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# Effect of bending and plant growth regulator on cut flower yield and quality of rose cv. top secret under protected condition

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**Abstract**
An experiment was conducted to determine the effect of bending and plant growth regulator on cut flower yield and quality of rose cv. Top Secret under protected conditions. From the output of the study, a significant effect of bending at shoot junction ($B_1$) was found with respect to maximum flower bud diameter (1.84 cm), maximum flower head diameter (7.57 cm), maximum stalk length (46.06 cm), highest stalk diameter (4.93 mm), maximum number of cut flower per plant (1.98) and per 1000 sq.m. (13856.31), maximum fresh weight of flower (13.80 g), highest *in-situ* longevity of flower (15.12) and maximum vase life of flower (10.43). The result of plant growth regulator was also observed significant and maximum flower head diameter (7.18 cm), the maximum number of cut flowers per plant (1.98) and per 1000 sq.m. (13830.07), highest fresh weight (13.68 g), highest dry weight (3.00 g), maximum *in-situ* longevity of flower (15.65) and maximum vase life of flower (10.31) were noted in the treatment of 200 ppm benzyl adenine ($G_2$). Among the interactions, bending at shoot junction with 200 ppm benzyl adenine ($B_1G_2$) significantly recorded maximum flower head diameter (8.65 cm), maximum *in-situ* longevity of flower (18.33) and maximum vase life of flower (12.00).

**Keywords:** Rose, bending, benzyl adenine, cut flower yield, quality

## Introduction

The flowers have been considered as the symbol of grace, elegance and a feast for our eyes. Rose is one of the most beautiful creations and the most ancient popular flower grown all over the world. It is a national flower of England and known as the queen of flowers. It is a versatile plant adapted to varying climatic conditions. Great diversity in plant growth, colour of flowers, the fragrance of flowers and keeping quality made roses so popular that it is grown commercially to meet the demand. Its cultivation developed with the distillation of roses. In India, roses are grown for loose flowers, cut flowers, making essential oils, rose water and *gulkand*. Dry petals of roses are used for making incense sticks. About 80% of rose flowers are utilized for rose water, 10% for *attar*, 1-2% for *pankhuri* and remaining for the manufacture of *gulkand* and *gul-rogan* in India.

Bending of rose shoots is a special cultural practice when they are cultivated under protected structures. Normally 60 to 90 days after plantation, the mother shoot is bended and it acts as a food factory for the growing basal shoots. It has been reported that bending of the primary shoot promotes the formation of axillary shoots by breaking apical dominance (Cline, 1991; Vasava *et al.* 2023) [6, 28]. The basal shoots are usually vigorous and act as an important source of flower production (Zieslin and Mor, 1981 and Anwarulhaq *et al.* 2021) [31, 3]. Applying shoot-bending to non-productive shoots resulted in increased stem length of harvestable flowering shoots at the expense of the number of flowering shoots per unit ground area (Kim and Lieth, 2004 and Parsana *et al.* 2023) [12, 21].

The plant growth regulators are compounds that in minor amounts modify the physiological processes of plants and ultimately alter the yield and quality. Numerous plant growth regulators have been widely used in many flowering plants and their efficacy have been demonstrated for nursery production, foliage plants and many other ornamental plants (Sanap *et al.*, 2000) [23]. Cytokinins are a large group of plant hormones, and benzyl adenine is one of the most active cytokinin (Buban, 2000) [5]. It has been identified as a natural cytokinin in a number of plants (Van and Crouch, 1996) [27]. Application of benzyl adenine have been shown to have effects on many other physiological and developmental processes, including leaf senescence, leaf chlorosis, increased vase life, delaying senescence by inhibiting ethylene biosynthesis (Cook *et al*., 1985) [7], nutrient mobilization, apical dominance, the formation and activity of shoot apical meristems, floral development, combating drought stress in plants (Waterland *et al*., 2010) [30].

## Materials and Methods

The present experiment was carried out at greenhouse unit-3, Hi-tech Horticulture Park, College of Horticulture, Junagadh Agricultural University, Junagadh during the year 2022. The experiment was laid out in Factorial Completely Randomized Design with four replications and twenty treatment combinations, consisting of five levels of bending *i.e.*, no bending ($B_0$), bending at shoot junction ($B_1$), bending above 1st leaf bud ($B_2$), bending above 2nd leaf bud ($B_3$) and bending above 3rd leaf bud ($B_4$) and four level of growth regulator *i.e*., 150 ppm benzyl adenine ($G_1$), 200 ppm benzyl adenine ($G_2$), 250 ppm benzyl adenine ($G_3$) and water spray ($G_4$).

