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Influence of PGR'S and cultivars on flower yield and economics of tuberose (*Polianthes tuberosa* L.) under Chhattisgarh plain

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Abstract
A field trail was conducted to study the effect of different levels of growth promoters and retardants on growth and flower yield of different cultivars of Tuberose. Two PGR's namely Gibberellins (GA_3) and Paclobutrazol (PBZ) were taken as growth promoter and growth retardant, respectively. Two cultivars namely Prajwal and Bidhan Ujjwal were taken to evaluate their suitability in Chhattisgarh. In this contest, an experiment was conducted to investigate the effect of different levels of growth promoter and retardant on growth and flower yield of different cultivars of Tuberose (*Polianthes tuberosa* L.) was carried out in Horticulture Research Farm at the Department of Floriculture and Landscape Architecture, IGKV, Raipur, Chhattisgarh, India, 2017-18 and 2018-19. The experiment was laid out in Factorial Randomized Block Design with three replication comprising treatment combination of two PGRs (GA_3 and Paclobutrazol) and two tuberose cultivars (Prajwal and Bidhan Ujjwal). The result indicated that the vegetative growth and flowering yield were significantly influenced by different plant growth regulators and cultivars. The maximum plant height was recorded with cv. Prajwal (V_1) as compared to cv. Bidhan Ujjwal (V_2). While, number of spike m^{-1} and weight of 10 florets (g) was recorded with cv. Prajwal (V_1). Among the growth regulators treatments GA_3 150 ppm (30 and 50 DAP) recorded maximum plant height. However, maximum spike yield $ha^{-1}$and bulb yield ha^{-1} was noticed with treatment GA_3 150 ppm (30 and 50 DAP). The pooled analysis of two year data also indicated that the general cost of tuberose cultivation was (219433.50 ha^{-1}) per hectear including labour cost, cost of various inputs and over head costs. The highest gross returns (952615.66 Rs. ha^{-1}), net returns (732937.16 Rs. ha^{-1}) and highest benefit: cost ratio (3.33) was found in the treatment GA_3 150 ppm (30 & 50 DAP) + PBZ 10 ppm (70 DAP). whereas the lowest (653088.00 Rs. ha^{-1}) was observed in control.

Keywords: Tuberose, Gibberellic acid (GA_3), Paclobutrazol (PBZ), Prajwal and Bidhan Ujjwal, Benefit: cost ratio

Introduction
Tuberose (*Polianthes tuberosa* L.), is an important commercial flower crop and is extensively cultivated in many sub-tropical and tropical parts of the world including India. It is a native of Mexico, belongs to the family Amaryllidaceous. Tuberose is a bulbous perennial plant with tuberous roots producing long spikes, which bear waxy white and fragrant flowers profusely throughout the year. In India, commercial tuberose cultivation is confined to one species *Polianthes tuberosa*, which is basically a white flowered type. There are four tuberose cultivars popularly grown in India *viz*., single, double, semi double and variegated. The cultivar single occupies the foremost position than the other. Apart from domestic consumption, tuberose cut spikes has got a very good export potential to other countries. Tuberose floral concrete and essential oil are fetching higher price than any other floral concretes and essential oils. In recent year, use of plant growth regulators is being increased to manipulate the growth, flowering and yield of many ornamental plants. Gibberellic acid and Paclobutrazol are very important plant growth regulators and are widely used in horticulture. Therefore, the combination of both growth promoter and growth retardant at their right level and their right stage of crop is highly desired. The GA_3 regulation of growth itself is involved with both cell division and cell enlargements without cell division (Haberand and Leopold, 1960) [2]. The application Paclobutrazol the so called growth retardant is generally used widely in the orchard plants like mango which regulates its alternate bearing habit but it is used very rarely in the flower crops. Paclobutrazol indirectly helps in increasing the flower quality and yield in the flower crops by regulating the gibberellin activity (Khan and Pal, 2009) [1].

There is very mere information regarding paclobutrazol effect in the floriculture sector hence we conducted this experiment to asses effect of paclobutrazol in different doses of PGR's. Thus, keeping in view the potentialities of growth regulators like GA_3 and PBZ, the present study was undertaken to find out the suitable concentration of these PGR's for better flowering and yield of tuberose.

