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Effects of Environmental Factors on Tulip (*Tulipa sp.*) Cultivars Grown in West Bengal Plains

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Authors' contributions

This work was carried out in collaboration among all authors. Author SD performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author SAK designed the study and author TM managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

To investigate the effects of environmental factors on tulip (*Tulipa sp.*) cultivars in the plains of West Bengal, a field experiment was conducted with ten tulip cultivars, considered as ten treatments (T) (T_1=Apeldorn, T_2=Maureen, T_3=Holland Cich, T_4=Day Dream, T_5=Pussima Design, T_6=Avignon, T_7=Roi-du-midi, T_8=Clear Water, T_9=Colouch and T_{10}=Jumbo Beauty), at Horticultural Research Station, Bidhan Chandra Krishi Viswavidyalaya, Mondouri, Nadia, West Bengal, India in two successive years of 2013-14 and 2014-15. Flower yield, flower length (cm), flower diameter (cm), plant height (cm) etc were observed and statistically analyzed and correlation was done between the morphological data and the environmental factors. The results showed that the short duration cultivars could be more suitable for cultivation under the short and mild winter conditions of the plains of West Bengal.

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1. INTRODUCTION

Tulips (*Tulipa sp*.) are one of the most historically significant and renowned cut flower in the world. Tulip is a monocotyledonous plant and also a premier ornamental flowering bulb belonging to family Liliaceae. Tulips are one of the most popular spring flowering bulbous plants of all times and ranked third among the top ten flowers sold worldwide [1]. Being originated in central Asia tulip is a temperate crop [2,3], but being the largest producer of tulip flowers and bulbs and thus becoming the backbone of flower industry in The Netherlands, now Holland is regarded as home of the tulip. In India tulips are successfully grown mainly under the temperate regions of Jammu and Kashmir, Himachal Pradesh and similar hilly regions, although the pre-cooled bulbs are being made to flower during winter in plains. Lang [4] pointed out that flower initiation in many plants is dependent on the interaction between genotype and very specific environmental conditions especially the inductive factors of low temperature and photoperiod. Temperature requirements of Tulip is 17–25ºC for flower induction and organogenesis, 4–9ºC for flower maturation, shoot development and during 12–18 weeks and 14–16ºC for aboveground growth [5] *T. clusiana* thrives in the Northern Mediterranean climate of California, possibly making it a candidate for breeding for warm-winter tolerance [6].

The potential for flower production in West Bengal plains is evident, since the light intensity is relatively high with appropriate winter temperatures for flower development. As the global demand for flower bulbs continues to increase, it is obvious that further marketing and production efforts are needed, not only for the leading genera, but also for the great diversity to be found among several hundred other genera. Thus, in a new production area with warm climate, the main efforts need to be focused on the development of new commercial crops and suitable methods for their production. There exists dire need to introduce new flower crops in the country based upon modern production practices compatible to our environmental and climatic conditions [7].

It is evident that there is very meager research works conducted on tulips in Indian plains and there is no evidence of conducting any investigations on tulips in West Bengal plains. By considering the potential of tulip as an innovative cut flower and being an unaccustomed crop by the growers in the country, this study was conducted with an aim for identifying the best suited cultivars under the climatic condition of West Bengal plains.

2. MATERIALS AND METHODS

The experiment was conducted during the winter season of 2013-2014 and 2014-15 Horticultural Research Station, Bidhan Chandra Krishi Viswavidyalaya, Mondouri, Nadia, West Bengal, India. Ten tulip cultivars were considered as ten treatments (T) (T_1=Apeldorn, T_2=Maureen, T_3=Holland Cich, T_4=Day Dream, T_5=Pussima Design, T_6=Avignon, T_7=Roi-du-midi, T_8=Clear Water, T_9=Colouch and T_{10}=Jumbo Beauty) in this study. Precooled bulbs were collected at both the year of the study from J & K. The crop was grown in sandy loam soil having pH of 6.6-6.7, 0.74% organic carbon, 161.75 Kg/ha total nitrogen, 78.50 kg/ha available P_2O_5 and 278.00 kg/ha available K_2O. Average annual rainfall of the experimental site is 1457 mm, 85 per cent of which is received from June to September and mean monthly temperature ranges from 10ºC – 37ºC. Winter is mild and short with day temperature varying between 15ºC to 17ºC and night temperature ranging from 7ºC to 10ºC.

