Effect of Foliar Application of Gibberellic Acid on Plant Growth, Flowering and Yield Attributes in Pansy (*Viola* × *wittrockiana* Gams.)

ABSTRACT

An investigation was carried out to study the effect of foliar application GA_3 on plant growth and quality attributes in Pansy (*Viola* × *wittrockiana* Gams.) during 2019-2020. The field experiment was laid out at randomized complete block design (RCBD). The 18 treatment combinations including 6 doses of GA_3 *i.e.,* 50, 100, 150, 200, 250 and 300 ppm were applied at 3 durations *i.e.,* 30, 40 and 50 DAT along with a non-factorial control. Of them, GA_3 @ 300 ppm at 40 DAT showed significant increment in plant height (34%), plant spread (32%), number of flowers per plant (25%), number of flowers per plot (25%), size of flowers (35%), flowering duration (25%), seed yield per plant (68%), seed yield per plot (68%) and seed yield per hectare (68%), number of seeds per capsule (48%), number of capsules per plant (38%) as compared to control checks whereas earliest flowering was observed due to GA_3 @ 300 ppm when applied at 30 DAT.

Keywords: Foliar, GA_3, Pansy, RCBD, DAT

INTRODUCTION

Pansy (*Viola* **×** *wittrockiana* Gams.), a popular, commercially important ornamental bedding plant in both developed and developing countries (Gandolfo *et al.,* 2016). It is a winter annual and belongs to family Violaceae. The word 'Pansy' has been derived from a French word 'Pensee' meaning 'loving thoughts' (Desai, 2009). It is basically derived from *Viola tricolor* and is native to Central Europe (Chattopadhyay, 2007). The Pansy producing purple colour flowers is believed to represent sweet memories. It is well-documented that the origin of modern pansy (*Viola* **×** *wittrockiana* Gams.) began in England in 1815 by hybridizing wild pansy (*Viola tricolour* L.) with some other *Viola* species (Anonymous, 1976). Pansies are divided in to two groups *viz.*, 'Clear types' bearing flowers with solid colour and 'Faced type', which are multi-coloured or with spots or patches of various colours. However, based on flower size, the pansy is categorized in three main types namely, large (with a bloom of 7.5-10 cm diameter), medium (bloom size 5.0-7.5 cm), and small (bloom size of 2.5-5.0 cm), respectively.

The pansy flowers are borne singly on the long stalk with attractive colours and shapes (Salunkhe *et al.,* 1987). These are ideal for utilizing in winter landscapes as they are cold tolerant plants and grow more luxuriantly with profuse flowering under cool and moist environment. They are often cultivated in garden beds, pots, borders, hanging baskets, or landscapes as annuals or biennials (Bailey, 1998).

The plant growth regulators of either natural or synthetic origin may incite some changes in the various processes of growth, development and flowering of plants in general and ornamentals in particular by manipulating the requisite physiological, biochemical and flower induction reactions during primary and secondary metabolism (Heldet, 1997). Gibberellins are naturally occurring plant growth regulators that are produced in response to both developmental and environmental cues (Iqbal and Ashraf, 2013). Yuan *et al*., (2003) has reviewed effect of GA_3 and stated that it regulates plant height, more number of branches as well as increase productivity. Gibberellins have an impact on plants at every phase of their life cycles, showing a remarkable diversity in their physiological activities (Pradeepkumar *et al*., 2020).

Numerous research works have revealed the effects of GA_3 on plant growth, flowering and yield attributes in several crops. Shrestha *et al* (2020), have shown that foliar application of gibberellic acid significantly improves quality of calendula flowers. Biswas *et al*., (2021), observed better plant growth and yield attributing characters with application of GA_3. Khangjarakpam *et al* (2019), also observed similar results in marigold with application of GA_3 in China aster. Husain and co-workers (2018) also observed increase in seed yield with GA_3 application in pea.

