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Effect of plant growth regulator on yield and quality parameters of calendula (*Calendula officinalis* L.)

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Abstract
An investigation on "Effect of plant growth regulator on yield and quality parameters of calendula (*Calendula officinalis* L.)" was carried out by the Dept. of Floriculture and Landscape architecture, Pt. K.L.S. College of Horticulture and Research Station, Rajnandgaon during the year 2020-21. The purpose of research was to observe the effect of different concentrations of Gibberellic acid (200, 250, 300, 350 ppm), Naphthalic acetic acid (100, 200, 300, 400 ppm) and Salicylic acid (50, 100, 150, 200 ppm) in calendula plants yield attributes and quality attributes. The result revealed that maximum diameter of fully opened flower (5.43 cm), highest fresh weight (2.57 g), maximum flower yield per plant (99.78 g) and Maximum flower yield per plot (1596.48 g) were noted under SA @ 100 ppm. In research, control was reported minimum for every trait from different concentrated PGR taken in the investigation.

Keywords: Calendula, plant growth regulator, yield and quality parameters

Introduction
Calendula (*Calendula officinalis* L) belong to Asteraceae family is a short lived aromatic herbaceous perennial plant that often known as pot marigold. It is assessed 80 cm tall with sparsely branched lax or erect stems. The leaves are oblong-lanceolate, 5-7 cm long. The inflorescences are yellow to orange, comprising a thick capitulum or flower head 4–7 cm diameter surrounded by two rows of hairy bracts. The disc florets are tubular and hermaphrodite and generally of a more intense orange-yellow colour than the female, tridentate peripheral ray florets. The flowers may appear all year long in favourable condition.
Ornamental uses of calendula included cut flowers, loose flower, floral arrangements border annuals, dried flower purpose, calendula oil etc. In ancient Greek, Roman and Indian cultures, calendula was used for its medicinal purposes like anti-inflammatory, anti-septic, anti-viral anti-bacterial properties and helps to boost the immune system as well as a colouring agent for fabrics, foods and cosmetics.
Gibberellic acid (GA_3) is a well-recognized plant growth regulator for flower induction in many herbaceous flower crops. The flower formation of long day or long short day plant can be controlled by regulating the endogenous level of gibberellins-like substances though the use of such growth promoter.
Use of naphthalene acetic acid (NAA) in calendula successfully induced more concentrated flowering thereby, facilitating harvesting as NAA had effect through the stimulation of ethylene production.
Salicylic Acid (SA), as a natural phenolic secondary metabolite, in various aspects of vital processes like ethylene biosynthesis, stomata conductance, respiration, senescence and the activation of defence systems against different pathogens is well documented. Applying salicylic acid to various species has been shown considerable change in flowering components, increased number of flowering parts in the plants.

Materials and Method
The research was conducted at the Horticultural Research cum Institutional Farm, Pt. K.L.S. College of Horticulture and Research Station, Pendri, Rajnandgaon, I.G.K.V. Raipur, Chhattisgarh, during the year 2020-2021. The region is located at around 21.10^0 N latitude and 81.03^0 E longitudes, with a standard altitude of 307 m above mean sea level. The soil of experimental site was clay in texture with pH 7.2, E.C of 0.25 dSm^{-1} and organic carbon of 0.64 percent. The available nitrogen, phosphorus and potassium contents were 207.04, 13.88 and 275.62 kg ha^{-1} respectively.

The experiment was laid out in Randomized Block Design with 3 replications and 13 treatments. The treatments *viz*. Control (T_1), GA_3 200 ppm (T_2), GA_3 250 ppm (T_3), GA_3 300 ppm (T_4), GA_3 350 ppm (T_5), NAA 100 ppm (T_6), NAA 200 ppm (T_7), NAA 300 ppm (T_8), NAA 400 ppm (T_9), Salicylic Acid 50 ppm (T_{10}), SA 100 ppm (T_{11}), SA 150 ppm (T_{12}) and SA 200 ppm (T_{13}). The seedlings of cv. Bon Bon with 4-5 leaves were planted in raised bed on 10th November 2020 at the spacing of 30cm x 20cm without burying the crown. The three regulators like gibberellic acid, naphthalene acetic acid and salicylic acid were taken.

