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Effect of exogenous application of Sodium Nitroprusside (SNP) and Gibberellic Acid (GA_3) on growth and flowering of Dahlia (*Dahlia variabilis* L.) CV. Kenya

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ABSTRACT: Dahlias (*Dahlia variabilis*) are popular ornamental plants cultivated in many countries which characterized by the rich variety, different forms and attractive flower colors. The present investigation was conducted to study the effect of Sodium Nitroprusside and Gibberellic acid on the growth and flowering of Dahlia cv. Kenya. During two successive season 2021-22 and 2022-23. Different concentration viz. 100 ppm, 150 ppm and 200 ppm of SNP and GA_3 as a foliar spray were used. Result indicated that tallest plant (121.54 cm) was those sprayed with GA_3 at 200mgL^{-1}. Additionally, it showed that foliar application of GA_3 at 200mgL^{-1} significantly increased the number of branches per plant (12.50), Plant Spread (98.72 cm), number of flowers per plant (15.00), stalk length (19.90 cm) and number of tubers (11.00) while maximum stem diameter (15.67 mm) and highest tuber yield per plant was recorded in GA_3 100 ppm and GA_3 150 ppm respectively. The most rapid flower bud initiation (50.21 days after planting) and days to 50% flowering (75.21 days) occurred when plants were sprayed with GA_3 at 200mgL1. SNP gives better result compared than control but Ga3 more improved the all attributes of dahlia plant. In conclusion, the vegetative flowering and yield characters of dahlia could be improved by application of either GA_3.

Keywords: *Dahlia variabilis*, GA_3, SNP, Morphological parameters, Foliar spray.

INTRODUCTION

Dahlia is a genus of flowering plants in the Asteraceae family, which includes other well-known plants such as sunflowers and daisies. They are native to the mountainous regions of Mexico, Central America, and Colombia (Pandey *et al.*, 2017). Dahlias are renowned for their stunning and diverse range of flower shapes, sizes, and colors, making them popular choices among gardeners and florists worldwide. The flowers can be as small as a few centimeters or as large as dinner plates, and their colors span the entire spectrum, from vibrant reds, oranges, and yellows to softer pastels, pinks, and whites (Khuriwal *et al.*, 2018). GA_3 (Gibberellic Acid) and SNP (Sodium Nitroprusside) play significant roles in influencing flower growth and yield in plants. GA_3, a natural plant hormone, promotes cell division, elongation, and reproductive development. Its application can lead to increased plant height, extended flowering periods, and enhanced flower production, thereby potentially boosting overall yield. However, it is crucial to apply GA_3 judiciously as excessive use may result in adverse effects on flower quality and growth patterns (Elsadek, 2018). On the other hand, SNP acts as a nitric oxide releaser, regulating various physiological processes in plants. Nitric oxide plays a vital role in flower formation and development. When applied appropriately, SNP can positively impact flower growth and yield. It influences the expression of genes involved in flower development and reproductive processes, leading to improved flower quality, increased flower quantity per plant.

However, the research on dahlia is limited. Plant growth regulators (PGRs) refer to artificially synthesised organic chemicals employed for the purpose of altering the growth of entire plants or specific plant parts. The components of a plant. Photosynthesis is responsible for providing carbon and respiration energy to facilitate plant growth. However, plants also create a class of compounds called plant growth regulators, which play a crucial role in regulating the growth and development of plants. In minute concentrations, these chemicals exert an influence on several physiological processes in

plants. They have the ability to either enhance or inhibit the growth of plants. Plant growth regulators (PGRs) are occasionally misconstrued as plant hormones, however there exist distinct dissimilarities between the two. The agrochemical sector employs the word PGRs specifically to refer to artificially produced plant growth regulators (Kumar *et al.*, 2022).

Although dahlia cultivation can be a significant option for the marketing of ornamental plants in India, it is one of the least studied and comprehended flowers. Considering the commercial significance of this, high-value plant and associated problem with this plant, to determine the optimal GA3 and SNP concentration for enhancing production, quality and the time of maximal vegetative and flowering growth. The investigation was conducted.

MATERIAL AND METHOD

A field experiment was carried out at the Horticultural Research Centre (HRC) of Sardar Vallabhbhai Patel University of Agriculture & Technology (SVPUA&T), Modipuram, Meerut, Uttar Pradesh, during two successive seasons 2021/22 and 2022/23 to study the effect of foliar pray of different concentrations of SNP and GA_3 as 100, 150 and 200 ppm compared with control on different vegetative, flowering and tuber yield parameter viz. Plant height, No. of branches, Plant spread, days taken for first flower bud initiation, days to 50% flowering, Number of flowers per plant, Stem diameter, stalk length (cm), no. of tubers per plants, tuber yield per plant of Dahlia.

Foliar spray of SNP and GA_3 was applied thrice after 30 days after planting ad repeated 2 times with 2 weeks intervals at early morning in both season. The control plants were not sprayed with PGRs. Dahlia tubers were cultivated in the field on the October month with P X P and R X R spacing of 45 and 60 cm respectively.

RESULT AND DISCUSSION

Effect of different treatments on morphological parameter of dahlia plant

During both season it was observed that the increments in all morphological parameters were often highly significant in comparison with control plants. The most effective treatments were the foliar spray of GA_3 as compared with SNP.

Plant Height. The plant height was slightly improved in the second year i.e., 2022-23 followed by the previous year i.e. 2021-22. In 2021, the results demonstrated that the treatment with GA_3 at a concentration of 200 ppm resulted in the maximum plant height of 115.65 cm, followed by the treatment with GA_3 at 100 ppm (107.32 cm), while the control condition had the lowest height of 75.67 cm. Similarly, in 2022, the treatment with GA_3 at 200 ppm exhibited the highest plant height of 121.54 cm, followed by the treatment with GA_3 at 100 ppm (110.43 cm), with the control condition having the lowest height of 77.58 cm as shown in Table 1.

Based on pool data, average maximum height of plant (118.60 cm) was noted with treatment GA_3 at 200 ppm while the average minimum height of plant recorded in control 76.63cm. Furthermore, increasing the concentration of GA_3 from 100mgL−1 to 200mgL−1 resulted in improved plant height these findings are consistent with the observations made by Sajid *et al.*, (2016) in *Chrysanthemum morifolium*, Elsadek (2018), Kumar *et al.* (2022), and Kumar *et al.*, (2020) in dahlia and Marigold (*Tagetes erecta* L.), respectively.