The experimental land was ploughed thoroughly with power tiller several times followed by harrowing and was exposed to sun for a period of about three weeks. A well rotten FYM @ 1 Kg/m^2, sand, MAP @ 100 g/m^2 and $MgSO_4$ @ 100 g/m^2were mixed properly with soil. The media was then sterilized with H_2O_2 @ 2 ml/L and left covered with polythene for 2 days. The cover was removed and the media was left uncovered for another week before planting. Bulbs were sown in the last week of November during the experimental years in 1 m x 1 m plots with a plant to plant spacing of 20 cm and row to row spacing of 25 cm and Randomized Complete Block Design (RCBD) was followed with three replications. Irrigation was given to maintain optimum soil moisture by applying water as and when required depending on the soil moisture status. Calcium nitrate @ 720 g/L of water and KNO_3 @ 50 g/L of water was applied in two weeks interval starting from 21 days after planting (DAP) up to full bloom stage. Irrigation was withheld from 3rd week of March and the plants were allowed to get dry. When the whole plant dried, harvesting of bulbs was done by

uprooting the whole plant in the first week of April.

During the experimental period flower yield (per sq m) was calculated for each cultivar as well as different environmental parameters [Tmax= Maximum temperature; Tmin= Minimum temperature; Tmean= Mean temperature; STI5= Soil temperature I at 5 cm depth; STI15= Soil temperature I at 15 cm depth; STI30= Soil temperature I at 30 cm depth; STII5= Soil temperature II at 5 cm depth; STII15= Soil temperature II at 15 cm depth; STII30= Soil temperature II at 30 cm depth; BSS= Bright sunshine hour; RHI= Relative humidity I; RHII= Relative humidity II; VPI= Vapor pressure I; VPII= Vapor pressure II] were measured for each of them.

The occurrence of different pheno-phases like flower bud emergence (FBE), bud burst (BB) and full bloom (FB) were then recorded and the mean and accumulated values of different weather parameters prevailing during the following pheno-phases of tulip were computed.

- Planting to flower bud emergence (P-FBE) (No. of days)
- Planting to bud burst (P-BB) (No. of days)
- Planting to full bloom (P-FB) (No. of days)
- Flower bud emergence to full bloom (FBE-FB) (No. of days)
- Bud burst to full bloom (BB-FB) (No. of days)

The phenophase-wise simple correlation studies involving mean and accumulated values of weather parameters and different plant parameters pertaining to flower quality, vegetative growth, phonological events, bulb quality and flower yield were carried out following the methods described by Gomez and Gomez [8].

3. RESULTS AND DISCUSSION

As the cultivars tested were of different durations, they have been categorized into short and long duration cultivars. The Cultivars attaining full bloom stage within 51 to 61 days have been considered as short duration and cultivars coming under this category are Apeldorn (T1), Holland Cich (T3), Day Dream (T4), Pussima Design (T5) and Jumbo Beauty (T10). On the other hand those cultivars reaching full bloom phase within 70 to 80 days have regarded as long duration cultivars which included Maureen (T2), Avignon (T6), Roi-du-midi (T7), Clear Water (T8) and Colouch (T9).

3.1 Flower Yield (per sq m) of Ten Tulip Cultivars

The data on number of flowers per sq m revealed significant differences during the experiment. Maximum number of flowers per sq m (16.7) were produced by T_1 followed by T_{10} (12.6), whereas the other short duration cultivars T_3, T_4, T_5 produced 5.1, 5.2 and 4.3 flowers per sq m respectively. On the other hand, among the long duration cultivars T_2 and T_6 produced 5.7 and 7.4 flowers per sq m, T_9 produced 4.4 flowers per sq m, whereas T_7 and T_8 (4.3) recorded as at par as well as they produced minimum number of flowers per sq m.