This growth regulator was given through foliar spray. They are soluble in ethyl alcohol and then diluted in water. It was applied after one month of transplanting. All the cultural operations were done as per the need of crop. The data were recorded on yield of flower per plant, yield of flower per plot, Fresh weight of flower and Diameter of fully opened flower were taken.

Results and Discussion

Yield and Quality parameters

There was significant effect obtained with respect to yield of flower per plant, yield of flower per plot, Fresh weight of flower and Diameter of fully opened flower in different concentration of plant growth regulators used in research work. The data and graphical representation shown in table no.1 and fig.1 respectively.

The maximum yield of flower per plant (99.78 g) was examined in SA @ 100 ppm (T_{11}) treatment and it was at par with NAA @ 100 ppm (T_6) (99.22 g) and NAA @ 200 ppm (T_7) (96.15 g). In research, control was reported minimum flower yield plant^{-1} (50.85 g) in all treatment of plant growth regulators. The effect of salicylic acid on plant and flower yield could be due to increased vegetative growth, photosynthetic pigments, minerals, and some bio constituents that affect plant growth. Pavan Kumar *et al.* (2015) 20125 was found identical results to the ones observed throughout the experiment in China aster. The maximum flower yield per plot (1596.48 g) was examined in SA @ 100 ppm (T_{11}) treatment and it was at par with NAA @ 100 ppm (T_6) (1587.52 g) and NAA @ 200 ppm (T_7) (1538.48 g). Control treatment was reported minimum flower yield per plot (813.59 g) from the all plant growth regulators taken in research. The maximum weight of fresh flower (2.57 g) was observed in SA @ 100 ppm (T_{11}) treatment and it was par with NAA @ 100 ppm (T_6) (2.35 g), NAA @ 200 ppm (T_7) (2.32 g), SA @ 150 ppm (T_{12}) (2.19 g) and SA @ 200 ppm (T_{13}) (2.16 g). Significantly minimum fresh weight of flower (1.61 g) obtained in control. The maximum diameter of fully opened flower (5.43 cm) was observed in SA @ 100 ppm (T_{11}) treatment and it was par with NAA @ 100 ppm (T_6) (5.24 cm), NAA @ 200 ppm (T_7) (5.17 cm) and NAA @ 200 ppm (T_8) (5.12 cm), while minimum diameter of fully opened flower (4.41 cm) was noted in control. The Salicylic acid has a beneficial influence on photosynthesis and glucose metabolism in leaves and stems, blossom size has enhanced. The synergy between salicylic acid and auxin might explain the rise in floral diameter and weight. Abou El-Yazeid (2011) [1] found a similar outcome in sweet paper crop when salicylic acid was applied.

Table 1: The effect of foliar application of PGR on the growth parameters

Treatment	Yield of flower per plant (gm)	Yield of flower per plot (gm)	Fresh weight of flower (gm)	Diameter of fully opened flower (cm)
T_1	50.85	813.59	1.61	4.41
T_2	52.59	841.44	2.05	4.84
T_3	63.80	1020.80	1.89	4.69
T_4	74.28	1188.48	1.82	4.69
T_5	59.61	953.76	1.66	4.60
T_6	99.22	1587.52	2.35	5.24
T_7	96.15	1538.40	2.32	5.17
T_8	74.37	1187.04	2.31	5.12
T_9	65.75	1052.00	1.89	4.74
T_{10}	83.19	1331.04	2.11	4.93
T_{11}	99.78	1596.48	2.57	5.43
T_{12}	70.59	1126.11	2.19	5.01
T_{13}	69.94	1119.04	2.16	4.99
S.E m±	2.56	57.83	0.14	0.12
CD @ 5%	7.57	168.79	0.41	0.36

Conclusion

According to the experimental result, it could be concluded that the treatment T_{11} (SA @ 100 ppm) were performed better for yield of flower per plant, yield of flower per plot, Fresh weight of flower and Diameter of fully opened flower. The treatment T_1 (control) was found most economical among all the treatment.

Reference

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