Number of branches/ plants. As shown in Table 2, in the year 2021, the treatment with GA_3 (Gibberellic Acid) at 200 ppm resulted in the maximum number of branches per plant (12.50 branches), followed by the treatments with GA_3 at 100 ppm and GA_3 at 150 ppm, which yielded 10.24 and 8.4 branches, respectively. In contrast, the control group showed the lowest number of branches per plant (5.97 branches). Similarly, in the year 2022, the plants treated with GA_3 at 200 ppm displayed the highest number of branches per plant (11.31 branches), followed by the treatment with GA_3 at 100 ppm, which resulted in 9.78 branches. The control group exhibited the minimum number of branches per plant (5.84 branches). Based on pool data average maximum number of branches per plant (11.91) were noted with treatment GA_3 200 ppm while the average minimum number of branches per plant recorded in control 5.91. Kumar *et al.* (2022) also reported that number of branches per plants maximum in PGRs spray as compared to control in dahlia.

Table 1: Effect of foliar spray of different concentration of GA_3 and SNP plant growth regulator on Plant height of Dahlia plant.

Treatment	1st year (21/22)	2nd Year (22/23)	Mean
CONT	75.67±3.78^{a}	77.58±3.88^{a}	76.63±3.84^{a}
GA_3 100	107.32±4.29^{de}	110.43±4.42^{de}	108.88±4.36^{de}
GA_3 150	98.53±5.91^{cd}	102.57±6.15^{cd}	100.55±6.03^{cd}
GA_3 200	115.65±9.25^{e}	121.54±9.72^{e}	118.60±9.49^{e}
SNP100	87.24±2.62^{abc}	91.70±2.75^{abc}	89.47±2.68^{abc}
SNP150	82.65±3.31^{ab}	86.07±3.44^{ab}	84.36±3.37^{ab}
SNP200	92.78±4.64^{bc}	95.12±4.76^{bc}	93.95±4.700^{bc}
SE(m)	**3.05**	**3.25**	**3.15**
C.D.	**10.171**	**10.594**	**10.381**
C.V.	**5.99**	**6.01**	**6.00**

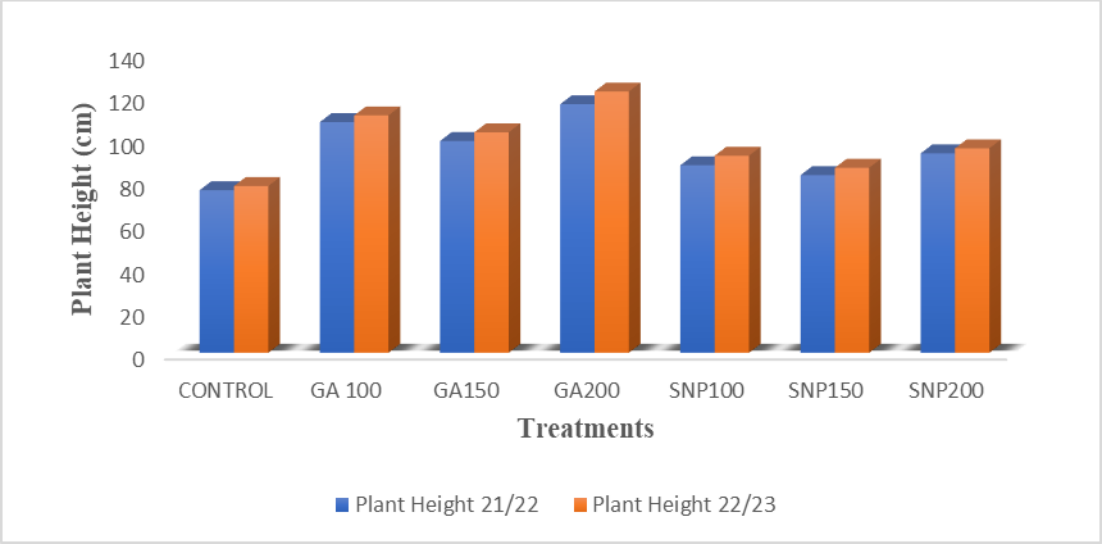

Fig. 1. Graph represent of foliar spray of different concentration of GA_3 and SNP plant growth regulator on Plant height of Dahlia plant.

Table 2: Effect of foliar spray of different concentration of GA_3 and SNP plant growth regulator on Number of branches.

Treatment	1st year (21/22)	2nd Year (22/23)	Mean
CONT	5.97±0.30^{a}	5.84±0.29^{a}	5.91±0.30^{a}
GA_3 100	10.24±0.41^{c}	9.78±0.39^{d}	10.01±0.40^{d}
GA_3 150	8.40±0.50^{b}	8.76±0.53^{cd}	8.58±0.51^{c}
GA_3 200	12.50±1.00^{d}	11.31±0.90^{e}	11.91±0.96$_{e}$
SNP100	6.67±0.20^{a}	7.27±0.22^{b}	6.97±0.21^{ab}
SNP150	6.21±0.25^{a}	6.90±0.28^{ab}	6.56±0.27^{ab}
SNP200	7.32±0.37^{ab}	8.20±0.41^{bc}	7.76±0.39^{bc}
SE(m)	**0.506**	**0.393**	**0.446**
C.D.	**0.962**	**0.932**	**0.948**
C.V.	**6.532**	**6.248**	**6.393**

