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Effect of Shoot Bending at Different Time on Production and Quality of Hybrid Tea Rose Cultivar Minu Pearle

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

A field experiment was undertaken from September to March for two consecutive years (2020 and 2021) to find out the best time for shoot bending in Hybrid Tea rose. Growth and development of rose cultivar Minu Pearle, was significantly influenced by shoot bending at different time (4th week of September to 4th week of December). Among the treatments tallest plants & maximum leaf area was produced in plants bended on T_5 whereas, the plant canopy was registered to be maximum in 2nd week of December. The highest rate of shoot elongation at 15 & 30 days after shoot bending was noted in second week of November and October respectively. Application of shoot bending on 2nd week of October recorded early blooming and slowest flower bud emergence was registered in T_5whereas, delayed sepal reflex and maximum days taken to attain cup shape was observed in T_6. In terms of flower quality parameters like length and diameter of flower bud and pedicel and weight of individual flower, T_5 proved to be superior. Shoot bending applied on 2nd week of November (T_4) produced long and thick stalks. Among the treatments maximum number of flowers, longest self and vase life, highest dry matter production from leaves and stem, greater chlorophyll and anthocyanin content was observed in T_5.

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Keywords: Rose; shoot bending; bending time; flower quality; quality improvement.

1. INTRODUCTION

Bending non-productive shoots (short stem, small stem calliper, potential blinds) down into the canopy or towards the aisle became a standard method in cut-flower rose production [1]; Särkkä and Rita, 1999). Bending is generally done continually over the entire growing season. While in traditional production, a tall hedgerow canopy assures ample foliage area to capture light, with this shoot-bending, it is theoretically possible to maintain the lower canopy height without sacrificing foliage area. Low canopy height also facilitates the light interceptions by basal shoots, emerged from or near the primary shoot. The basal shoots are usually vigorous and important source of flower production [2].

Ohkawa and Suematsu [1] reported that bending resulted in higher shoot quality but less harvestable shoots per plant in commercial greenhouses. They suggested that the production count per area, however, could be compensated by increasing plant density. Similar results were reported by Särkkä and Rita (1999) who found that bending resulted in higher quality of flowers, fewer blind shoots (aborted flower buds) and higher yield in 'Mercedes'. The success of applying bending to rose production has been generally attributed to the possibility of bent shoots acting as a source of carbohydrates, presuming that they capture ample light and actively photosynthesize after bending.

Kool and Lenssen [3] reported that in newly developing young rose plants, bending increased the development rate, stem diameter, weight, leaf area index (LAI) and cross-sectional area of basal shoots. Stem diameter and degree of branching of basal shoots determine the potential flower production of the plant [4]. Mosherp and Turner [5] compared the productivity of a canopy management system that they named "trellis", described as a system restraining the basal shoots at an angle of approximately 30◦, with the traditional management system. The trellis system produced more flowering shoots and longer stems for cvs. 'Gabrielle' and 'Kardinal'. Mosher and Turner [5] attributed the increased production and quality in the trellis system to increased light penetration to basal parts, and to bending of basal shoots per se that stimulated the formation of more basal shoots. Le Bris et al. [6] reported that when a primary shoot was bent horizontally to promote the growth of proximal secondary buds, these buds gave rise to basal shoots.

With widespread adoption of this practice, it is necessary to find out effective time of shoot bending for better growth and quality of rose. As, we know that in roses economic return is directly related to stalk length and number of produced shoots. With limited study on rose grown in open field condition and its response to different bending times, the objective of the study was to standardize effective bending time to assess the plant performance with respect to growth parameters and flower quality in Hybrid Tea rose cultivar Minu Pearle.

2. MATERIALS AND METHODS

2.1 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 23Nº latitude and 89Eº longitude at an elevation of 9.75 meters from Mean Sea Level. The texture of the soil of the proposed investigation site is sandy loam, well drained with pH level of 6.7, organic matter is 0.74%, total nitrogen 0.07%, Phosphorus 28.50 kg/hectare and K_2O 78 kg/hectare.

Climate condition: The area where the experiment is conducted, comes under subtropical climate. The highest temperature during the summer season (April to June) ranges between 24.2ºC to 39.2ºC while during winter season (December to January) it is recorded between 19.6ºC to 29.6ºC. The average relative humidity during the entire period of experiment was recorded between 55.5% to 100%. All meteorological observation was recorded during the period of experiment and displayed in Fig. 1.

