Agriculture Association of Textile Chemical and Critical Reviews Journal (2023) 190-194

AATCC Review

24 October 2022: Received
22 January 2023: Revised
02 February 2023: Accepted
11 March 2023: Available Online

www.aatcc.peerjournals.net

Research Article

Open Access

Influence of shoot bending angles on performance of Hybrid Tea Rose cultivar "Minu Pearle"

Heera Lal Atal*, Madhumita Mitra (Sarkar)

Department of Floriculture and Landscaping, Bidhan Chandra Krishi Viswavidyalaya, West Bengal, , 741252-India

ABSTRACT

An experiment was conducted to explore the effect of shoot bending at different angles on the performance of the Hybrid Tea Rose cultivar 'Minu Pearle' for two consecutive years. From the study, a significant effect was observed in terms of vegetative traits as well as flowering characteristics. The cultivar performance was recorded to be superior with shoot bending at 30°and 45°angle in terms of vegetative traits and flower quality parameters such as shoot length, stalk length, flower diameter, self-life and vase life of flowers. Similarly, in terms of flowering traits (days to flower bud emergence, sepal reflex, and days to attain cup shape from the date of bending) earliest was recorded with shoot bending at a 30°followed by45° angle, and the slowest flower development was obtained at 90° angle. A similar trend was also followed in terms of the number of flowers per plant in bent shoots. This is the first-ever report on the effect of shoot bending angles on roses and this practice can help in enhancing the production of a higher number of quality roses at the commercial level.

Keywords: *Bending angle; Cut flower; Flower quality; Quality improvement; Rose; Shoot bending*

List of abbreviations

CD – Critical difference; FBE – Flower bud emergence; RHS – Royal Horticulture Society; S.Em. – Standard error mean

INTRODUCTION

Rose is a popular commercial flower crop grown as pot plants, garden plants and as cut flowers. Among all other cut flowers, the rose which has been grown since ancient times, has maintained its place as the "Queen of Flowers" and is a potential cut flower crop. In India, it is grown for both domestic and export purposes.

Cut roses are in high demand throughout the year with red roses in demand on Valentine's Day. High-quality criteria are implemented during cut rose commerce, and even a minute defect concerning the size of flowers, marks of plant protection chemicals, blackening of petals (especially in red roses) or any disorder greater than 5%, might classify them as of lower quality [17], resulting in a lower profit to the growers. To address the issue, there is a need to improve the growing practices that can improve the quality of the flower and increase the total number of cut roses produced, as well as assist farmers in scheduling harvest in order to maintain and even boost profit.

Shoot bending, a typical cultural strategy has been reported to be successfully used in both fruit tree and cut-flower cultivation, which produces a canopy with both horizontally bent and upright shoots [11]. Shoot bending has been found to produce disparities in nutrition availability and hormone synthesis in plants due to differential shoot development. Shoot bending in roses has been reported to promote budding and increase the total number and quality of blooms [11, 12]. Shoot bending has also been shown to break apical dominance by altering the plant's hormonal balance and encouraging the production of axillary shoots [9, 7].

In greenhouse production, the shoot bending technique is gradually replacing the classic upright growth technique. Both cultivation and research faced additional hurdles as a result of this new technique [13]. Bending has become a regular cultural method in the production of cut roses, and it is usually practiced repeatedly during the growing season. The basic principle behind shoot-bending is that instead of pinching or pruning undesired or marginal stems, they are left in the canopy to preserve leaf area and as a result, produce assimilates. This study was performed to explore overall growth, production of flowering shoots, and bloom quality in Hybrid Tea rose cv. Minu Pearle in response to different bending angles in open field conditions, with limited study in rose grown in open field conditions and on the response of the rose to different bending angles.

MATERIAL AND METHODS

Site description

The investigation was performed at Horticulture Research Station, Mandouri, Faculty of Horticulture, Bidhan Chandra Krishi Viswavidyalaya, Nadia, West Bengal. The site of study is located at 23N latitude and 89E longitude at an elevation of 9.75

**Corresponding Author: Heera Lal Atal*
Email Address: heera.atal93@gmail.com

DOI: https://doi.org/10.58321/AATCCReview.2023.11.02.190

meters from the mean sea level. The texture of the soil of the proposed investigation site is sandy loam, well-drained with a pH level of 6.7 containing 0.74% of organic matter, 0.07% of total nitrogen, 28.50 kg/hectare phosphorous and 78 kg/hectare potassium oxide (K_2O).