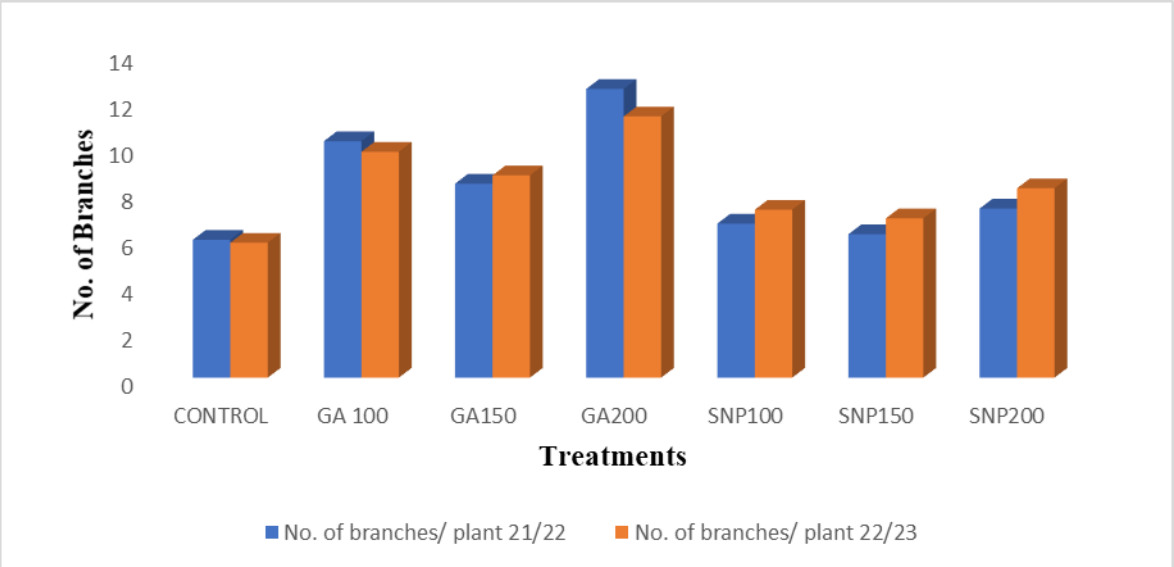

Fig. 2. Graph represent of foliar spray of different concentration of GA_3 and SNP plant growth regulator on Number of branches.

Plant Spread. In the year 2021, it was observed that the plants treated with GA_3 (Gibberellic Acid) at 200 ppm exhibited the highest plant spread of 98.72 cm, followed by the treatments with GA_3 at 100 ppm and GA_3 at 150 ppm, which recorded plant spreads of 91.05 cm and 87.63 cm, respectively. Conversely, the plants in the control group displayed the lowest plant spread of 58.01 cm. Similarly, in the year 2022, the plants treated with

GA_3 at 200 ppm demonstrated the maximum plant spread of 95.34 cm, followed by the treatment with GA_3 at 100 ppm, which resulted in a plant spread of 93.21 cm. The control group, once again, exhibited the minimum plant spread of 60.26 cm (Table 3). Based on pool data, average maximum plant spread (96.19) were noted with treatment GA_3 200 ppm while the average minimum plant spread recorded in control 59.70. Furthermore, increasing the concentration of GA_3 from 100mgL^{-1} to 200mgL^{-1} resulted in improved plant spread these findings are consistent with the observations made by Sajid *et al.,* (2016) in *Chrysanthemum morifolium*, Elsadek (2018), Kumar *et al.,* (2022), and Kumar *et al.,* (2020) in dahlia and Marigold (*Tagetes erecta* L.), respectively.

Days taken to 1st flower bud initiation. As shown in Table 4, In 2021, the control group took the longest time for the first flower bud initiation, with a duration of 69.75 days. Conversely, the treatment involving Gibberellic Acid (GA_3) at 200 ppm exhibited the shortest duration of 50.21 days followed by GA_3 at 100 ppm and GA_3 at 150 ppm resulted in first flower bud initiation taking 53.98 days and 56.81 days, respectively. Similarly, in 2022, the plants treated with GA_3 at 200 ppm displayed the shortest duration for first flower bud initiation, requiring only 52.32 days. The treatment with GA_3 at 100 ppm followed closely with a duration of 56.72 days. On the other hand, the control group demonstrated the longest time for first flower bud initiation, with a duration of 70.1 days.

In pool data average minimum days taken to first flower bud initiation (51.27 days) were noted with treatment GA_3 at 200 ppm while the average maximum days (69.93 days) were recorded in control. Similar finding observed by Kumar *et al.,* 2022 in dahlia plant in which 1st flower bud initiation maximum in control treatment as compared to PGRs spray.

Days to 50 % flowering. In the year 2021, the GA_3 at 200 ppm showed the maximum number of days (94.75 days) taken to achieve 50% flowering, whereas the control exhibited the minimum number of days (75.21 days). The treatments with GA_3 at 100 ppm and GA_3 at 150 ppm resulted in 78.98 days and 81.81 days, respectively, for reaching 50% flowering. Similarly, in the year 2022, the plants treated with GA_3 at 200 ppm demonstrated the Maximum number of days to 50% flowering (95.10 days), followed by the treatment with GA_3 at 100 ppm, which took 81.72 days. The control group exhibited the minimum number of days to 50% flowering (77.32 days) as presented in Table 5. Based on pool data, average maximum number of days to 50% flowering (94.93) were noted with GA_3 at 200 ppm while the average minimum number of days to 50% flowering recorded in control.

Table 3: **Effect of foliar spray of different concentration of GA_3 and SNP plant growth regulator on plant spread.**

Treatment	1st year (21/22)	2nd Year (22/23)	Mean
CONT	58.01±2.90^{a}	60.26±3.01^{a}	59.70±2.99^{a}
GA_3 100	91.05±3.64^{de}	93.21±3.73^{d}	92.67±3.71^{de}
GA_3 150	87.63±5.26^{cde}	89.28±5.36^{cd}	88.87±5.33^{cde}
GA_3 200	98.72±7.90^{e}	95.34±7.63^{d}	96.19±7.70^{e}
SNP100	75.63±2.27^{bc}	77.83±2.33^{bc}	77.28±2.32^{bc}
SNP150	68.43±2.74^{ab}	72.09±2.88^{ab}	71.18±2.85^{ab}
SNP200	82.24±4.11^{cd}	80.63±4.03^{bc}	81.03±4.05^{bcd}
SE(m)	**3.007**	**2.72**	**2.785**
C.D.	**8.718**	**8.678**	**8.696**
C.V.	**6.040**	**5.393**	**5.988**