3.2 Daily Temperature Parameters

Daily values of maximum temperature (Tmax) recorded during two growing seasons of 2013-14 and 2014-15 revealed that Tmax decreased after planting and the lowest Tmax was found to occur 25 days after planting and thereafter, it increased gradually with fluctuations at different times during growing season. Tmax values were greater in 2014-15 than those in 2013-14.

In 2013-14 crop season, the lowest Tmax was noted 46 days after planting, beyond which it increased accompanied by fluctuations in different times during crop season. Thus, the short duration cultivars reaching full bloom within 51 to 61 days from planting experienced lesser maximum temperature, while long duration cultivars requiring 70 to 80 days to reach full bloom from planting experienced higher maximum temperature.

From the values of daily minimum temperature (Tmin) it is evident that the lowest Tmin was observed 25 days after planting and thereafter it increased gradually along with fluctuations. In 2013-14 crop season, the lowest Tmin was observed at 45 days after planting, after which it increased gradually. It is worthwhile to mention that Tmin was more in 2013-14 than in 2014-15 in maximum number of days during growing season. However, differences in Tmin between 2013-14 and 2014-15 crop seasons were lesser during bud burst to full bloom (BB-FB) than those in other phases of growth. Thus, it is apparent that the short duration cultivars reaching full bloom within 51 to 61 days from planting experienced lesser minimum temperature, while the long duration cultivars requiring 70 to 80 days

to attain full bloom from planting experienced higher minimum temperature.

During the experimental period maximum temperatures varied from 24.8ºC to 25.4ºC and the minimum temperatures varied from 11.1ºC to 13.3ºC for short duration cultivars. The maximum and temperatures varied from 25.4ºC to 25.6ºC and 11.5ºC to 13.8ºC for long duration cultivars, respectively during the study.

Daily mean temperature (Tmean) values which are averages of daily maximum and minimum temperatures recorded during two growing seasons of 2013-14 and 2014-15 revealed that Tmean decreased after planting with the lowest Tmean occurring at 25 days after planting, beyond which it increased gradually with fluctuations at different times during growing season. Tmean values were greater in 2014-15 than those in 2013-14. It is obvious that the short duration cultivars reaching full bloom within 51 to 61 days from planting experienced lesser mean temperature, while long duration cultivars requiring 70 to 80 days to full bloom from planting experienced higher mean temperature.

3.3 Variation in Different Weather Parameters during Different Phases of Growth of Tulip

Phenology, regarded as an art of observing life cycle phases of pants, is the study of the timing of recurring biological events, the causes of their timing with regard to biotic and abiotic forces and interrelation among phases of the same or different species [9].

In the present study, the whole life cycle of tulip, i.e. the period of planting to full bloom was subdivided into five distinct developmental phases [Planting to flower bud emergence (P-FBE), planting to bud burst (P-BB), planting to full bloom (P-FB), flower bud emergence to full bloom (FBE-FB) and bud burst to full bloom (BB-FB)], called phenophases, on the basis of external morphological characteristics.

The number of days required for completion of vegetative phase (P-FBE) for short duration cultivars ranged between 43 to 54 days over the crop seasons 2013-14 and 2014-15. The number of days needed for completion of vegetative phase (P-FBE) for long duration cultivars ranged between 64 and 73 days over the crop seasons 2013-14 and 2014-15. On the other hand, the planting to full bloom (P-FB) phase needed 51 to 61 days for short duration cultivars over the crop seasons 201314 and 2014-15. The days to arrive at full bloom stage from planting (P-FB) for long duration cultivars varied from 70 to 80 days over the crop seasons 2013-14 and 2014-15.

3.4 Impact of Environmental Factors on Phenophase Durations

Results of the correlation study (Table 1) revealed that the greater values of maximum temperature, and afternoon soil temperatures at 5, 15 and 30 cm depths were associated with longer duration at vegetative phase, while higher values of the said parameters prevailing at reproductive phase shortened the duration of this phase.

