Effect of Plant Growth Regulators (GA3, NAA and BA) on Growth and Flowering of Gladiolus (Gladiolus hybridus Hort.) cv. White Prosperity

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A B S T R A C T

The present investigation entitled “Effect of plant growth regulators on growth and flowering characters of gladiolus (Gladiolus hybridus Hort.) cv. White Prosperity” was conducted at Horticulture Research Center (HRC), College of Agriculture, Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut-250110 (U.P.) during the rabi season of 2018-2019. The investigation revealed that plant growth regulators showed significant results on gladiolus as GA3 at 400 ppm or 800 ppm concentration was significantly superior to other treatments in improving the growth, days of sprouting, plant height, length of longest leaf, number of days required for visibility of first spike, days required for opening of first floret, diameter of spike, number of florets per spike, diameter of floret, longevity of spike. NAA at 200, 400 and 600 ppm increases the number of leaves per plant, plant height. When the different treatments of application were compared, it was found that corm dipping + foliar spraying treatment was significantly superior to control.

Introduction

Gladiolus (Gladiolus hybridus Hort.) is an ornamental cormelous plant native to South Africa. It belongs to monocot family Iridaceae and sub-family Ixioideae. Iridaceae family contains some 106 genera, containing mostly bulbous ornamentals. Gladiolus takes its name from latin word ‘Gladius’ because of sword like shape, therefore this is also known as
“Sword lily”. Gladiolus is grown as flower bed in gardens and used in floral arrangements for interior decoration as well as making high quality bouquets (Lepcha et al., 2007).

Gladiolus is cultivated in most of the tropical and subtropical countries of the world. Its spikes takes 60 to 100 days after planting to be harvested depending upon the cultivars and time of year (Jenkins et al., 1970). The major gladiolus growing area in India are Kalimpong (West Bengal), New Delhi, Srinagar, Jammu & Kashmir, Pune, Ludhiana, Bengaluru and Uttarakhand.

This phenomenal growth of floriculture in India during the last couple of decade has led the world floriculture experts to visualize for country as major player in floriculture trade in future.

To enhance yield and quality of any flower crop various cultural management practices like good planting material, suitable time of planting, spacing, irrigation included plant protection measure are required. The planting material corm is important factor, which governs the growth and development of gladiolus. Plant growth regulators or phytohormones are organic substances produced naturally in higher plants, controlling growth or other physiological functions at a site remote from its Place of production and active in minute amounts. The application of plant growth regulators is one of the most important factors in improving the growth, yield and flower quality (Nuvale et al., 2010).

Gibberellic acids has an important role in different plant processes, including seed germination, stem elongation, leaf expansion and flower development (Olszewski et al., 2002) and was found highly effective for increasing the sprouting percentage of corm, increased cormel production and cormel size in gladiolus (Padmalatha et al., 2013).

Materials and Methods

An experiment was conducted at Horticulture Research Centre of Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut (UP) during the rabi season (October 2018-April 2019). The experiment was laid out in randomized block design (RBD) with 28 treatments in three replications. The growth regulators viz., GA₃, NAA and BA were used each at three different concentrations applied as corm dipping, foliar spraying and corm dipping + foliar spraying. A control of untreated corms was also maintained with three replications. The experimental field was prepared by repeated tractor plough followed by harrowing. Weeds and crop residue were removed and the land was levelled. Thus pulverized field was later divided into plots.

Irrigation channel, bunds and path were left around the experimental field according to the requirement. Analysis for estimation of growth and flowering characters was done.

Vegetative growth characters

Growth observations were measured at 30, 60, and 90, days after planting of corms. For getting the sharp results of following growth observations, four plants were selected in each plot mean values of the observations were expressed for representing of each treatment separately.

Days of sprouting

The days of sprouting of corms were recorded from the day after planting. The mean of the days of sprouting was obtain by some days of sprouting of four randomly selected plants and further average value was calculated.

Plant height (cm)

The height of the plant was measured from the soil surface to the tip of the longest leaves
with the help of meter scale at 30, 60 and 90 days after planting and their average was worked out.

**Number of leaves per plant**

The total number of leaves in four plants in each plot was counted at 30, 60, and 90 days after planting then average was worked out.

**Length of longest leaf (cm)**

The length of the longest leaf was measured with the help of meter scale of selected plants at 30, 60, and 90 days interval and average leaf length was calculated.

**Flowering characters**

The measure the flowering performance only those plants were observed in each plot, which were measured for the performance of vegetative growth. Here also mean values of the observations were expressed for representing of each treatment separately. The flowering observations recorded are as follows.

**Days required for visibility of first spike (Days)**

Days required for the visibility of first spike were counted from the date of planting of the corms.

**Days required for opening of first floret (Days)**

Days required for opening of first flower were counted from the date of planting of the corms.

**Number of florets per spike**

The numbers of florets per spike were counted and mean values were expressed.

**Diameter of floret (cm)**

The diameter of floret was measured with the help of vernier calipers and mean values were expressed in cm.

