Effect of Foliar Application of Chemicals on Plant Architecture in Potted *Ixora chinensis* var. ‘Mini Double’

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Authors’ contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The investigation aimed to study the effect of foliar application of chemicals on the plant canopy, vegetative growth and flowering, as well as on overall appearance of the *Ixora chinensis* plants grown in pot. Application of salicylic acid, benzyl adenine and silicon at different concentrations significantly influenced the growth, flowering, pigments as well as overall appearance of *Ixora chinensis* plants as compared to untreated plants (control). Plants treated with 10 mg/l and 20 mg/l salicylic acid showed significant increase in plant height, plant spread, number of branches with thicker stems and number of leaves and leaf area during the experiment. Further, the number of inflorescence per plant, inflorescence diameter and flowers per inflorescence were observed maximum in plants treated with 10 mg/l salicylic acid. Improved flowering period (89.60 days), delayed senescence and maximum in situ flower longevity (14.87 days) was observed in ixora plants sprayed with benzyl adenine at 30 mg/l. The maximum chlorophyll content (1.81 mg/g) in leaves and maximum anthocyanin content (0.282 mg/g) in petal tissue was observed with application of silicon at 1.5 % concentration, which was followed by silicon at 1.0 % concentration. The highest overall appearance as pot plant (4.15) on a visual basis was noted in ixora plants.

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sprayed with salicylic acid at 10 mg/l, which was followed by salicylic acid at 30 mg/l and benzyl adenine 30 mg/l.

Keywords: Salicylic acid; benzyl adenine; silicon; Ixora chinensis; plant architecture.

1. INTRODUCTION

“Ixora chinensis is one of the most beautiful ornamental plants in the spurge family Rubiaceae and native to China. The species is mainly appreciated for the beauty of the inflorescence, continuous flowering and the hardiness of the plants” [1]. “The plants of ixora can be grown year-round in dry, high temperature and high solar radiation areas as potted or garden plants” [2]. Ixora chinensis is a much esteemed plant for pot culture owing to its brilliant inflorescences.

Foliar application of chemicals viz. salicylic acid [3], benzyl adenine [4] and silicon [5, 6] have been known to play important roles in influencing branching as well as physiological management of plant architecture in different ornamental plants. The aim of this study was to examine the effect of foliar application of chemicals on Ixora chinensis plants and to develop a plant architecture model with a good plant canopy with quality flowers.

2. MATERIALS AND METHODS

The present study was conducted in a naturally ventilated polyhouse located at ATC of Soilless System, Dept. of Floriculture and Landscape Architecture, ACHF, NAU, Navsari, Gujarat. The experiment was laid out in a completely randomized design and replicated thrice. Uniform plants of Ixora chinensis var. ‘Mini Double’ plants were exposed to foliar spray of different concentrations of salicylic acid (10, 20 and 30 mg/l), benzyl adenine (1.0, 2.0 and 3.0 mg/l) and silicon (0.5, 1.0 and 1.5 %) after 30 days of planting and repeated twice at 15 days interval. Each plant was sprayed with approximately 10 ml of freshly prepared solution at the above mentioned concentrations. Plants considered as control were not exposed to foliar spray. The data on various vegetative, flowering and flower quality parameters were recorded at 15, 30 and 45 days after spraying (DAS). The total chlorophyll content was determined by the acetone method of Sadasivam and Manickam [7] and expressed in mg/g of fresh weight. Anthocyanin content in the petal tissue was analysed by the methods of Fuleki and Francis [8]. Ornamental appearance as a pot plant was measured on a visual basis with consideration of the plant canopy and the inflorescence quality of Ixora chinensis plants. The statistical analysis was done by adopting the appropriate standard error (S.Em. ±) method in each case as suggested by Panse and Sukhatme [9].