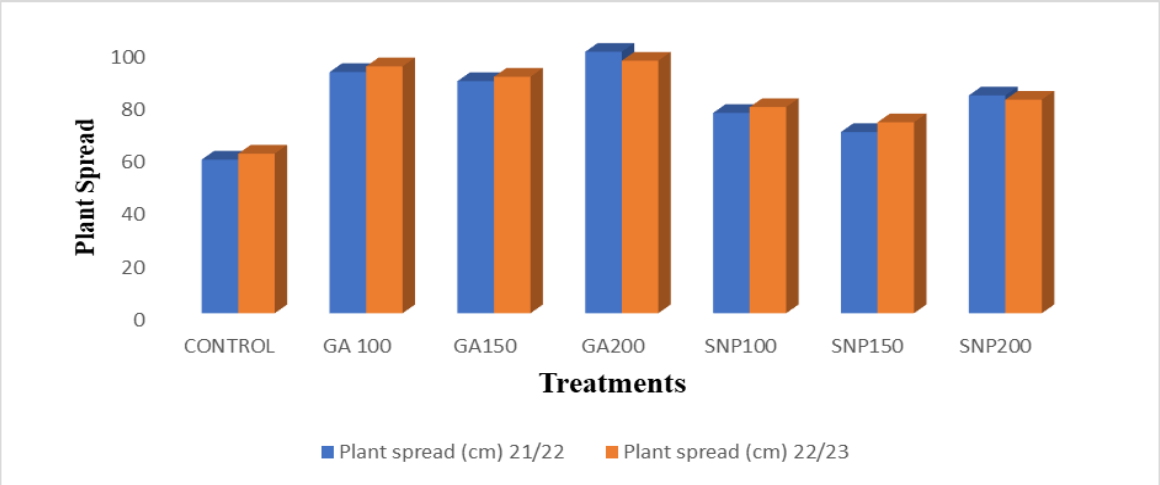

Fig. 3. Graph represent of foliar spray of different concentration of GA_3 and SNP plant growth regulator on plant spread.

The number of days required for flowering is an important parameter for flowering plants. The application of GA_3 was found to accelerate flower bud development in *Ajania pacifica* (Zalewska and Antkowiak 2013). There are two proposed explanations for the early flowering observed in plants treated with GA_3 and SNP. Firstly, it may be due to a decrease in the concentration of ABA (abscisic acid) in shoots (Phengphachanh *et al.,* 2012). Secondly, these growth regulators likely play a crucial role in the production and regulation of floral stimuli. Many authors have supported our findings that GA_3 promotes early flowering, such as Jaleel *et al.,* (2007) in *Catharanthus roseus* and Gomathinayagam *et al.,* (2009) in *Andrographis paniculata.* Chandel *et al.,* 2023 also reported maximum Days taken to flowering in control treatment as compared to different concentration of GA_3 in lily flowering plant.

Table 4: **Effect of foliar spray of different concentration of GA_3 and SNP plant growth regulator on plant spread on Days taken to 1st flower bud.**

Treatment	1st year (21/22)	2nd Year (22/23)	Mean
CONT	69.75±3.49^{d}	70.10±3.51^{d}	69.93±3.50^{d}
GA_3 100	53.98±2.16^{ab}	56.72±2.27^{ab}	55.35±2.21^{ab}
GA_3 150	56.81±3.41^{ab}	57.2±3.43^{ab}	57.01±3.43^{ab}
GA_3 200	50.21±4.02^{a}	52.32±4.19^{a}	51.27±4.11^{a}
SNP100	61.24±1.84^{bc}	63.21±1.9^{bcd}	62.23±1.87^{bcd}
SNP150	65.82±2.63^{cd}	66.05±2.64^{cd}	65.94±2.64^{cd}
SNP200	59.02±2.95^{bc}	58.72±2.94^{abc}	58.87±2.94^{abc}
SE(m)	**1.499**	**1.387**	**1.439**
C.D.	**5.838**	**5.948**	**5.890**
C.V.	**5.450**	**5.455**	**5.450**

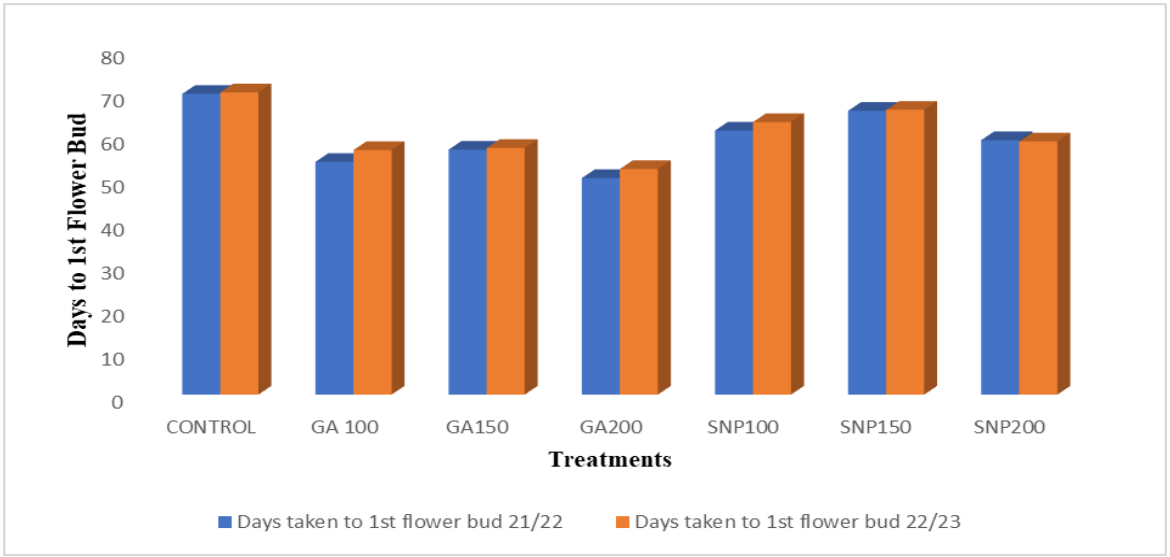

Fig. 4. Graph represent of foliar spray of different concentration of GA_3 and SNP plant growth regulator on plant spread on Days taken to 1st flower bud.

Table 5: Effect of foliar spray of different concentration of GA_3 and SNP plant growth regulator on days to 50 % flowering.

Treatment	1st year (21/22)	2nd Year (22/23)	Mean
CONT	94.75±4.74^{c}	95.10±4.76^{c}	94.93±4.75^{c}
GA_3 100	78.98±3.16^{ab}	81.72±3.27^{ab}	80.35±3.21^{ab}
GA_3 150	81.81±4.91^{ab}	82.20±4.93^{ab}	82.01±4.93^{ab}
GA_3 200	75.21±6.02^{a}	77.32±6.19^{a}	76.27±6.11^{a}
SNP100	86.24±2.59^{abc}	88.21±2.65^{abc}	87.23±2.62^{abc}
SNP150	90.82±3.63^{bc}	91.05±3.64^{bc}	90.94±3.64^{bc}
SNP200	84.02±4.20^{abc}	83.72±4.19^{abc}	83.87±4.19^{bc}
SE(m)	**1.601**	**1.499**	**1.546**
C.D.	**8.362**	**8.474**	**8.415**
C.V.	**5.498**	**5.502**	**5.499**