Materials and Methods

The experiment was carried out during two seasons of the years 2017-18 and 2018-19, was carried out in Horticultural Research cum Instruction Farm at the Department of Floriculture and Landscape Architecture, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Raipur, (C.G.). The experiment was laid out in Factorial Randomized Block Design with three replications comprising sixteenth treatment combinations of Eight levels of PGR's *viz*., G_1 GA_3 150 ppm at 30 DAP, G_2 GA_3 150 ppm at 50 DAP, G_3 $GA_3$150 ppm at 30 and 50 DAP, G_4 PBZ 10 ppm at 70 DAP, G_5 GA_3 150 ppm at 30 DAP + PBZ 10 ppm at 70 DAP, G_6 GA_3 150 ppm at 50 DAP+ PBZ10 ppm at 70 DAP, G_7 $GA_3$150 ppm at 30 and 50 DAP + PBZ 10 ppm at 70 DAP, along with G_8 distill control (water spray) and two varieties *viz*., Prajwal and Bidhan Ujjwal of tuberose were taken. Bulbs of tuberose cv. Prajwal were provided by Horticulture Research Farm at the Department of Floriculture and Landscape Architecture, Indra Gandhi Krishi Vishwavidyalaya, Raipur and the other cv. Bidhan Ujjwal were provided by Horticulture Research Farm, Mandouri, Bidhan Chandra Krishi Vishwavidyalaya, West Bengal. Before planting the bulbs were stored in well ventilated semi shady place for two months. Older leaves emerging from the neck of the bulbs were trimmed off. Before planting, the bulbs were treated with fungicide copper oxychloride (0.1%) and the individual bulbs. weighing 15-30 g with 1.5- 2.5 cm in diameter were selected for planting. Five plants were selected randomly from each plot for recording data on various quality attributes. Desired quantities of the GA_3 were first dissolved in few drops of alcohol (C_2H_5OH) and then volume was made up to 500 ml dissolved water to make the proper concentrations of GA_3. Paclobutrazol was dissolved in required amount of distilled water for preparation of stock solution and then diluted before spraying. The spraying was done in the morning hours with the help of hand spraying. Two time periods of crop growth were chosen for spraying of PGR's i.e., first at 30, 50 DAP and at 70 DAP. Observations were recorded at 30, 60 and 90 days after planting. In this article the data was furnished for the parameters plant of plant and length of spike were recorded for observation. The yield parameters like number of florets per spike, weight of 10 florets and spike yield ha^{-1} and bulb yield ha^{-1}were also recorded.

Results and Discussion

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads:

Effect of Cultivars

Data presented in (Table1) show that the varieties of Tuberose had significantly influenced on growth parameters characters. The maximum plant of height was recorded with cv. Prajwal (V_1) as (50. 65, 51.20 cm) and (84.09, 83.93 cm) in the year 2017-18 and 2018-19, respectively. While, minimum plant of height was measured under cv. Bidhan Ujjwal (V_2) as (43.84 and 43.70 cm) and (61.31cm) and 60.90 cm). The pooled mean data revealed that maximum length of spike (cm), number of florets $spike^{-1}$, weight of 10 florets (g), spike yield ha^{-1} and bulb yield ha^{-1} were also recorded under Prajwal (V_1). Whereas, it was found minimum under cv. Bidhan Ujjwal (V_2). The maximum plant height followed due to positive response to height by the variety. The variation in plant height, leght of spike (cm), number of florets $spike^{-1}$, weight of 10 florets (g) spike yield ha^{-1} and bulb yield ha^{-1} between Tuberose varieties might be due to congenial environment to express the dominant genes in the genotypes and also different genetic makeup of the the different varieties. Similar results were reported by Rachana *et al.* (2015) [13], Vijayalaxmi and Lakshmidevamma (2016) and by Madhumati *et al*. (2018) [11] in tuberose.

