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Studies on effect of plant growth regulators and micronutrients on growth, floral characters and yield of tuberose (*Polianthes tuberosa* L.) cv. 'PRAJWAL'

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ABSTRACT : Field experiment was conducted during May 2009 to April 2010 in tuberose cv. Prajwal to study the growth and yield as influenced by plant growth regulators and micronutrients in Factorial Randomized Block Design. The treatment comprised of dipping the bulbs in two growth regulators namely, GA_3 @ 200 ppm for 12 h, CCC @ 5000 ppm for 1 h were given at planting and foliar spray of micronutrients namely, H_3BO_3 0.1 %, $ZnSO_4$ 0.5 % and $FeSO_4$ 0.2 % were applied either alone or in combinations on 60, 120, 180 and 240 days after sprouting. Observations were recorded on sprouting, growth, flowering and yield parameters. The results revealed that dipping of bulbs in GA_3 @ 200 ppm for 12 hours recorded 100 per cent sprouting and early sprouting by 5 days over control (12.75 days). Dipping the bulbs in GA_3 @ 200 ppm and foliar spray of all the micronutrients (B, Zn and Fe) recorded highest plant height (49.56 cm) at first spike emergence, total leaf area per clump (2317.20 cm2), spike length (100.59 cm), number of flowers per spike (45.74), improved flower length (7.24 cm), enhanced flower yield per hectare (16.24 t) and highest estimated net income of Rs. 6,44,444 per hectare. The dipping treatments with CCC@ 5000 ppm for 1 h significantly increased the number of leaves at first spike emergence (25.29), diameter of unopened flower bud (3.78 cm) and extended duration of flowering (21.38 days). The increase in yield is resulted by the assimilatory power of growth regulators and contributory role of all the micronutrients involved. Economic analysis also revealed that micronutrient sprays at 60, 120, 180 and 240 days after sprouting could be beneficial when dipping of bulbs in GA_3 @ 200 ppm for 12 h and this will be quite profitable to the farmers cultivating in the marginal soils.

KEY WORDS : Tuberose, Gibberellic acid, Cycocel, Boric acid, Zinc sulphate, Ferrous sulphate

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Tuberose (*Polianthes tuberosa* Linn), an important commercial flower crop of Tamil Nadu. The whole fragrant flowers are popularly used for making garlands and also for essential concrete extraction. It is often grown in medium rich soil in different parts of Tamil Nadu where both soil and irrigation water quality is not very ideal. Growing of tuberose in soils with higher pH range (>7.5 to 8.0) makes many micronutrients unavailable to the crop and there is a possibility of the micronutrient deficiencies, inhibiting the growth and development. Certain-growth regulators like gibberellic acid (GA_3), cycocel (CCC) and micronutrients such as boron, zinc and iron have been successfully used to modify the assimilate partitioning pattern in tuberose resulting in higher growth, flowering and yield. Singh *et al.* (2008) found that bulb dipping in 200 ppm GA_3 for 12 hours resulted in improved earliness in days to spike emergence, spike length, number of florets per spike, number of spikes per clump and spike weight in cv. Single. Therefore, the present studies were carried out to find the influence of micronutrients either alone or in combination with growth regulators for improving growth, flowering and yield of tuberose.

RESEARCH METHODS

The experiment was carried out at the Botanical Garden, Department of Floriculture and Landscaping, Horticultural