Testing material

The cultivar selected for the study was Minu Pearle, belonging to the class Hybrid Tea, bearing red flowers (RHS 53C). The experiment was taken up in three years old plants, planted in September 2017. The budded plants were purchased from Pusphanjali Rose Nursery, Jakpur, West Bengal.

Treatment details

The experiment was performed with 5 treatments, (T1- Bending at 30˚, T2- Bending at 45˚, T3- Bending at 60˚, T4-Bending at 75˚ and T5- Bending at 90˚ angle).The treatments were applied in the third week (22nd) of November for two consecutive years (2020 & 2021). All the experimental shoots (having 4 mm flower bud) were bent above 3 nodes and at angles as per treatments using a protractor keeping the shoots to be bent as base zero with the midpoint of the internode (above the 3rd node) as the vertex of the angle and thus bending from this point was done (Fig. -1, 2, 3, 4 &5).

Experimental design and crop management

The experiment was arranged in a Randomized Block Design with 5 treatments and 4 replications. The plants were planted in a raised bed (1.5×1.0 m2) at a spacing of 50×30 cm 9 plants per bed. The crop was raised following the standard cultural practices and recommended dose of fertilizer for the rose was applied.

Statistical analysis

The collected data for all traits were statistically analyzed according to the Fishers analysis of variance technique. The level of significance used for the field experiment was P = 0.05, where a tsignificant difference was observed between all the treatments, and the standard error mean (S.Em) was also calculated with a critical difference (CD at 5%).

RESULT

Vegetative parameters

As evident from Table-1 &Figure-1, the vegetative parameters (plant height, leaf area, and days to first bud sprout after bending) were significantly influenced by the different treatments (bending angles of shoots). In terms of plant height and leaf area, the plants receiving the treatment T1 (bending at 30˚ angle) recorded the highest value (68.97 cm & 27.12 cm2)followed by T2 (bending at 45˚ angle). The shortest plants with the smallest leaves were registered in the plants bent at a 90˚ angle. A similar trend was also observed in the case of days to vegetative bud sprouts after the shoots were bent at a different angle. Early bud sprout (6.65 days) was recorded in shoots bent at a 30˚ angle, while delayed bud sprout was observed in shoots bent at 90˚.

Flowering parameters

As evident from Table-1 &Figure-1, the vegetative parameters (plant height, leaf area, and days to first bud sprout after bending) were significantly influenced by the different treatments (bending angles of shoots). In terms of plant height and leaf area, the plants receiving the treatment T1 (bending at 30˚ angle) recorded the highest value (68.97 cm & 27.12 cm2)followed by T2 (bending at 45˚ angle). The shortest plants with the smallest leaves were registered in the plants bent at a 90˚ angle. A similar trend was also observed in the case of days to vegetative bud sprouts after the shoots were bent at a different angle. Early bud sprout (6.65 days) was recorded in shoots bent at a 30˚ angle, while delayed bud sprout was observed in shoots bent at 90˚.

Flower quality parameters

Data recorded for the quality parameters of flowers as influenced by the bending angles is presented in Table-2 and 3. The parameters such as length and diameter of flower bud, flower diameter, flowering shoot length, flower stalk length, and diameter, and individual flower weight attained a level of significance in response to the treatments. As evident from the table – 2 and 3 flower quality parameters (length of flower bud, the diameter of flower bud, diameter of flower at cup shape stage, flower stalk length, and weight of flower) T1 produced significant variation with T3, T4, and T5. Where maximum value for above-discussed flower quality parameters was recorded in plants bent at a 30° angle (2.77cm, 2.02cm, 4.7cm, 40.97cm, 30.12cm, and 19.07g) followed by those bend at 45°(2.57cm, 1.85cm, 4.50cm, 39.05cm, 29.75cm, and 17.70g). Shoot bending at a 90° angle (T5) resulted in smaller bud size, flower diameter at harvest (cup shape), and least values in the flower shoot length (2.05cm, 1.57cm, 3.65cm, and 33.57cm). A similar trend was also recorded in the case of flower stalk length, stalk diameter, and pedicel length where bending at a 30° angle proved superior to other treatments with minimum readings for the trait being recorded in T5. Data recorded for pedicel length produced nonsignificant results as a result of the treatments.