**Diameter of spike (cm)**

Diameter of spike was measured with the help of Vernier calipers and mean values were expressed in cm.

**Number of spikes per plant**

The number of the spikes per plant was counted and means values were expressed.

**Longevity of spike (Days)**

The longevity of spike was observed in the field. The data were recorded from first flower bud opening to last flower faded and mean values were expressed.

**Statistical analysis**

The experimental data were analyzed statistically by the techniques of analysis of variance described by Snedecor and Cochran (1967).

The significance of the treatments was tested with the help of “F” (variance ratio) test. Critical difference was calculated by the following formula.

\[
CD\ at\ 5% = \sqrt{2EMS} \cdot \frac{X}{t} \cdot \frac{t}{r}
\]

Where, \(CD = \) Critical difference

\(EMS = \) Error means sum of square

\(r = \) Number of replications

\(t = \) t value at 5% level of significance at error degree of freedom.
Results and Discussion

Vegetative growth characters

The data pertaining to the days of sprouting as presented in table 1 showed that the minimum days taken to sprouting of corms (10.28) were recorded under the treatments of GA$_3$ at 800ppm while maximum days taken to sprouting of corms (14.67) were recorded under the control. Similar results with the application of GA$_3$ have been also reported by Kirad et al., (2001), Sharma et al., (2006) and Kumar et al., (2009) in gladiolus.

Out of the growth regulating chemicals the maximum plant height (95.53 cm) was observed under the treatment GA$_3$ at 400ppm applied as corm dipping alone whereas, the minimum plant height i.e. (86.40 cm) was found under the control. This observation on increase in the plant height with the application of GA$_3$ are in agreement with the findings of Kirad et al., (2001), Prasad et al., (2002), Tawar et al., (2002) and Kumar et al., (2005) in gladiolus.

It is also clear from the data that maximum number of leaves per plant i.e. (5.66) were recorded under treatment of GA$_3$ at 400ppm applied as corm dipping alone whereas, the minimum number of leaves per plant (5.19) was recorded under control. The findings are in conformity with the observation of Kirad et al., (2001), Kumar et al., (2005) in gladiolus.

It is evident from the data that the significantly maximum length of the leaf per plant (57.23 cm) was recorded under the treatment GA$_3$ at 800ppm applied as corm dipping + foliar spraying whereas, the minimum length of the leaf was recorded to be (50.25 cm) under control. Similar increases in the length of the leaf with application of GA$_3$ have been also reported by Gaur et al., (2003), Rana et al., (2005) and Sharma et al., (2006) in gladiolus (Table 2–4).

Flowering characters

The data on days taken to the number of days required for the visibility of first spike from the date of planting of corms as presented in table 5 that the minimum days taken for visibility of first spike (86.54) were found under the treatment BA at 25ppm applied as foliar spraying followed and the maximum days taken for visibility of first spike (87.59) under the BA treatment at 100ppm applied as corm dipping + foliar spraying alone. Similar results on the visibility of first spike with the application of BA have been also reported by Mahesh and Misra (1993) in gladiolus. Significantly, minimum number of days taken to complete opening of first floret on the spike (89.71) noted under the GA$_3$ treatment at 800ppm applied as corm dipping + foliar spraying alone.

However, the maximum number of days taken to complete opening of first floret on the spike from the date of planting were observed to be (100.81) under the control. An early flowering in gladiolus with the application of GA$_3$ has been also reported by Ravidas et al., (1992), Kumar et al., (2008) and Chaudhry et al., (2018) in gladiolus (Table 6).

The data in the given table 7 clearly reveals that the maximum numbers of spikes per plant (1.080) were observed under the treatment GA$_3$ at 400ppm applied as foliar spraying and the minimum number of spikes per plant (1.017) was recorded under treatment BA at 100ppm applied as corm dipping alone.
Table 1 Effect of plant growth regulators on days taken to sprouting of corms in gladiolus cv. White Prosperity

| S. No. | Treatments                     | Days of sprouting |
|--------|-------------------------------|-------------------|
| 1.     | Control                        | 14.67             |
| 2.     | Corm dipping                   |                   |
| 3.     | GA<sub>3</sub> 200 ppm         | 11.34             |
| 4.     | GA<sub>3</sub> 400 ppm         | 11.33             |
| 5.     | GA<sub>3</sub> 800 ppm         | 10.28             |
| 6.     | NAA 200 ppm                   | 10.40             |
| 7.     | NAA 400 ppm                   | 10.78             |
| 8.     | NAA 600 ppm                   | 11.43             |
| 9.     | BA 25 ppm                     | 12.33             |
| 10.    | BA 50 ppm                     | 12.46             |
| 11.    | BA 100 ppm                    | 14.25             |
|        | Foliar spraying               |                   |
| 12.    | GA<sub>3</sub> 200 ppm         | 14.20             |
| 13.    | GA<sub>3</sub> 400 ppm         | 14.25             |
| 14.    | GA<sub>3</sub> 800 ppm         | 14.51             |
| 15.    | NAA 200 ppm                   | 14.51             |
| 16.    | NAA 400 ppm                   | 13.65             |
| 17.    | NAA 600 ppm                   | 14.23             |
| 18.    | BA 25 ppm                     | 14.20             |
| 19.    | BA 50 ppm                     | 14.44             |
| 20.    | BA 100 ppm                    | 13.45             |
|        | Corm dipping + foliar spraying |                   |
| 21.    | GA<sub>3</sub> 200 ppm         | 11.35             |
| 22.    | GA<sub>3</sub> 400 ppm         | 11.31             |
| 23.    | GA<sub>3</sub> 800 ppm         | 10.23             |
| 24.    | NAA 200 ppm                   | 10.38             |
| 25.    | NAA 400 ppm                   | 10.77             |
| 26.    | NAA 600 ppm                   | 11.46             |
| 27.    | BA 25 ppm                     | 12.46             |
| 28.    | BA 50 ppm                     | 12.51             |
| 29.    | BA 100 ppm                    | 14.22             |