3. RESULTS AND DISCUSSION

Ixora chinensis plants sprayed with different growth enhancing chemicals significantly influenced vegetative growth parameters as compared to untreated (control) plants (Tables 1 and 2). Foliar application of salicylic acid positively influenced plant growth and development of Ixora chinensis var. ‘Mini Double’. Significantly, maximum plant height at 15 DAS (8.07 cm), 30 DAS (8.29 cm) and 45 DAS (8.49 cm), as well as plant spread at 15 DAS (7.50 cm), 30 DAS (7.67 cm) and 45 DAS (7.83 cm) was recorded with 10 mg/l salicylic acid (T1). Plants treated with salicylic acid at 10 mg/l (T1) exhibited increased stem girth at 15 DAS (2.04 mm), at 30 DAS (2.13 mm) and at 45 DAS (2.27 mm) and plants showed higher number of leaves at 15 DAS (25.80), at 30 DAS (29.33) and at 45 DAS (33.80) with increased branch number. Further, application of 10 mg/l salicylic acid (T1) showed maximum leaf area and leaf area index at 15 DAS (1.62 cm² and 0.215), at 30 DAS (1.69 cm² and 0.253) and at 45 DAS (1.76 cm² and 0.293), respectively. Salicylic acid, being a phenolic compound of hormonal nature, is known to play an important role in plant growth by regulating physiological processes [10] viz. germination, plant growth [11], transpiration rate, stomatal regulation and photosynthesis, ion uptake and transport [12]. Further, there is evidence of a cross-talk between the SA and auxin signalling pathways during plant vegetative growth [13,14], which may have also contributed to vegetative growth as also observed in Euphorbia milii [15].
Table 1. Effect of foliar application of chemicals on vegetative growth parameters of *Ixora chinensis* var. ‘Mini Double’

| Treatments       | Plant height (cm)       | Plant spread (cm)       | Stem girth (mm)       |
|------------------|-------------------------|-------------------------|-----------------------|
|                  | 15 DAS | 30 DAS | 45 DAS | 15 DAS | 30 DAS | 45 DAS | 15 DAS | 30 DAS | 45 DAS | 15 DAS | 30 DAS | 45 DAS |
| **T**<sub>1</sub> – SA– 10 mg/l | 8.07   | 8.29   | 8.49   | 7.50   | 7.67   | 7.83   | 2.04   | 2.13   | 2.27   |        |        |        |
| **T**<sub>2</sub> – SA– 20 mg/l | 7.36   | 7.71   | 8.09   | 7.53   | 7.74   | 7.89   | 2.10   | 2.21   | 2.30   |        |        |        |
| **T**<sub>3</sub> – SA– 30 mg/l | 7.27   | 7.63   | 8.12   | 6.96   | 7.11   | 7.33   | 2.18   | 2.25   | 2.37   |        |        |        |
| **T**<sub>4</sub> – BA– 10 mg/l | 7.37   | 7.74   | 8.29   | 7.21   | 7.33   | 7.45   | 1.85   | 2.03   | 2.25   |        |        |        |
| **T**<sub>5</sub> – BA– 10 mg/l | 7.31   | 7.71   | 8.10   | 7.21   | 7.37   | 7.55   | 1.77   | 1.91   | 2.04   |        |        |        |
| **T**<sub>6</sub> – BA– 10 mg/l | 7.88   | 7.93   | 8.29   | 7.07   | 7.28   | 7.48   | 1.77   | 1.88   | 1.94   |        |        |        |
| **T**<sub>7</sub> – Si– 0.5 % | 6.67   | 7.01   | 7.35   | 7.54   | 7.77   | 7.99   | 1.85   | 1.86   | 1.95   |        |        |        |
| **T**<sub>8</sub> – Si– 1.0 % | 6.77   | 7.20   | 7.62   | 6.78   | 6.99   | 7.27   | 1.75   | 1.83   | 1.93   |        |        |        |
| **T**<sub>9</sub> – Si– 1.5 % | 6.67   | 6.96   | 7.28   | 6.69   | 6.87   | 7.06   | 1.67   | 1.75   | 1.83   |        |        |        |
| **T**<sub>10</sub> – Control | 7.08   | 7.25   | 7.44   | 7.37   | 7.49   | 7.66   | 1.87   | 1.96   | 2.03   |        |        |        |
| **S**<sub>E</sub>. ± |        | 0.20   | 0.18   | 0.20   | 0.23   | 0.20   | 0.18   | 0.05   | 0.04   | 0.05   |        |        |
| **C.D.** at 5 % | 0.58   | 0.54   | 0.60   | NS     | 0.59   | 0.52   | 0.15   | 0.13   | 0.15   |        |        |        |
| **C.V.** %    | 4.70   | 4.20   | 4.46   | 5.54   | 4.69   | 4.07   | 4.54   | 3.82   | 4.33   |        |        |        |