The well-grown pencil-thickness size shoots were selected and flower buds and flowers were removed from these shoots. Bending was done in the afternoon after 90 days of planting because of less moisture content in plant which prevents the stem from breaking during bending. The shoots were gently twisted and bent toward the path as per different levels of treatments. Benzyl adenine solutions of 150, 200 and 250 ppm concentration were prepared by dissolving a calculated quantity of chemical in 75% ethanol and then volume was made up to one litre with distilled water. The prepared BA solution was sprayed uniformly with the help of hand atomizer to the treatments immediately after bending and the remaining three sprays were sprayed at 15 days intervals.

## Results and Discussion

### Flowering and cut flower yield parameters

### Effect of bending

The treatment of bending at shoot junction ($B_1$) was found to be superior over other treatments for majority of flowering and cut flower yield parameters. Significantly maximum flower bud diameter (1.84 cm), maximum flower head diameter (7.57 cm), maximum stalk length (46.06 cm), highest stalk diameter (4.93 mm), maximum number of cut flowers per plant (1.98) and maximum number of cut flowers per 1000 sq.m. (13856.31) was recorded with treatment of bending at shoot junction ($B_1$). This truth might be attributed due to the presence of a higher amount of assimilates in the bottom portion of the shoots that would ensure vigorous growth and development of the newly emerged stems. The results were supported by Kool *et al.* (1996) [14], Sarkka and Rita (1999) [24], Matloobi *et al*. (2009) [16], Patil *et al.* (2012) [22] and Vasudevan and Kannan (2014) [29] in rose. Whereas, the minimum days taken to first flower bud appearance (29.33) was recorded in no bending ($B_0$). It might be due to the release of apical dominance. Without bending, the apical meristem is not inhibited, which allows the plant to grow and mature quickly. Maximum flower bud length (2.68 cm) was exhibited in bending above 3rd leaf bud ($B_4$) and maximum number of petals per flower (60.08) was noted in bending above 2nd leaf bud ($B_3$). There was no significant difference observed in different treatments of bending for days to the first flower opening, flowering span and pedicel length of flower.

**Table 1:** Effect of bending and plant growth regulator on flowering and cut flower yield parameters of rose cv. Top Secret under protected condition

| Treatment | | Days to first flower bud appearance | Days to first flower opening | Flower bud length (cm) | Flower bud diameter (cm) | Flower head diameter (cm) | Flowering span (days) |
|---|---|---|---|---|---|---|---|
| **Factor A - Bending (B)** | | | | | | | |
| $B_0$ | No bending | 29.33 | 14.20 | 2.39 | 1.72 | 6.52 | 24.11 |
| $B_1$ | Bending at shoot junction | 37.02 | 14.57 | 2.44 | 1.84 | 7.57 | 24.41 |
| $B_2$ | Bending above 1st leaf bud | 37.41 | 14.30 | 2.56 | 1.60 | 6.88 | 24.13 |
| $B_3$ | Bending above 2nd leaf bud | 38.53 | 14.18 | 2.46 | 1.63 | 7.13 | 23.97 |
| $B_4$ | Bending above 3rd leaf bud | 37.58 | 14.51 | 2.68 | 1.64 | 7.00 | 24.01 |
| S.Em.± | | 0.493 | 0.113 | 0.025 | 0.024 | 0.069 | 0.340 |
| C.D. at 5% | | 1.40 | NS | 0.07 | 0.06 | 0.19 | NS |
| **Factor B – Plant growth regulator (G)** | | | | | | | |
| $G_1$ | 150 ppm benzyl adenine | 36.41 | 14.35 | 2.71 | 1.73 | 6.92 | 24.26 |
| $G_2$ | 200 ppm benzyl adenine | 34.98 | 14.50 | 2.48 | 1.64 | 7.18 | 24.21 |
| $G_3$ | 250 ppm benzyl adenine | 35.90 | 14.23 | 2.43 | 1.70 | 7.02 | 24.20 |
| $G_4$ | Water spray (control) | 36.62 | 14.36 | 2.42 | 1.69 | 7.00 | 23.85 |
| S.Em.± | | 0.441 | 0.101 | 0.023 | 0.021 | 0.062 | 0.304 |
| C.D. at 5% | | NS | NS | 0.06 | NS | 0.17 | NS |
| **Interaction (B x G)** | | | | | | | |
| S.Em.± | | 0.986 | 0.227 | 0.051 | 0.048 | 0.139 | 0.680 |
| C.D. at 5% | | NS | NS | NS | NS | 0.39 | NS |
| C.V. % | | 5.48 | 3.17 | 4.10 | 5.79 | 3.98 | 5.63 |

