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Influence of plant growth regulators on vegetative growth in gaillardia (*Gaillardia pulchella*) cv. local double

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Abstract
The field trial was undertaken at College of Horticulture, Dapoli, Dist. Ratnagiri during *Rabi* season of the year 2019-20 undertaken to assess the influence of plant growth regulators on vegetative growth in Gaillardia cv. Local double'. The experiment was laid out in Randomized Block Design (RBD) with three replications with nine treatments of plant growth regulator *viz*; T_1- NAA @ 100 ppm, T_2- NAA @ 200 ppm, T_3- GA_3 @ 100 ppm, T_4- GA_3 @ 200 ppm, T_5- CCC @ 1500 ppm, T_6- CCC @ 3000 ppm, T_7- PBZ @ 250 ppm, T_8- PBZ @ 500 ppm and T_9- Control. Among the different plant growth regulators used, application of T_4 GA_3 200 ppm (T_4) was found significantly superior with respect to maximum plant height (80.48 cm), maximum plant spread i.e E-W (49.47 cm) and N-S (50.19 cm), maximum primary and secondary branches (27.33 and 42.27 respectively), leaf area (37.33 cm^2).

Keywords: *Gaillardia*, GA_3, growth, of plant growth regulators

Introduction
Gaillardia (*Gaillardia pulchella*) is one of the most popular flower in India because of its easy cultivation, wide adaptability to varying soils and climatic conditions with long duration of flowering and attractive flower colours. It is popularly known as "Blanket Flower''. In India, Maharashtra occupies an important place in floriculture industry. It is perhaps the only state which took initiative in developing and promoting floriculture at Government level. Floriculture in Maharashtra is mainly concentrated in the districts of Nasik, Ahmednagar, Pune, Satara, Sangli and Kolhapur. But the contribution of Konkan region in flower trade is very negligible.

Plant growth regulators are defined as organic compounds other than nutrients which in small amounts regulate, modify or enhance growth processes in plants, at very low concentrations. These growth substances are undoubtedly required for the complete development of a plant (Sheela, 2011) [10].

Gaillardia is one of the extensively grown annual flower in most of the parts of country. In the development of the sustainable package of practices for achieving higher yield of flowers, use of the growth regulators (bioregulators) is one of the means. Hence, the present investigation was undertaken to assess the influence of plant growth regulators on vegetative growth in Gaillardia cv. Local double'.

Material and Methods
The field trial was undertaken at College of Horticulture, Dapoli, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Dist. Ratnagiri during *Rabi* season of the year 2019-20. The experiment was laid out in Randomized Block Design (RBD) with three replications with nine treatments of plant growth regulator *viz*; T_1- NAA @ 100 ppm, T_2- NAA @ 200 ppm, T_3- GA_3 @ 100 ppm, T_4- GA_3 @ 200 ppm, T_5- CCC @ 1500 ppm, T_6- CCC @ 3000 ppm, T_7- PBZ @ 250 ppm, T_8- PBZ @ 500 ppm and T_9- Control. The preparatory tillage operations were carried out and the flat beds of 2.7m X 1.8 m were prepared. The healthy, 30 days old seedlings of gaillardia (cv. Local double) were transplanted at spacing of 45 X 45 cm. The recommended cultural practices were followed uniformly to experimental plots to grow the crop. As per the treatments, the spraying of different growth regulators in prescribed concentration was done at 30, 45 and 60 days after transplanting. The observations on growth *viz*: plant height, plant spread, number of branches and leaf area were recorded on randomly selected five plants at 30, 60 and 90 days after transplanting.

The data were statistical analyzed by standard method of analysis of variance as given by Panse and Sukhatme (1985) [7].

Results and Discussion

The data on plant height of gaillardia as influenced by the plant growth regulator treatments are presented in Table 1. It is revealed that the plant growth regulators had significant influence on the plant height at 60 DAT and 90 DAT. At 30 DAT plant height was not significantly altered by PGR treatments as the plants showed uniform growth till 30 DAT.

At 60 DAT, treatment T_4 (GA_3 @ 200 ppm) recorded the maximum plant height (52.46 cm) which was significantly superior over rest of the treatments.