College and Research Institute, Tamil Nadu Agricultural University, Coimbatore during the period May 2009 to April 2010. The climate of this area is tropical. The mean maximum temperatures varied from 29^0 C to 35.6^0 C and mean minimum temperatures varied from 20.2^0 C to 23.7^0 C. Medium sized bulbs (3-3.5 cm) weighing about 25 grams obtained from the field of cv. Prajwal was used for the study. The experiment was laid out in Factorial Randomized Block Design with three replications. Three bulb dipping treatments *viz.*, dipping in water for 12 hours (G_1), dipping in GA_3 200 ppm for 12 hours (G_2) and dipping in CCC 5000 ppm for 1 hour (G_3) at the time of sowing of bulbs formed the first factor. The second factor comprised of eight different micronutrient sprays *viz.*, M_1- Control, M_2- H_3BO_3 0.1 %, M_3- $ZnSO_4$ 0.5 %, M_4- $FeSO_4$ 0.2 %, M_5- H_3BO_3 0.1 % + $ZnSO_4$ 0.5 %, M_6- H_3BO_3 0.1 % + $FeSO_4$ 0.2 %, M_7- ZnSO4 0.5 % + $FeSO_4$ 0.2 % and M_8- H_3BO_3 0.1 % + $ZnSO_4$ 0.5 % + $FeSO_4$ 0.2 %. The dipping treatments were given at the time of sowing and micronutrient sprays at 60, 120, 180 and 240 days after sprouting. Planting of treated bulbs was done in the plots in the month of June at the depth of 6-8 cm. The plot size of each treatment combination was 2.4 x 1.2 m^2 and 25 treated bulbs were planted in each plot with a spacing of 45 x 20 cm. Total leaf area of the clump was measured directly with leaf area meter (Model, Li- 3100).

Observations on growth parameters, earliness in flowering and yield parameters were recorded time to time and data were statistically analysed and presented in the Tables 1, 2, 3 and shown in graphs Fig. A, B and C.

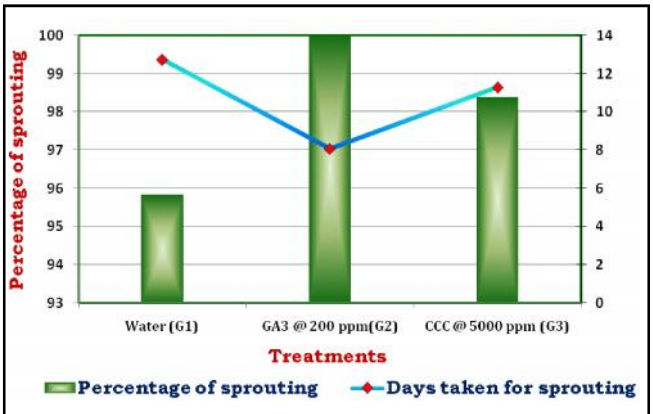

Fig. A : Influence of growth regulators on days taken for sprouting and percentage of sprouting

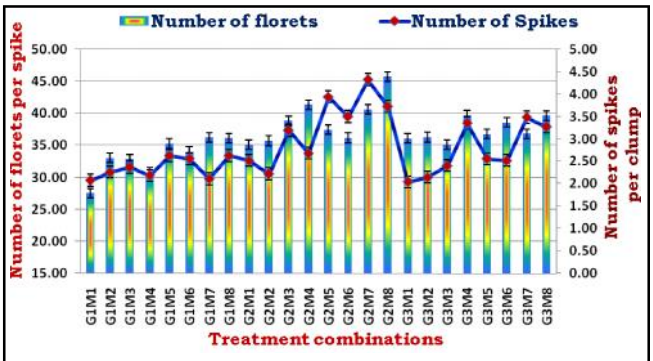

Fig. B : Influence of growth regulators and micronutrients on number of spikes per clump and florets per spike

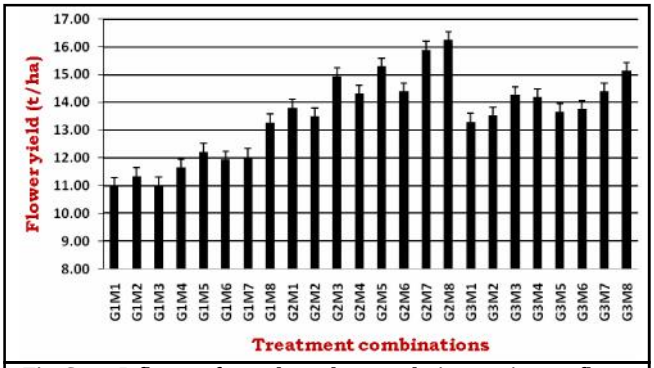

Fig. C : Influence of growth regulators and micronutrients on flower yield (t/ha)