### Effect of plant growth regulator

Flowers are the main economic part of flowering plants and flowering and cut flower parameters are found to be significant with both 150 and 200 ppm benzyl adenine treatment. Flower bud length (2.71 cm), stalk length (44.33 cm), stalk diameter (4.78 mm) and number of petals per flower (57.06) were found maximum with 150 ppm benzyl adenine. Whereas, flower head diameter (7.18 cm), number of cut flowers per plant (1.98) and number of cut flowers per 1000 sq.m. (13830.07) was observed maximum with 200 ppm benzyl adenine. The higher yield in BA-treated plants might be due to higher chlorophyll levels leading to increased photosynthesis. The results are in agreement with those found by Serek and Andersen (1993) [25] and Vasudevan and Kannan (2014) [29] in rose; Gawade *et al.*, (2019) in chrysanthemum and Meera *et al.*, (2021) [17] in mango. All the other parameters were found non-significant.

**Table 2:** Effect of bending and plant growth regulator on flowering and cut flower yield parameters of rose cv. Top Secret under protected condition

| Treatment | | Stalk length (cm) | Pedicel length of flower (cm) | Stalk diameter at the base of cut flower (mm) | Number of petals per flower | Number of cut flowers per plants | Number of cut flowers per 1000 sq.m. |
|---|---|---|---|---|---|---|---|
| **Factor A - Bending (B)** | | | | | | | |
| $B_0$ | No bending | 32.44 | 5.84 | 4.18 | 46.77 | 1.83 | 12847.55 |
| $B_1$ | Bending at shoot junction | 46.06 | 6.07 | 4.93 | 54.19 | 1.98 | 13864.34 |
| $B_2$ | Bending above 1st leaf bud | 43.04 | 5.92 | 4.61 | 53.09 | 1.97 | 13856.31 |
| $B_3$ | Bending above 2nd leaf bud | 41.30 | 6.06 | 4.55 | 60.08 | 1.78 | 12498.52 |
| $B_4$ | Bending above 3rd leaf bud | 44.50 | 6.02 | 4.50 | 48.58 | 1.80 | 12669.02 |
| S.Em.± | | 0.515 | 0.077 | 0.052 | 0.925 | 0.035 | 246.292 |
| C.D. at 5% | | 1.46 | NS | 0.14 | 2.63 | 0.10 | 701.00 |
| **Factor B – Plant growth regulator (G)** | | | | | | | |
| $G_1$ | 150 ppm benzyl adenine | 44.33 | 5.98 | 4.78 | 57.06 | 1.88 | 13192.97 |
| $G_2$ | 200 ppm benzyl adenine | 40.74 | 5.84 | 4.65 | 52.17 | 1.98 | 13830.07 |
| $G_3$ | 250 ppm benzyl adenine | 41.31 | 6.05 | 4.49 | 54.56 | 1.83 | 12830.86 |
| $G_4$ | Water spray (control) | 39.51 | 6.08 | 4.31 | 46.39 | 1.82 | 12734.69 |
| S.Em.± | | 0.460 | 0.069 | 0.046 | 0.827 | 0.031 | 220.290 |
| C.D. at 5% | | 1.31 | NS | 0.13 | 2.35 | 0.08 | 627.00 |
| **Interaction (B x G)** | | | | | | | |
| S.Em.± | | 1.030 | 0.154 | 0.104 | 1.850 | 0.070 | 492.584 |
| C.D. at 5% | | NS | NS | NS | 5.26 | NS | NS |
| C.V. % | | 4.96 | 5.16 | 4.56 | 7.04 | 7.49 | 7.49 |

**Interaction effect**

The combination of bending and plant growth regulator was found non-significant for most of the flowering and cut flower yield parameters. Only two parameters were found significant. Among which flower head diameter (8.65 cm) was found significant with treatment combination of bending at shoot junction with 200 ppm benzyl adenine ($B_1G_2$). This might be due to sufficient allocation of assimilates by bent shoot to upright growing shoot with appropriate cell division through benzyl adenine. The results are in agreement with those found by Kim and Lieth (2004) [12] and Vasudevan and Kannan (2014) [29] in rose. The number of petals per flower (72.49) was also found significant with a treatment combination of bending above 2nd leaf bud with 150 ppm benzyl adenine ($B_3G_1$). It might be due to the treatment combination have provided a favourable environment for floral bud differentiation and development, resulting in an increased number of petals per flower. The results are in conformity with those obtained by Kool and Lenssen (1997) [13] and Amanullah *et al*. (2010) [1] in rose.