2.2 Experimental Details

2.2.1 Tested material

The study was undertaken on Hybrid Tea rose cultivar Minu Pearle, belonging to the class Hybrid Tea, with RHS 53C. The investigation was worked out in three years old plants in open field condition, planted in September 2017. The budded plants were purchased from Pusphanjali Rose Nursery, Jakpur, West Bengal.

2.2.2 Treatment details

The experiment was performed with 7 treatments, (T_1- Bending on 4th week of September, T_2- Bending on 2nd week of October, T_3- Bending on 4th week of October, T_4-Bending on 2nd week of November, T_5- Bending on 4th week of November, T_6- Bending on 2nd week of December and T_7- Bending on 4th week of December) All the experimental shoots (having 4 mm flower bud) were bended above 3 nodes.

2.2.3 Experimental design and crop management

Experiment was planned in a Randomize Block Design with 7 treatments and 4 replications. The plants were planted in raised bed (1.5X1.0 m^2) at a spacing of 50X30 cm 9 plants per bed. The crop was raised following the standard cultural practices and recommended dose of fertilizer for rose was applied.

2.2.4 Application of treatments

Healthy budded plants of Hybrid Tea rose cultivar 'Minu Pearle' planted in the year 2017 was taken as experimental material and moderately pruned in the first week of September 2020 and 2021 respectively, to remove diseased, dried and damaged shoots. Application of treatments started from last week of September and continued as per the treatments details. Bending angle was maintained below 90º& bending was done above 3 nodes from the base on primary shoots with 4mm flower bud.

2.2.5 Chlorophyll content estimation

To determine chlorophyll content, fresh leaves were collected from each plot during active vegetative stage. One gram freshly harvested leaves were taken and soaked overnight in 80% acetone in dark condition. Acetone soaked leaves were crushed, filtered, diluted and finally, chlorophyll content was determined by spectrophotometric observation [7].

Total chlorophyll (mg/g of leaf) = 20.0 (A_{645}) + 8.02 (A_{663}) x (V/ (W X 100))

Where,

A= absorbance at specific wavelength

V= Final volume of chlorophyll extract in 80% Acetone (ml)

W= Fresh weight of leaves (g)

The findings of each treatment were averaged.

2.2.6 Anthocyanin content estimation

Anthocyanin content was recorded from freshly harvested flower petals. Flower petals were macerated with ethanolic hydrochloric acid and kept overnight in dark at 4ºC. Next day, the solution was separated by using Whatman No.1 and again kept in dark condition for 2 hours. Then after diluting the filtrate solution, optical density was determined with the help of spectrophotometer, and total anthocyanin content of flower petals was calculated [8].

Total Anthocyanin (mg/100g) = Total OD/100g)/98.2

Where, Total OD/100 g = (OD X Volume makeup x 100)/weight of the sample.

2.2.7 Statistical analysis

The collected data for all traits were statistically analysed according to the Fishers analysis of variance technique as given by Gomez & Gomez (1984). The level of significance used for field experiment was P = 0.05, where significance difference was observed between all the treatments and standard error mean (S.Em±) was also calculated with critical difference (CD at 5%).

3. RESULTS

3.1 Vegetative Parameters

As revealed from the Table 1, the plants receiving the treatment in the 4th week of November proved to be superior in case of plant height measured at peak flowering stage, whereas plant spread was greater in plants bended in the month of December, while treatment T_1 (bending on 4th week of September) registered with least values for both plant spread and plant height. In terms of individual leaf area, the trend followed was similar to plant height, largest (23.37 cm2) leaves were produced by the plants receiving the treatment in the 4th week of November. The rate of shoot elongation in the bent shoots at 15 and 30 days after bending was recorded highest (3.84 and 27.85 cm) in treatments second week of November and second week of October respectively (Fig. 1), whereas treatment T_1(15 days) and T_5(30 days) registered values (0.74 and 10.07 cm) for the trait rate of shoot elongation. In terms of dry matter accumulation in stem and leaves, treatment T_5 (bending on 4th week of November) exhibited greater (38.34 and 37.82 g) values, whereas bending ending was early as 2nd fortnight of September registered with least (31.71 and 31.10 g) values (Fig. 2).