RESEARCH FINDINGS AND DISCUSSION

The results obtained from the present investigation are summarized below :

Growth parameters:

Soaking of bulbs in GA_3 200 ppm for 12 hours registered the earliest mean number of 8.07 days and resulted in 100 per cent sprouting whereas water dipping (G_1) recorded the most mean number of 12.73 days for sprouting (Fig. A). CCC at 5000 ppm (G_3) took 11.28 days for sprouting. Gibberellin is known to overcome endogenous dormancy factors and promote sprouting as it has influence on promoting cell elongation. CCC is a growth retardant and has also promoted percentage of sprouting but without any noticeable earliness in sprouting. In studies with gladiolus, Kumar and Singh (2005) and Arora *et al.* (1994) also reported earlier sprouting of corms in gladiolus using GA_3.

The bulbs treated with GA_3 200 ppm and combination of three micronutrients (G_2M_8) recorded highest plant height of 49.56 cm at first spike emergence at par with G_2M_2 and G_2M_5 (Table 1). This might be due to active role of cell division and cell enlargement due to GA_3 and as well as the contributory role of different micronutrients in meristematic growth, nitrogen assimilation, hormonal biosynthesis, protein synthesis and photosynthetic processes. Similar results were also obtained in gladiolus and African marigold (Misra *et al.*, 1993; Rajput *et al.*, 2003). Inhibited plant height due to CCC @ 5000 ppm was pronounced even when it is combined with 0.5 % $ZnSO_4$. CCC is known to interfere with nutrient metabolic activity inside the plant system and reduce cell division and cell elongation. The findings in the present study are in agreement with similar retardation

effects reported in tuberose (Susamma *et al.,* 1991).

The persual of data presented in the Table 1 shows that CCC 5000 ppm with 0.1 % H_3BO_3 and 0.2 % $FeSO_4$ (G_3M_6) recorded highest number of 25.29 leaves at par with G_3M_8 at first spike emergence. This might be due to CCC could have suppressed the shoot elongation and promoted lateral formation of leaves. Due to their involvement in protein synthesis, hormonal translocations and nitrogen assimilation, zinc and boron might have complemented higher leaf production. Similar results of increased leaf numbers due to boron have been reported in tuberose by Nath and Biswas (2002).

GA_3 200 ppm with 0.5 % $ZnSO_4$ and 0.2 % FeSO4 (G_2M_7) registered the highest total leaf area of 3282.20 cm2 at 180 DAP (Table 1). The increase in total leaf area may be due to synergistic interaction of these micronutrients when early growth promoted by applying GA_3.

Earliness in flowering:

GA_3 200 ppm with H_3BO_3 @ 0.1 % and $ZnSO_4$ @ 0.5 %

Table 1 : Influence of growth regulators and micronutrients on plant height at first spike emergence(cm), number of leaves at first spike emergence and total leaf area at 180 DAP (cm^2) of tuberose cv. Prajwal

Treatments	Plant height at first spike emergence (cm)				Number of leaves at first spike emergence				Total leaf area at 180 DAP (cm^2)			
	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean
M_1	24.61	31.09	28.49	28.06	15.37	17.00	17.78	16.72	1227.20	1394.20	1601.36	1407.58
M_2	30.17	40.31	26.58	32.35	16.06	19.67	20.33	18.69	1765.75	2546.97	1869.50	2060.74
M_3	28.08	30.63	22.14	26.95	19.48	18.33	17.89	18.57	1566.14	2132.39	1598.31	1765.61
M_4	32.65	32.14	24.02	29.61	20.44	19.70	20.74	20.30	1410.88	2012.56	2678.38	2033.94
M_5	33.09	39.53	25.22	32.61	19.52	19.22	19.52	19.42	1715.84	1690.46	2823.88	2076.73
M_6	29.63	45.67	28.49	34.60	20.52	22.44	25.29	22.75	1480.76	3089.74	2323.00	2297.83
M_7	30.34	30.21	28.40	29.65	18.22	18.56	18.63	18.47	1926.34	3282.20	2164.43	2457.65
M_8	33.91	49.56	36.65	40.04	18.26	19.08	23.26	20.20	1721.86	2389.07	1394.58	1835.17
Mean	30.31	37.39	27.50	31.73	18.48	19.25	20.43	19.39	1601.84	2317.20	2056.68	1991.91
	G	M	G x M		G	M	G x M		G	M	G x M	
S.E.±	1.628	2.658	4.605		0.463	0.755	1.308		47.368	77.352	133.978	
C.D. (P=0.05)	3.277	5.352	9.270		0.931	1.521	2.634		95.350	155.705	269.690	