MATERIAL AND METHODS

The experiment was conducted on pansy (*Viola* **×** *wittrockiana* Gams.) during winter season of 2019-2020 at Dr YS Parmar University, Nauni, Solan. The treatment combinations consisted of 6 different doses of gibberellic acid (GA_3), *viz.*, 50 ppm, 100 ppm, 150 ppm, 200 ppm, 250 ppm and 300 ppm at three different times *i.e.*, 30 DAT, 40 DAT and 50 DAT along with control. The experimental design followed in field was randomized complete block design (RCBD)with three replications per treatment. The plant spacing was 30 × 25 cm which occupies 12 plants per plot. Sowing was done on first fortnight of October and transplanting was carried out 30 days after sowing and standard cultural practices like hoeing, irrigation, weeding and fertilizer application were followed as per the requirement of the crop. Data on various growth, flowering and yield parameters were recorded and statistically analyzed by applying the technique of analysis of variance. Statistical interference was implied with ANOVA, keeping the level of significance at 5% (P=0.05).

RESULTS AND DISCUSSION

Growth parameters:

The analysis of variances obtained for the parameters under study have exhibited significant variations among different treatments alone and in combinations as well. As regards the effects of GA_3 doses, G_6 (GA_3 @ 300ppm), recorded highest values for plant height (30.24 cm). Moreover, GA_3 application at 40 DAT(40 days after transplanting; D_2) produced maximum plant height (27.44 cm). Maximum plant height (31.29 cm) was significantly induced by the interaction effects of $G_6 \times D_2$.In general, the increase of plant height by GA_3 treatment could be due to the induction of cell division and cell elongation on faster rate. The results are in line with the research findings obtained in African marigold cultivar's 'Pusa Narangi' and 'Pusa Basanti' (Ramdevputra *et al.,* 2009), *Dahlia pinnata* (Youssef *et al*., 2008), sunflower (Sethy *et al*., 2016) in as well as *Calendula officinalis* cv. 'Bon Bon' (Khudus *et al*., 2017).

The plant spread was also found higher in G_6 (25.81 cm), D_2 (24.11 cm) and their interaction $G_6 \times D_2$ (17.87), which could be as a consequence of division and enlargement of cells and tissues as well as production of more number of side branches. Similar results have been reported by Khudus *et al* (2017) in *Calendula officinalis* cv. 'Bon Bon' and Khangjarakpam *et al* (2019) in African marigold.

More number of flowers per plant, flowers per plot, is higher when GA_3 is applied @ 300 ppm as well as when applied at 40 days after transplanting (See Table No. 1 & 2). Their interaction $G_6 \times D_2$ produced highest flowers (See Table No. 3). The production of more flowers per plant might be as a consequence of producing maximum number of lateral particularly at juvenile stages of growth leading to developing of maximum vegetative buds. In due course of time, these buds have differentiated and converted in to flowering buds. Similar results have also been documented in gerbera (Patra *et al.,* 2015), Sweet William (Thakur *et al.,* 2018), and marigold cv. 'Pusa Narangi Gainda' (Thakur *et al.,* 2019).

Increase in size of flowers (2.70), is when 300 ppm GA_3 is applied as well as when applied at D_2 *i.e.,* 40 DAT (2.24 cm). The interaction $G_6 \times D_2$ significantly shows increase in the size of flower (2.81 cm). The application of GA_3 particularly at higher doses and optimum stage of growth might have increased flower size as a consequence of forming a better source - sink duo so as to accumulate higher concentration of metabolites and their utilization by the plants resulting in the production of large size flowers. Similar results have also been documented in chrysanthemum (Sharifuzzaman *et al.*, 2011), carnation (Kumar *et al*., 2012), *Dianthus caryophyllus* L (El-Naggar *et al*., 2009), calendula (Shrestha *et al*., 2020).

The maximum duration of flowering (88.00 days) occurs with application of 300 ppm of GA_3. The increase in flowering duration results in D_2 (83.50 days). The interaction $G_6 \times D_2$ significantly shows extend in flowering duration (89.33 days).

Seed yield and yield contributing characters:

More number of capsules per plant (53.33) were observed to be significantly superior in G_6. The number of capsules per plant (47.39) is higher in D_2 (GA_3 at 40 DAT). The interaction $G_6 \times D_2$ significantly produced more number of capsules (54.33) per plant. More number of capsules per plant could be attributed to the production of maximum flowers of better size and quality. Subsequently, these flowers upon pollination could develop capsules in sufficient quantum, hence, more number of capsules were produced per plant.

