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Effect of plant bioregulators on quality, productivity and profitability of tuberose cv. Prajwal

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Abstract
In order to explore the possibility of improving the quality, productivity and profitability of tuberose (*Polianthes tuberosa* L.) cv. Prajwal using different plant bioregulators, an experiment was conducted during 2015-16 and 2016-17 at Horticultural Research Station, Kovvur of Dr. YSR Horticultural University, Andhra Pradesh. Five plant bioregulators (Gibberellic acid, Benzyl Adenine, Salicylic acid, Ethephon and Spermidine) each at two concentrations in addition to water spray as control were evaluated in randomised block design with three replications. The results revealed that the foliar sprays of plant bioregulators at 30 and 60 days after sprouting of bulbs, significantly influenced floret quality, floret yield and bulb yield. Significantly maximum length (6.12 cm), diameter of floret (4.34 cm), 100-floret weight (210.85 g), floret yield (12.02 t ha^{-1}) and bulb yield (11.57 t ha^{-1}) was recorded in the plants sprayed with GA_3 at 200 ppm over control. The same treatment recorded the highest benefit – cost of 3.02.

Keywords: Tuberose, bioregulators, floret yield, bulb yield, economics

Introduction
Tuberose is (*Polianthes tuberosa* L.) a member of *Asparagaceae* family. In India, it is one of the important fragrant flowers commercially cultivated in an area of 7.77 thousand ha with a production of 40.22 thousand tonnes (NHB, 2015) [14]. Tuberose is widely used in making flower garlands which are offered to the god or used as wedding ornaments and also used in perfumery industries. Owing to the availability of improved cultivars, the area under this crop is expanding at a fast pace. It has a good potential for export to many countries like Malaysia, Singapore, Sri Lanka and Gulf.

In horticultural crops, the use of plant bioregulators (PBRs) is one of the scientific approaches to explore the possibilities to enhance the productivity and profitability. Low concentration of plant bioregulators are applied externally at a suitable developmental stage to boost the plant signaling which finally leads to enhanced growth and crop yield (Srivastava *et al.*, 2016) [25]. It is apparent that crop responses to PGRs vary and that the response is dependent on the concentration of PGR used. A low concentration increases the photosynthetic potential of leaves and translocation of photosynthates to sink, while high concentration adversely affects these traits. Sink potential is determined after growth and flowering and phytohormones have a prominent role in modifying it. Phytohormones have been implicated in various aspects of the control of photosynthesis and distribution of photosynthates to sink. They have been found engaged in increasing photosynthetic and yield potential of several crops, and increasing source-sink interactions (Khan *et al.*, 2007) [9]. Taking these facts under consideration an experiment entitled "Effect of plant bioregulators on quality, productivity and profitability of tuberose cv. Prajwal" was conducted.

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. The soil was black alluvial, having pH 7.6, low in organic carbon (0.48%) and available nitrogen

(188.6 kg ha^{-1}) and medium in available phosphorus (20.5 kg ha^{-1}) and high in available potassium (543.9 kg ha^{-1}). Healthy tuberose 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 in the experimental plots of 2.4 x 2.4 m size. At the time of final ploughing, well decomposed farmyard manure @25 t ha^{-1} was incorporated into the experimental plots. 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 dose 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. All other intercultural practices and plant protection measures were followed as per the recommended schedule. Eleven treatments comprising of five bioregulators at two different concentrations were tested in randomized block design with three replications. The treatments were T_1: GA_3 100 ppm, T_2: GA_3 200 ppm, T_3: SA 50 ppm, T_4: SA 100 ppm, T_5: BA 50 ppm, T_6: BA 100 ppm, T_7: Ethephon 250 ppm, T_8: Ethephon 500 ppm, T_9: Spermidine 50 ppm, T_{10}: Spermidine 100 ppm and T_{11}: Water spray (Control). As per the treatments respective bioregulators were sprayed two times at 30 and 60 days after sprouting (DAS) of bulbs on the foliage. Observations on floret quality, floret and bulb yield were recorded and pooled the data. The data was statistically analyzed as per the methods given by Panse and Sukhatme (1989) [16]. Economics was worked out on the basis of prevailing market prices of inputs and outputs.