Self-life and vase life of flowers

In terms of self-life and vase life of flowers significant difference was observed, but in the case of the vase life of the flower variation between T1 and T2 was recorded at par values (Table 4). The lowest bending angles recorded the maximum self-life and vase life of the flowers.

Number of flowers per plant in bent shoots

Similarly, in terms of the number of flowers per plant in bent shoots, the maximum (10.84 flowers per plant in bent shoots) was recorded in T1(30°angle)followed by T2 (45°) (9.87) and lowest in shoots bent at 90° (Fig.2).

Dry matter accumulation

It is evident from Fig.3, the highest dry matter in stem and leaves was recorded in T_1 (41.5 g/100 g) and T_4 (37.8 g/100 g) followed by T_2 (37.35 & 36.6 g/100 g), while minimum value was obtained from T_4 (31.15 g/100 g) and T_5 (35.15 g/100 g). Whereas Fig.4 indicates that in the case of dry matter accumulation from stem and leaf from above the bend, the highest was recorded in T_5 (17.24 & 14.00 g/100 g) followed by T_4 (15.15 & 14.00 g/100g).

Chlorophyll content

Although the angle of shoot bending significantly influenced the chlorophyll content in leaves with the treatments, the highest chlorophyll content was recorded in treatment T_3 (2.96 mg/g) and lowest in T_1 (2.27 mg/g) (Table4).
It was visible that the shoots arising above the bend exhibited

poor shoot elongation rate, and shorter shoot lengths with smaller flower buds. The petal count per flower was also significantly low. The visible difference in the overall growth characteristics and the flower quality parameters were more prominent in shoots bent at 30°, 45°, and 60°.

DISCUSSION

The study was taken up to compare the performance of Hybrid Tea rose cultivar 'Minu Pearle' in response to different bending angles. The results obtained revealed that bending of shoots at different angles significantly influenced the vegetative, flowering, and majority of the flower quality parameters.

Bending at a 30^0 angle proved superior as compared to bending at 45^0, 60^0, 75^0 & 90^0 angles for the vegetative bud sprout after bending. Early (6.65 days) axillary bud sprout in shoots bent at 30^0 may be attributed to open center and better light penetration due to sharp shoot bending as compared to that of 90^0, which may have caused obstruction to light penetration. This can also be supported by the calculated values obtained for the trait when bending angles were maintained below 90^0. Bending of branches to increase light interception in rose bushes has also been proposed by earlier researchers [4, 6, 14]. [8] opined that the uppermost leaves of flowering rose shoots showed higher net photosynthesis with higher N content than the lower ones, and this pattern also appeared to correspond with the light profile inside the canopy. Also, from the experimental evidence obtained, it may be debated that the first leaf below the bend might have performed as the first leaf of a naturally growing vertical shoot with greater photosynthetic capacity. While these findings by researchers can support the supremacy of bending at 30^0 angle for the vegetative parameters like plant height and leaf area, an increase in leaf size with descending order of bending angles is also supported by [18] in strawberries, where they also reported shorter runners when strawberry shoots were trained at higher angles.

Discussing the flowering attributes i.e., days to flower bud emergence, days to sepal reflex, and days to attain cup shape stage after bending, 30^0 and 45^0 angle bending proved its dominance over greater bending angles. A similar trend was also evident from the empirical results for flower quality characters relating to the effect of bending which results in compression of xylem vessels on one side and tension on the other side whereas, acute bending angles might have resulted in extreme xylem pathway constriction making them non–functional in water conductance. [12] communicated that hydraulic conductivity is reduced as a result of the bending of shoots due to disturbed xylem tissues and that the reduced photosynthetic rate of bent shoots is a function of water status. Leaves retained above bending failed to photosynthesize due to non-functional xylem as a consequence of bending treatments, impeding the translocation from source to sink.