Table 2. Effect of foliar application of chemicals on vegetative growth parameters of *Ixora chinensis* var. ‘Mini Double’

| Treatments       | Number of branches | Number of leaves | Leaf area (cm<sup>2</sup>) | Leaf area index |
|------------------|-------------------|-----------------|-----------------------------|-----------------|
|                  | 30 DAS | 45 DAS | 15 DAS | 30 DAS | 45 DAS | 15 DAS | 30 DAS | 45 DAS | 15 DAS | 30 DAS | 45 DAS |
| **T**<sub>1</sub> – SA– 10 mg/l | 2.33   | 5.13   | 25.80  | 29.33  | 33.80  | 1.62   | 1.69   | 1.76   | 0.215  | 0.253  | 0.293  |
| **T**<sub>2</sub> – SA– 20 mg/l | 3.07   | 6.07   | 19.67  | 22.67  | 26.20  | 1.18   | 1.28   | 1.33   | 0.110  | 0.145  | 0.176  |
| **T**<sub>3</sub> – SA– 30 mg/l | 2.33   | 4.73   | 22.53  | 26.40  | 30.07  | 1.35   | 1.46   | 1.55   | 0.148  | 0.188  | 0.230  |
| **T**<sub>4</sub> – BA– 10 mg/l | 2.07   | 3.80   | 18.93  | 21.93  | 25.40  | 1.34   | 1.38   | 1.43   | 0.122  | 0.151  | 0.161  |
| **T**<sub>5</sub> – BA– 10 mg/l | 2.13   | 4.13   | 19.40  | 22.47  | 25.20  | 1.39   | 1.53   | 1.58   | 0.136  | 0.168  | 0.195  |
| **T**<sub>6</sub> – BA– 10 mg/l | 2.47   | 4.87   | 17.27  | 21.00  | 24.93  | 1.48   | 1.58   | 1.66   | 0.126  | 0.165  | 0.204  |
| **T**<sub>7</sub> – Si– 0.5 % | 2.27   | 4.27   | 20.00  | 22.67  | 25.87  | 1.45   | 1.61   | 1.67   | 0.142  | 0.181  | 0.214  |
| **T**<sub>8</sub> – Si– 1.0 % | 2.20   | 4.13   | 16.87  | 21.07  | 24.53  | 1.29   | 1.39   | 1.45   | 0.110  | 0.145  | 0.176  |
| **T**<sub>9</sub> – Si– 1.5 % | 1.60   | 3.27   | 16.80  | 19.00  | 22.00  | 1.45   | 1.49   | 1.61   | 0.119  | 0.142  | 0.176  |
| **T**<sub>10</sub> – Control | 1.87   | 3.40   | 19.67  | 22.00  | 24.93  | 1.27   | 1.37   | 1.43   | 0.123  | 0.150  | 0.176  |
| **S**<sub>E</sub>. ± | 0.07   | 0.11   | 0.54   | 0.62   | 0.69   | 0.04   | 0.04   | 0.04   | 0.004  | 0.004  | 0.005  |
| **C.D.** at 5 % | 0.21   | 0.33   | 1.59   | 1.82   | 2.06   | 0.11   | 0.11   | 0.11   | 0.010  | 0.011  | 0.014  |
| **C.V.** %    | 5.42   | 4.49   | 4.74   | 4.66   | 4.60   | 4.52   | 4.18   | 4.24   | 4.56   | 3.85   | 3.98   |
Table 3. Effect of foliar application of chemicals on flowering and flower quality of *Ixora chinensis* var. ‘Mini Double’