Table 1. Correlation coefficient between phase duration (days) and mean weather parameters during corresponding phases of tulip

Weather parameters	Growth phases				
	P-FBE	P-BB	P-FB	FBE-FB	BB-FB
Tmax	0.26	0.70	0.54	-0.01	0.14
Tmin	-0.21	-0.06	0.05	0.30	0.24
Tmean	0.03	0.30	0.37	0.19	0.22
STI5	-0.07	0.17	0.40	0.25	0.45
STI15	-0.03	0.17	0.32	0.24	0.14
STI30	0.06	0.18	0.27	0.17	0.13
STII5	0.38	0.49	0.40	-0.17	-0.06
STII15	0.21	0.40	0.43	0.11	0.38
STII30	0.07	0.22	0.35	-0.63	0.03
BSS	0.80	0.81	0.82	-0.32	-0.32
RHI	-0.04	0.39	0.63	-0.18	-0.18
RHII	-0.49	-0.43	-0.51	-0.43	0.15
VPI	-0.16	0.06	0.19	-0.66	0.04
VPII	-0.38	-0.29	-0.29	-0.57	0.05

Table 2. Correlation coefficient between number of flowers per m^2 and accumulated weather parameters during different phases of growth of tulip

Weather parameters	Growth phases				
	P-FBE	P-BB	P-FB	FBE-FB	BB-FB
Tmax	-0.33	-0.31	-0.33	-0.32	-0.38
Tmin	-0.29	-0.24	-0.26	-0.08	-0.30
Tmean	-0.32	-0.29	-0.31	-0.24	-0.36
STI5	-0.31	-0.29	-0.37	-0.23	-0.31
STI15	-0.30	-0.29	-0.36	-0.25	-0.31
STI30	-0.29	-0.29	-0.35	-0.26	-0.25
STII5	-0.28	-0.28	-0.36	-0.37	-0.40
STII15	-0.30	-0.29	-0.36	-0.31	-0.33
STII30	-0.30	-0.29	-0.36	-0.25	-0.26
BSS	-0.27	-0.32	-0.39	-0.31	-0.30
RHI	-0.27	-0.30	-0.38	-0.22	-0.24
RHII	-0.27	-0.28	-0.35	0.04	0.02
VPI	-0.28	-0.28	-0.36	-0.15	-0.33
VPII	-0.26	-0.27	-0.34	-0.04	-0.11

Table 3. Correlation coefficient between phase duration (days) and flower yield (per sq m) of tulip

Flower yield	Growth phases				
	P-FBE	P-BB	P-FB	FBE-FB	BB-FB
Flowers/sq m	-0.33	-0.33	-0.33	0.09	-0.13

[Significance of correlation coefficient (r), at 1% level of significance, r=0.56 and at 5% level of significance, r=0.44]

[P-FBE=Planting to flower bud emergence, P-BB=Panting to bud burst, P-FB=Planting to full bloom, FBE-FB=Flower bud emergence to full bloom, BB-FB=Bud burst to full bloom]

3.5 Impact of Environmental Factors on Number of Flowers per sq m

Correlation coefficients (Table 2) involving number of flowers per sq m and accumulated weather parameters during different phases of growth of ten tulip cultivars grown over two years revealed that accumulated weather parameters prevailing during vegetative and reproductive phases as well as during the entire growth period (P-FB) exhibited negative correlation with number of flowers per sq m. All values of correlation coefficients were found to be statistically non-significant.

3.6 Impact of Duration of Growth Phases on Flower Yield per sq m

Correlation coefficients (Table 3) involving phase duration and flower yield (per sq m) demonstrated that the flower yield showed negative correlation with number of days needed for completion of vegetative phase (P-FBE) and with total duration from planting to full bloom. Hence it is clear that the short duration cultivars produced more flowers (per sq m) in this study.

4. CONCLUSION

It is evident from the research that during the experimental period, the maximum and minimum temperatures varied from 24.8ºC to 25.4ºC and 11.1ºC to 13.3ºC for short duration cultivars and 25.4ºC to 25.6ºC and 11.5ºC to 13.8ºC for long duration cultivars, respectively. Thus, the results emanated from the study lead to conclude that short duration cultivars could be more suitable for cultivation under the short and mild winter conditions of the plains of West Bengal.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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