3.2 Flowering Parameters

Flowering parameters like days to flower bud emergence, days to sepal reflex and days to attain cup shape stage (harvesting stage) from the date of bending. As indicated from the tabular representation (Table 1) shoots bending at different time significantly influenced the flowering parameters. From the table

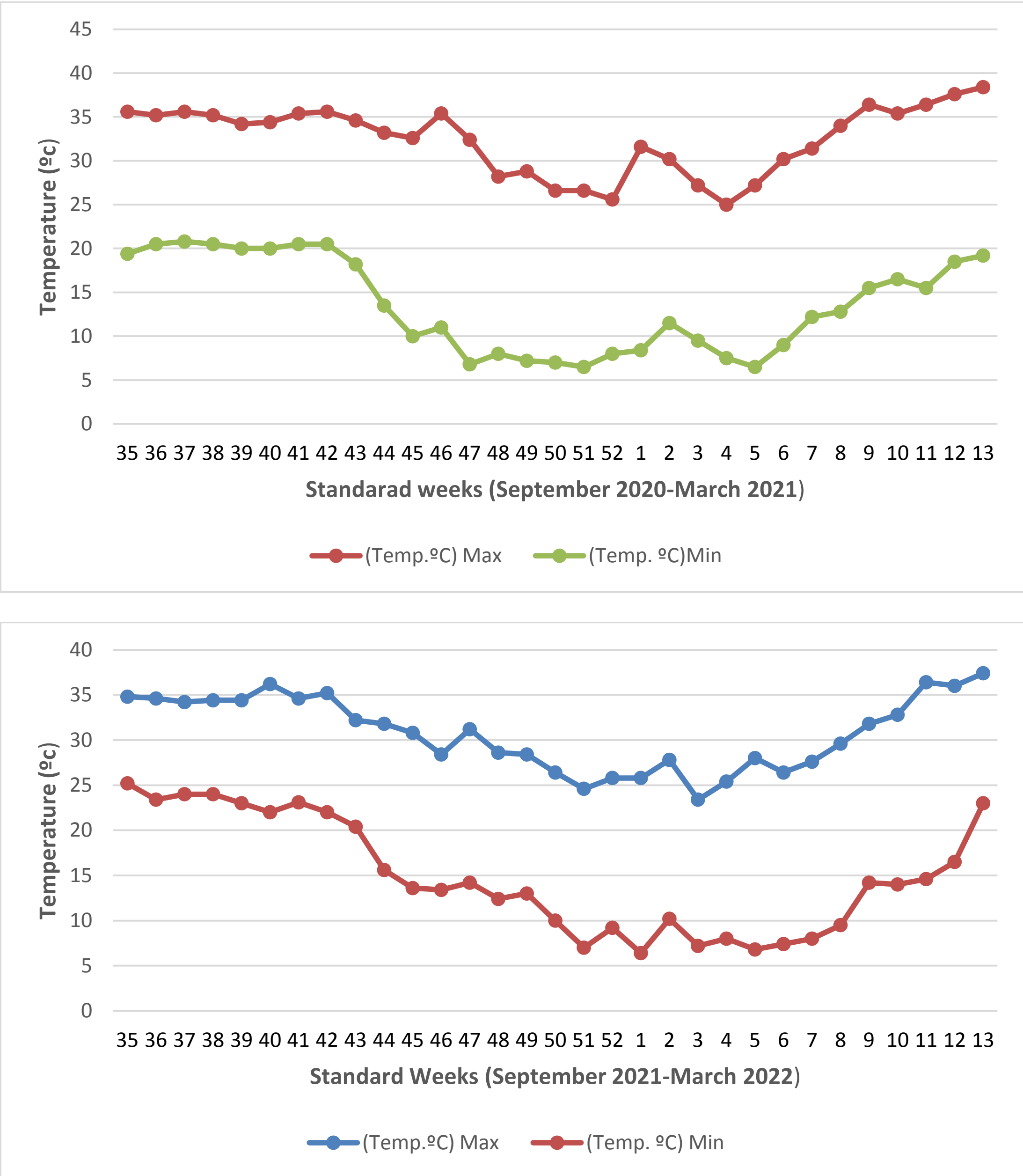

Fig. 1. Weekly meteorological observation on maximum and minimum temperature (ºC) during the experimental period