Results and Discussion

Floret quality

Quality of florets in terms of floret length, floret diameter, 100-floret weight registered marked variation with application of plant bioregulators (Table 1). Maximum floret length was noticed with GA_3 treatment over all other plant bioregulators under study. The highest floret length was observed in GA_3 200 ppm (6.12 cm) sprayed plants whereas the lowest value was recorded in control (5.37 cm) which was on par with ethephon 500 ppm (5.42 cm). The elongating effect of gibberellin in many plant organs was reported by Audus (1972) [3] which might have caused increased floret length in tuberose. The present results are in agreement with the observations made by Rani and Singh (2013) [18], Kurve (2016) [12] in tuberose.

Significant differences were noticed among different bioregulating chemicals for floret diameter. Among different bioregulating chemicals sprayed, maximum floret diameter was observed in GA_3 200 ppm (4.34 cm) whereas minimum floret diameter was recorded in control (3.81 cm) which was on par with ethephon 500 ppm (3.84 cm). Application of GA_3 200 ppm significantly increased the floret diameter. In addition to its role in early floral initiation, gibberellins also play a role in floral development (Brooking and Cohen, 2002) [4]. The above results are in accordance with the findings of Kurve (2016) [12] in tuberose. GA_3 followed by SA also enhanced the floret diameter. The present results are in accordance with the earlier findings of Anwar *et al.* (2014) [2], Khodakhah *et al.* (2014) [10] in tuberose. SA might have altered the biophysical properties of cell wall and increased the floret size. However, Ethephon 500 ppm treated plants slightly reduced the florets size both in terms of length and diameter than ethephon 250 ppm treated plants. Similarly, Singh and Bijimol (2001) [20] observed decrease in floret diameter with increase in ethrel concentration in tuberose cv. Double.

Plant bioregulators differed significantly with respect to 100-floret weight. Among the plant bioregulators, 100-floret weight was maximum in GA_3 200 ppm (210.85 g) sprayed plants while it was minimum in control (184.95 g) which was on par with ethephon 500 ppm (186.73 g). Increase in 100-floret weight in GA_3 treated plants might be attributed to the fact that GA_3 enhances flower dimensions (6.12 cm / 4.34 cm) by drawing more photosynthates to the flower as a consequence of intensification of the sink (Zieslin *et al.*, 1974) [26]. Floret yield (100-floret weight) was minimum in control which was on par with ethephon 500 ppm treatment. Singh *et al.* (2010) [24] also reported similar results at 1000 ppm ethephon in tuberose cv. Double. It could be due to reduction in floret size (5.42 cm / 3.84 cm) at higher concentration of ethephon.

Table 1: Effect of plant bioregulators on floret quality and yield of tuberose cv. Prajwal

Treatments	Length of floret (cm)	Diameter of floret (cm)	100-floret weight (g)	Floret yield (t ha^{-1})
T_1: GA_3 100 ppm	6.02	4.26	207.15	11.81
T_2: GA_3 200 ppm	6.12	4.34	210.85	12.02
T_3: SA 50 ppm	5.88	4.16	202.34	11.54
T_4: SA 100 ppm	5.91	4.19	203.45	11.60
T_5: BA 50 ppm	5.75	4.07	197.90	11.28
T_6: BA 100 ppm	5.80	4.11	199.75	11.39
T_7: Ethephon 250 ppm	5.59	3.96	192.35	10.97
T_8: Ethephon 500 ppm	5.42	3.84	186.73	10.51
T_9: Spermidine 50 ppm	5.64	4.00	194.20	11.07
T_{10}:Spermidine 100 ppm	5.69	4.03	196.05	11.18
T_{11}: Water spray (Control)	5.37	3.81	184.95	10.86
Mean	5.74	4.07	197.79	11.29
S.Em	0.02	0.01	0.67	0.14
C.D. at 5%	0.06	0.04	1.97	0.41