The present finding indicate that the application of GA_3 and Paclobutrazol at various levels had highly significant influence on number of spike m^{-1} and weight of 10 florets (g) in Tuberose. The maximum number of spike m^{-1} and weight of 10 florets (g) (29.58) and (15.40 g, respectively) were recorded under the PGRs combination of GA_3 150 ppm (30 & 50 DAP) + PBZ 10 ppm (70 DAP) whereas, minimum was recorded in distilled water (Table 1). Similar results were reported by Singh (2004) [3], Krishan and Misra (2005) [4], Prashanta *et al*. (2016) [5], Fatmi and Singh (2020) [6] in tuberose.

Flowering and yield parameters

GA_3 and paclobutrazol application at various levels had highly significant effect on the spike yield ha-^{1} and bulb yield q ha^{-1} in Tuberose (Table 2). Maximum spike yield ha-^{1} and bulb yield q ha^{-1} was recorded with the treatment GA_3 150 ppm (30 & 50 DAP) + PBZ 10 ppm (70 DAP. The increase in spike yield ha-^{1} and bulb yield q ha^{-1} with GA_3 and paclobutrazol spray may be due to more plant height and leaves per plant and also increase the number of spike m^{-1}, thus ultimately increased the spike yield and bulb yield ha^{-1}. Similar results were also reported by Fatmi and Singh (2020) [6] in tuberose, Narayana and Jayanthi 1993 in African marigold.

Therefore combined use of GA_3 and Paclobutrazol is better option over the sole application of GA_3 and Paclobutrazol. Experimental findings also show that the number of spike m^{-1} in Tuberose was significantly affected by GA_3 + Paclobutrazol applications at various concentrations without affecting the initiation of florets bud as well as commencement of flowering. Maximum weight of 10 florets was recorded with the treatment GA_3 150 ppm (30 & 50 DAP) + PBZ 10 ppm (70 DAP) as compared with control (Table 2).

The interaction between varieties and growth regulators did not show any significant results for vegetative characters and flowering and yield components. This may be because of these treatments acted independently rather than synergistically. Similar results were also reported by Singh and Karuna (2011) [7] in tuberose and Sunitha *et al*., 2007) [8] in African marigold. Thus, it can be concluded that varieties and foliar spray of plant growth regulators (GA3 and PBZ) jointly or separately gave higher flower yield in Tuberose.

Economics

An inquisition of the pooled data in Table 2 also depicted the general cost of Tuberose cultivation was (219433.50/-. Rs. ha-

[1]) per hectare including labour cost, cost of various inputs and over head costs. The highest gross return of (952615.66 Rs. ha^{-1}) was found in the treatment GA_3 150 ppm (30 & 50 DAP) + PBZ 10 ppm (70 DAP) followed by by G_3 GA_3 150 ppm (30 and 50 DAP of Rs. 948537.66 /-, whereas the lowest (Rs. 653088.00 /-) was fond in control. The highest benefit-cost ratio (3.33) was calculated in G_7 GA3 150 ppm (30 and 50 DAP) + PBZ 10 ppm (70 DAP) followed by GA_3 150 ppm (30 and 50 DAP (3.31). Thus, the treatment combination G_7 GA3 150 ppm (30 and 50 DAP) + PBZ 10 ppm (70 DAP) proved to be the most beneficial. As per the economic point of view the G_7 GA3 150 ppm (30 and 50 DAP) + PBZ 10 ppm (70 DAP) gained more benefit-cost ratio, thus this was more better for high return from the cultivation of tuberose. This might be due to the fact that the foliar application of growth regulators and varietal response might have improved the yield and quality of tuberose flowers. Similar findings are noticed by Rajamanickam and Ravindran (2019) [9] in tuberose, Naik *et al*. (2005) [10] in African Marigold.

Table 1: Influence of varieties and plant growth regulators on Number of spike m^{-1} and Weight of 10 florets (g) of Tuberose (*Polianthes tuberosa* L.) in during the year 2017-18 and 2018 -19.