Source: Department of Agricultural Meteorology and Physics, BCKV, Mohanpur it is evident that plants receiving the treatment in the 2nd week of October exhibited early (29.07 days) flower bud emergence, whereas delayed (42.72 days) flower bud emergence registered in treatment T_5 (bending on 4th week of November). In terms of days to sepal reflex and to attain cup shape stage similar trend was followed and early (40.81 and 43.65 days) sepal reflex and cup shape attained in the treatment T_2 (bending on 2nd week of October) revealed earliness for both the traits. Flower bud emergence was delayed by 13.65 days in shoots bended in 4th week of November as compared to bending in October 2nd week. The traits days to sepal reflex and days to attain harvestable stage (cup stage) was also delayed in the shoots bended in December irrespective of the time of bending.

3.3 Flower Quality Parameters

Data recorded for the flower quality traits were influenced by the time of shoot bending and presented in Table 2. The traits length and diameter of flower bud, flower diameter at harvest, shoot length of flowering shoot, length and diameter of flower stalk, length and diameter of pedicel and weight of individual flower with stalk attained levels of significance in response to shoot bending done commencing from last week of September to December in both the years of study. Bending as early as September was reported to be best in terms of quality attributes like length and diameter of flower bud, length and diameter of pedicel and weight of individual flower with stalk. Among the treatment schedule, bending in the 2nd week of December, produced biggest (4.56 cm) size flowers at cup shape stage (harvesting stage). Application of shoot bending in the 2nd week of November proved to be superior in terms of flower quality parameters like shoot length of flower, stalk length of flower and thickness of stalk, while plants received treatment in the 4th week of September registered with least values for all the flower quality traits. As we can see from the graphical presentation (Fig. 3), greater number of flowers from the bent shoots were recorded in the treatment T_5 (bending on 4th week of November), while minimum was registered in T_1 (bending on 4th week of September).

Life of flowers in the field condition and in vase solution was observed maximum from the plants received treatment in the 4th week of November, whereas minimum values for self-life and vase life of flowers was recorded from treatment T_1 (Bending on 4th week of September). Similar trend was also followed in terms of number of flowers per plant in bent shoots. The maximum (10.13) number of flowers were produced from the treatment T_5 (bending on 4th week of November).

3.4 Chlorophyll and Anthocyanin Content

As presented in Fig. 4, chlorophyll content in leaf tissues and anthocyanin content in flower petals was maximum in the plants receiving treatment in the 4th week of November, whereas minimum values for these traits was recorded in shoots produced as a result of bending in the 2nd fortnight of September.

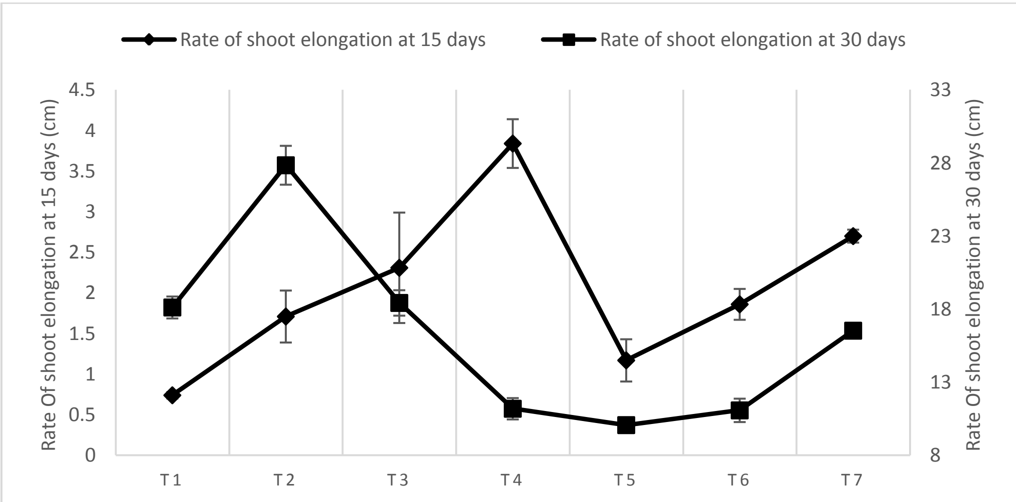

Fig. 2. Effect of shoot bending at different time on rate of shoot elongation at 15 and 30 days after bending of hybrid tea rose cultivar minu pearle