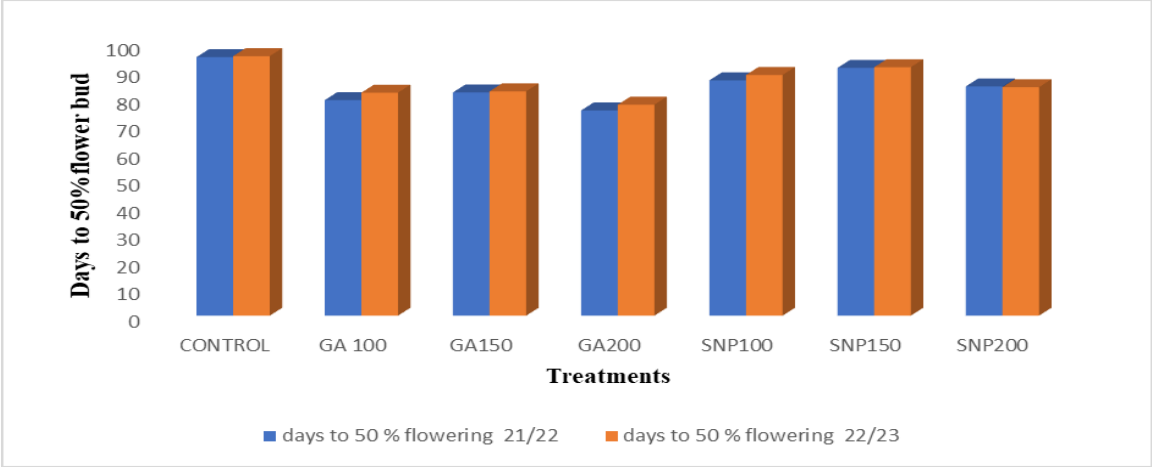

Fig. 5. Graph represent of foliar spray of different concentration of GA_3 and SNP plant growth regulator on plant spread on Days to 50% flower bud initiation.

Flowers per plant. In the year 2021, the treatment with GA_3 (Gibberellic Acid) at 200 ppm resulted in the highest production of Flowers per plant (15 flowers), followed by the treatments with GA_3 at 100 ppm and GA_3 at 150 ppm, which yielded 12.74 and 10.9 Flowers, respectively. In contrast, the control group showed the lowest number of flowers per plant (6.82 flowers). Similarly, in the year 2022, the plants treated with GA at 200 ppm displayed the highest number of Flowers per plant (14.31 flowers), followed by the treatment with GA_3 at 100 ppm, which resulted in 12.78 flowers. The control group exhibited the minimum number of flowers per plant (8.5 flowers).

Based on pool data, average maximum Flowers per plant (14.66) were noted with treatment GA_3 200 ppm while the average minimum Flowers per plant recorded in control 7.66 (Table 6). The application of GA_3 and SNP resulted in an increased number of flowers, potentially attributed to an increase in the number of leaves and leaf area compared to the control. This increase in leaf production and area likely enhanced photosynthesis, leading to a greater allocation of resources to flower production (Sharifuzzaman *et al.,* 2011). Kumar *et al.,* (2012) observed a significant increase in the number of flowers in carnation plants treated with GA_3 at a concentration of 150 mgL. Similarly, Elsadek (2018) found that increasing the concentration of GA_3 in dahlia resulted in the highest number of flowers compared to the control.

Stem diameter (mm). Table 7 presented that, in the year 2021, the treatment with GA_3 (Gibberellic Acid) at 100 ppm resulted in the maximum stem diameter (15.23 mm), followed by the treatments with GA_3 at 200 ppm and GA_3 at 150 ppm, which yielded 13.42 and 10.21 mm, respectively. In contrast, the control group showed the minimum stem diameter (8.56 mm). Similarly, in the year 2022, the plants treated with GA_3 at 100 ppm displayed the maximum stem diameter (15.67 mm), followed by the treatment with GA_3 at 200 ppm, which resulted in 14.81 mm and the control show the minimum stem diameter (9.02 mm).Based on pool data, average maximum stem diameter (15.45mm) were noted with treatment GA_3 100 ppm while the average minimum stem diameter recorded in control 8.79 mm. Naiga, 2023 showed that different concentration of GA3 on *Veronica cultivars* showed maximum stem diameter as compared to control.

Table 6: **Effect of foliar spray of different concentration of GA_3 and SNP plant growth regulator on Flowers per plant.**

Treatment	1st year (21/22)	2nd Year (22/23)	Mean
CONT	6.82 ± 0.34^{a}	8.50 ± 0.43^{a}	7.66 ± 0.38^{a}
GA_3 100	12.74 ± 0.51^{d}	12.78 ± 0.51^{de}	12.76 ± 0.51^{d}
GA_3 150	10.9 ± 0.65^{c}	11.76 ± 0.71^{cd}	11.33 ± 0.68^{cd}
GA_3 200	15.00 ± 1.20^{e}	14.31 ± 1.14^{e}	14.66 ± 1.18^{e}
SNP100	9.17 ± 0.28^{b}	10.27 ± 0.31^{abc}	9.72 ± 0.29^{bc}
SNP150	8.71 ± 0.35^{b}	9.90 ± 0.40^{ab}	9.31 ± 0.38^{ab}
SNP200	9.82 ± 0.49^{bc}	11.20 ± 0.56^{bcd}	10.51 ± 0.53^{bc}
SE(m)	**0.547**	**0.415**	**0.493**
C.D.	**1.196**	**1.230**	**1.214**
C.V.	**6.363**	**6.078**	**6.223**

