

Original Research Article

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Response of Tuberose (*Polianthes tuberosa* L.) cv. Pajwal to Flower Inducing Chemicals

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ABSTRACT

The present experiment was aimed to evaluate different flower inducing chemicals on flowering of tuberose (*Polianthes tuberosa* L.) cv. Prajwal at Horticultural Research Station, Kovvur, Andhra Pradesh during the years 2015-16 and 2016-17. Experiment conducted with 11 treatments which includes spraying of GA₃, BA, SA, spermidine, ethephon each at two concentrations at 30 and 60 days after sprouting along with control and laid out in randomized block design, replicated thrice. All the growth regulating chemicals significantly increased the number of leaves clump⁻¹, leaf area, LAI, blooming period of a spike with increasing concentrations except at high concentration of ethephon over control. Similar trend was followed for spike parameters also. However, days to 50% flowering and days to opening of first floret in a spike were significantly early in GA₃ sprayed plants. GA₃ excelled all other flower inducing chemicals for spike yield per hectare.

Keywords

Tuberose, Prajwal, Flower inducing chemicals, Flowering, Spike yield

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Introduction

Tuberose (*Polianthes tuberosa* L.) is native to Mexico and recently it has been placed under the family *Asparagaceae*. The area under this crop has been expanding at a faster rate, due to increased demand in both domestic and international market for its beautiful fragrant

spikes. The long flower spikes are excellent cut flowers for table decoration. Among the commercial flowers cultivated in India, tuberose is extensively cultivated in an area of 7.77 thousand ha with a production of 40.22 thousand tonnes in Assam, Maharashtra, Gujarat, Haryana, Karnataka, Andhra Pradesh, Tamilnadu, West Bengal, Uttar Pradesh,

Uttarakhand and Orissa. In Andhra Pradesh, the area under cultivation of tuberose accounts to 2,310 ha with a production of 13.88 thousand tonnes of flowers (NHB, 2015). Its commercial cultivation is more concentrated in East Godavari, Guntur, Chittoor, YSR Kadapa and Krishna districts of Andhra Pradesh.

The timing of the flower induction is of paramount importance in horticulture especially in floriculture. Exogenously applied growth regulating chemicals, act through the alteration in the levels of naturally occurring hormones, thus modifying the growth and development of the plant. These chemicals play an important role in overcoming the factors limiting the yield and quality of flowers by changing both morphology and physiology of plants. The response exhibited by plants to these chemicals varies with the species, cultivars, stage of the crop and concentration.

Hence, the present study is proposed to investigate the effect of different pre-harvest plant growth regulating chemicals on flower induction and development of tuberose spikes.

Materials and Methods

The experiment was carried out at Horticultural Research Station, Kovvur, West Godavari District, Andhra Pradesh, during 2015-2016 and 2016-2017 with the tuberose cv. Prajwal. Healthy and uniform bulbs with more than 2.0 cm diameter were used as planting material. Bulbs were planted at a spacing of 30 cm x 30 cm at 5 – 6 cm depth in plots of 2.4 x 2.4 m size. Well decomposed farmyard manure 25 t ha⁻¹ was incorporated into all experimental plots uniformly at the time of last ploughing. Nitrogen, phosphorus and potassium were applied @ 200:200:200 kg ha⁻¹ in the form of urea, single super phosphate and muriate of potash respectively.

Entire dose of phosphorus and potassium was applied as basal and nitrogen was applied in three split doses at 30, 60 and 90 days after planting. Irrigations were given at an interval of one to two weeks depending on the soil moisture.

There were eleven treatments, viz., Gibberellic Acid (GA₃) at 100 and 200 ppm, Salicylic Acid (SA) at 50 and 100 ppm, Benzyl Adenine (BA) at 50 and 100 ppm, Ethephon at 250 and 500 ppm, Spermidine at 50 and 100 ppm and water spray as control, replicated thrice in Randomized Block Design. As per the treatments, freshly prepared growth regulating chemicals mixed with commercial surfactant (0.05%) were used for foliar sprays at 30 and 60 days after sprouting. Spraying was carried out during early morning, until the spray solution was run off all plants by using a manual sprayer. Observations on vegetative growth, flowering and yield parameters were recorded and statistically analyzed as per the methods given by Panse and Sukhatme (1989).