| Treatments   | Number of inflorescence per plant | Inflorescence diameter (cm) | Number of buds and flowers per inflorescence | Flower diameter (cm) |
|--------------|-----------------------------------|-----------------------------|-----------------------------------------------|----------------------|
|              | 15 DAS  | 30 DAS  | 45 DAS  | 15 DAS  | 30 DAS  | 45 DAS  | 15 DAS  | 30 DAS  | 45 DAS  | 15 DAS  | 30 DAS  | 45 DAS  |
| T<sub>1</sub> – SA– 10 mg/l | 1.47    | 2.47    | 3.67    | 2.61    | 4.92    | 6.11    | 26.53   | 32.46   | 37.60   | 1.36    | 1.38    | 1.39    |
| T<sub>2</sub> – SA– 20 mg/l | 1.27    | 2.20    | 3.47    | 2.47    | 4.71    | 5.93    | 22.87   | 28.13   | 33.06   | 1.27    | 1.29    | 1.32    |
| T<sub>3</sub> – SA– 30 mg/l | 1.27    | 2.33    | 3.47    | 2.12    | 4.46    | 5.76    | 20.07   | 26.40   | 31.93   | 1.28    | 1.30    | 1.33    |
| T<sub>4</sub> – BA– 10 mg/l | 1.53    | 2.47    | 3.53    | 2.14    | 4.51    | 5.79    | 20.87   | 28.73   | 33.40   | 1.21    | 1.22    | 1.23    |
| T<sub>5</sub> – BA– 10 mg/l | 1.27    | 2.27    | 3.33    | 2.33    | 4.69    | 5.83    | 21.47   | 26.20   | 31.13   | 1.22    | 1.24    | 1.26    |
| T<sub>6</sub> – BA– 10 mg/l | 1.20    | 2.27    | 3.33    | 2.50    | 4.81    | 6.01    | 24.13   | 30.33   | 34.87   | 1.25    | 1.27    | 1.29    |
| T<sub>7</sub> – SI– 0.5 % | 1.13    | 2.20    | 3.20    | 2.51    | 4.88    | 6.08    | 22.80   | 25.33   | 30.73   | 1.25    | 1.26    | 1.27    |
| T<sub>8</sub> – SI– 1.0 % | 1.13    | 2.13    | 3.33    | 2.32    | 4.65    | 5.79    | 20.67   | 24.53   | 28.60   | 1.23    | 1.25    | 1.27    |
| T<sub>9</sub> – SI– 1.5 % | 1.20    | 2.07    | 3.00    | 2.07    | 4.33    | 5.52    | 20.87   | 22.73   | 26.33   | 1.21    | 1.23    | 1.25    |
| T<sub>10</sub>–Control | 1.07    | 1.73    | 2.53    | 1.74    | 4.14    | 5.37    | 16.20   | 23.07   | 27.00   | 1.20    | 1.22    | 1.23    |
| S. Em. ±   | 0.06    | 0.06    | 0.08    | 0.05    | 0.13    | 0.11    | 0.54    | 0.62    | 0.86    | 0.02    | 0.03    | 0.02    |
| C.D. at 5 % | 0.18    | 0.18    | 0.23    | 0.14    | 0.37    | 0.33    | 1.58    | 1.82    | 2.52    | 0.06    | 0.08    | 0.07    |
| C.V. %     | 8.24    | 4.67    | 4.16    | 3.69    | 4.75    | 3.31    | 4.29    | 4.00    | 4.72    | 2.91    | 3.85    | 3.18    |