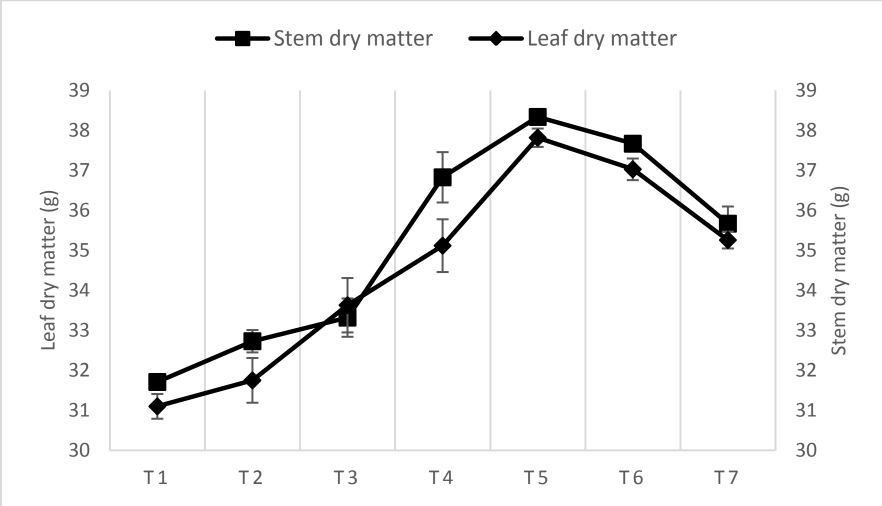

Fig. 3. Effect of shoot bending at different time on leaf and stem dry matter accumulation per 100 g of fresh weight of hybrid tea rose cultivar minu pearle

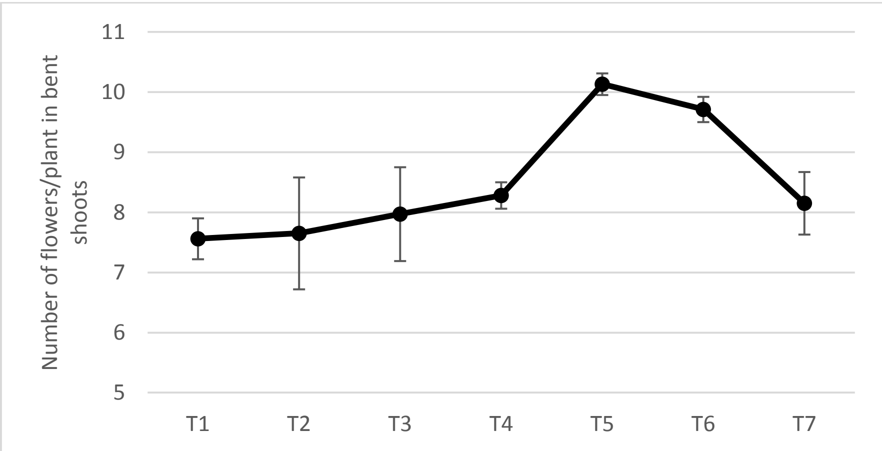

Fig. 4. Effect of shoot bending at different time on number of flowers per plant in bent shoots of hybrid tea rose cultivar minu pearle

