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Research Article
Flowering Phenology of European Plum (*Prunus domestica* L.) in the Semi-arid Environment of North-west India

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Abstract

Background and Objective: European plum (*Prunus domestica* L.) is a new introduction in the semi-arid environment of north-west India. The objective of the present study was to investigate the flowering phenology of European plum under the semi-arid environment of northwest India. **Materials and Methods:** The studies were made on three varieties of the European plum (*Prunus domestica* L.) planted at the Horticultural Research Farm of CCS Haryana Agricultural University, Hisar (India) during 2009 and 2010. **Results:** The results revealed that the flowering period of plum lasted for 40-42 days in both the observational years. The time of anthesis in all the three varieties was at 800 h in the morning. Maximum anthesis in the three varieties took place between 1200 and 1400 h and continued till 1800 h during both the years. Dehiscence of anthers started with the opening of flowers, flower longevity was about 3 days. **Conclusion:** The flowering phenology of plum in the north-western part of India revealed that this is a winter flowering plant, anthesis and anther dehiscence peak is in the middle of the day and flower longevity is about 3 days.

Key words: Anthesis, flower longevity, European plum, flowering phenology, *Prunus domestica*

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

European plum (*Prunus domestica* L.) is an important fruit plant. The plum fruit is a good source of vitamins, minerals, fiber and enzymes and has a high nutritional and medicinal value. It is rich in proteins, calcium, potassium and phosphorus[1]. Due to the presence of these ingredients, the plum fruit is good for the digestive system and is positively associated with nutrient intake. It improves the anthropometric measurements, a useful antistresser[2] and reduces the risk of hypertension[3,4]. In addition to the presence of various sugars, acids, pectins, tannins and enzymes. European plum fruits also contain several important secondary metabolites such as flavonoids and phenolic acids[5-8], which have a strong anti-oxidant capacity[9-18]. Ascorbic acid is another anti-oxidant present in plum fruit, essential for higher primates and a small number of other species[6]. Prunes are anti hyper-cholestremia[19] and anti-cancerous[20] also, increase bone mass, prevent osteoporosis[21,22], improve the bone health[23] and the liver function[24] and enhance the resistance to fungal infection[25].

The duration of flowering period is collectively referred to as flowering phenology. Many factors affect the flowering phenology of plants, European plum is no exception. Among these factors, the timing, frequency and duration of the flowering period is obviously of great importance[26]. The phenology of a species not only encompasses when, how often and how long reproduction takes place but also determines the degree of reproductive synchrony with other plant species[27,28]. Synchrony among species might be advantageous if the presence of one species facilitates increases in pollinator visitation and thus fruit/seed set in another species[26,29,30]. Conversely, in the case of wind-pollinated species or species sharing generalist biotic pollinators, there might be divergence in flowering times, presumably to reduce interspecific pollen collection and possible stigma clogging[31,32]. Perhaps similarly, competition for biotic pollinator visits favors divergence, given that reduced visitation rates due to competition among simultaneously flowering species can result in lower pollen transfer and thus lower fruit/seed set[26,33]. Some studies have already been made on the reproductive biology of plums under temperate conditions. It is now known that the plums are self-incompatible[34,35] and melittophilous mode of pollination predominates[36]. However, its flower phenology under semi-arid environment is not completely understood. In earlier study, the pollinators and pollination mechanism of this plant was investigated in this region[36]. The present study deals with flowering phenology of this fruit plant in the semi-arid environment of north-west India.

MATERIALS AND METHODS

The present study was carried out at the Research Farm of Department of Horticulture and in the Apidology Laboratory of the Department of Zoology, CCS Haryana Agricultural University, Hisar (India). Three varieties of plum (*Prunus domestica* L.) viz. Alu Bokhara, Titron and Kala-Amritsari, selected for this study were grown in the adjacent plots (Fig. 1).

The date of appearance of first fresh flowers on the trees was considered as the beginning and the date of complete disappearance as the cessation of the flowering season. The number of flowers per square meter were counted at 6 ft height once a week and categorized as scanty flowers when number was 1-3 flowers per square meter, mediocre when number was 4-6 flowers per square meter and peak when the number was more than 7 flowers per square meter. The ambient temperature and relative humidity prevailed during the flowering period of this plant were also recorded Fig. 2.