**Quality parameters**

**Effect of bending**

The result showed significant variation in quality parameters due to different bending treatments. Maximum fresh weight (13.80 g), highest *in-situ* longevity of flower (15.12) and maximum vase life of flower (10.43) was noted in bending at shoot junction ($B_1$). Whereas, maximum dry weight (3.36 g) was noted in bending above 1st leaf bud ($B_2$). It might be due to bending control growth of the plant and directing its energy towards producing better quality flowers by redirection of the reserved food sources to newly developing flowering shoots rather than investing them on unusable flower (Anonymous, 2019) [2]. Bending stimulates the production of more growth hormones or other chemical compounds that promote flower growth, such as cytokinins or gibberellins. These substances can influence the physiological processes of plant and improve the productivity and quality of flowers. The results were in accordance with those obtained by Lissa *et al*. (1999) [15], Kajihara and Katsutani (2008) and Vasudevan and Kannan (2014) [29] in rose.

**Effect of plant growth regulator**

The variation in quality parameters was also found significant due to treatment of plant growth regulator. Highest fresh weight (13.68 g) and highest dry weight (3.00 g) was obtained in 200 ppm benzyl adenine ($G_2$). This might be due to higher production and accumulation of organic compounds due to increased photosynthesis. The results are in agreement with those found by Kim and Miller (2008) [11] in tulip, Ramalingam (2008) [32], Muthu Kumar *et al*. (2012) [20] and Mondal and Sarkar (2017) [19] in rose. Maximum *in-situ* longevity of flower (15.65) and maximum vase life of flower (10.31) was also observed superior in the same treatment. The positive effect of BA on *in-situ* longevity and vase life might be attributed to the ability of cytokinin to retard senescence and slow the ageing process. These results were a good agreement with those concluded by Guo *et al*. (2003) [9] and Singh and Madhubala (2018) [26] in chrysanthemum and Baghele *et al*. (2012) [4]; Vasudevan and Kannan (2014) [29] in rose and Mishra and Varu (2022) [18] in pomegranate.

**Table 3:** Effect of bending and plant growth regulator on quality parameters of rose cv. Top Secret under protected condition

| Treatment | | Fresh weight of cut flower (g) | Dry weight of cut flower (g) | *In-situ* longevity of flower (days) | Vase life of flower (days) |
|---|---|---|---|---|---|
| **Factor A - Bending (B)** | | | | | |
| $B_0$ | No bending | 12.08 | 2.29 | 11.85 | 8.16 |
| $B_1$ | Bending at shoot junction | 13.80 | 3.17 | 15.12 | 10.43 |
| $B_2$ | Bending above 1st leaf bud | 13.35 | 3.36 | 14.37 | 9.99 |
| $B_3$ | Bending above 2nd leaf bud | 12.01 | 2.45 | 14.20 | 9.28 |
| $B_4$ | Bending above 3rd leaf bud | 11.01 | 2.08 | 13.70 | 9.14 |
| S.Em.± | | 0.245 | 0.054 | 0.167 | 0.108 |
| C.D. at 5% | | 0.69 | 0.15 | 0.47 | 0.30 |
| **Factor B – Plant growth regulator (G)** | | | | | |
| $G_1$ | 150 ppm benzyl adenine | 12.35 | 2.67 | 14.43 | 9.60 |
| $G_2$ | 200 ppm benzyl adenine | 13.68 | 3.00 | 15.65 | 10.31 |
| $G_3$ | 250 ppm benzyl adenine | 12.51 | 2.56 | 14.36 | 9.88 |
| $G_4$ | Water spray (control) | 11.26 | 2.47 | 10.96 | 7.83 |
| S.Em.± | | 0.219 | 0.049 | 0.150 | 0.097 |
| C.D. at 5% | | 0.62 | 0.13 | 0.42 | 0.27 |
| **Interaction (B x G)** | | | | | |
| S.Em.± | | 0.491 | 0.109 | 0.335 | 0.217 |
| C.D. at 5% | | NS | NS | 0.95 | 0.61 |
| C.V. % | | 7.89 | 8.21 | 4.84 | 4.62 |

**Interaction effect**

In quality parameters *in-situ* longevity (18.33) and vase life (12.00) of the flower was found significant for the treatment combination of bending at shoot junction with 200 ppm benzyl adenine ($B_1G_2$). It might be due to a combination of bending at the shoot junction and the application of benzyl adenine allows for better water uptake and hormonal balance in the flower, leading to a longer *in-situ* longevity and vase life. Earlier similar kind of results has been found by Vasudevan and Kannan (2014) [29] in rose. Whereas, fresh weight and dry weight was found non-significant for the interaction effect of bending and plant growth regulator.

**Conclusion**

The findings of experiment revealed that greenhouse rose production could be improved by implementing bending practices at shoot junction ($B_1$) and applying a foliar spray of 200 ppm benzyl adenine ($G_2$), resulting in superior flowering, cut flower yield and quality parameters of the flowers.

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