Treatments	Number of spike m^{-2}			Weight of 10 florets (g)		
Varieties	**2017-18**	**2018-19**	**Pooled Mean**	**2017-18**	**2018-19**	**Pooled Mean**
Prajwal-V_1	28.00	29.13	28.56	15.15	15.45	15.30
Bidhan Ujjwal- V_2	26.03	26.63	26.35	10.04	10.21	10.13
S.Em±	0.27	0.31	0.29	0.27	0.29	0.28
CD (0.05)	0.77	0.91	0.84	0.78	0.83	0.80
PGRs						
GA_3 150 ppm at 30 DAP	27.67	28.67	28.17	12.30	12.44	12.37
GA_3 150 ppm at 50 DAP	26.67	26.50	26.58	11.59	12.37	11.98
$GA_3$150 ppm at 30 and 50 DAP	28.17	29.83	29.00	14.20	14.52	14.40
PBZ 10 ppm at 70 DAP	26.00	26.17	26.08	11.43	11.37	11.40
GA_3 150 ppm at 30 DAP + PBZ 10 ppm at 70 DAP	27.17	28.50	27.83	12.39	12.58	12.48
GA_3 150 ppm at 50 DAP + PBZ10 ppm at 70 DAP	26.33	27.17	26.75	12.26	12.41	12.34
$GA_3$150 ppm at 30 and 50 DAP + PBZ10 ppm at 70 DAP	29.00	30.17	29.58	15.31	15.49	15.40
Control (water spray)	25.33	26.00	25.67	11.28	11.44	11.36
S.Em±	0.53	0.63	0.58	0.54	0.57	0.56
CD (0.05)	1.54	1.81	1.68	1.56	1.66	1.61
Treatment combinations (PGR X V) (p=0.05)	NS	NS	NS	NS	NS	NS

Table 2: Influence of varieties and plant growth regulators on Economics (Rs. ha^{-1}) of Tuberose in during the year 2017-18 and 2018 -19.

Treatment combination	Cost of cultivation (Rs. ha^{-1})	Spike yield (ha^{-1})	Bulb Yield (q ha^{-1})	Gross return (Rs. ha^{-1})	Net return (Rs. ha^{-1})	Net benefit-cost ratio
G_1 V_1 - GA_3 150 ppm (30 DAP)	219538.50	596666.67	37.44	843792.66	624254.16	2.84
G_1 V_2- GA_3 150 ppm (30 DAP)	219538.50	530000.00	32.49	734412.00	524873.50	2.39
G_2 V_1 - GA_3 150 ppm (50 DAP)	219538.50	553333.33	33.46	774147.33	554608.83	2.52
G_2 V_2 - GA_3 150 ppm (50 DAP)	219538.50	510000.00	29.52	704854.00	485315.50	2.21
G_3 V_1 - GA_3 150 ppm (30 and 50 DAP)	219643.50	626666.67	48.77	948537.66	728894.16	3.31
G_3V_2 - GA_3 150 ppm (30 and 50 DAP)	219643.50	556666.67	41.26	828993.66	609350.16	2.77
G_4 V_1 - PBZ 10 ppm (70 DAP)	219468.50	540000.00	30.07	738440.00	518971.50	2.36
G_4 V_2 - PBZ 10 ppm (70 DAP)	219468.50	503333.33	25.51	671721.33	452252.83	2.06
G_5 V_1 - GA_3 150 ppm (30 DAP) + PBZ 10 ppm (70 DAP)	21957.50	590000.00	49.58	917250.00	697676.50	3.17
G_5 V_2 - GA_3 150 ppm (30 DAP) + PBZ 10 ppm (70 DAP)	219573.50	523333.33	41.77	798993.33	579419.83	2.63
G_6 V_1- GA_3 150 ppm (50 DAP) + PBZ 10 ppm (70 DAP)	219573.50	550000.00	29.43	744216.00	524642.50	2.38
G_6 V_2- GA_3 150 ppm (50 DAP) + PBZ 10 ppm (70 DAP)	219573.50	520000.00	26.91	697584.00	478010.50	2.17
G_7 V_1- GA_3 150 ppm (30 & 50 DAP) + PBZ 10 ppm (70 DAP)	219678.50	596666.67	53.93	952615.66	732937.16	3.33
G_7 V_2- GA_3 150 ppm (30 and 50 DAP) + PBZ 10 ppm (70 DAP)	219678.50	563333.33	45.91	866306.33	646627.83	2.94
G_8 V_1- Control (water spray)	219433.50	516666.67	26.16	689344.66	469911.16	2.14
G_8 V_2- Control (water spray)	219433.50	510000.00	21.68	653088.00	433654.50	1.97

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