Results and Discussion

Growth parameters

Number of leaves clump⁻¹

All the growth regulating chemicals significantly increased the number of leaves clump⁻¹ with increasing concentrations except ethephon over control (Table 1). Maximum number of leaves clump⁻¹ was observed at BA 100 ppm (99.66) followed by BA 50 ppm (97.91) whereas lowest number of leaves clump⁻¹ was recorded in control (87.42) which was on par with ethephon 500 ppm (89.85). Increased leaf number by spraying BA over gibberellins was observed by Kumar and Gautam (2011) in tuberose. Increased production of leaves in BA sprayed plants might be attributed to enhanced induction of

leaf initial break *i.e.*, differentiation of leaf primordial in the apical growing region as reported by Singh (2010) in tuberose.

Leaf area clump⁻¹ (dm²)

Maximum leaf area clump⁻¹ was recorded in plants treated with GA₃ 200 ppm (86.06 dm²) which was on par with GA₃ 100 ppm (84.55 dm²). The leaf area clump⁻¹ was lowest in control (75.49 dm²) and was on par with 500 ppm ethephon (77.56 dm²) (Table 1). GA₃ found to enhance the leaf area clump⁻¹ as earlier reported by Rani and Singh (2013), Kurve (2016) in tuberose. The increase in leaf area might be due to the fact that GA₃ enhances cell division and also involved in the leaf expansion (Yamaguchi, 2008) which led to elongated leaves (Sarkar *et al.*, 2009) in tuberose.

Though the number of leaves produced by BA was more than GA₃, the leaf area was more in GA₃. This might be due to the role of GA₃ in leaf expansion due to cell elongation and improved plasticity.

Leaf Area Index (LAI)

The maximum LAI was noticed in plants sprayed with GA₃ 200 ppm (9.563) followed by GA₃ 100 ppm (9.395). The minimum LAI was recorded in plants sprayed with water (8.388) which was on par with ethephon 500 ppm (8.620) (Table 1). The highest leaf area index with GA₃ might be due to enhanced leaf area induced by gibberellins through cell elongation, cell division or both (Singh *et al.*, 1991). The results are in conformity with the finding of Sarkar *et al.*, (2009) in tuberose.

Flowering parameters

Days to 50% flowering (d)

Earliest 50% flowering was observed in plants sprayed with GA₃ 200 ppm (97.77 d) which

was on par with GA₃ 100 ppm (99.51 d) and SA 100 ppm (101.32 d). The flowering was delayed in plants sprayed with ethephon 500 ppm (111.46 d) which was on par with control (108.21 d) (Table 2). Application of GA₃ at both the concentrations and SA at high concentration had significant stimulatory effect on days to 50% flowering compared to control. Comparatively SA treatments were less effective than GA₃. Similar results were reported by Saidulu *et al.*, (2016) in marigold.

GA₃ application enhanced vegetative growth parameters *viz.*, leaf area and LAI which in turn enhanced the photosynthetic activity and translocation of food materials to shoot apex for the development of floral primordia, advanced bud formation and onset of flowering. The results are in accordance with the findings of Sarkar *et al.*, (2009), Sultana *et al.*, (2016) in tuberose.

Further, Kumar and Gautam (2011) explained that GA₃ at high concentration reduce juvenile period and at the termination of juvenile phase apical meristem starts producing flowers instead of vegetative growth and hence early flowering in tuberose. It is evident at molecular level that GA is perceived by a soluble receptor protein, GID1. Downstream of GID1 was controlled by a family of nuclear growth repressor proteins, DELLAs. Accumulation of DELLAs in turn represses LFY and SOC1 genes, thus flowering was delayed. DELLAs subsequently regulate the development of flowers themselves, via transcriptional repression of the floral homeotic genes APETALA3, PISTILLATA, and AGAMOUS. Thus, GA promotes growth and flowering via destruction of DELLAs (Achard *et al.*, 2007).

Days to emergence of spike (d)

Among different growth regulating chemicals, the lowest number of days taken for spike emergence was registered with GA₃ 200 ppm

(128.66 d) and was on a par with GA₃ 100 ppm (130.98 d). However, the highest number of days taken for spike emergence was noticed with ethephon 500 ppm (146.88 d) followed by control (142.56 d) (Table 2). GA₃ was found best for early spike initiation as reported by several workers *viz.*, Gawai *et al.*, (2014), Ajmeera *et al.*, (2015) in tuberose.

Early spike emergence was observed at both the concentrations of GA₃ over the other treatments might be due to an induced alteration in source/sink relationships as suggested by Sachs (1977) who proposed the 'nutrient diversion' theory which proclaims that chemical induction of flowering might be the result of greater source or sink activity, leading to an increased carbohydrate status of the apex.