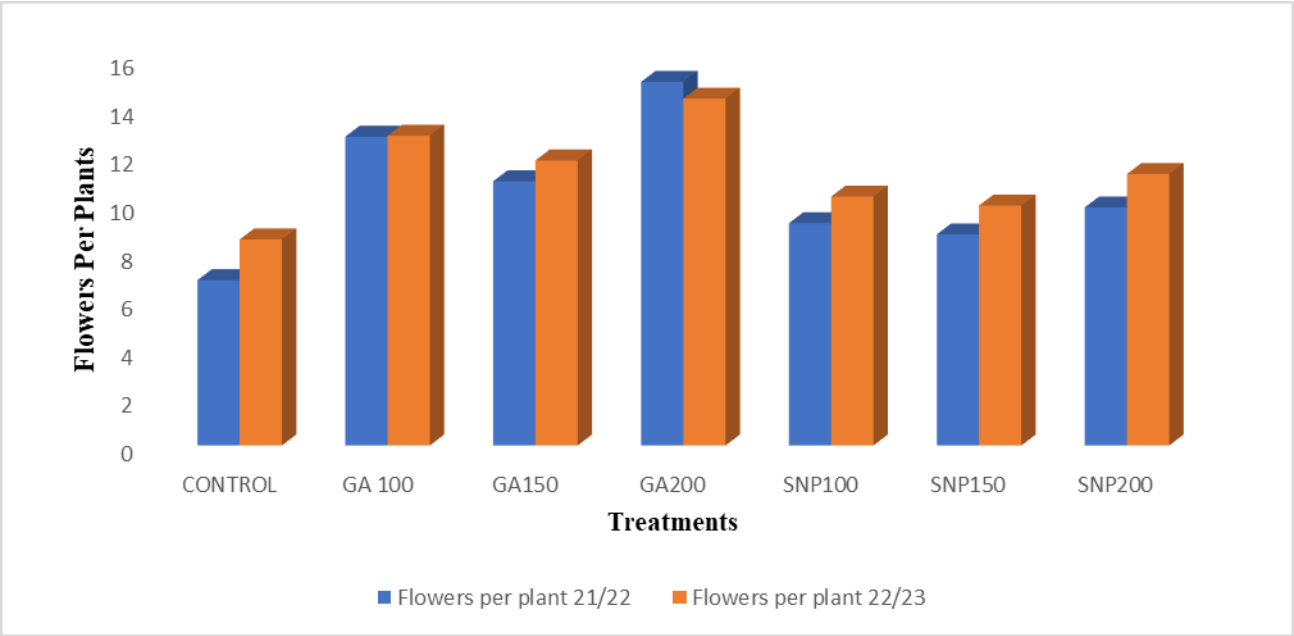

Fig. 6. Graph represent of foliar spray of different concentration of GA_3 and SNP plant growth regulator on Flowers per plant.

Table 7: Effect of foliar spray of different concentration of GA_3 and SNP plant growth regulator on Stem diameter (mm).

Treatment	1st year (21/22)	2nd Year (22/23)	Mean
CONT	8.56±0.43^{a}	9.02±0.45^{a}	8.79±0.44^{a}
GA_3 100	15.23±0.61^{d}	15.67±0.63^{d}	15.45±0.62^{d}
GA_3 150	10.21±0.61^{ab}	11.82±0.71^{bc}	11.02±0.67^{bc}
GA_3 200	13.42±1.07^{c}	14.81±1.18^{d}	14.12±1.13^{d}
SNP100	9.91±0.30^{a}	10.21±0.31^{ab}	10.06±0.30^{ab}
SNP150	9.32±0.37^{a}	10.02±0.4^{ab}	9.67±0.39^{ab}
SNP200	11.87±0.59^{bc}	12.42±0.62^{c}	12.15±0.61^{c}
SE(m)	**0.51**	**0.532**	**0.519**
C.D.	**1.191**	**1.297**	**1.245**
C.V.	**5.904**	**6.010**	**5.965**

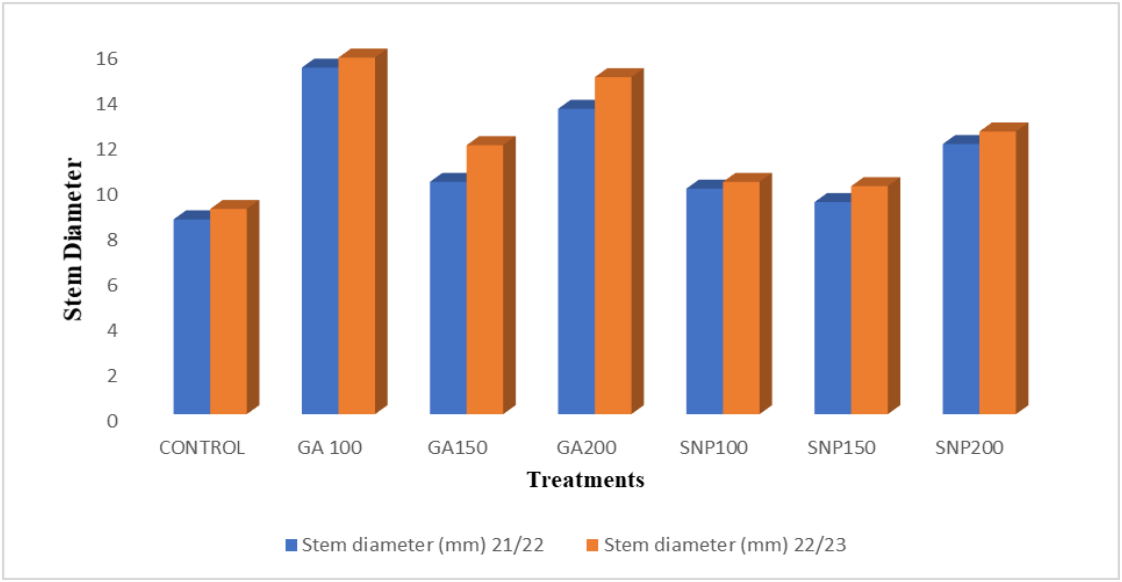

Fig. 7. Graph represent of foliar spray of different concentration of GA_3 and SNP plant growth regulator on Stem diameter (mm).

Table 8: Effect of foliar spray of different concentration of GA_3 and SNP plant growth regulator on Stalk length.

Treatment	1st year (21/22)	2nd Year (22/23)	Mean
CONT	10.20±0.51[a]	10.90±0.55[a]	10.55±0.53[a]
GA_3 100	20.40±0.82[d]	21.20±0.85[d]	20.80±0.83[d]
GA_3 150	16.50±0.99[b]	18.00±1.08[bc]	17.25±1.04[bc]
GA_3 200	19.00±1.52[cd]	19.90±1.59[cd]	19.45±1.56[cd]
SNP100	15.20±0.46[b]	15.80±0.47[b]	15.50±0.47[b]
SNP150	12.40±0.50[a]	13.20±0.53[a]	12.80±0.51[a]
SNP200	17.00±0.85[bc]	18.00±0.90[bc]	17.50±0.88b[c]
SE(m)	**0.756**	**0.777**	**0.766**
C.D.	**1.705**	**1.800**	**1.752**
C.V.	**5.994**	**5.989**	**5.988**