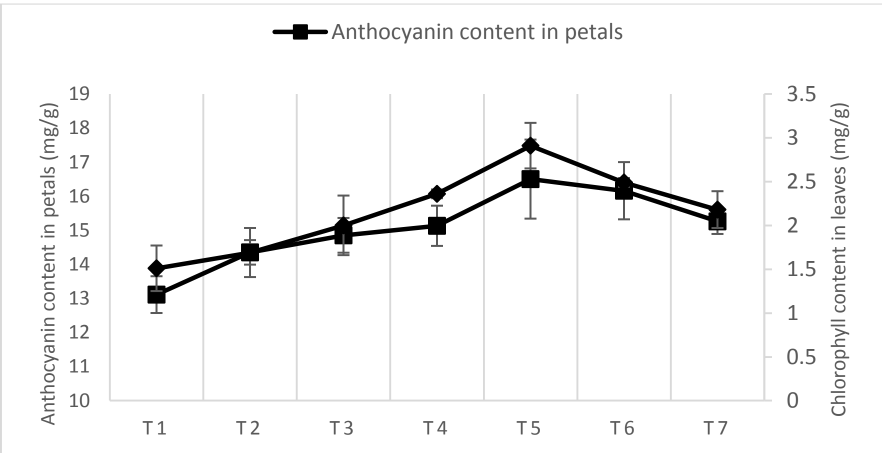

Fig. 5. Effect of shoot bending at different time on chlorophyll (leaf) and anthocyanin (petal) content of hybrid tea rose cultivar minu pearle

Table 1. Effect of shoot bending at different time on different vegetative and flowering parameters of hybrid tea rose cultivar minu pearle

Treatment	Vegetative parameters				Flowering parameters		
	Plant height (cm)	Plant spread (E-W) (cm)	Plant spread (N-S) (cm)	Individual leaf area (cm^2)	Days to FBE	Days to sepal reflex	Days to cup shape
T_1	44.13	46.35	46.97	15.40	29.70	45.22	47.84
T_2	46.38	52.27	49.77	16.78	29.07	40.81	43.65
T_3	54.43	57.07	56.39	16.78	36.74	49.92	51.92
T_4	59.16	54.90	53.90	21.73	38.51	49.05	53.15
T_5	63.75	58.40	58.02	23.37	42.72	54.91	59.20
t_6	61.53	62.26	65.10	21.10	42.45	59.92	66.25
t_7	57.10	65.60	61.50	19.43	41.47	58.65	65.23
S.Em. ±	**1.99**	**2.23**	**1.63**	**0.97**	**0.55**	**0.82**	**0.60**
C.D. at 5 %	**5.70**	**6.39**	**4.67**	**2.78**	**1.57**	**2.34**	**1.72**

Table 2. Effect of shoot bending at different time on flower quality parameters of hybrid tea rose cultivar minu pearle

Treatments	Length of flower bud (cm)	Diameter of flower bud (cm)	Diameter of flower at harvest (cm)	Shoot length (cm)	Stalk length (cm)	Stalk diameter (cm)	Pedicel length (cm)	Pedicel diameter (cm)	Weight of individual flower (g)	Self-life of flower (days)	Vase life of flower (days)
T_1	1.73	1.30	2.65	31.01	23.15	0.48	5.07	0.39	5.45	5.48	4.58
T_2	2.22	1.35	2.61	34.91	25.82	0.61	4.50	0.41	6.83	4.67	4.37
T_3	2.01	1.22	2.36	38.01	28.54	0.56	4.92	0.36	5.88	5.20	4.83
T_4	2.28	1.26	3.90	42.56	33.58	0.77	6.48	0.47	13.58	6.93	5.62
T_5	2.61	1.77	4.44	40.46	31.46	0.66	7.35	0.49	15.02	7.21	7.08
t_6	2.11	1.75	4.56	39.14	31.73	0.57	7.11	0.43	12.65	6.21	6.48
t_7	1.88	1.57	4.08	37.48	28.92	0.47	6.36	0.40	11.74	5.58	5.35
S.Em. ±	**0.06**	**0.02**	**0.10**	**0.90**	**0.75**	**0.03**	**0.18**	**0.03**	**0.31**	**0.21**	**0.24**
C.D. at 5 %	**0.19**	**0.14**	**0.29**	**2.59**	**2.14**	**0.09**	**0.53**	**0.08**	**0.89**	**0.61**	**0.68**