Days to opening of first floret (d)

Less number of days was taken for opening of first floret in a spike with GA₃ 200 ppm (17.26 d) sprayed plants. However, ethephon 500 ppm sprayed plants took more number of days for opening of first floret in a spike (19.27 d) which was on par with control (19.11 d). The results pertaining to SA, BA and spermidine were intermediary (Table 2).

Opening of first floret in a spike was earlier with GA₃ over other plant growth regulating chemicals. The results are in line with the findings of Kumar and Gautam (2011), Shanker and Sharma (2012) in tuberose. The opening of the first floret in a spike is dependent on the mobilization of sugars to the developing young florets. It could be evident from the present experiment that GA₃ application increased leaf area and LAI which might have favoured the synthesis of more carbohydrates and better partitioning of assimilates towards the developing young florets.

Days to opening last floret (d)

The number of days required for opening of last floret in a spike did not differ significantly with the application of different growth regulating chemicals.

Blooming period (d)

Significantly the longest blooming period (19.50 d) was observed in plants sprayed with GA₃ 200 ppm (Table 2). The present results are in line with those reported by Shanker and Sharma (2012), Rani and Singh (2013), Ajmeera *et al.*, (2015) in tuberose. The longest blooming period with GA₃ 200 ppm might be due to the early opening of the first floret, more number of florets spike⁻¹ and continued supply of photoassimilates to the developing florets.

Shortest blooming period was recorded with ethephon 500 ppm (17.45 d) spray and on par with control (17.61 d) (Table 2). The shortest blooming period was recorded with ethephon 500 ppm might be due to the delayed opening of the first floret and presence of less number of florets spike⁻¹. Singh *et al.*, (2010) also observed the reduced blooming period at higher concentration of ethephon (1000 ppm) in tuberose cv. Double. Less number of florets spike⁻¹ were promulgated as a reason for a constricted length of duration between opening of first and last floret in a spike.

Spike parameters and spike yield

Length of spike (cm)

The longest spike length was observed in plants sprayed with GA₃ 200 ppm (111.16 cm) which was on par with GA₃ 100 ppm (109.21 cm) while the spike length was shortest in plants sprayed with ethephon 500 ppm (97.96 cm) which was on par with control (100.44 cm) (Table 3).

Table.1 Effect of different growth regulating chemicals on growth parameters in tuberose cv. Prajwal

Treatments	Number of leaves clump ⁻¹	Leaf area (dm ²) clump ⁻¹	Leaf area Index (LAI)
T ₁ : GA ₃ 100 ppm	95.63	84.55	9.395
T ₂ : GA ₃ 200 ppm	96.16	86.06	9.563
T ₃ : SA 50 ppm	93.54	80.78	8.975
T ₄ : SA 100 ppm	94.41	81.53	9.059
T ₅ : BA 50 ppm	97.91	82.59	9.177
T ₆ : BA 100 ppm	99.66	83.04	9.227
T ₇ : Ethephon 250 ppm	90.91	78.51	8.724
T ₈ : Ethephon 500 ppm	89.85	77.56	8.620
T ₉ : Spermidine 50 ppm	91.79	79.27	8.808
T ₁₀ :Spermidine 100 ppm	92.66	80.02	8.891
T ₁₁ : Water spray (Control)	87.42	75.49	8.388
Mean	93.63	80.86	8.984
S.Em	0.85	0.73	0.082
C.D. at 5%	2.50	2.17	0.240

GA₃: Gibberellic acid; SA: Salicylic acid; BA: Benzyl Adenine

Table.2 Effect of different growth regulating chemicals on days to 50% flowering, days to spike emergence, floret opening and blooming period of a spike in tuberose cv. Prajwal