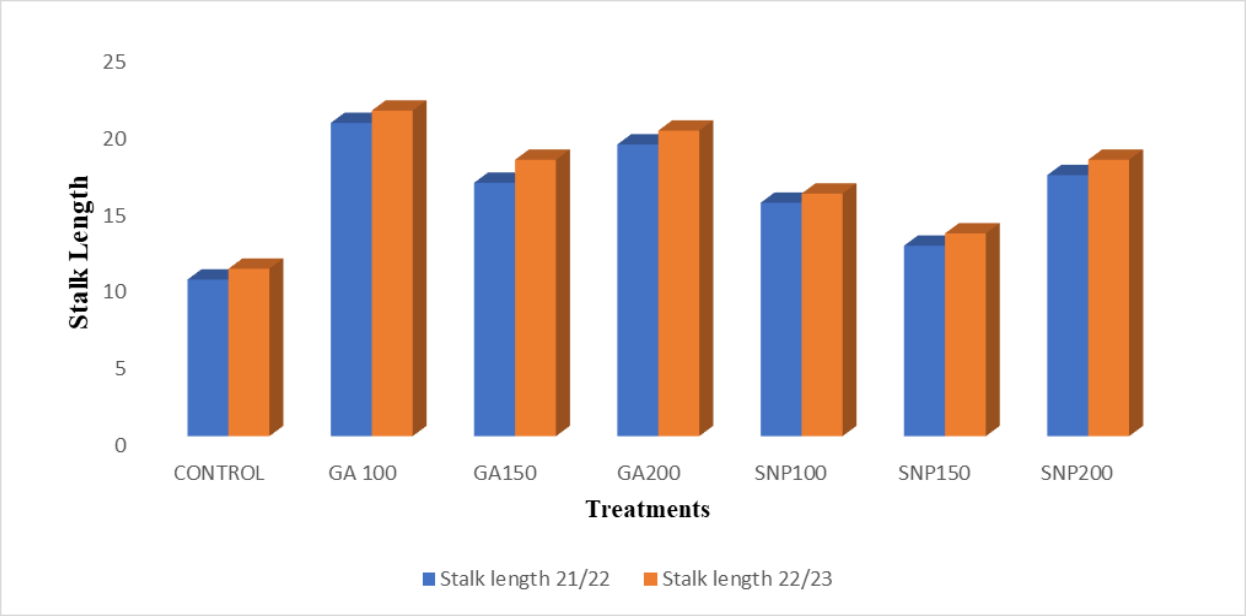

Fig. 8. Graph represent of foliar spray of different concentration of GA_3 and SNP plant growth regulator on Stalk length.

Stalk length (cm). In the year 2021, the treatment with GA (Gibberellic Acid) at 100 ppm resulted in the maximum Stalk Length (20.4 cm), followed by the treatments with GA at 200 ppm and GA at 150 ppm, which yielded 19.0 and 16.5 cm, respectively. In contrast, the control group showed the minimum Stalk Length (10.2 cm). Similarly, in the year 2022, the plants treated with GA at 100 ppm displayed the maximum Stalk Length (21.2 cm), followed by the treatment with GA at 200 ppm, which resulted in 19.9 cm and the control show the minimum Stalk Length (10.9 cm). In pool data average maximum Stalk Length (20.80cm) were noted with treatment GA100 while the average minimum Stalk Length recorded in control 10.55cm. Similar finding also reported by Khuriwal *et al.*, 2018 in dahlia.

Number of tubers per plant. In 2021, applying 200 ppm of Gibberellic Acid (GA_3) resulted in the highest number of tubers per plant (10.71 tubers per plant), followed by treatments with 100 ppm and 150 ppm of GA_3, which yielded 8.92 and 8.21 tubers per plant, respectively. On the other hand, the control group had the lowest number of tubers per plant (3.42 tubers per plant). Similarly, in 2022, plants treated with 200 ppm of GA_3 exhibited the highest number of tubers per plant (11.00 tubers per plant), followed by the treatment with 100 ppm of GA_3, which resulted in 9.32 tubers per plant. The control group had the lowest number of tubers per plant (4.2 tubers per plant) as shown in Table 9. Based on pool data, average maximum number of tubers per plant (10.86) were noted with treatment GA_3 200 ppm while the average minimum number of tubers per plant recorded in control 3.81. similarly, Elsadek, 2018 showed that Foliar spray of different concentrations of GA3 increased the Number of tubers per plant as compared to control in dahlia.

Table 9: Effect of foliar spray of different concentration of GA_3 and SNP plant growth regulator on No. of tubers per plant.

Treatment	1st year (21/22)	2nd Year (22/23)	Mean
CONT	3.42±0.17[a]	4.20±0.21[a]	3.81±0.19[a]
GA_3 100	8.92±0.36[e]	9.32±0.37[d]	9.12±0.36[d]
GA_3 150	8.21±0.49[de]	9.05±0.54[d]	8.63±0.52[d]
GA_3 100	10.71±0.86[f]	11.00±0.88[e]	10.86±0.87[e]
GA_3 150	6.43±0.19[c]	6.91±0.21[c]	6.67±0.20[c]
GA_3 200	4.81±0.19[b]	5.56±0.22[b]	5.19±0.21[b]
SNP200	7.56±0.38[cd]	8.21±0.41[d]	7.89±0.40[cd]
SE(m)	**0.52**	**0.493**	**0.506**
C.D.	**0.850**	**0.899**	**0.872**
C.V.	**6.609**	**6.446**	**6.509**

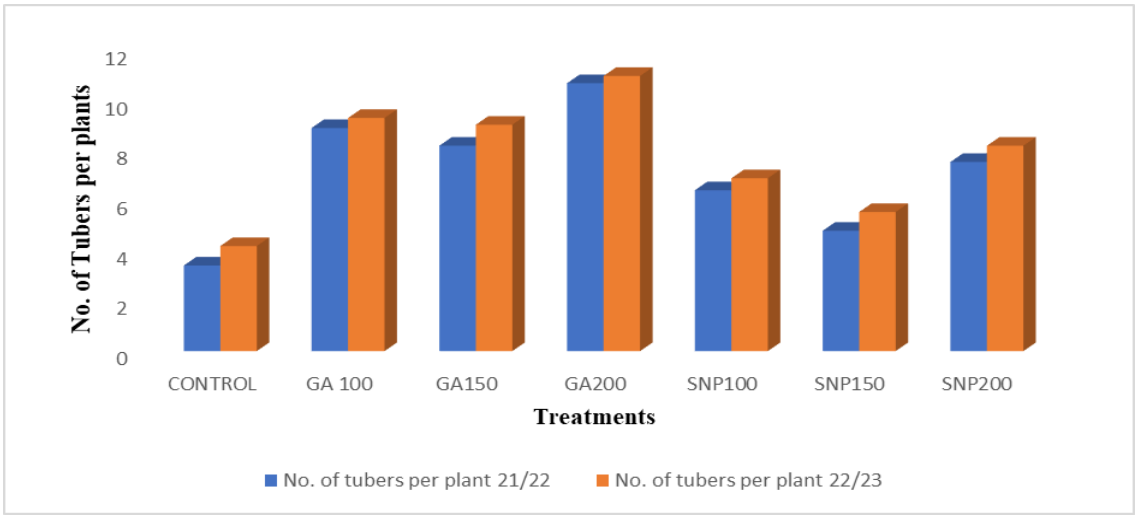

Fig. 9. Graph represent of foliar spray of different concentration of GA_3 and SNP plant growth regulator on No. of tubers per plant.