C.D. at 5% SE(m)±

|        |                   | 0.17             |
|        |                   | 0.06             |
Table 2: Effect of plant growth regulators on plant height (cm) at different growth stages in *gladiolus* cv. White Prosperity

| S. No. | Treatments | Plant Height (cm) | 30 DAP | 60 DAP | 90 DAP |
|--------|------------|------------------|--------|--------|--------|
| 1      | Control    |                  | 40.40  | 60.61  | 86.40  |
|        | **Corm dipping** |               |        |        |        |
| 2      | GA$_3$ 200 ppm |                | 45.38  | 65.63  | 90.93  |
| 3      | GA$_3$ 400 ppm |                | 45.55  | 67.26  | 95.53  |
| 4      | GA$_3$ 800 ppm |                | 45.63  | 66.73  | 90.89  |
| 5      | NAA 200 ppm  |                  | 45.50  | 65.81  | 89.69  |
| 6      | NAA 400 ppm  |                  | 45.61  | 65.78  | 88.73  |
| 7      | NAA 600 ppm  |                  | 45.53  | 65.83  | 90.48  |
| 8      | BA 25 ppm    |                  | 45.63  | 68.84  | 90.83  |
| 9      | BA 50 ppm    |                  | 45.61  | 66.88  | 88.74  |
| 10     | BA 100 ppm   |                  | 45.66  | 66.80  | 88.90  |
|        | **Foliar Spraying** |           |        |        |        |
| 11     | GA$_3$ 200 ppm |                | 45.80  | 67.73  | 90.70  |
| 12     | GA$_3$ 400 ppm |                | 45.20  | 65.63  | 89.58  |
| 13     | GA$_3$ 800 ppm |                | 45.45  | 66.56  | 90.73  |
| 14     | NAA 200 ppm  |                  | 46.72  | 66.91  | 89.33  |
| 15     | NAA 400 ppm  |                  | 45.90  | 67.13  | 88.17  |
| 16     | NAA 600 ppm  |                  | 46.80  | 66.60  | 90.39  |
| 17     | BA 25 ppm    |                  | 46.63  | 67.26  | 87.69  |
| 18     | BA 50 ppm    |                  | 46.73  | 67.36  | 86.77  |
| 19     | BA 100 ppm   |                  | 46.35  | 67.81  | 90.72  |
|        | **Corm dipping + foliar spraying** |           |        |        |        |
| 20     | GA$_3$ 200 ppm |                | 46.45  | 69.21  | 91.43  |
| 21     | GA$_3$ 400 ppm |                | 46.53  | 69.30  | 90.39  |
| 22     | GA$_3$ 800 ppm |                | 46.62  | 68.82  | 90.70  |
| 23     | NAA 200 ppm  |                  | 46.85  | 69.25  | 92.60  |
| 24     | NAA 400 ppm  |                  | 47.62  | 70.17  | 92.95  |
| 25     | NAA 600 ppm  |                  | 46.42  | 70.20  | 90.56  |
| 26     | BA 25 ppm    |                  | 47.84  | 70.33  | 90.83  |
| 27     | BA 50 ppm    |                  | 46.85  | 70.35  | 89.34  |
| 28     | BA 100 ppm   |                  | 46.90  | 70.43  | 90.65  |

C.D. at 5%: 0.12, 0.22, 1.13

SE(m)±: 0.04, 0.07, 0.40
### Table 3: Effect of plant growth regulators on number of leaves per plant in gladiolus cv. White Prosperity