Treatments	Days to 50% flowering (d)	Days to emergence of spike (d)	Days to opening of first floret (d)	Days to opening of last floret (d)	Blooming period of a spike (d)
T ₁ : GA ₃ 100 ppm	99.51	130.98	17.57	36.73	19.16
T ₂ : GA ₃ 200 ppm	97.77	128.66	17.26	36.76	19.50
T ₃ : SA 50 ppm	101.88	134.13	17.99	36.70	18.71
T ₄ : SA 100 ppm	101.32	133.39	17.89	36.71	18.82
T ₅ : BA 50 ppm	104.17	137.17	18.39	36.70	18.30
T ₆ : BA 100 ppm	103.20	135.89	18.22	36.70	18.47
T ₇ : Ethephon 250 ppm	107.17	141.17	18.92	37.30	18.38
T ₈ : Ethephon 500 ppm	111.46	146.88	19.27	36.73	17.45
T ₉ : Spermidine 50 ppm	106.15	139.81	18.74	36.71	17.96
T ₁₀ :Spermidine 100 ppm	105.15	138.48	18.57	36.70	18.13
T ₁₁ : Water spray (Control)	108.21	142.56	19.11	36.71	17.61
Mean	103.78	136.66	18.36	36.77	18.41
S.Em	1.35	1.56	0.06	-	0.06
C.D. at 5%	3.97	4.61	0.18	NS	0.18

GA₃: Gibberellic acid; SA: Salicylic acid; BA: Benzyl Adenine

Table.3 Effect of different plant growth regulating chemicals on spike characters in tuberose cv. Prajwal

Treatments	Length of spike (cm)	Length of rachis (cm)	Girth of spike (cm)	No. of florets spike ⁻¹	Floret weight spike ⁻¹ (g)
T ₁ : GA ₃ 100 ppm	109.21	39.25	4.34	51.82	95.45
T ₂ : GA ₃ 200 ppm	111.16	39.95	4.42	52.75	97.15
T ₃ : SA 50 ppm	106.68	38.34	4.24	50.62	93.23
T ₄ : SA 100 ppm	107.26	38.55	4.26	50.90	93.74
T ₅ : BA 50 ppm	104.34	37.50	4.15	49.51	91.19
T ₆ : BA 100 ppm	105.31	37.85	4.18	49.97	92.04
T ₇ : Ethephon 250 ppm	101.41	36.45	4.03	48.12	88.63
T ₈ : Ethephon 500 ppm	97.96	35.20	3.91	47.66	86.04
T ₉ : Spermidine 50 ppm	102.39	36.80	4.07	48.59	89.48
T ₁₀ :Spermidine 100 ppm	103.36	37.15	4.11	49.05	90.33
T ₁₁ : Water spray (Control)	100.44	36.10	3.87	46.27	85.22
Mean	104.50	37.56	4.14	49.57	91.14
S.Em	0.87	0.32	0.01	0.17	0.31
C.D. at 5%	2.58	0.93	0.04	0.49	0.91

GA₃: Gibberellic acid; SA: Salicylic acid; BA: Benzyl Adenine

Table.4 Effect of different plant growth regulating chemicals on spike yield in tuberose cv. Prajwal

Treatments	Number of spikes clump ⁻¹	Number of spikes ha ⁻¹ (lakhs)
T ₁ : GA ₃ 100 ppm	2.056	1.830
T ₂ : GA ₃ 200 ppm	2.092	1.862
T ₃ : SA 50 ppm	2.008	1.787
T ₄ : SA 100 ppm	2.019	1.797
T ₅ : BA 50 ppm	1.964	1.748
T ₆ : BA 100 ppm	1.982	1.764
T ₇ : Ethephon 250 ppm	1.909	1.699
T ₈ : Ethephon 500 ppm	1.876	1.667
T ₉ : Spermidine 50 ppm	1.927	1.715
T ₁₀ :Spermidine 100 ppm	1.946	1.732
T ₁₁ : Water spray (Control)	1.891	1.683
Mean	1.970	1.753
S.Em	0.007	0.006
C.D. at 5%	0.020	0.017

GA₃: Gibberellic acid; SA: Salicylic acid; BA: Benzyl Adenine

Except at high concentration of ethephon, all the growth regulating chemicals increased the spike length over control. Significantly the longest spike length was noticed at both the concentrations of GA₃. The results are in line with the findings of Rani and Singh (2013), Sultana *et al.*, (2016), Amin *et al.*, (2017) in tuberose.

Increased spike length with GA₃ might be due to rapid internodal elongation that could be ascribed to the enhanced cell division, increased carbohydrate hydrolysis and increased cell-wall plasticity (Sachs, 1961). Acid invertase activity was increased in response to GA₃ application and helps in hydrolysis of sucrose into hexose sugars. The hexose sugars thus formed were easily transported to the sink, thereby increasing sink strength and resulted in rapid elongation of flowering stalk (Iqbal *et al.*, 2011).

Spike length was reduced with higher concentration of ethephon as compared to control. It was also demonstrated by Mukhopadhyay and Bankar, 1983 in tuberose. Ethephon application reduces the rate of DNA synthesis not only in the apical meristem, but also in elongating zone of the stem where no cell divisions occur. However, RNA synthesis is not affected in these tissues (Burg, 1973).