Table 4. Effect of foliar application of chemicals on flowering, flower quality, overall appearance and pigments of *Ixora chinensis* var. ‘Mini Double’

| Treatments   | Flowering days | In situ longevity (days) | Ornamental appearance (on visual basis) | Chlorophyll content (mg/g) | Anthocyanin content (mg/g) |
|--------------|----------------|-------------------------|----------------------------------------|---------------------------|----------------------------|
|              | 15 DAS  | 30 DAS  | 45 DAS  | 15 DAS  | 30 DAS  | 45 DAS  | 15 DAS  | 30 DAS  | 45 DAS  | 15 DAS  | 30 DAS  | 45 DAS  |
| T<sub>1</sub> – SA– 10 mg/l | 81.73   | 9.93    | 12.00   | 12.60   | 4.15    | 1.11    | 0.221   |
| T<sub>2</sub> – SA– 20 mg/l | 77.67   | 9.87    | 11.67   | 12.40   | 4.04    | 1.16    | 0.236   |
| T<sub>3</sub> – SA– 30 mg/l | 72.40   | 9.53    | 11.20   | 12.47   | 4.09    | 1.26    | 0.246   |
| T<sub>4</sub> – BA– 10 mg/l | 78.67   | 9.73    | 12.07   | 13.53   | 3.95    | 0.54    | 0.188   |
| T<sub>5</sub> – BA– 10 mg/l | 78.73   | 10.33   | 12.67   | 13.67   | 3.71    | 0.71    | 0.196   |
| T<sub>6</sub> – BA– 10 mg/l | 89.60   | 11.33   | 13.47   | 14.87   | 4.06    | 1.11    | 0.205   |
| T<sub>7</sub> – SI– 0.5 % | 73.93   | 8.13    | 9.53    | 10.00   | 3.22    | 0.71    | 0.228   |
| T<sub>8</sub> – SI– 1.0 % | 77.60   | 8.47    | 9.60    | 10.73   | 2.97    | 1.37    | 0.270   |
| T<sub>9</sub> – SI– 1.5 % | 81.20   | 9.13    | 10.27   | 10.80   | 3.13    | 1.81    | 0.282   |
| T<sub>10</sub>–Control | 59.40   | 9.20    | 9.40    | 9.60    | 2.40    | 0.97    | 0.175   |
| S. Em. ±   | 2.11    | 0.20    | 0.29    | 0.26    | 0.10    | 0.03    | 0.001   |
| C.D. at 5 % | 6.23    | 0.58    | 0.87    | 0.77    | 0.30    | 0.07    | 0.003   |
| C.V. %     | 4.75    | 3.55    | 4.56    | 3.73    | 4.94    | 4.03    | 1.01    |
Plants sprayed with salicylic acid at 10 mg/l (T₁) recorded the maximum number of inflorescence per plant at 15 DAS (1.47), at 30 DAS (2.47) and at 45 DAS (3.67) as well as highest maximum diameter at 15 DAS (2.61 cm), at 30 DAS (4.92 cm) and at 45 DAS (6.11 cm). The maximum number of buds and flowers per inflorescence at 15 DAS (26.53), at 30 DAS (32.46) and at 45 DAS (37.60) with improved flower size, at 15 DAS (1.36 cm), at 30 DAS (1.38 cm) and at 45 DAS (1.39 cm) was achieved with foliar application of 10 mg/l salicylic acid (T₁), Table 3. “Flower promotion with salicylic acid application has been elucidated to be an indirect effect as SA alters the synthesis and/or signalling pathways of other plant hormones including jasmonic acid, ethylene and auxin” [16,17]. It has been known to act as an endogenous regulator for flowering by regulating physiological processes and showing positive effects on flowering through an increase in the photosynthetic rate and increase in the nutrient uptake [10]. “In addition to this, exogenous application of SA raises the content of endogenous bioactive GA in response, changes the hormonal status of the plant” [18] and influencing flowering [19]. Other scientists have also reported beneficial effect of SA on flower quality in Euphorbia [4].