4. DISCUSSION

Significant difference in the vegetative traits, plant height, plant spread & leaf area was observed among the treatments. The findings of the study displayed tallest plants (63.75 cm) with largest leaves (23.37 cm^2) in Bending on 4th week of November & shortest plants (44.13 cm) with smallest leaves (15.40 cm^2) in September bended shoots. These findings are in conformity to the results obtained by Shin et al. [9] in rose, where they suggested that with decreasing temperature stem length and leaf area increased and this difference may be due to exposure of plants to lower temperature during treatment application and thereafter gradual fall of temperature. Better plant growth in rose with the progress in winter after pruning treatment was reported by Younis et al. [10]. Decreased leaf area as evident in the findings (Table 1) during September & October (irrespective of weeks) bending, can be ascribed to the high temperature as observed in the meteorological data [35 ºC approximate average monthly temperature (Fig. 1) which can be related to the research results obtained by Rezazadeh et al. [11], where increasing temperature from 15 to 25 ºC enhanced leaf expansion, nonetheless 35 ºC resulted in less leaf expansion. Decrease in growth in field grown rose under hot climate was also suggested by Nadeem et al. [12]. Minimum values of vegetative parameters namely plant height, leaf area, rate of shoot elongation & plant spread at prevailing high temperature (bending treatments applied in September & October 2nd and 4th week) can be imported to lower photosynthesis rate at high temperature as reported by Ushio et al. [13] and Xie et al. [14]. Much as a trend was observed in the findings of the study, reduced minimum and maximum temperature led to greater plant height, plant spread and leaf area. It was also noted that the traits registered minimum values when bending was done in the 2nd fortnight of December, this may be attributed to the sudden fall in the minimum temperature after 2nd week of December as evident from the meteorological observations recorded (Fig. 1) & can be explained that plant growth in low temperature condition is slower due to low carbon use efficiency.

With respect to plant spread (East to West & North to South) more spread of plants canopy during both the years of study (65.60 cm & 65.10 cm, respectively) was in T_6 (Bending on 2nd week of December) followed by Bending on 4th week of December. Younis et al. [10] documented pruning in *Rosa centifolia* during end of December resulted in maximum growth. Minimum spread in September bending can be supported by research findings that high temperature led to decrease in growth of rose bush as reported by Nadeem et al. [12]. Bending on 2nd week of November resulted in maximum (3.84 cm) shoot elongation rate when measured 15 days after bending. However, greater (27.85 cm) shoot elongation rate was recorded 30 days later (i.e.when measured in the 2nd week of November) as a result of response of shoots to bending in 2nd week of October. From meteorological observation made when the crop was in the field, the better performance of October bending can be credited to a gradual decrease of about 3-5ºC (Fig. 1) in temperature recorded between application of treatment and the time when the data was recorded (30 ºC prevailing temperature as against 33-35ºC during treatment application). Yeo et al. [15] working with single stem rose identified temperature as an appropriate weather variable for explaining growth of the crop. Increase rate of shoot elongation at 30 ºC may be attributed to increased photosynthetic rates as reported by Pasian and Lieth [16] in greenhouse grown rose Cv. Cara Mia.

Early flower bud emergence was recorded in shoots bend at 2nd week of October and 4th week of September (29.07 & 29.70 days, respectively), Moe and Kristoffersen [17] found at higher temperature, the days to flowering was lesser in rose. However, days taken to flower bud emergence were longer with delayed bending. The calculated value exhibited delayed bending resulted in gradual increase in the number of days taken to flower bud emergence from bending as may be influenced by the average monthly maximum-minimum temperature, which decreased till January. Delayed flower bud emergence due to lower temperature appeared to be in parallel to the findings of Shin et al. [9], where number of days to bud break in 15 ºC was 3 times that of in 30 ºC. Discussing the other flowering attributes as presented in Table 1, days to sepal reflex & attaining of cup shape stage (harvesting stage) was least (40.81 & 43.65 days, respectively) in the shoots bended on 2nd week of October (T_2). Impact of higher temperature on flowering traits in terms of earliness to blooming (FBE to harvestable stage) was in accordance to the conclusion drawn by Dieleman et al. [18], supported by De Vries et al. [19], Van den Berg (1987) and Marcelis van

Acker [20] in rose. The flowering traits FBE, sepal reflex and cup shape was seen to be delayed by decrease in the maximum-minimum temperature, these results match the observations recorded by Khattak and Pearson [21] in Antirrhinum, where flowering was delayed as temperature decreased.