G_1 - Dipping of bulbs in water for 12 hours
G_2 – Dipping of bulbs in GA_3 @ 200 ppm for 12 hours
G_3 – Dipping of bulbs in CCC @ 5000 ppm for 1 hour

M_1 – No spray
M_2 – Foliar spray of H_3BO_3 @ 0.1 %
M_3 - Foliar spray of $ZnSO_4$ @ 0.5 %
M_4 – Foliar spray of $FeSO_4$ @ 0.2 %
M_5 – Foliar spray of H_3BO_3 @ 0.1 % + $ZnSO_4$ @ 0.5 %
M_6 – Foliar spray of H_3BO_3 @ 0.1 % + $FeSO_4$ @ 0.2 %
M_7 - Foliar spray of $ZnSO_4$ @ 0.5 %+ $FeSO_4$ @ 0.2 %
M_8 – Foliar spray of H_3BO_3 @ 0.1 % + $ZnSO_4$ @ 0.5 % + $FeSO_4$ @ 0.2 @ 0.2 %

Table 2 : Influence of growth regulators and micronutrients on days taken for first flowering, duration of flowering (days) and spike length (cm) of tuberose cv. Prajwal

Treatments	Days taken for first flowering				Duration of flowering (days)				Spike length (cm)			
	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean
M_1	120.22	99.65	105.89	108.59	11.81	12.67	14.33	12.94	65.76	73.72	71.37	70.29
M_2	110.63	95.49	112.77	106.30	11.67	12.15	14.30	12.70	67.04	74.08	70.66	70.59
M_3	112.39	98.26	109.62	106.76	10.70	13.04	12.74	12.16	67.54	77.31	66.60	70.48
M_4	112.66	95.82	111.44	106.64	11.96	13.98	18.01	14.65	72.13	78.36	69.32	73.27
M_5	102.38	81.65	107.40	97.14	12.37	12.48	14.18	13.01	69.73	84.02	71.29	75.01
M_6	105.15	90.29	95.67	97.04	12.00	13.00	16.75	13.92	71.55	80.12	70.21	73.96
M_7	110.00	95.92	103.52	103.15	12.56	13.11	17.08	14.25	70.77	93.86	73.60	79.41
M_8	108.70	87.51	105.23	100.48	12.70	14.18	21.38	16.09	71.16	100.59	76.09	82.61
Mean	110.27	93.07	106.44	103.26	11.97	13.08	16.10	13.71	69.46	82.76	71.14	74.45
	G	M	G x M		G	M	G x M		G	M	G x M	
S.E.±	0.445	0.726	1.259		0.276	0.450	0.780		0.684	1.118	1.936	
C.D. (P=0.05)	0.896	1.463	2.534		0.555	0.907	1.570		1.378	2.250	3.897	

G_1 - Dipping of bulbs in water for 12 hours
G_2 – Dipping of bulbs in GA_3 @ 200 ppm for 12 hours
G_3 – Dipping of bulbs in CCC @ 5000 ppm for 1 hour