Graphical presentation of flower number per plant on bent shoots (Fig.2) revealed a significant influence of bending angles, with 30^0 bending angles followed by 45^0 being promising in positively influencing the trait. [10] obtained a maximum number of fruits in the wax apple when bent at a 45^0 angle, while the lowest in 85^0, thus the investigation findings may be credited to sharp bending angles aiding to reduction in source-sink relationship. [5] reported the stimulating effect of bending with regards to flowering and fruiting in mandarin citrus as compared to control trees. Removing apical dominance chemically or manually was effective in stimulating flushing in citrus species [1, 15]. In bending treatment, the bending process probably caused micro-damage along the shoot that reduced the apical dominance effect.

The predominance of bending at 30^0 angle in terms of growth and flowering in Hybrid Tea rose cv. Minu Pearle can thus be discussed in the light of bending techniques aiding to the removal of apical dominance, as the basipetal flow of auxin is restricted and cytokinin levels are enhanced [2, 3]. Further as reported by [12] bending leads to constriction in xylem conductors thus facilitating the movement of water and nutrients through xylem pathways to the buds present below the bend only on the other hand restriction of the phloem pathway checked auxin flow to downwards removing apical dominance, these conditions promoted more number of laterals, better growth and also quality blooms.

Acknowledgment

The authors are thankful to the Bidhan Chandra Krishi Viswavidyalaya, West Bengal India.

Author contribution

Conceptualization of research [MM(S)]; Designing of the experiment and contribution of the experimental material [HLA, MM(S)]; Execution of field/lab experiments and data collection (HLA); Analysis of data (HLA); Preparation of the manuscript [HLA, MM(S)].

Conflict of interest

No conflict of interest declared

Funding

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Data availability statement

All data supporting the findings of this study are available within the paper and its supplementary materials published online.

Table 1: Effect of shoot bending angles on vegetative and flowering parameters

Treatment	Vegetative parameters			Flowering parameters		
	Plant height (cm)	Individual leaf area (cm^2)	Days to bud sprout	Days to FBE	Days to sepal reflex s	Days to cup shape
T_1	68.97	27.12	6.65	35.15	57.97	64.27
T_2	66.87	25.27	7.62	36.10	58.77	64.82
T_3	63.72	22.87	7.97	37.02	60.07	68.00
T_4	62.57	19.27	7.00	38.72	60.67	69.05
T_5	60.70	15.67	10.12	41.50	62.62	70.85
S.Em. ±	**0.81**	**3.32**	**0.24**	**0.55**	**0.6**	**0.64**
C.D. at 5 %	**2.36**	**4.50**	**0.72**	**1.61**	**1.77**	**1.88**

T_1 (Bending at 30° angle), T_2 (Bending at 45° angle), T_3 (Bending at 60° angle), T_4 (Bending at 75° angle), T_5 (Bending at 90° angle)

Table 2: Effect of shoot bending angles on flower quality parameters like (length and diameter of flower bud, flower diameter at harvest and shoot length of flower)

Treatments	Length of flower bud (cm)	Diameter of flower bud (cm)	Flower diameter at harvest (cm)	Shoot length of flower (cm)
T_1	2.77	2.02	4.70	40.97
T_2	2.57	1.85	4.50	39.05
T_3	2.30	1.70	4.40	36.22
T_4	2.22	1.62	3.82	34.82
T_5	2.05	1.57	3.65	33.57
S.Em. ±	**0.10**	**0.05**	**0.08**	**0.57**
C.D. at 5 %	**0.30**	**0.17**	**0.24**	**1.68**

T_1 (Bending at 30° angle), T_2 (Bending at 45° angle), T_3 (Bending at 60° angle), T_4 (Bending at 75° angle), T_5 (Bending at 90° angle)

Table 3: Effect of shoot bending angles on flower quality parameters like (flower stalk length and diameter and weight of individual flower)

Treatments	Stalk length (cm)	Stalk diameter (cm)	Weight of individual flower (g)
T_1	30.12	0.62	19.07
T_2	29.75	0.57	17.70
T_3	26.62	0.55	16.62
T_4	24.52	0.42	14.05
T_5	23.35	0.42	11.92
S.Em. ±	**0.5**	**0.04**	**0.54**
C.D. at 5 %	**1.47**	**0.13**	**1.59**

T_1 (Bending at 30° angle), T_2 (Bending at 45° angle), T_3 (Bending at 60° angle), T_4 (Bending at 75° angle), T_5 (Bending at 90° angle)

Table 4: Effect of shoot bending angles on flower quality parameters like (self-life and vase life) and chlorophyll content in leaves.