Flower quality parameters were significantly influenced by bending at different time, except the traits, flower bud length and diameter which showed negligible variation as appeared in readings presented in Table 2 However, the flower diameter measured at harvest offered to suggest that bending in December 2nd week was superior to September, October and early November bending, thus it can be discussed that plants receiving lower temperature regimes during application of the treatment & thereafter till harvest was promising in terms of flower diameter. This observation made can be discussed in the light that flower development required carbon import from the source organs (leaves), sucrose hydrolysis in the sink organs (flowers) is necessary to establish a concentrate gradient for carbon transport between the sources and sink [22]. High temperature reduced sucrose hydrolysis and therefore increase its concentration in flowers, which reduces or inhibits uptake of carbon by the developing flower buds & may consequently reduce final flower size. The difference in the day and night temperature in November, December & January favoured higher flower diameter. Flower shoot length and stalk length registered greater values (42.56 cm & 33.58 cm respectively) when the plants received bending treatments in 2nd week of November and reduced shoot length at bending in the month of September and October. When the prevailing temperature was as high as 35 ºC with 100% RH reduced shoot length at temperature above 20 ºC in rose was described by Dieleman et al. [18], Shin et al. [9], Marcelis-van Acker [20] and De Vries et al. [23] in rose. The perusal of data in Table 2 revealed the influence of winter months on the pedicel length. The computed values in the Table 2, indicates the significant effect of bending time on weight of individual flowers with stalk, with heaviest flowers (15.02 g) resulting from bending of primary shoots in the 4th week of November (T_5), flower weight with least values (5.45 g) was seen in shoot bended as early as September 4th week (T_1) followed by bending in October 2nd week (T_2), where the values were statistically at par. Difference in the performance of November bending treatments with that of September & October bending treatments may be due to the negative impact of high temperature on flowering during the month of September and October. The result of the present study can be supported by research report of earlier workers Moe and Kristoffersen [17], who suggested less number of petals may be the reason of lower flower weight as a result of high temperature. Significant variation was observed in the trait number of flowers per plant in bent shoots, highest (10.13) number of flowers were recorded in the plant receiving treatment in the month of November (T_5), while lowest number of flowers from bent shoots were harvested in T_1 (Bending on 4th week of September). Several researchers [24] reported that as temperature increased to 30ºC there was a decrease in flower production. Mean Daily Temperature (MDT) influenced flower number such that flower number decreased with rise in MDT [25,26]. Increase in Mean Daily Temperature ranging from 16-26 ºC decreased flower count in *Coreopsis grandiflora* by 80%, in *Leucanthemum superbum* by 53% and in *Rudbeckia fulgida* by 75% [27].

Dry matter accumulation from the stem and leaf was calculated per 100 g of fresh weight (Fig. 3). Maximum dry matter accumulated was recorded in the stems and leaves bended on the 4th week of November, whereas minimum was in September treatments. This is further evident that a reduction in the percentage of dry matter that is partitioned to the flowers relative to vegetative structure under high temperature [28]. In contrast to results of the present investigation, shoot biomass was found to increase with increasing temperature in American marigold, toria & globe amaranth. Similar results are reported in celosia [29], summer snapdragon [30]. High temperature also reduces photosynthesis efficiency because of incomplete photorespiration [31]. The pigments , Chlorophyll and Anthocyanin, in leaves and flower petals were significantly influenced with shoot bending at different time. The greater amount of chlorophyll and anthocyanin was recorded from the plants receiving treatment in the month of November, while values were least in T_1 (Bending on 4th week of September). Leaf chlorophyll degradation due to high temperature (35-37ºC) was reported by Tsialtas & Maslaris [32]. Similar finding in respect to higher amount of chlorophyll was also reported by Shin et al. [9], whereas in case of anthocyanin content the finding was supported by Biran and Halevy [33] & Shisa and Takano [34] in rose and Maekawa and Nakamura [35] in carnation. higher anthocyanin content in flowers which were produced during December and January, may be due exposure to low temperature and high light intensity is likely to be helped in increase sugar content in petals.

5. CONCLUSION

Thus from the compilation of results it can be concluded that bending in the month of irrespective of the weeks of treatment application & 4th week of November, resulted in better overall growth and flower quality parameters, nonetheless delayed flowering parameters were observed but with larger flowers at harvest. Early bending in the month of September and October can be recommended for early harvest to catch the market during festive season but with smaller flowers, sorter stalk length & less yield.

DATA AVAILABILITY

All data supporting the findings of this study are available within the paper.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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