It was followed by T_3 (GA_3 @ 100 ppm) 48.72 cm, T_2 (NAA @ 200 ppm). However, the lowest plant height at 60 DAT was recorded by the treatment T_6 (CCC @ 3000 ppm) 34.25 cm.

At 90 DAT, the maximum plant height (80.48 cm) was also recorded by T_4 (GA_3 @ 200 ppm). It was statistically at par with T_3 (GA_3 @ 100 ppm) 79.42 cm. It was followed by T_2 (NAA @ 200 ppm) 57.40 cm, T_1 (NAA @ 100 ppm) 56.90 cm, T_9 (Control) 52.19 cm, T_7 (PBZ @ 250 ppm) 48.72 cm, T_8 (PBZ @ 500 ppm) 47.15 cm and T_5 (CCC @ 1500 ppm) 47.11 cm. The lowest plant height at 90 DAT was recorded by the treatment T_6 (CCC @ 3000 ppm) 42.89 cm.

The Gibberellic acid is known for its effect on cell elongation in the plants. The increase in plant height with increase in GA_3 concentration is observed in current experiment. The rapid growth is due to a greater number of cells formed and increased elongation of the individual cell. These results are in close confirmatory with Delvadia *et al.* (2009) [2], Ghadage *et al.* (2013) [3] and Moon *et al.* (2018) [6] in gaillardia.

The retarded growth with application of paclobutrazol may be due to its very high concentrations, which has inhibitorier role on cell division and cell elongation of apical meristematic cells and also on gibberellins synthesis. Jadhav *et al*. (2015) [4] also reported similar effects of PBZ on plant height in marigold, zinnia and helicona respectively.

The difference in plant height with the type and concentration of growth retardants may be due to their different mode of action in inhibiting plant growth regulators particularly gibberellins and auxins.

The data on effect of PGR on plant spread in gaillardia is presented in Table 2 perused that the plant growth regulators showed the significant effect on this character at 60 DAT and 90 DAT. At 30 DAT, plant spread did not significantly varied due to PGR as the treatments were given at 30 DAT.

The highest east-west plant spread was observed in T_4 (GA_3 @ 200 ppm) i.e. 35.47 cm at 60 DAT and 49.47 cm at 90 DAT, respectively.

It was statistically at par with T_3 (GA_3 @ 100 ppm) 33.67 cm, and T_8 (PBZ @ 500 ppm) 33.92 cm at 60 DAT. However, at 90 DAT it was statistically superior over rest of the treatments. The lowest values for the east-west plan spread at 60 DAT and 90 DAT was observed in T_1 (NAA @ 100 ppm) 26.81 and 38.43 cm, respectively.

However, at 60 DAT the highest north-south plant spread (34.18 cm) was recorded in T_8 (PBZ @ 500 ppm) and it was at par with T_9 (Control) 33.47 cm, T_6 (CCC @ 3000 ppm) 33.35 cm, T_7 (PBZ @ 250 ppm) 33.17 cm and T_4 (GA_3 @ 200 ppm) 32.57 cm. Whereas at 90 DAT, the highest north-south plant spread was observed in T_4 (GA_3 @ 200 ppm) i.e. 50.19 cm and it was at par with T_8 (PBZ @ 500 ppm) 49.79 cm, T_3 (GA_3 @ 100 ppm) 49.60 cm and T_7 (PBZ @ 250 ppm) 48.81 cm. The lowest the north-south plant spread at 60 DAT and 90 DAT (28.85 cm and 41.72 cm respectively) was observed in T_1 (NAA @ 100 ppm).

The significant effect of various growth regulators treatments was observed on East-West and North-South plant spread. GA_3 was found effective in increasing plant spread in gaillardia. According to Verma (1991) [11], it was due to the formation of new cells in meristematic region and an increase in size and mass of cells produced. The favorable effect of gibberellins on growth may be due to increasing auxin level of tissues which causes cell division and cell elongation which in terms induces the lateral growth and ultimately also increases the number of branches and thereby plant spread. The similar results were also reported by Patil (2002) [8] and Delvadia *et al.* (2009) [2] in gaillardia.

