced in treatments like soaking in GA_3 (200 ppm) or IAA (100 ppm), or spraying with GA_3 (1 000 ppm) or IAA (500 ppm) or soaking + spraying with IAA (100 ppm). The increase in the number of corms due to BA application as observed in this study is similar to the findings of Mahesh and Misra (1993) in gladiolus. There are also reports (Jager *et al.* 1998) stating that BA application has increased the corm production/plant in gladiolus under *in vitro* conditions. The maximum volume (53.67 cc) was recorded from those plants which were sprayed with IAA at 100 ppm and the minimum (31.67 cc) in the control. From these findings it may be inferred that all these chemicals have potential in increasing the corm size in terms of volume, as these would have participated in cell enlargement in the corms.

Table 1 Effect of growth regulators on vegetative growth and flowering of gladiolus cv. Snow Princess

Treatment (ppm)	Shoots/ corm	Leaves/ plant	Total leaf area (dm^2)	Plant height (cm)	Days to flowering	Floret diameter (cm)	Florets/ spike	Spike longevity (days)	Spike length (cm)	Rachis length (cm)
Control	2.05	5.14	3.22	87.30	109.19	11.36	10.19	13.93	65.71	41.23
Soaking alone										
GA_3 200	2.00 (–2.44)	5.48	3.53 (9.63)	90.97	11.48 (12.66)	18.33 (31.59)	11.48 (12.66)	18.33 (31.59)	63.68	42.59
GA_3 500	2.05 (–0.00)	5.48	3.53 (21.12)	92.52	11.43 12.17)	18.33 (31.59)	11.43 12.17)	18.33 (31.59)	66.03	43.02
GA_3 1000	2.09 (1.95)	5.33	3.44 (6.83)	88.16	11.48 (12.66)	17.71 (27.14)	11.48 (12.66)	17.71 (27.14)	62.00	40.77
BA 25	2.43 (18.54)	5.33	2.87 (–10.87)	88.72	10.57 (3.73)	15.19 (9.05)	10.57 (3.73)	15.19 (9.05)	63.26	39.94
BA 50	2.86 (39.51)	5.43	2.73 (–15.22)	87.46	9.95 (–2.36)	13.76 (–1.22)	9.95 (–2.36)	13.76 (–1.22)	62.69	41.42
BA 100	3.52 (71.71)	5.33	3.82 (18.63)	88.34	10.05 (–1.37)	12.57 (–9.76)	10.05 (–1.37)	12.57 (–9.76)	63.27	38.69
IAA 100	2.05 (0.00)	5.38	3.35 (4.04)	88.21	9.57 (–6.08)	14.91 (7.04)	9.57 (–6.08)	14.91 (7.04)	61.42	38.41
IAA 250	2.14 (4.39)	5.14	3.47 (7.76)	90.32	10.67 (4.31)	16.38 (17.59)	10.67 (4.31)	16.38 (17.59)	66.12	41.08
IAA 500	1.95 (–4.88)	5.62	4.05 (25.78)	89.05	10.57 (3.73)	16.24 (16.58)	10.57 (3.73)	16.24 (16.58)	63.90	40.94
Spraying alone										
GA_3 200	1.96 (–4.39)	5.25	3.82 (18.63)	90.57	108.14 (–0.96)	11.63	10.74 (5.40)	17.27 (23.98)	65.20	40.12
GA_3 500	2.00 (–2.44)	5.33	3.84 (19.25)	87.83	108.00 (–1.96)	11.18	10.62 (4.22)	16.91 (21.39)	64.35	37.17
GA_3 1000	1.91 (–6.83)	5.43	3.80 (18.01)	84.29	109.33 (0.13)	10.85	10.67 (4.71)	16.91 (21.39)	60.61	38.78
BA 25	2.05 (0.00)	5.24	3.52 (9.32)	85.88	111.81 (2.40)	11.16	9.95 (-2.36)	14.24 (14.24)	61.24	38.26
BA 50	2.28 (11.22)	5.10	2.85 (–11.49)	91.94	108.47 (–0.66)	10.99	10.53 (3.34)	17.16 (23.19)	65.79	40.11
BA 100	2.05 (0.00)	5.24	3.21 (–0.31)	86.28	110.43 (1.14)	11.20	10.00 (-1.84)	15.91 (9.05)	64.51	39.75
IAA 100	1.81 (–11.71)	5.53	4.57 (41.93)	89.86	109.00 (–0.17)	11.49	10.24 (0.49)	15.72 (12.85)	63.41	39.22
IAA 250	2.14 (4.39)	5.20	2.65 (–17.70)	88.12	110.57 (1.26)	11.33	10.66 (4.61)	15.14 (8.69)	65.52	39.96
IAA 500	1.90 (–7.32)	5.33	2.55 (–20.81)	90.04	111.10 (1.75)	11.40	10.52 (3.24)	14.95 (7.32)	64.68	39.62
Soaking + spraying										
GA_3 200	2.19 (6.83)	5.33	3.87 (20.19)	90.88	105.62 (–3.27)	11.46	10.91 (7.07)	17.28 (24.05)	63.95	39.64
GA_3 500	2.09 (1.95)	5.43	3.69 (14.60)	89.09	103.72 (–5.01)	11.69	12.14 (19.14)	19.00 (36.40)	65.06	41.65
GA_3 1000	1.95 (–4.88)	5.16	2.73 (–15.22)	89.55	100.19 (–8.24)	11.75	11.95 (17.27)	18.95 (36.04)	62.89	42.01
BA 25	2.09 (1.95)	5.19	2.70 (–16.15)	91.78	113. 29 (–3.75)	11.49	10.72 (5.20)	14.38 (3.23)	64.83	41.35