| S. No. | Treatments                        | Number of leaves per plant |
|--------|-----------------------------------|----------------------------|
|        |                                   | 30 DAP | 60 DAP | 90 DAP |
| 1.     | Control                           | 2.33   | 4.13   | 5.19   |
| 2.     | Corm dipping GA<sub>3</sub> 200 ppm | 2.67   | 4.52   | 5.47   |
| 3.     | Corm dipping GA<sub>3</sub> 400 ppm | 2.88   | 4.54   | 5.66   |
| 4.     | Corm dipping GA<sub>3</sub> 800 ppm | 2.96   | 4.56   | 5.37   |
| 5.     | Corm dipping NAA 200 ppm           | 2.64   | 4.56   | 5.30   |
| 6.     | Corm dipping NAA 400 ppm           | 2.67   | 4.90   | 5.62   |
| 7.     | Corm dipping NAA 600 ppm           | 2.68   | 4.96   | 5.38   |
| 8.     | Corm dipping BA 25 ppm             | 2.85   | 4.92   | 5.41   |
| 9.     | Corm dipping BA 50 ppm             | 2.94   | 4.91   | 5.30   |
| 10.    | Corm dipping BA 100 ppm            | 2.97   | 4.95   | 5.43   |
| 11.    | Foliar spraying GA<sub>3</sub> 200 ppm | 2.91   | 4.62   | 5.36   |
| 12.    | Foliar spraying GA<sub>3</sub> 400 ppm | 2.93   | 4.65   | 5.38   |
| 13.    | Foliar spraying GA<sub>3</sub> 800 ppm | 2.95   | 4.67   | 5.62   |
| 14.    | Foliar spraying NAA 200 ppm        | 2.95   | 4.93   | 5.60   |
| 15.    | Foliar spraying NAA 400 ppm        | 2.97   | 4.96   | 5.39   |
| 16.    | Foliar spraying NAA 600 ppm        | 2.97   | 4.98   | 5.37   |
| 17.    | Foliar spraying BA 25 ppm          | 2.85   | 4.95   | 5.25   |
| 18.    | Foliar spraying BA 50 ppm          | 2.92   | 4.95   | 5.24   |
| 19.    | Foliar spraying BA 100 ppm         | 2.95   | 4.96   | 5.34   |
| 20.    | Corm dipping + foliar spraying GA<sub>3</sub> 200 ppm | 2.96   | 4.55   | 5.40   |
| 21.    | Corm dipping + foliar spraying GA<sub>3</sub> 400 ppm | 2.98   | 4.60   | 5.44   |
| 22.    | Corm dipping + foliar spraying GA<sub>3</sub> 800 ppm | 2.95   | 4.63   | 5.30   |
| 23.    | Corm dipping + foliar spraying NAA 200 ppm | 2.87   | 4.50   | 5.40   |
| 24.    | Corm dipping + foliar spraying NAA 400 ppm | 2.90   | 4.53   | 5.50   |
| 25.    | Corm dipping + foliar spraying NAA 600 ppm | 2.93   | 4.59   | 5.56   |
| 26.    | Corm dipping + foliar spraying BA 25 ppm | 2.97   | 4.30   | 5.34   |
| 27.    | Corm dipping + foliar spraying BA 50 ppm | 2.98   | 4.35   | 5.64   |
| 28.    | Corm dipping + foliar spraying BA 100 ppm | 2.97   | 4.36   | 5.36   |
|        | C.D. at 5%                         | 0.026  | 0.047  | 0.041  |
|        | SE(m)±                             | 0.009  | 0.016  | 0.015  |
### Table 4: Effect of plant growth regulators on length of longest leaf (cm) in gladiolus cv. White Prosperity

| S. No. | Treatments                      | Length of longest leaf (cm) |
|--------|---------------------------------|----------------------------|
|        |                                 | 30 DAP | 60 DAP | 90 DAP |
| 1.     | Control                         | 25.17  | 43.40  | 50.25  |
|        | **Corm dipping**                |        |        |        |
| 2.     | GA₃ 200 ppm                     | 26.32  | 44.92  | 54.37  |
| 3.     | GA₃ 400 ppm                     | 26.38  | 44.81  | 55.79  |
| 4.     | GA₃ 800 ppm                     | 26.39  | 45.25  | 56.65  |
| 5.     | NAA 200 ppm                     | 25.73  | 44.28  | 53.38  |
| 6.     | NAA 400 ppm                     | 25.79  | 44.59  | 55.33  |
| 7.     | NAA 600 ppm                     | 25.81  | 44.63  | 55.20  |
| 8.     | BA 25 ppm                       | 25.84  | 44.89  | 53.72  |
| 9.     | BA 50 ppm                       | 25.87  | 44.92  | 55.42  |
| 10.    | BA 100 ppm                      | 25.92  | 44.95  | 53.73  |
|        | **Foliar spraying**             |        |        |        |
| 11.    | GA₃ 200 ppm                     | 26.17  | 44.92  | 54.45  |
| 12.    | GA₃ 400 ppm                     | 25.91  | 45.86  | 55.93  |
| 13.    | GA₃ 800 ppm                     | 26.15  | 45.93  | 56.83  |
| 14.    | NAA 200 ppm                     | 26.41  | 44.85  | 53.45  |
| 15.    | NAA 400 ppm                     | 26.50  | 45.95  | 55.95  |
| 16.    | NAA 600 ppm                     | 27.20  | 45.61  | 54.18  |
| 17.    | BA 25 ppm                       | 27.26  | 45.40  | 54.45  |
| 18.    | BA 50 ppm                       | 27.26  | 45.36  | 54.86  |
| 19.    | BA 100 ppm                      | 26.83  | 44.93  | 54.71  |
|        | **Corm dipping + foliar spraying** |         |        |        |
| 20.    | GA₃ 200 ppm                     | 26.13  | 45.46  | 55.20  |
| 21.    | GA₃ 400 ppm                     | 27.16  | 45.66  | 56.20  |
| 22.    | GA₃ 800 ppm                     | 27.15  | 45.76  | 57.23  |
| 23.    | NAA 200 ppm                     | 25.73  | 44.93  | 55.52  |
| 24.    | NAA 400 ppm                     | 25.84  | 45.21  | 55.93  |
| 25.    | NAA 600 ppm                     | 25.95  | 45.38  | 54.43  |
| 26.    | BA 25 ppm                       | 25.51  | 44.80  | 51.87  |
| 27.    | BA 50 ppm                       | 25.89  | 44.85  | 55.91  |
| 28.    | BA 100 ppm                      | 25.81  | 44.96  | 51.77  |
|        | **C.D. at 5%**                  | 0.06   | 0.17   | 3.18   |
|        | **SE(m)±**                      | 0.02   | 0.06   | 1.12   |
Table 5 Effect of plant growth regulators on days required for visibility of first spike in gladiolus cv. White Prosperity