Length of rachis (cm)

Foliar spray with GA₃ 200 ppm recorded significantly longest rachis length (39.95 cm) followed by GA₃ 100 ppm (39.25 cm) (Table 3). The results are in close conformity with the findings of Rani and Singh (2013), Amin *et al.*, (2017) in tuberose.

Application of GA₃ increased the rachis length which might be due to rapid internodal elongation which in turn could be a consequence of increased cell production and elongation in the intercalary meristem (Sauter and Kende, 1992).

Moreover, shortest rachis length was observed with ethephon 500 ppm (35.20 cm) which was on par with control (36.10 cm) (Table 3). Similar results were also observed by Singh *et al.*, (2010) in tuberose.

Reduction in rachis length was noticed in ethephon treated plants due to inhibitory action of ethephon on cell elongation there by it reduced the internodal length.

Girth of spike (cm)

Among different growth regulating chemicals studied, maximum spike girth was recorded with GA₃ treated plants. Significantly highest spike girth was registered in plants sprayed with GA₃ 200 ppm (4.42 cm) (Table 3). Similar results were reported Amin *et al.*, (2017) in tuberose.

The lowest spike girth was observed in control (3.87 cm) which was on par with ethephon 500 ppm (3.91 cm) (Table 3).

Maximum number of florets spike⁻¹ was observed in plants sprayed with GA₃ 200 ppm (52.75) compared to control (46.27) (Table 3).

Number of florets spike⁻¹

GA₃ excelled all other flower inducing chemicals regarding number of florets spike⁻¹. The results are in close conformity with the findings of Shanker *et al.*, (2011), Rani and Singh (2013), Amin *et al.*, (2017) in tuberose. GA₃ increased the substrate availability at the time of flower initiation (Corr and Widmer, 1987) which resulted in increased number of florets spike⁻¹.

Floret weight spike⁻¹ (g)

All growth regulating chemicals improved the floret weight spike⁻¹ over the control. Among different growth regulating chemicals applied, GA₃ 200 ppm registered highest floret weight

spike⁻¹ (97.15 g) and lowest floret weight spike⁻¹ was observed in control (85.22 g) which was on par with ethephon at 500 ppm (86.04 g) (Table 3). Increase in floret weight spike⁻¹ with GA₃ was attributed to the production of more number of bigger size florets as gibberellins are important for differentiation and growth of more number of flower primordia (Alpi *et al.*, 1976). These results are in line with the findings of Sajjad *et al.*, (2015) in gladiolus.

Number of spikes clump⁻¹

Application of GA₃ 200 ppm produced significantly more number of spikes clump⁻¹ (2.092) whereas less number of spikes clump⁻¹ was produced in ethephon 500 ppm (1.876) treatment which was on par with control (1.891) (Table 4).

Plants treated with GA₃ at higher concentration produced more number of spikes than at low concentrations. Brooking and Cohen (2002) reported that high gibberellin doses induce more rapid floral initiation than lower doses. Further, Chang (1999) suggested that hydroxylated C-19 GAs play an important role in flower induction which was supported by the observations that there was an increase in endogenous GA₂₀ level coincided with the transition from the vegetative phase to early floral initiation and flower differentiation stages in tuberose. Similar results were recorded by Rani and Singh (2013), Amin *et al.*, (2017) in tuberose.

Number of spikes ha⁻¹ (lakhs)

Maximum number of spikes ha⁻¹ was obtained from the plants sprayed with GA₃ 200 ppm (1.862 lakhs) while the minimum number of spikes ha⁻¹ was recorded in ethephon 500 ppm (1.667 lakhs) which was on par with control (1.683 lakhs) (Table 4).

Increased production of spikes with GA₃ might be due to promotion of cell division and regulation of differentiation of cells at the time of transformation of vegetative to floral primordial. Similar result was reported by Ajmeera *et al.*, (2015) in tuberose.

Ethephon at higher concentration (500 ppm) produced significantly minimum number of spikes ha⁻¹ compared to rest of the treatments and on par with control. Similarly, Singh (2010) noticed minimum mean spike yield m⁻² at higher concentration of ethrel (300 ppm) in tuberose.

Conclusion of the study is as follows:

From the present investigation it is revealed that foliar application of GA₃ at both the concentrations significantly increased spike quality and yield of tuberose cv. Prajwal.

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