Benzy1 adenine showed a significant effect on the flowering and flower quality of Ixora chinensis plants (Tables 3 and 4). Foliar application of benzy1 adenine at 30 mg/l (T₆) showed improved flowering period (89.60 days), delayed senescence and maximum in situ flower longevity (14.87 days) followed by SA@10 mg/l. BA is a synthesized form of cytokinin, which plays a central role in the regulation of the cell cycle and numerous developmental processes, viz. delaying senescence, controlling abscission, increase in flowering period and flowering quality by reducing the protein degradation and improving membrane stability as observed in carnation [20]. Some earlier studies have also found extended flowering parameters with exogenous application of BA in ixora [4] as well as in gladiolus by Goswami et al. as well as by Faraji and Basaki [21, 22].

Plants sprayed with silicon at 1.5% (T₃) recorded significantly higher pigment content anthocyanins (0.282 mg/g) in flower as well as chlorophyll in the leaves (1.81 mg/g), which was followed by treatment T₆ (silicon at 1.0 %) and T₃ (Salicylic Acid at 30 mg/l), Table 4. “Anthocyanins belong to a parent class of flavonoids which is synthesized via the phenylpropanoid pathway. Inclusion of Si has been reported to increase chlorophyll content in leaves by improving the cell ultrastructure of leaves” [23]. “Higher chlorophyll content with silicon application has been earlier reported in Kentucky bluegrass” [24] and in marigold [6]. Similarly, other scientists have observed elevated levels of pigments in spinach [25] and Euphorbia mili [14,15] in response to the application of silicon.

Ixora chinensis plants sprayed with salicylic acid at 10 mg/l (T₁) showed an excellent quality score (5) on a 5-point scale basis, followed by salicylic acid at 30 mg/l (T₃) and benzy1 adenine at 30 mg/l (T₆) (Table 4). Scores (2.40 and 2.97) were recorded in untreated plants (T₀) and in silicon applications at 1.0 % (T₉), respectively. Improved plant growth parameters with good plant spread, branching along with a greater number of inflorescences with increased inflorescence size added visual appeal to ixorapotted plants.

4. CONCLUSION

Foliar application of salicylic acid at 10 mg/l can be effectively used to develop improved plant architecture with regard to good plant canopy with branching and leaves with a greater number of quality inflorescences, prolonged flowering period with enhanced flower longevity and higher pigment content in Ixora chinensis as a pot plant.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Bhattacharjee SK. Studies on propagation of Hamelia patens and Ixora singaporesensis from stem cuttings. Progressive Horti. 1992;24(3):157-164.
2. Gupta VN, Kher MA. A note on the effect of root promoting hormones on rooting
3. Zarghami M, Shoor M, Ganjali A, Moshtaghi N, Tehranifar A. Effect of salicylic acid on morphological and Ornamental characteristics of Petunia hybrid at drought stress. Indian J. Fundamental and Appl. Life Sci. 2014;4(3):523-532.

4. Saadawy F and Abdel-Moniem AM. Effect of some factors on growth and development of *Euphorbia milii* var. longifolia. Middle East J. Agric. Res. 2015; 4(4):613-628.

5. Kamenidou S, Cavins TJ, Matek SM. Silicon supplements affect floricultural quality traits and elemental nutrient concentrations of greenhouse produced gerbera. Hortic. Sci. 2010;123:390-394.

6. Sivanesan I, Son MS, Lee JP, Jeong BR. Effect of silicon on growth of *Tagetes patula*. Boy orange and yellow boy seedling cultured in an environment controlled chamber. Propag. Ornam. Plants. 2010;10:136-140.

7. Sadasivam S, Manickam A. “Biochemical methods.” New Age International (P) Limited, New Delhi. 1996:2;152-160.

8. Fuleki T, Francis FJ. Quantitative methods for anthocyanins I. Extraction and determination of total anthocyanin in cranberries. J. Food Sci. 1968;33:72-77.