| S. No. | Treatments                        | Days required for visibility of first spike (DAP) |
|--------|-----------------------------------|--------------------------------------------------|
| 1.     | Control                           | 87.93                                            |
|        | **Corm dipping**                   |                                                  |
| 2.     | GA<sub>3</sub> 200 ppm            | 83.57                                            |
| 3.     | GA<sub>3</sub> 400 ppm            | 82.40                                            |
| 4.     | GA<sub>3</sub> 800 ppm            | 81.73                                            |
| 5.     | NAA 200 ppm                       | 86.26                                            |
| 6.     | NAA 400 ppm                       | 86.45                                            |
| 7.     | NAA 600 ppm                       | 86.65                                            |
| 8.     | BA 25 ppm                         | 86.75                                            |
| 9.     | BA 50 ppm                         | 86.57                                            |
| 10.    | BA 100 ppm                        | 86.84                                            |
|        | **Foliar spraying**               |                                                  |
| 11.    | GA<sub>3</sub> 200 ppm            | 84.48                                            |
| 12.    | GA<sub>3</sub> 400 ppm            | 84.32                                            |
| 13.    | GA<sub>3</sub> 800 ppm            | 84.91                                            |
| 14.    | NAA 200 ppm                       | 86.64                                            |
| 15.    | NAA 400 ppm                       | 86.13                                            |
| 16.    | NAA 600 ppm                       | 86.61                                            |
| 17.    | BA 25 ppm                         | 86.54                                            |
| 18.    | BA 50 ppm                         | 86.67                                            |
| 19.    | BA 100 ppm                        | 86.86                                            |
|        | **Corm dipping + foliar spraying**|                                                  |
| 20.    | GA<sub>3</sub> 200 ppm            | 81.34                                            |
| 21.    | GA<sub>3</sub> 400 ppm            | 80.70                                            |
| 22.    | GA<sub>3</sub> 800 ppm            | 78.84                                            |
| 23.    | NAA 200 ppm                       | 85.92                                            |
| 24.    | NAA 400 ppm                       | 87.10                                            |
| 25.    | NAA 600 ppm                       | 87.27                                            |
| 26.    | BA 25 ppm                         | 87.34                                            |
| 27.    | BA 50 ppm                         | 87.33                                            |
| 28.    | BA 100 ppm                        | 87.59                                            |
|        | **C.D. at 5%**                    | 0.40                                             |
|        | **SE(m)±**                        | 0.14                                             |
Table 6 Effect of plant growth regulators on days required for opening of first floret in gladiolus cv. White Prosperity

| S. No. | Treatments                  | Days required for opening of first floret (DAP) |
|--------|-----------------------------|-----------------------------------------------|
| 1.     | Control                     | 100.81                                        |
|        | **Corm dipping**            |                                               |
| 2.     | GA$_3$ 200 ppm              | 98.37                                         |
| 3.     | GA$_3$ 400 ppm              | 97.47                                         |
| 4.     | GA$_3$ 800 ppm              | 90.67                                         |
| 5.     | NAA 200 ppm                 | 99.45                                         |
| 6.     | NAA 400 ppm                 | 99.34                                         |
| 7.     | NAA 600 ppm                 | 99.61                                         |
| 8.     | BA 25 ppm                   | 99.75                                         |
| 9.     | BA 50 ppm                   | 100.06                                        |
| 10.    | BA 100 ppm                  | 100.17                                        |
|        | **Foliar spraying**         |                                               |
| 11.    | GA$_3$ 200 ppm              | 96.55                                         |
| 12.    | GA$_3$ 400 ppm              | 96.28                                         |
| 13.    | GA$_3$ 800 ppm              | 96.81                                         |
| 14.    | NAA 200 ppm                 | 100.16                                        |
| 15.    | NAA 400 ppm                 | 99.62                                         |
| 16.    | NAA 600 ppm                 | 99.87                                         |
| 17.    | BA 25 ppm                   | 99.16                                         |
| 18.    | BA 50 ppm                   | 99.28                                         |
| 19.    | BA 100 ppm                  | 100.12                                        |
|        | **Corm dipping + foliar spraying** |                               |
| 20.    | GA$_3$ 200 ppm              | 96.56                                         |
| 21.    | GA$_3$ 400 ppm              | 90.65                                         |
| 22.    | GA$_3$ 800 ppm              | 89.71                                         |
| 23.    | NAA 200 ppm                 | 99.41                                         |
| 24.    | NAA 400 ppm                 | 100.16                                        |
| 25.    | NAA 600 ppm                 | 100.05                                        |
| 26.    | BA 25 ppm                   | 100.03                                        |
| 27.    | BA 50 ppm                   | 99.91                                         |
| 28.    | BA 100 ppm                  | 99.95                                         |
|        | **C.D. at 5%**              | 0.34                                          |
|        | **SE(m)±**                  | 0.12                                          |
Table 7 Effect of plant growth regulators on number of spike per plant in gladiolus cv. White Prosperity