The data pertaining to the effect of plant growth regulators on number of primary and secondary branches at 30, 60 and 90 days interval during rabbi season are presented in Table 3. At 30 DAT, numbers of primary and secondary branches in gaillardia were not significantly affected by PGR as the treatments were given at 30 DAT.

The highest number of primary branches at 60 DAT and 90 DAT (23.53 and 27.33, respectively) were observed in T_4 (GA_3 @ 200 ppm). It was at par with T_3 (GA_3 @ 100 ppm) 21.60, T_1 (NAA @ 100 ppm) 21.87 and T_2 (NAA @ 200 ppm) 22.47 at 60 DAT. However, at 90 DAT it was at par with T_3 (GA_3 @ 100 ppm) 26.93 only. The least number of primary branches at 60 DAT and 90 DAT (17.47 and 21.40 respectively) were observed in T_9 (Control).

At 60 DAT and 90 DAT the maximum number of secondary branches were observed in T_4 (GA_3 @ 200 ppm) i.e. 30.40 and 42.27 respectively. It was at par with T_3 (GA_3 @ 100 ppm) 29.00 and 41.27 at 60 DAT and 90 DAT respectively. The lowest number of secondary branches at 60 DAT (23.93) was recorded T_6 (CCC @ 3000 ppm) and at 90 DAT was observed in T_5 (CCC @ 1500 ppm) 32.47. The number of secondary branches in control was 24.07 at 60 DAT and 34.13 at 90 DAT.

The increased number of branches in GA_3 treatment might be due to hyper elongation of internodal length and resultant increase in internodal count of the main axis. Consequently these nodes increased number of dormant buds from where the primary branches may have originated. The similar observations were also recorded by Makwana (1999) [5] and Patil (2002) [8] in gaillardia.

A perusal of data in Table 4 which is graphically illustrated in clearly shows that the application of plant growth regulators did not cause significant variation in leaf area at 30 DAT. However, the leaf area at 60 DAT was significantly maximum (14.70 cm^2) in the treatment T_4 (GA_3 @ 200 ppm). It was at par with the treatment T_3 (GA_3 @ 100 ppm) (13.90 cm^2). It was followed by T_2 (NAA @ 200 ppm) 11.64 cm^2, T_1 (NAA @ 100 ppm) 11.54 cm^2, T_6 (CCC @ 3000 ppm 10.77 cm^2, T_7 (PBZ @ 250 ppm) 10.73 cm^2, T_5 (CCC @ 1500 ppm) 9.80 cm^2 and T_8 (PBZ @ 500 ppm) 9.69. The lowest leaf area (8.27 cm^2) was found in the treatment T_9 (Control).

The data revealed that the leaf area at 90 DAT, was significantly highest (37.33 cm^2) in the treatment T_4 (GA_3 @ 200 ppm). It was at par with the treatment T_3 (GA_3 @ 100 ppm) (35.25 cm^2). These treatments were followed by T_2 (NAA @ 200 ppm) 31.05 cm^2, T_9 (Control) 28.68 cm^2, T_1 (NAA @ 100 ppm) 28.16 cm^2, T_5 (CCC @ 1500 ppm) 26.91 cm^2, T_7 (PBZ @ 250 ppm) 25.52 cm^2, T_6 (CCC @ 3000 ppm

24.78 cm^2. The lowest leaf area (23.79 cm^2) was found in the treatment T_8 (PBZ @ 500 ppm). The increase in leaf area in most of the GA_3 and NAA treatments was due to the fact that the primary physiological effect of auxin is to stimulate the elongation of cells due to increased amylase activity. The GA_3 is known to increase the sink strength of the actively growing plant parts. This would have resulted into the better leaf area. Paclobutrazol reduced the leaf area because of the reason that gibberellin activities, stimulating meristematic cell division and growth, were prevented by paclobutrazol. These findings are in conformity with Dani *et al.* (2010) [1] in marigold and Saiyad *et al.* (2010) [9] in Gaillardia.