9. Panse VG, Sukhamte PV. Statistical Methods for Agricultural Workers. ICAR, New Delhi. 1985;14-33.

10. Karlidag H, Yildirim E, Turan M. Exogenous applications of salicylic acid affect quality and yield of strawberry grown under antifrost heated greenhouse conditions. J. Plant Nutr. Soil Sci. 2009; 172:270-276.

11. Kong J, Dong YJ, Xu LL, Liu S, Bai XY. Effects of foliar application of salicylic acid and nitric oxide in alleviating iron deficiency induced chlorosis of *Arachis hypogaea*. L. Bot. Stud. 2014;55:9.

12. Khan W, Prithiviraj B, Smith DL. Photosynthetic response of corn and soybean to foliar application of salicylates. J. Plant Physio. 2003;160:485-492.

13. Rivas-San VM, Plasencia J. Salicylic acid beyond defence: its role in plant growth and development. J. Experimental Botany. 2011;62:3321–3338.

14. Kapadiya DB, Singh A, Bhandari AJ, Ahlawat TR. Effect of plant growth enhancing substances on plant architecture of *Euphorbia milii* var. ‘Pink Bold Beauty’J. of Pharmacognosy and Phytochemistry. 2017;6(6):742-748.

15. Kapadiya DB, Singh A, Bhandari AJ, Bhatt D, Bhatt S. Impact of plant growth enhancing substances on plant canopy, growth and flowering of *Euphorbia milii* var. ‘White Centenary’. International Journal of Chemical Studies. 2017;5(5):1068-1072.

16. Vlot AC, Dempsey MA, Klessig DF. Salicylic acid, a multifaceted hormone to combat disease. Annu. Rev. Phytopathol. 2009;47:177–206.

17. Pacheco AC, Cabral C, Fermino ES, Aleman CC. Salicylic acid-induced changes to growth, flowering and flavonoids production in marigold plants. J. Medicinal Plant Res. 2013;7(42):3158-3163.

18. Mukherjee D, Kumar R. Kinetin regulates plant growth and biochemical changes during maturation and senescence of leaves, flowers, and pods of *Cajanus cajan* (L.). Biologia Plantarum. 2007;50:80-85.

19. Kim YH, Hamayun M, Khan AL. Exogenous application of plant growth regulators increased the total flavonoid content in *Taraxacum officinale* (Wigg.). African J. Biotech. 2009;8:5727-5732.

20. Mahzaz K, Moazzam HA, Hedayat Z. Increasing plant longevity and associated metabolic events in potted carnation (*Dianthus caryophyllus* L.). Brazilian Soc. Plant Physio.2013;24(4):247-252.

21. Goswami RK, Aier S, Langthasa S, Hazarika DN, Gautam BP. Influence of GA and BA on morphological, phenological and yield attributes in Gladiolus cv. Red Candyman. J. Agric. Vet Sci. 2015;8:37-42.

22. Faraji S, Basaki T. Effect of indole acetic acid and benzyl adenine on morphological and bio-chemical properties of gladiolus. J. Curr. Res. Sci. 2014;5:580-584.

23. Khalid A, Zhujun Z, Qinhua S. Influence of silicon supply on chlorophyll content, chlorophyll fluorescence, and antioxidative enzyme activities in tomato plants under salt stress. *Journal of Plant Nutrition*. 2005;(27)12:2101-2115

24. Bae EJ, Lee KS, Huh MR, Lim CS. Silicon significantly alleviates the growth inhibitory effects of NaCl in salt-sensitive ‘Perfection’ and ‘Midnight’ Kentucky *Ixoracoccinea* L. by tip cuttings under intermittent mist. Prop. Horti. 1989;21(2):138-140.
bluegrass (*Poa pratensis* L). Hort. Environ. Biotech. 2012;53:477-483.

25. Gunes A, Inal A Bagci EG, Coban S, Pilbeam DJ. Silicon mediates changes to some physiological and enzymatic parameters symptomatic for oxidative stress in spinach grown under B- toxicity. Scientia Horticulturae. 2007;113:113-119.

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