GA_3: Gibberellic acid; SA: Salicylic acid; BA: Benzyl Adenine

Floret yield

Foliar spray of plant bioregulators significantly influenced floret yield ha^{-1} (Table 1). Highest floret yield ha^{-1} was recorded in GA_3 200 ppm sprayed plants (12.02 t ha^{-1}) and it was on par with GA_3 100 ppm sprayed plants (11.81 t ha^{-1}). While the lowest floret yield ha^{-1} was observed in ethephon 500 ppm sprayed plants (10.51 t ha^{-1}) and it was statistically on par with control (10.86 t ha^{-1}). Similar results were reported by Padaganur *et al.* (2005) [15] in tuberose. Gibberellic acid is known to improve the photosynthetic efficiency through its influence on photosynthetic enzymes, light interception and enhanced nutrient use efficiency in

plants. The integrated mechanisms enhance source potential and redistribution of photosynthates by GA_3 results in increased sink strength (Khan *et al.*, 2007) [9]. Salicylic acid also enhanced floral attributes and floret yield next to GA_3 treatments. Similar results were obtained by Anwar *et al.* (2014) [2], Khodakhah *et al.* (2014) [10] in tuberose. This might be due to greater improvement in the net photosynthetic activity and its partitioning into florets which lead to better productivity in SA treated plants. Exogenous application of SA increased the endogenous content of SA and positively influenced the plant growth and flowering (Kim *et al.*, 2009) [11]. Moreover, salicylic acid might have stimulated the flowering in plants by inducing a greater uptake of nutrients, through its influence on development of extensive and elaborative root systems (Machado *et al.*, 2007) [13]. Lowest floret yield ha^{-1} was recorded with ethephon 500 ppm foliar spray. However, ethephon at 250 ppm significantly increased floret yield ha^{-1} than control. This might be attributed to the fact that, plants have the capacity to respond to ethylene in a biphasic manner, *i.e.*, with growth promotion at lower doses and growth reduction at higher doses as explained by Pierik *et al.* (2007) [17].

Bulb parameters

Foliar spray of different plant bioregulators registered significant variation with regard to various bulb parameters and bulb yield (Table 2). Maximum number of bulbs $clump^{-1}$ was recorded in plants treated with BA 100 ppm (8.16) as compared to control (7.16) which was on par with ethephon 500 ppm (7.23). Similar results were obtained by Aier *et al.* (2015) [1], Chopde *et al*. (2015) [6] in gladiolus. Singh (1999) [21] reported highest number of bulbs $plant^{-1}$ with 100 ppm kinetin in tuberose. This effect of kinetin might be attributed to its role in an increase in cell division in apical meristem and cambial tissue or elimination of apical dominance (Chase, 1989) [5]. Further, Benzyl adenine is also known to promote cell division and lateral bud development, which might have resulted in an increase in number of daughter bulbs as well as bulblets $clump^{-1}$. Moreover, Singh *et al.* (2008) [23] found more number of bulbs $clump^{-1}$ in tuberose with the application of GA_3 200 ppm which is also evident in the present study. The number of bulbs $clump^{-1}$ were more in plants treated with BA followed by GA_3. Foliar spray with GA_3 at 200 ppm significantly enhanced the weight of bulbs $clump^{-1}$ (135.67 g) over control (119.01 g) while it was on par with ethephon 500 ppm (120.15 g). The increase in weight of the bulbs $clump^{-1}$ with the application of GA_3 could be attributed to an increase in leaf area $plant^{-1}$ which further increased the photoassimilates. These assimilates were transported to the daughter bulbs, thereby increased the bulb weight $clump^{-1}$. Similar findings have also been reported by Shanker *et al.* (2011) [19], Singh *et al.* (2013) [22] in tuberose.