| S. No. | Treatments                          | Number of spike per plant |
|-------|------------------------------------|---------------------------|
| 1.    | Control                            | 1.000                     |
| 2.    | Corm dipping                        |                           |
|       | GA<sub>3</sub> 200 ppm              | 1.023                     |
| 3.    | GA<sub>3</sub> 400 ppm              | 1.033                     |
| 4.    | GA<sub>3</sub> 800 ppm              | 1.043                     |
| 5.    | NAA 200 ppm                        | 1.040                     |
| 6.    | NAA 400 ppm                        | 1.047                     |
| 7.    | NAA 600 ppm                        | 1.043                     |
| 8.    | BA 25 ppm                          | 1.053                     |
| 9.    | BA 50 ppm                          | 1.060                     |
| 10.   | BA 100 ppm                         | 1.017                     |
| 11.   | Foliar spraying                     |                           |
|       | GA<sub>3</sub> 200 ppm              | 1.060                     |
| 12.   | GA<sub>3</sub> 400 ppm              | 1.080                     |
| 13.   | GA<sub>3</sub> 800 ppm              | 1.070                     |
| 14.   | NAA 200 ppm                        | 1.053                     |
| 15.   | NAA 400 ppm                        | 1.063                     |
| 16.   | NAA 600 ppm                        | 1.067                     |
| 17.   | BA 25 ppm                          | 1.030                     |
| 18.   | BA 50 ppm                          | 1.040                     |
| 19.   | BA 100 ppm                         | 1.050                     |
| 20.   | Corm dipping + foliar spraying      |                           |
|       | GA<sub>3</sub> 200 ppm              | 1.053                     |
| 21.   | GA<sub>3</sub> 400 ppm              | 1.013                     |
| 22.   | GA<sub>3</sub> 800 ppm              | 1.067                     |
| 23.   | NAA 200 ppm                        | 1.063                     |
| 24.   | NAA 400 ppm                        | 1.070                     |
| 25.   | NAA 600 ppm                        | 1.047                     |
| 26.   | BA 25 ppm                          | 1.050                     |
| 27.   | BA 50 ppm                          | 1.053                     |
| 28.   | BA 100 ppm                         | 1.050                     |
|       | C.D. at 5%                         | 0.029                     |
|       | SE(m)±                              | 0.010                     |
### Table 8: Effect of plant growth regulators on number of floret per spike in gladiolus cv. White Prosperity

| S. No. | Treatments                  | Number of floret per spike |
|--------|-----------------------------|----------------------------|
| 1.     | Control                     | 10.72                      |
| 2.     | Corm dipping                 |                            |
| 2.     | GA<sub>3</sub> 200 ppm      | 12.71                      |
| 3.     | GA<sub>3</sub> 400 ppm      | 13.27                      |
| 4.     | GA<sub>3</sub> 800 ppm      | 14.27                      |
| 5.     | NAA 200 ppm                 | 11.20                      |
| 6.     | NAA 400 ppm                 | 11.75                      |
| 7.     | NAA 600 ppm                 | 11.81                      |
| 8.     | Foliar spraying             |                            |
| 8.     | BA 25 ppm                   | 10.94                      |
| 9.     | BA 50 ppm                   | 10.83                      |
| 10.    | BA 100 ppm                  | 10.85                      |
| 11.    | Corm dipping + foliar spraying |                       |
| 11.    | GA<sub>3</sub> 200 ppm      | 11.51                      |
| 12.    | GA<sub>3</sub> 400 ppm      | 12.66                      |
| 13.    | GA<sub>3</sub> 800 ppm      | 13.65                      |
| 14.    | NAA 200 ppm                 | 11.33                      |
| 15.    | NAA 400 ppm                 | 11.30                      |
| 16.    | NAA 600 ppm                 | 11.48                      |
| 17.    | BA 25 ppm                   | 10.83                      |
| 18.    | BA 50 ppm                   | 10.88                      |
| 19.    | BA 100 ppm                  | 10.92                      |
| 20.    | Corm dipping + foliar spraying |                       |
| 20.    | GA<sub>3</sub> 200 ppm      | 11.37                      |
| 21.    | GA<sub>3</sub> 400 ppm      | 12.49                      |
| 22.    | GA<sub>3</sub> 800 ppm      | 11.34                      |
| 23.    | NAA 200 ppm                 | 11.75                      |
| 24.    | NAA 400 ppm                 | 11.73                      |
| 25.    | NAA 600 ppm                 | 11.83                      |
| 26.    | BA 25 ppm                   | 10.75                      |
| 27.    | BA 50 ppm                   | 10.82                      |
| 28.    | BA 100 ppm                  | 10.84                      |
|        | C.D. at 5%                  | 0.15                       |
|        | SE(m)±                       | 0.05                       |
Table 9 Effect of plant growth regulators on diameter of floret (cm) in gladiolus cv. White Prosperity