Table 1: Effect of plant growth regulators on plant height of Gaillardia

Treatments		Plant height (cm)		
		30 DAT	60 DAT	90 DAT
T_1	NAA 100 ppm	15.25	34.31	56.90
T_2	NAA 200 ppm	16.05	39.91	57.40
T_3	GA_3 100 ppm	15.99	48.72	79.42
T_4	GA_3 200 ppm	18.53	52.46	80.48
T_5	CCC 1500 ppm	18.09	37.51	47.11
T_6	CCC 3000 ppm	15.01	34.25	42.89
T_7	PBZ 250 ppm	16.72	38.14	48.72
T_8	PBZ 500 ppm	18.75	36.40	47.15
T_9	Control	16.80	35.97	52.19
S.Em. ±		1.15	1.10	2.09
C. D. at 5%		NS	3.29	6.25

*DAT - Days after Transplanting

Table 2: Effect of plant growth regulators on plant spread of Gaillardia

Treatments		Plant spread E-W (cm)			Plant spread N-S (cm)		
		30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT
T_1	NAA 100 ppm	19.01	26.81	38.43	19.13	28.85	41.72
T_2	NAA 200 ppm	21.95	29.41	40.37	19.04	31.52	44.25
T_3	GA_3 100 ppm	20.82	33.67	44.87	20.03	31.79	49.60
T_4	GA_3 200 ppm	20.98	35.47	49.47	19.68	32.57	50.19
T_5	CCC 1500 ppm	17.03	31.53	42.10	18.88	32.11	44.70
T_6	CCC 3000 ppm	20.15	31.93	43.53	19.04	33.35	43.77
T_7	PBZ 250 ppm	19.36	32.24	45.22	19.46	33.17	48.81
T_8	PBZ 500 ppm	21.33	33.92	44.36	20.49	34.18	49.79
T_9	Control	21.85	32.86	45.85	19.73	33.47	46.85
S.Em. ±		0.94	0.82	0.97	0.76	0.61	0.83
C. D. at 5%		NS	2.45	2.90	NS	1.83	2.50

Table 3: Effect of plant growth regulators on number of branches per plant in Gaillardia

Treatments		Primary branches (No.)			Secondary branches (No.)		
		30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT
T_1	NAA 100 ppm	12.17	21.87	24.27	14.93	25.80	34.40
T_2	NAA 200 ppm	11.57	22.47	24.93	14.40	24.20	32.73
T_3	GA_3 100 ppm	11.03	21.60	26.93	13.60	29.00	41.27
T_4	GA_3 200 ppm	12.37	23.53	27.33	14.20	30.40	42.27
T_5	CCC 1500 ppm	12.40	20.27	23.27	14.07	24.13	32.47
T_6	CCC 3000 ppm	13.03	20.33	23.33	14.67	23.93	33.20
T_7	PBZ 250 ppm	11.83	18.27	21.87	14.47	24.40	33.53
T_8	PBZ 500 ppm	13.27	18.47	21.93	14.20	25.13	33.67
T_9	Control	11.13	17.47	21.40	13.80	24.07	34.13
S.Em. ±		0.62	0.75	0.67	0.38	0.55	0.42
C. D. at 5%		NS	2.24	2.00	NS	1.65	1.26

Table 4: Effect of plant growth regulators on leaf area in Gaillardia

Treatments		Leaf area (cm^2)		
		30 DAT	60 DAT	90 DAT
T_1	NAA 100 ppm	2.47	11.53	28.16
T_2	NAA 200 ppm	2.10	11.64	31.05
T_3	GA_3 100 ppm	2.57	13.90	35.25
T_4	GA_3 200 ppm	2.33	14.70	37.33
T_5	CCC 1500 ppm	2.53	9.80	26.91
T_6	CCC 3000 ppm	2.43	10.77	24.78
T_7	PBZ 250 ppm	2.47	10.73	25.52
T_8	PBZ 500 ppm	1.93	9.69	23.79
T_9	Control	1.70	8.27	28.68
S.Em. ±		0.26	0.39	0.96
C. D. at 5%		NS	1.17	2.88

Conclusion

From the present investigation it can be concluded that, plant growth regulators had significant effect on vegetative growth of gaillardia (*Gaillardia pulchella*). The gibberellic acid treatments were having profound effect of all the growth. The treatment T_4 i.e. GA_3 200 ppm spray was found best with respect to plant height, plant spread, leaf area, number of branches.

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