Contd.

Table 1 *concluded*

Treatment (ppm)	Shoots/ corm	Leaves/ plant	Total leaf area (dm^2)	Plant height (cm)	Days to flowering	Floret diameter (cm)	Florets/ spike	Spike longevity (days)	Spike length (cm)	Rachis length (cm)
BA 50	2.90 (41.46)	5.38	3.25 (0.95)	88.05	115.72 (-5.98)	11.33	10.10 (-0.88)	13.12 (-5.81)	61.74	38.87
BA 100	4.20 (104.88)	5.26	3.12 (–3.11)	87.58	120.48 (–10.34)	11.41	9.96 (–2.26)	12.66 (–9.12)	61.37	39.68
IAA 100	2.05 (0.00)	5.38	3.64 (13.04)	91.30	108.57 (–0.57)	11.14	10.43 (2.36)	16.00 (14.86)	64.53	41.37
IAA 250	2.19 (6.83)	5.38	4.35 (35.09)	92.88	109.19 (–0.00)	11.29	10.62 (4.22)	15.81 (13.50)	64.09	40.98
IAA 500	2.24 (9.27)	5.48	4.55 (41.30)	90.55	109.95 (–0.70)	11.42	10.43 (2.36)	15.39 (10.48)	67.47	40.30
SE m±	0.0089	0.21	0.146	0.47	2.03	0.153	0.216	0.211	0.146	0.21
CD at 5%	0.18	NS	0.29	0.94	4.07	0.31	0.43	0.42	0.29	0.42

Values in parentheses are per cent increase/decrease over control

Table 2 Effect of growth regulators on corm and cormel production of gladiolus cv. Snow Princess