| S. No. | Treatments                        | Diameter of floret (cm) |
|--------|-----------------------------------|-------------------------|
| 1.     | Control                           | 11.25                   |
| 2.     | Corm dipping                       |                         |
| 3.     | GA<sub>3</sub> 200 ppm            | 11.86                   |
| 4.     | GA<sub>3</sub> 400 ppm            | 12.82                   |
| 5.     | GA<sub>3</sub> 800 ppm            | 11.54                   |
| 6.     | NAA 200 ppm                       | 11.41                   |
| 7.     | NAA 400 ppm                       | 11.45                   |
| 8.     | NAA 600 ppm                       | 11.31                   |
| 9.     | BA 25 ppm                         | 11.32                   |
| 10.    | BA 50 ppm                         | 11.37                   |
| 11.    | BA 100 ppm                        | 11.48                   |
| 12.    | Foliar spraying                    |                         |
| 13.    | GA<sub>3</sub> 200 ppm            | 11.67                   |
| 14.    | GA<sub>3</sub> 400 ppm            | 11.37                   |
| 15.    | GA<sub>3</sub> 800 ppm            | 11.54                   |
| 16.    | NAA 200 ppm                       | 11.60                   |
| 17.    | NAA 400 ppm                       | 11.65                   |
| 18.    | NAA 600 ppm                       | 11.58                   |
| 19.    | BA 25 ppm                         | 11.25                   |
| 20.    | BA 50 ppm                         | 11.32                   |
| 21.    | BA 100 ppm                        | 11.39                   |
| 22.    | Corm dipping + foliar spraying     |                         |
| 23.    | GA<sub>3</sub> 200 ppm            | 11.61                   |
| 24.    | GA<sub>3</sub> 400 ppm            | 11.78                   |
| 25.    | GA<sub>3</sub> 800 ppm            | 11.42                   |
| 26.    | NAA 200 ppm                       | 11.33                   |
| 27.    | NAA 400 ppm                       | 11.40                   |
| 28.    | NAA 600 ppm                       | 11.36                   |
|        | BA 25 ppm                         | 11.37                   |
|        | BA 50 ppm                         | 11.41                   |
|        | BA 100 ppm                        | 11.51                   |
|        | C.D. at 5%                         | 0.13                    |
|        | SE(m)±                             | 0.04                    |
Table 10  Effect of plant growth regulators on diameter of spike (cm) in gladiolus cv. White Prosperity

| S. No. | Treatments                      | Diameter of spike (cm) |
|--------|---------------------------------|------------------------|
| 1.     | Control                         | 0.800                  |
| 2.     | Corm dipping: GA3 200 ppm       | 0.867                  |
| 3.     | GA3 400 ppm                     | 0.887                  |
| 4.     | GA3 800 ppm                     | 0.837                  |
| 5.     | NAA 200 ppm                     | 0.827                  |
| 6.     | NAA 400 ppm                     | 0.853                  |
| 7.     | NAA 600 ppm                     | 0.867                  |
| 8.     | Foliar spraying: BA 25 ppm      | 0.883                  |
| 9.     | BA 50 ppm                       | 0.837                  |
| 10.    | BA 100 ppm                      | 0.853                  |
| 11.    | GA3 200 ppm                     | 0.853                  |
| 12.    | GA3 400 ppm                     | 0.863                  |
| 13.    | GA3 800 ppm                     | 0.837                  |
| 14.    | NAA 200 ppm                     | 0.863                  |
| 15.    | NAA 400 ppm                     | 0.880                  |
| 16.    | NAA 600 ppm                     | 0.870                  |
| 17.    | BA 25 ppm                       | 0.870                  |
| 18.    | BA 50 ppm                       | 0.857                  |
| 19.    | BA 100 ppm                      | 0.850                  |
| 20.    | Corm dipping + foliar spraying: GA3 200 ppm | 0.870 |
| 21.    | GA3 400 ppm                     | 0.867                  |
| 22.    | GA3 800 ppm                     | 0.843                  |
| 23.    | NAA 200 ppm                     | 0.847                  |
| 24.    | NAA 400 ppm                     | 0.850                  |
| 25.    | NAA 600 ppm                     | 0.873                  |
| 26.    | Corm dipping + foliar spraying: BA 25 ppm | 0.853 |
| 27.    | BA 50 ppm                       | 0.837                  |
| 28.    | BA 100 ppm                      | 0.843                  |
|        | C.D. at 5%                      | 0.029                  |
|        | SE(m)±                           | 0.010                  |
Table 11 Effect of plant growth regulators on longevity of spike (Days) in gladiolus cv. White Prosperity