Treatments	Self-life (days)	Vase life (days)	Chlorophyll content in leaf (mg/g)
T1	6.51	6.42	2.27
T2	5.86	5.90	2.84
T3	3.84	4.94	2.96
T4	3.69	4.89	2.82
T5	3.66	4.55	2.52
S.Em. ±	**0.22**	**0.28**	**0.10**
C.D. at 5 %	**0.64**	**0.83**	**0.31**

T_1 (Bending at 30° angle), T_2 (Bending at 45° angle), T_3 (Bending at 60° angle), T_4 (Bending at 75° angle), T_5 (Bending at 90° angle)

Figures

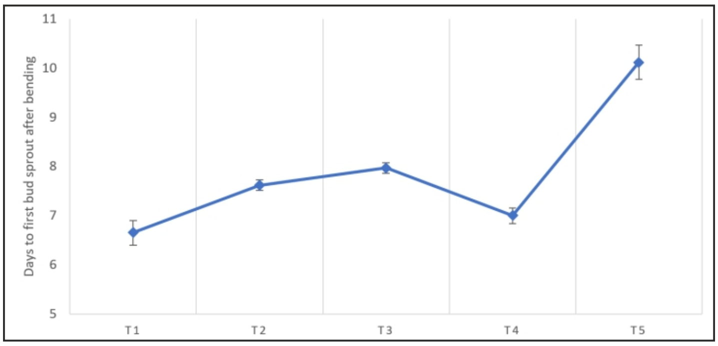

Fig. 1: Effect of shoot bending angles on days to bud sprout after bending

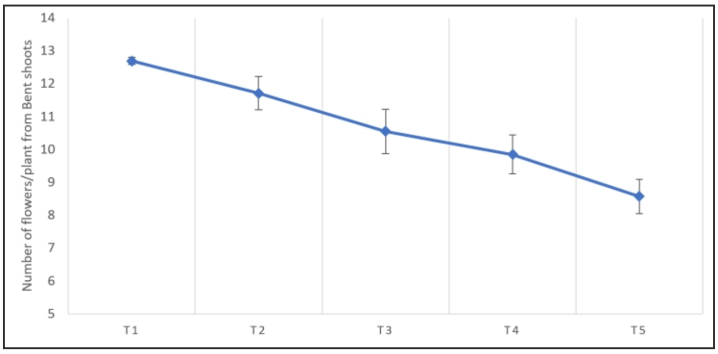

Fig. 2: Effect of shoot bending angles on number of flowers per plant from bent shoots

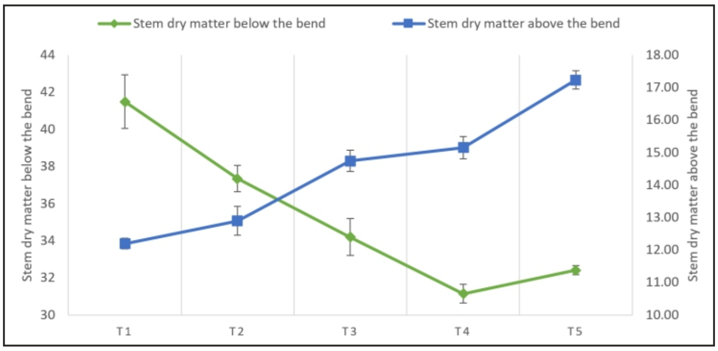

Fig. 3: Effect of shoot bending angles on stem dry matter accumulation from above and below the bend/100 g of fresh weight