Treatment (ppm)	Corms/plant	Cormels/plant	Corm weight (g)	Cormels weight/plant (g)	Corm diameter (cm)	Corm volume (cc)	Propagation coefficient (%)
Control	2.13	36.20	30.90	6.27	3.63	31.67	233.61
Soaking alone							
GA_3 200	2.00 (–6.10)	42.20 (16.57)	38.07 (–23.20)	7.53 (20.10)	3.91	51.17 (61.57)	270.80
GA_3 500	2.07 (–6.02)	36.27 (0.19)	40.93 (32.46)	6.80 (8.45)	4.09	49.33 (55.76)	295.88
GA_3 1000	2.20 (3.29)	35.47 (–2.02)	34.67 (12.00)	7.33 (16.91)	3.78	44.50 (40.51)	27.50
BA 25	2.40 (12.68)	39.80 (9.94)	29. 93 (–3.14)	6.53 (4.15)	3.82	43.83 (38.40)	253.67
BA 50	2.73 (28.17)	31.47 (–13.07)	26.42 (–14.50)	5.40 (–13.88)	3.82	42.17 (33.15)	251.14
BA 100	3.60 (69.01)	26.53 (–26.71)	18.61 (–39.77)	5.27 (–15.95)	3.39	39.50 (24.72)	233.82
IAA 100	2.00 (–6.10)	38.53 (6.44)	33.65 (8.90)	6.60 (5.26)	3.85	44.00 (38.93)	239.17
IAA 250	2.33 (9.39)	52.00 (43.65)	38.95 (26.05)	9.47 (51.04)	4.06	51.50 (62.61)	324.74
IAA 500	2.20 (3.29)	42.93 (18.59)	35.71 (15.57)	8.73 (39.23)	3.81	47.33 (49.45)	282.30
Spraying alone							
GA_3 200	2.07 (–2.82)	46.13 (27.43)	37.18 (20.32)	7.67 (22.33)	3.92	43.67 (37.89)	273.55
GA_3 500	2.20 (3.29)	39.33 (8.65)	31.32 (1.36)	6.87 (9.57)	3.79	43.00 (35.78)	245.22
GA_3 1000	2.00 (–6.10)	41.73 (15.28)	34.45 (11.49)	7.87 (25.52)	3.93	47.17 (48.94)	248.54
BA 25	2.40 (12.68)	37.93 (4.78)	28.99 (-6.18)	6.80 (8.45)	3.76	44.17 (39.47)	247.28

Contd.

Table 2 *concluded*

Treatment (ppm)	Corms/plant	Cormels/plant	Corm weight (g)	Cormels weight/plant (g)	Corm diameter (cm)	Corm volume (cc)	Propagation coefficient (%)
BA 50	2.07 (–2.82)	46.60 (28.73)	38.35 (24.11)	8.13 (29.67)	4.03	50.50 (59.46)	282.86
BA 100	2.07 (–2.82)	51.40 (41.99)	37.03 (19.83)	8.73 (39.23)	3.97	44.50 (40.51)	275.94
IAA 100	2.07 (–2.82)	37.53 (3.67)	34.73 (12.39)	6.33 (0.96)	4.00	53.67 (69.47)	252.79
IAA 250	2.33 (9.39)	36.27 (0.19)	30.34 (-1.81)	6.87 (9.57)	3.70	41.67 (31.58)	251.37
IAA 500	2.00 (–6.10)	32.07 (–1.41)	33.08 (7.06)	6.00 (-4.31)	3.99	46.83 (47.87)	233.55
Soaking + spraying							
GA_3 200	2.40 (–12.68)	43.80 (20.99)	32.03 (3.66)	7.60 (21.12)	4.01	43.50 (37.35)	273.28
GA_3 500	2.33 (9.39)	35.00 (-3.31)	36.10 (16.83)	8.47 (35.09)	3.78	41.67 (31.58)	300.02
GA_3 1000	2.27 (6.57)	45.40 (25.41)	29.48 (–4.60)	8.13 (29.67)	3.69	38.33 (21.03)	242.62
BA 25	2.27 (6.57)	38.60 (6.63)	31.19 (0.94)	7.13 (13.72)	3.67	43.50 (37.35)	251.86
BA 50	3.33 (56.34)	34.53 (–4.61)	21.54 (–30.29)	6.47 (3.19)	3.49	38.83 (22.61)	253.33
BA 100	4.67 (119.25)	22.33 (–38.31)	14.44 (–53.27)	4.27 (-9.12)	3.20	32.33 (2.08)	264.55
IAA 100	2.00 (–6.10)	44.47 (22.85)	37.33 (20.81)	7.07 (12.76)	4.11	50.33 (58.92)	41.37
IAA 250	2.27 (6.57)	48.80 (934.81)	35.28 (14.17)	8.27 (31.90)	3.89	50.50 (59.46)	285.50
IAA 500	2.13 (0.00)	46.33 (27.98)	35.88 (16.12)	7.40 (18.02)	3.85	49.83 (57.34)	271.71
CD at 5%	0.118	0.424	0.107	0.37	0.065	0.5.72	12.65