Tuber yield per plant (kg). In 2021, the application of 100 ppm of Gibberellic Acid (GA_3) led to the highest tuber yield per plant, reaching 0.92 kg. This was followed by treatments with 150 ppm and 200 ppm of GA_3, resulting in tuber yields of 0.84 kg and 0.8 kg per plant, respectively. Conversely, the control group had the lowest tuber yield per plant, amounting to 0.39 kg. Likewise, in 2022, plants treated with 100 ppm of GA_3 exhibited the highest tuber yield per plant, with a measurement of 0.95 kg. The treatment with 150 ppm of GA_3 followed closely, yielding 0.89 kg per plant. Once again, the control group demonstrated the lowest tuber yield per plant, measuring 0.49 kg (Table 10). Based on pool data, average maximum tuber yield per plant (0.94 kg) were noted with treatment GA_3 100 while the average minimum tuber yield per plant recorded in control 0.44 kg. Similar studies showed by Khuriwal, *et al.*, 2018 in dahlia in which 200 ppm of GA3 show maximum tuber yield per plant in dahlia.

Table 10: Effect of foliar spray of different concentration of GA_3 and SNP plant growth regulator on tuber yield per plant (kg).

Treatment	1st year (21/22)	2nd Year (22/23)	Mean
CONT	0.39±0.02[a]	0.49±0.02[a]	0.44±0.02[a]
GA_3 100	0.92±0.04[d]	0.95±0.04[d]	0.94±0.04[d]
GA_3 150	0.84±0.05[cd]	0.89±0.05[cd]	0.87±0.06[cd]
GA_3 200	0.80±0.06[c]	0.85±0.07b[cd]	0.83±0.07[cd]
SNP100	0.63±0.02[b]	0.75±0.02[b]	0.69±0.02[b]
SNP150	0.49±0.02[a]	0.59±0.02[a]	0.54±0.02[a]
SNP200	0.75±0.04[c]	0.80±0.04[bc]	0.78±0.04[bc]
SE(m)	**0.04**	**0.035**	**0.037**
C.D.	**0.075**	**0.080**	**0.077**
C.V.	**6.071**	**5.825**	**5.881**

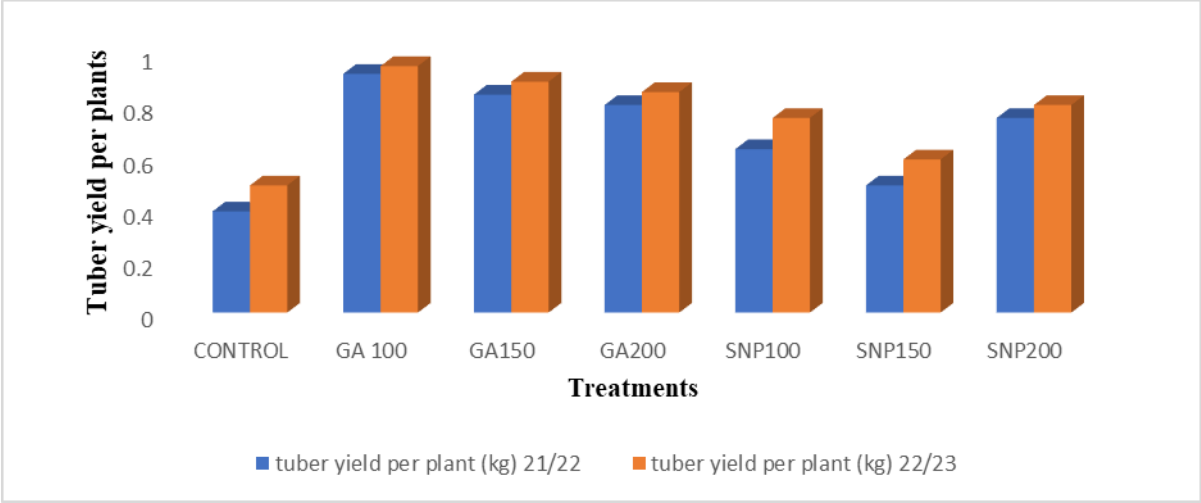

Fig. 10. Graph represent of different concentration of foliar spray of GA_3 and SNP plant growth regulator on tuber yield per plant (kg).

CONCLUSION

This study investigated the potential functions of SNP and GA_3 in enhancing the overall growth of dahlia plants relative to the control. Foliar application of GA_3 was more able than SNP to increase all vegetative, flowering, and tuber characteristics, and this could be a good and economical method for enhancing flower's visual and marketable quality. To produce plants with taller shoots useful for getting more high-quality flowers, 200 ppm of GA_3 is suggested. Economically, SNP is a low-cost compound that has the potential to enhance the vegetative growth and flowering of dahlia plants, while GA_3 is more expensive than SNP. Also recommended is the foliar application of 200 ppm SNP followed by 200 ppm GA_3.

FUTURE SCOPE

The escalating phenomenon of climate change has led to a rise in environmental stress, particularly in terms of prolonged periods of high temperatures and water stress. These conditions have resulted in a decline in agricultural output and quality across various dimensions. The adoption of foliar spray in response to unforeseen obstacles is increasingly recognised. However, the specific effects of foliar spray under various environmental stressors are not yet fully understood. Despite this knowledge gap, there is a growing body of research supporting the efficacy of foliar spray in promoting resilient agricultural practises.

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Conflict of Interest. The authors affirm that they do not possess any identifiable conflicting financial interests or personal ties that may have potentially influenced the research findings presented in this manuscript.

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