M_1 – No spray
M_2 – Foliar spray of H_3BO_3 @ 0.1 %
M_3 - Foliar spray of $ZnSO_4$ @ 0.5 %
M_4 – Foliar spray of $FeSO_4$ @ 0.2 %
M_5 – Foliar spray of H_3BO_3 @ 0.1 % + $ZnSO_4$ @ 0.5 %
M_6 – Foliar spray of H_3BO_3 @ 0.1 % + $FeSO_4$ @ 0.2 %
M_7 - Foliar spray of $ZnSO_4$ @ 0.5 %+ $FeSO_4$ @ 0.2 %
M_8 – Foliar spray of H_3BO_3 @ 0.1 % + $ZnSO_4$ @ 0.5 %+ $FeSO_4$ @ 0.2 @ 0.2 %

(G_2M_5) recorded the earliest by registering 81.65 days for first flowering and the treatment combinations G_2M_6, G_2M_7 and G_2M_8 at par with G_2M_5 than the control (Table. 2). Earliness in flowering was also reflected due to GA_3 bulb dipping treatments. Similar findings in earlier flowering due to GA_3 were reported in rose (Bhattacharjee, 1996). The extended duration of flowering was recorded in cycocel treated plants *viz.*, G_3M_8 (21.38 days) and followed by G_3M_4 (18.01 days) and the treatment combinations G_3M_6 and G_3M_7 at par with G_3M_4 (Table 2). This is most likely due to suppression of apical dominance by acting against auxin or gibberellin levels by CCC and enhancement of flower retention due to micronutrients like boron and zinc.

Yield parameters:

The highest number of spikes per clump (4.32) was obtained when bulbs treated with GA_3 200 ppm with spraying $ZnSO_4$ @ 0.5 % and $FeSO_4$ 0.2 % (G_2M_7) and the treatment combinations G_2M_5 (3.94) and G_2M_8 (3.72) at par with G_2M_7 (Table 3). This might be due to the action of GA, stimulating the conversion of storage polymers (polysaccharides, proteins and fats) into sucrose or mobile amino acids to facilitate their translocation via phloem into and throughout the young root and shoot system and thus influencing spike production. Similar effects have also been reported in Day lily (Das *et al.*, 1992). CCC @ 5000 ppm (G_3M_1) recorded lowest number of spikes per clump may be due to the anti-gibberellin activity of CCC.

G_2M_8 registered the longest spike length (100.59 cm) and it was followed by G_2M_7 (93.86 cm) whereas control registered shortest spike length of 65.76 cm (Table 2). The higher spike length in tuberose is might be due to GA which promotes cell division, cell enlargement, vegetative growth and increase the photosynthetic and metabolic activities resulting in transport and utilization of photosynthetic products (Maurya and Nagda, 2002). Application of zinc must have also enhanced the vegetative growth and this may be ascribed due to its influence on auxin synthesis. In gladiolus also similar findings were reported (Uma Devi *et al*., 2007 and Naveen Kumar *et al.*, 2008). The combination of CCC @ 5000 ppm with $ZnSO_4$ @ 0.5 % (G_3M_3) however, drastically reduced the spike length (66.60 cm). This might be due to the inhibitory action of CCC on cell division and cell enlargement as described earlier.

The graph showing persual of data in the Fig. B reveals that highest number of flowers per spike (45.74) was obtained with GA_3 200 ppm and combination of three micronutrients (G_2M_8) and it was followed by G_2M_4 (41.33). This might be probably due to the effect of GA_3 enhancing available substrate at the time of floral initiation promoting flower production in combination with zinc and iron. These results are also in close conformity with the findings of Kumar *et al.* (2001) in gladiolus.

The bulbs treated with GA_3 200 ppm and combination of three micronutrients (G_2M_8) recorded highest flower length (7.24 cm) compared to control (Table 3). The increased growth achieved by GA_3 may be attributed to stimulations of both cell division and cell enlargement and also may be due to the role of iron and boron in the enzymatic reaction of metabolism leading to the biosynthesis of photo assimilates. Similar results have been reported by Dutta *et al.* (1993) in chrysanthemum.