Values in parentheses are per cent increase/decrease over control

The diameter of the corm was comparatively less affected by growth regulators. IAA 100 ppm (soaking + spraying) gave the maximum diameter of the corm (4.11 cm), followed by soaking treatment with GA_3 at 500 ppm (4.09 cm) and the minimum (3.20 cm) was recorded in BA 100 ppm (soaking + spraying) treatment. Increase in diameter of the corm with GA_3 was earlier reported by Bhattacharjee (1984). Surprisingly, growth regulator treatments increased the weight and volume of the corm to great extent without increasing the diameter of the corm proportionately. This could be because, the elongation of the cells in the corm would have taken place in the vertical direction thereby increasing the thickness of the corm and not the diameter. The corm weight was maximum in soaking treatment with 500 ppm of GA_3 (40.93 g), followed by soaking in IAA at 250 ppm (38.95 g). BA 100 ppm (soaking + spraying) gave the lowest weight of corm (14.44 g). The present findings on the increase in corm weight by GA_3 are in accordance with the findings of Pal and Chowdhury (1998) in gladiolus cv. Tropic Sea.

Maximum number of cormels (52.00) was produced by IAA treatment as soaking at 250 ppm, followed by spraying with BA at 100 ppm (51.40). Increase in corm production may hamper the subsequent cormel production as energy required for cormel development may be diverted towards corm production. The cormel weight was recorded maximum in plants treated with IAA 250 ppm (9.47 g) as soaking treatment and minimum in BA at 100 ppm (soaking + spraying) (4.27 g). Increase in cormel weight by BA 50 ppm and GA_3 40 ppm were also observed by Mahesh and Misra (1993) and Pal and Chowdhury (1998), respectively in gladiolus.

Propagation coefficient reveals the multiplication rate by which, at a glance, one can visualize the overall corm and cormel production potential. The propagation coefficient was

maximum (324.74) in IAA (250 ppm) as soaking, followed by GA_3 500 ppm (soaking + spraying) (300.02) indicating that these treatments are the best for rapid multiplication of gladiolus. The propagation coefficient was least in the case of BA 100 ppm (soaking + spraying), even though it produced the maximum number of corms, where the corm size was found to be highly reduced. This treatment would have encouraged other lateral buds present on the corms, in dormant form, to accelerate their growth. Therefore, the energy required for the corm *vis- a-vis* cormel development would have been diverted towards aerial plant development, hence corm as well as cormel development was found poor which ultimately reduced propagation coefficient in this treatment. In fact, corm starts forming just after sprouts start taking growth, and cormel starts forming normally at the time of spike formation. In the case of IAA (250 ppm) treatment, the weight of corm was high and hence had a high propagation coefficient.

SUMMARY

The earliness in sprouting was observed with all the treatments of IAA and GA_3 irrespective of the concentrations, however, the earliest (10.00 days) was recorded in corms dipped in GA_3 (1 000 ppm). GA_3 was found to be the best in increasing the floret diameter, number of florets/spike, rachis length and field durability of spike and in earliness to flowering. The number of cormels/plant and volume were highly increased by IAA treatment. Both IAA and GA_3 were found equally effective in increasing the weight of corm and cormels, diameter of the corm and propagation coefficient, spike length, leaf area and early sprouting of the corms. Among the different modes of application, soaking treatment helps in the efficient absorption of the growth regulator solutions and its effect on sprouting and early vegetative growth is pronounced whereas spraying influences the corm characters and to some extent the flowering behaviour. Soaking + spraying treatment had lasting effect throughout the crop period and hence was superior to all other treatments.

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