| S. No. | Treatments                     | Longevity of spike (Days) |
|-------|-------------------------------|---------------------------|
| 1.    | Control                        | 12.95                     |
| 2.    | Corm dipping GA<sub>3</sub> 200 ppm | 15.49                     |
| 3.    | GA<sub>3</sub> 400 ppm        | 16.81                     |
| 4.    | GA<sub>3</sub> 800 ppm        | 17.48                     |
| 5.    | NAA 200 ppm                   | 13.59                     |
| 6.    | NAA 400 ppm                   | 14.26                     |
| 7.    | NAA 600 ppm                   | 14.27                     |
| 8.    | Foliar spraying BA 25 ppm     | 14.44                     |
| 9.    | BA 50 ppm                     | 15.44                     |
| 10.   | BA 100 ppm                    | 15.52                     |
| 11.   | GA<sub>3</sub> 200 ppm        | 15.25                     |
| 12.   | GA<sub>3</sub> 400 ppm        | 16.38                     |
| 13.   | GA<sub>3</sub> 800 ppm        | 15.87                     |
| 14.   | NAA 200 ppm                   | 13.92                     |
| 15.   | NAA 400 ppm                   | 14.71                     |
| 16.   | NAA 600 ppm                   | 15.86                     |
| 17.   | Foliar spraying BA 25 ppm     | 14.95                     |
| 18.   | BA 50 ppm                     | 15.36                     |
| 19.   | BA 100 ppm                    | 15.45                     |
| 20.   | Corm dipping + foliar spraying GA<sub>3</sub> 200 ppm | 14.92                     |
| 21.   | GA<sub>3</sub> 400 ppm        | 15.81                     |
| 22.   | GA<sub>3</sub> 800 ppm        | 16.37                     |
| 23.   | NAA 200 ppm                   | 13.69                     |
| 24.   | NAA 400 ppm                   | 14.72                     |
| 25.   | NAA 600 ppm                   | 15.49                     |
| 26.   | Corm dipping + foliar spraying BA 25 ppm | 15.11                     |
| 27.   | BA 50 ppm                     | 15.44                     |
| 28.   | BA 100 ppm                    | 15.52                     |
|       | C.D. at 5%                    | 0.25                      |
|       | SE(m)±                         | 0.08                      |

Similar results of a maximum number of spikes with foliar spraying has been also reported by Chopde et al., (2013) and Yadav and Bhatia (2018) in gladiolus. The data on the number of florets per spike as presented in table 8 showed that the maximum number of florets per spike (14.27) was observed under the treatment GA<sub>3</sub> at 800 ppm applied as corm dipping while the minimum number of spikes per plant (1.00) was obtained under the control. Similar increases in the number of florets with the application of GA<sub>3</sub> have been also reported by Prasad et al.,
The diameter of florets (11.25cm) was noted significantly lower (11.86 cm) under control. Out of growth regulators treatments, the significantly greater diameter of florets (12.82cm) was observed under the treatments GA$_3$ at 400ppm applied as corm dipping alone. These results are in close conformity with the findings of Ram et al., (2001), Aier et al., (2015) and Chaudhray et al., (2018) in gladiolus.

It is evident from the data that the diameter of spike (0.800cm) was registered minimum under the control while the maximum diameter of the spike (0.887cm) was found under the treatment GA$_3$ at 400ppm concentration applied as corm dipping alone. The similar results have been also reported by Attia et al., (2001) and Chopde et al., (2013) in gladiolus.

The longevity of (12.95 days) was recorded under control. Out of the growth regulating chemicals (Table 11), the significantly maximum longevity of spike (17.48 days) was obtained under the treatment of GA$_3$ at 800ppm concentration applied as corm dipping alone. The favorable effects of GA$_3$ application in promoting the longevity of whole spike have also been reported by Ram et al., (2001), Gaur et al., (2003) and Kumar and Singh (2005) in gladiolus.

On the basis of above finding, it can be concluded that GA$_3$ at 400 ppm or 800 ppm concentration was significantly superior to other treatments in improving the growth, days of sprouting, plant height, length of longest leaf, number of days required for visibility of first spike, days required for opening of first floret, diameter of spike, number of florets per spike, diameter of floret, longevity of spike. NAA at 200, 400 and 600 ppm increases the number of leaves per plant, plant height. When the different treatments of application were compared, it was found that corm dipping + foliar spraying treatment was significantly superior to other treatments.

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