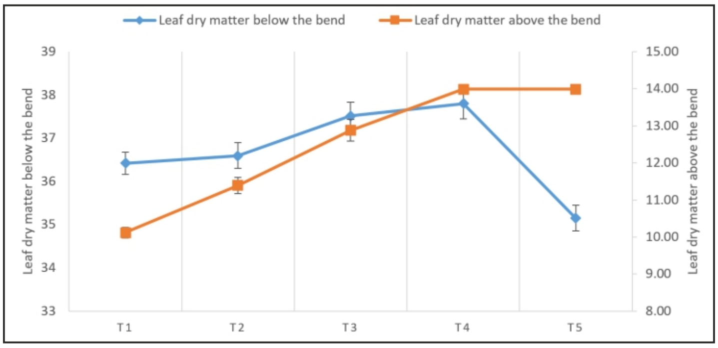

Fig. 4: Effect of shoot bending angles on leaf dry matter accumulation from above and below the bend/100 g of fresh weight

REFERENCES

1. Aliyah M, Susanto S, Sukma D, Ardie, SW. 2015. Performance improvement of young pummelo citrus (*Citrus maxima* (Burm.) Merr.) by strangulation application and pinching. *Asian Journal of Agriculture Research* 9(2), 77-83.

2. Bangerth F. 1990. Polar auxin transport in fruit trees in relation to fruit drop. *Acta Horticulturae* 275, 461–468.

3. Bangerth F. 1993. Polar auxin transport as a signal in the regulation of tree and fruit development. *Acta Horticulturae* 329, 70–76.

4. Brito P. 1999. Structuring the rose plant 'chassis' the bending technique. Floral culture International, November 1999, 42-46.

5. Budiarto R, PoerwantoR, Santosa E, Efendi D. 2018. Shoot manipulations improve flushing and flowering of mandarin citrus in Indonesia. *Journal of Applied Horticulture* 20(2), 112-118.

6. Carpy M. 1998. Wel of nietinbuigen van rozenkeuzetuseenproductieenkwaliteit,Vakbladvoor de Bloemisterij16, 54-55.

7. Cline MG. 1991. Apical dominance. *Botanical Review* 57(4), 318-358.

8. Gonzalez-Real MM, Baillis A. 2000. Changes in leaf photosynthetic parameters with leaf position and nitrogen content within a rose plant canopy (Rosa hybrid). *Plant Cell and Environment*23, 351-363.

9. Hosokawa Z, Shi L, Prasad TK, Cline MG. 1990. Apical dominance control in Ipomoea nil: the influence of the shoot apex, leaves and stem. *Annals of Botany* 65, 547–556

10. Khandaker MM, Ismail NH, Abdulrahman MD, Yusoff N, Mohd KH, Badaluddin NA, Saifuddin M. 2020. Effects of branch bending angle on growth and flowering of wax apple *(Syzygiumsamarangense). Plant Archives*20(2), 5907-13.

11. Kim SH, Lieth JH. 2004. Effect of shoot bending on productivity and economic value estimation of cut flower roses grown in coir and UC Mix. *Scientia Horticulturae*99, 331-343.

12. Kim SH, Shackel KA, Lieth JH. 2004. Bending alters water balance and reduces photosynthesis of rose shoots. *Journal of American Societyof Horticultural Science* 129(6), 896-901.

13. Sarkka L. 2004. Yield, quality and vase life of cut roses in year-round greenhouse production. Department of Applied Biology Publication NO. 23, University of Helsinki, Finland.

14. Sarkka LE, Rita HJ. 1999. Yield and quality of cut roses produced by pruning or by bending down shoots. *Gartenbauwissenschaft*64(4), 173-176.

15. Singh J, Dashora LK, Bhatnagar P, Singh B. 2016. Impact of pruning rejuvenation of declining Nagpur Mandarin *(Citrus recticulata Blanco.)* orchard. *Indian Journal of Agroforestry*18(1), 53-57.

16. Steen M. 2010. A world of flowers: Dutch flower auctions and the market for cut flowers. *Journal of Applied Horticulture* 12(2), 113-121.

17. UN/ECE standards for cut flowers - AGRI/WP.1/46 standard for fresh cut unifloral roses H-3, revised 1994. Report of the United Nations Economic Commission for Europe about trading cut flowers, available online: https://www.unece.org/fileadmin/DAM/trade/agr/standard/flowers/flower_e/h3rroses.pdf

18. Zhao J, Li Y, Park YG, Hu J, Jeong BR. 2020. Runner Training Angle Affects Growth of Runners in 'Seolhyang' and 'Maehyang' Strawberries. *Journal of Bio-Environment Control* 29(3), 231-238.