Table 3 : Influence of growth regulators and micronutrients on number of flowers per spike, flower length (cm) and diameter of unopened flower bud (cm) in tuberose cv. Prajwal

Treatments	Number of flowers per spike				Flower length (cm)				Diameter of unopened flower bud (cm)			
	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean
M_1	27.51	35.04	36.07	32.87	5.37	6.09	6.09	5.85	2.37	3.29	3.24	5.85
M_2	33.01	35.70	36.26	34.99	5.91	6.10	6.05	6.02	3.40	3.38	3.28	6.02
M_3	32.84	38.85	35.07	35.59	5.97	5.94	6.18	6.03	3.30	3.37	3.38	6.03
M_4	30.74	41.33	39.67	37.25	5.90	6.32	6.22	6.15	3.44	3.22	3.44	6.15
M_5	35.26	37.42	36.78	36.49	5.52	6.25	6.10	5.96	3.15	3.35	3.49	5.96
M_6	34.00	36.15	38.56	36.24	6.05	6.65	6.09	6.26	3.38	3.30	3.45	6.26
M_7	36.25	40.61	36.81	37.89	6.19	6.23	6.15	6.19	3.30	3.39	3.78	6.19
M_8	36.11	45.74	39.63	40.49	6.23	7.24	5.95	6.47	3.31	3.40	3.55	6.47
Mean	33.22	38.86	37.36	36.48	5.89	6.35	6.11	6.12	3.21	3.34	3.45	6.12
	G	M	G x M		G	M	G x M		G	M	G x M	
S.E. ±	0.694	1.134	1.964		0.075	0.123	0.213		0.043	0.071	0.123	
CD (P=0.05)	1.398	2.282	3.953		0.151	0.247	0.428		0.087	0.143	0.247	

G_1 - Dipping of bulbs in water for 12 hours
G_2 – Dipping of bulbs in GA_3 @ 200 ppm for 12 hours
G_3 – Dipping of bulbs in CCC @ 5000 ppm for 1 hour

M_1 – No spray
M_2 – Foliar spray of H_3BO_3 @ 0.1 %
M_3 - Foliar spray of $ZnSO_4$ @ 0.5 %
M_4 – Foliar spray of $FeSO_4$ @ 0.2 %
M_5 – Foliar spray of H_3BO_3 @ 0.1 % + $ZnSO_4$ @ 0.5 %
M_6 – Foliar spray of H_3BO_3 @ 0.1 % + $FeSO_4$ @ 0.2 %
M_7 - Foliar spray of $ZnSO_4$ @ 0.5 %+ $FeSO_4$ @ 0.2 %
M_8 – Foliar spray of H_3BO_3 @ 0.1 % + $ZnSO_4$ @ 0.5 % + $FeSO_4$ @ 0.2 @ 0.2 %

Table 3 revealed that cycocel treated plants (G_3M_7) registered the highest diameter of unopened flower bud (3.78 cm) and the treatment combination G_3M_8 at par with G_3M_7. The increase in flower diameter due to CCC could be because of better allocation of resources to limited sink *i.e.* limited number of flowers when compared to GA_3 which induced flower diameter. The result in the present study is in agreement with earlier report in Dahlia (Bhattacharjee *et al*., 1974).

GA_3 200 ppm with all the three micronutrient combinations registered the highest flower yield of 4.68 kg per plot which was 48.01 per cent higher than G_1M_1 (control). The next best yield of 4.58 kg was recorded by G_2M_7 (Fig. C). This might be due to increase in plant height, number of leaves, number of flowers per spike and more number of spikes per clump which was found to be better in G_2M_8 when compared to all other treatments. Complimentary influence of these yield attributes could be best described as the favourable influence of GA_3 in promoting early growth and earliness in flowering coupled with enhanced metabolic process due to micronutrients involved in these treatments. The supportive role of micronutrients in enhancing the yield could very well be attributed to their influence on early plant growth and development enhanced physiological functions and synergistic effects with the growth regulators used.

Hence, it is concluded that among the growth regulators, dipping of tuberose bulbs in GA_3 200 ppm for 12 h was found to be effective in reducing dormancy and cause earlier and 100 per cent sprouting. The combination of three micronutrients (B, Zn and Fe) along with GA_3 200 ppm was effective in increasing plant height, number of flower per spike, total leaf area, number of spikes per clump, spike length and yield per plot.

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