More number of seeds per capsule (64.00) were significantly higher in GA_3 i.e. 300 ppm (G_6). The number of seeds per capsule (52.50) was higher with application of GA_3 at 40 DAT. The interaction $G_6 \times D_2$ significantly produced more number of seeds (52.50) per capsule. Production of more seeds with higher doses of GA_3 at proper stage may be as a consequence of better growth and flowering of plants as well as improving pollination and fertilization resulting in better seed setting. Therefore, said treatment combination could produce maximum seeds in a capsule. These results are in line with the findings of Hoque and Haque (2002), who observed more number of seeds per pod in mung bean with the application of higher doses of GA_3. Similarly Thakur *et al*. (2019) in African marigold also observed more seeds per head.

The maximum seed yield (3.42 g/plant), (41.00 g/plot and (409.95 kg/ha) was found in G6. The seed yield (2.29 g/plant), (27.42 g/plot) and (274.20 kg/ha) is highest in D_2. The interaction revealed that GA_3 @ 300 ppm after 40 days of transplanting $G_6 \times D_2$ produced maximum seed yield (3.57 g/plant), (42.86 g/plot) and (428.60 kg/ha).

Whereas, the minimum plant height, plant spread, number of flowers per plant, number of flowers per plot, size of flowers, duration of flowering, seed yield, number of seeds per capsule, number of capsules per plant, as well as maximum time to first flowering were reported with the application of GA_3 @ 50 ppm (G_1; See Table No.1).

However, the plant height, plant spread, number of flowers per plant, number of flowers per plot, size of flowers, duration of flowering, number of seeds per capsule, number of capsules per plant, seed yield were observed to be the minimum with the application of GA_3 after 50 days of transplanting (D_3; See Table No.2).

On the contrary, the values for plant height, plant spread, number of flowers per plant, number of flowers per plot, size of flowers, duration of flowering, number of seeds per capsule, number of capsules per plant, seed yield, were observed to be the lowest in control (T_1; See Table No. 3).

Table 1. Effect of different doses and durations of GA_3 on various growth and quality parameters of pansy (*Viola* × *wittrockiana* Gams.)

Treatments	Plant height (cm)	Plant spread (cm)	Flower diameter (cm)	Days to first flowering	Duration of flowering	Number of flowers/plant	Number of flowers/plot	Number of capsules/ plant	Number of seeds/capsule	Seed yield/plant (g)	Seed Yield/ plot (g)	Seed Yield/ ha (kg)
Doses of GA_3 (ppm)												
G_1 (GA3 50ppm)	22.48	20.41	1.87	74.56	70.56	102.33	1228.00	38.67	37.11	1.44	17.25	172.47
G_2 (GA_3 100ppm)	24.58	22.61	1.90	71.44	75.89	115.61	1387.33	41.67	44.78	1.87	22.18	221.83
G_3 (GA_3 150ppm)	26.19	23.39	1.96	66.89	82.89	121.89	1462.67	44.89	47.33	2.13	25.50	255.01
G_4 (GA_3 200ppm)	27.71	24.07	2.15	65.67	85.22	125.67	1508.00	47.89	52.44	2.51	30.15	301.53
G_5 (GA_3 250ppm)	28.90	24.99	2.51	61.11	86.11	129.44	1542.22	52.11	60.33	3.14	37.74	377.39
G_6 (GA_3 300ppm)	30.24	25.81	2.70	58.78	88.00	130.22	1562.67	53.33	64.00	3.42	41.00	409.95

Table 2. Effect of different durations of GA_3 application on various growth and quality parameters of pansy (*Viola* × *wittrockiana* Gams.)

Treatments	Plant height (cm)	Plant spread (cm)	Flower diameter (cm)	Days to first flowering	Duration of Flowering	Number of flowers/plant	Number of flowers/plot	Number of capsules/ plant	Number of seeds/capsule	Seed yield/plant (g)	Seed yield/ plot (g)	Seed yield/ha (kg)
Durations of GA_3												
D_1 (30 DAT)	26.52	23.49	2.18	64.83	81.44	120.39	1444.67	46.33	51.33	2.43	29.14	291.36
D_2 (40 DAT)	27.44	24.11	2.24	66.39	83.50	123.08	1477.00	47.39	52.50	2.54	30.35	303.53
D_3 (50 DAT)	26.09	23.04	2.12	68.00	79.39	119.11	1423.78	45.56	49.17	2.29	27.42	274.20

Table 3. Effect of different doses and durations of GA_3 application on various growth and quality parameters of pansy (*Viola* × *wittrockiana* Gams.)