Table 2: Effect of plant bio regulators on bulb parameters and yield of tuberose cv. Prajwal

Treatments	Number of bulbs $clump^{-1}$	Weight of bulbs $clump^{-1}$ (g)	Bulb yield (t ha^{-1})
T_1: GA_3 100 ppm	7.83	133.29	11.37
T_2: GA_3 200 ppm	7.88	135.67	11.57
T_3: SA 50 ppm	7.66	127.34	10.86
T_4: SA 100 ppm	7.73	128.53	10.96
T_5: BA 50 ppm	8.02	130.20	11.10
T_6: BA 100 ppm	8.16	130.91	11.16
T_7: Ethephon 250 ppm	7.45	123.77	10.55
T_8: Ethephon 500 ppm	7.23	120.15	10.45
T_9: Spermidine 50 ppm	7.52	124.96	10.66
T_{10}:Spermidine 100 ppm	7.59	126.15	10.76
T_{11}: Water spray (Control)	7.16	119.01	10.15
Mean	7.66	125.67	10.74
S.Em	0.03	0.43	0.04
C.D. at 5%	0.08	1.27	0.11

GA_3: Gibberellic acid; SA: Salicylic acid; BA: Benzyl Adenine

Bulb yield

Significant differences were noticed among different plant bioregulators for bulb yield ha^{-1} (Table 2). Bulb yield varied significantly due to the application of GA_3 compared to the other plant bioregulators under study. Plants sprayed with GA_3 200 ppm produced the highest bulb yield of 11.57 t while the lowest yield of 10.15 t was registered in plants sprayed with water (Control). These findings are in agreement with the results found by Jamil *et al.* (2015) [8] in amaryllis who recorded the highest bulb yield (40.56 t ha^{-1}) with GA_3 at 500 ppm. It might be due to an efficient transportation of photoassimilates towards the growing daughter bulbs which lead to an increase in bulb yield ha^{-1}. Similarly, Devadanam *et al.* (2007) [7] and Shanker *et al.* (2011) [19] also registered highest bulb yield ha^{-1} with GA_3 in tuberose.

Further, it could be implied from the present study is that for both floret and bulb production foliar spray of GA_3 is best followed by SA for floret yield and BA for bulb production.

Economics

Economic analysis of different plant bioregulators revealed variation in profitability of tuberose (Table 3). Total cost of cultivation varied due to the variation in the cost of bioregulating chemicals. Due to the variation in the floret and bulb yield as influenced by different bioregulators, gross returns also varied. Hence benefit – cost ratio exhibited a wide variation among the treatments. The highest yield, gross and net returns were obtained by GA_3 200 ppm followed by GA_3 100 ppm with highest benefit – cost ratio of 3.02 and 3.00 respectively.

Table 3: Effect of plant bioregulators on economics of tuberose cv. Prajwal

Treatments	Total cost (₹)	Gross return (₹)		Total Gross return (₹)	Net return (₹)	Benefit-cost ratio
		Floret	Bulb			
T_1: Gibberellic Acid 100	542308	944800	682200	1627000	1084692	3.00
T_2: Gibberellic Acid 200	548596	961600	694200	1655800	1107204	3.02
T_3: Salicylic Acid 50 ppm	535577	923200	651600	1574800	1039224	2.94
T_4: Salicylic Acid 100 ppm	536093	928000	657600	1585600	1049507	2.96
T_5: Benzyl Adenine 50 ppm	536358	902400	666000	1568400	1032042	2.92
T_6: Benzyl Adenine 100 ppm	540136	911200	669600	1580800	1040664	2.93
T_7: Ethephon 250 ppm	531556	877600	633000	1510600	979044	2.84
T_8: Ethephon 500 ppm	528452	840800	627000	1467800	939348	2.78
T_9: Spermidine 50 ppm	596072	885600	639600	1525200	929128	2.56
T_{10}:Spermidine 100 ppm	661244	894400	645600	1540000	878756	2.33
T_{11}: Water spray (Control)	530100	868800	609000	1477800	947700	2.79

Conclusion

After going through the results obtained in the investigation, it is inferred that the floret and bulb production of tuberose were maximum in the plants sprayed with GA_3 200 ppm with highest net returns (Rs. 1107204 ha^{-1}) and B: C ratio (3.02). Hence, two foliar sprays of GA_3 200 ppm at 30 and 60 DAS is recommended to obtain higher economic yield and returns in tuberose cv. Prajwal.

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