Treatments	Plant height (cm)	Plant spread (cm)	Flower diameter (cm)	Days to first flowering	Duration of Flowering	Number of flowers/plant	Number of flowers/plot	Number of capsules/ plant	Number of seeds/capsule	Seed yield/plant (g)	Seed Yield / plot (g)	Seed Yield/ ha (kg)
T_1 (Control)	20.63	17.87	1.82	79.67	67.33	98.00	1176.00	33.67	34.00	1.14	13.68	136.84
T_2 $G_1 \times D_1$	22.03	20.07	1.87	73.67	70.00	101.00	1212.00	38.67	37.33	1.44	17.34	173.36
T_3 $G_1 \times D_2$	23.63	21.20	1.89	74.00	72.00	105.67	1268.00	39.67	38.00	1.51	18.11	181.12

T_4 G_1 × D_3	21.77	19.97	1.86	76.00	69.67	100.33	1204.00	37.67	36.00	1.36	16.29	162.92
T_5 G_2 × D_1	24.33	22.93	1.90	70.00	76.33	115.00	1380.00	41.33	45.33	1.88	25.50	225.04
T_6 G_2 × D_2	25.33	23.48	1.91	71.00	79.67	119.83	1438.00	42.67	46.33	1.98	23.05	230.53
T_7 G_2 × D_3	24.07	21.42	1.89	73.33	71.67	112.00	1344.00	41.00	42.67	1.75	20.99	209.92
T_8 G_3 × D_1	26.10	23.10	1.96	65.00	84.00	121.67	1460.00	44.67	47.33	2.12	25.38	253.84
T_9 G_3 × D_2	26.87	24.13	1.98	67.67	85.33	123.67	1484.00	45.67	48.33	2.21	26.49	264.88
T_{10} G_3 × D_3	25.60	22.95	1.94	68.00	79.33	120.33	1444.00	44.33	46.33	2.05	24.63	246.32
T_{11} G_4 × D_1	27.67	24.10	2.17	64.00	85.00	125.67	1508.00	47.67	53.00	2.53	30.33	303.28
T_{12} G_4 × D_2	28.40	24.47	2.30	66.00	87.00	127.00	1524.00	48.67	54.33	2.65	31.74	317.40
T_{13} G_4 × D_3	27.07	23.63	1.99	67.00	83.67	124.33	1492.00	47.33	50.00	2.37	28.39	283.92
T_{14} G_5 × D_1	28.97	25.00	2.54	59.00	85.67	129.00	1548.00	52.67	60.33	3.18	38.13	381.32
T_{15} G_5 × D_2	29.13	25.23	2.56	61.33	87.67	131.00	1572.00	53.33	62.33	3.32	39.86	398.64
T_{16} G_5 × D_3	28.60	24.73	2.43	63.00	85.00	128.33	1506.00	50.33	58.33	2.94	35.22	352.20
T_{17} G_6 × D_1	30.00	25.75	2.65	57.33	87.67	130.00	1560.00	53.00	64.67	3.43	41.13	411.33
T_{18} G_6 × D_2	31.29	26.17	2.81	58.33	89.33	131.33	1576.00	54.33	65.67	3.57	42.86	428.60
T_{19} G_6 × D_3	29.43	25.52	2.63	60.67	87.00	129.33	1552.00	52.67	61.67	3.25	38.99	389.92

CONCLUSION

Application of GA_3 had a beneficial influence on almost all growth and flowering characteristics of Pansy. Among all the six doses of GA_3, application of GA_3 @ 300 ppm was significantly superior over other five concentrations w.r.t. various growth, flowering, seed yield and seed quality parameters this could be due to the induction of cell division and cell elongation on faster rate which ultimately gives more lateral branches, higher flowers per plant and hence greater seed yield. The foliar spray of GA_3 at 40 DAT has exhibited its eminence over other durations in terms of various growth, flowering, seed yield and seed quality parameters. Therefore it is concluded that GA_3 @ 300 ppm sprayed after 40 days of transplanting has proved to be the most effective treatment combination enhancing growth and yield parameters in pansy.

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