Fig. 1: Plants of plum crop in the field in peak blooming stage

Fig. 2: An inflorescence of plum

The flower buds due to open, the next day were tagged on the previous evening. The number of fully opened flowers was noticed from 0500-1700 h at hourly interval. Similarly, the dehiscence of anthers was determined by observing the presence of yellow powdery mass of pollen on the anthers with the help of a hand lens and presence of nectar at the base of the flower with the help of a micro-capillary and a hand lens. In each case, the observations were recorded at weekly intervals for 7 weeks and 350 flowers. Likewise, the longevity of the flower was determined by recording the time of its opening till it was shed and was repeated in 350 flowers. The data needing statistical analysis were separately subjected to one way Completely Randomized Design" following Snedecor and Cochran[37] and means were tested at 5% level of significance.

RESULTS

Commencement and cessation of flowering: All the three varieties of plum viz. Alu Bokhara, Titron and Kala-Amritsari flowered once a year for about 40-42 days in 3rd/4th week of January to last week of February/first week of March (Table 1, 2). The flowering started when minimum and maximum temperatures fluctuated around 10 and 24°C, respectively. Thereafter, the flowering was mediocre for around a week when maximum and minimum temperatures fluctuated around 11 and 26°C , respectively. Peak flowering occurred in the 2nd/3rd week of February when the minimum and maximum temperatures 8.5-13.7°C and 23-30.5°C, respectively. Thereafter, the flowering started to decline from 21st-25th February when the minimum and maximum temperatures were around ranged between 12 and 27°C, respectively. Flowering ceased completely in the last week of February or 1st week of March when minimum and maximum temperatures were around 15 and 32°C, respectively (Table 1, 2).

Time of anthesis, anther dehiscence and nectar production: Anthesis in plum took place rather slowly. The sepals were pushed backward gradually by expanding petals. It took 1 day for this process. The next day, petals appeared as a dome above the sepals. Slowly the outermost petal started straightening up and was followed by the next in succession. Gradually, they got pushed backwards exposing the stamen and the pistil. The pattern of anthesis was same in all the varieties of plum of this study. Peak anthesis in these varieties took place at 1300 h. Anthesis started at 800 h and continued till 1800 h (Fig. 3, 4). Dehiscence of anthers first started in inner whorl of anthers. Dehiscence started only after complete opening of the flower and went on for a day. It took more than a day to complete the dehiscence of all the anthers in a single flower. Dehiscence of anthers also reached a peak at 1300 h and continued till 1800 h (Fig. 5, 6).

Floral longevity: Flower in all the three varieties of plum lasted for about 2.5 days and inter-varietal differences were non-significant. It was 59.07±1.87 h for Alu Bukhara, 59.79±1.65 h for Titron and 59.65±1.31 h for Kala-Amritsari (Table 3).

DISCUSSION

Phenology is the scientific study of periodic biological phenomena, such as flowering, breeding and migration in

Table 1: Flowering phenology of plum (*Prunus domestica*) in 2009 in relation to ambient temperature

			Range of ambient temperature (°C)		Mean ambient temperature (°C)	
Crop parameters	Time interval	Duration (days)	Minimum	Maximum	Minimum	Maximum
Commencement of flowering	19-1-2009 to 23-1-2009	5	8.3-11.8	20.9-25.7	10.35	24.10
Scanty flowering	24-1-2009 to 28-1-2009	5	8.8-13.3	23.5-26.7	10.61	24.45
Mediocre flowering	29-1-2009 to 4-2-2009	7	8.8-13.6	24.2-29.6	10.73	25.83
Peak flowering	5-2-2009 to 20-2-2009	16	8.5-13.7	23.0-30.5	11.35	27.07
Scanty flowering	21-2-2009 to 25-2-2009	5	8.1-13.8	29.1-31.7	11.63	30.48
Cessation of flowering	26-2-2009 to 28-2-2009	3	13.8-15.9	28.5-31.4	14.64	31.83

Table 2: Flowering phenology of plum (*Prunus domestica*) in 2010 in relation to ambient temperature

			Range of ambient temperature (°C)		Mean ambient temperature (°C)	
Crop parameters	Time interval	Duration (days)	Minimum	Maximum	Minimum	Maximum
Commencement of flowering	25-1-2010 to 28-1-2010	4	7.3-12.8	21.5-25.5	10.25	23.50
Scanty flowering	29-1-2010 to 3-2-2010	6	8.3-12.5	24.2-28.2	10.31	25.90
Mediocre flowering	4-2-2010 to 10-2-2010	7	8.5-12.8	23.2-29.7	10.51	26.55
Peak flowering	11-2-2010 to 24-2-2010	14	9.1-16.2	22.1-31.2	12.04	27.58
Scanty flowering	25-2-2010 to 1-3-2010	5	14.7-18.3	26.6-34.7	15.28	31.47
Cessation of flowering	2-3-2010 to 5-3-2010	4	14.9-19.4	32.8-34.8	17.17	33.72

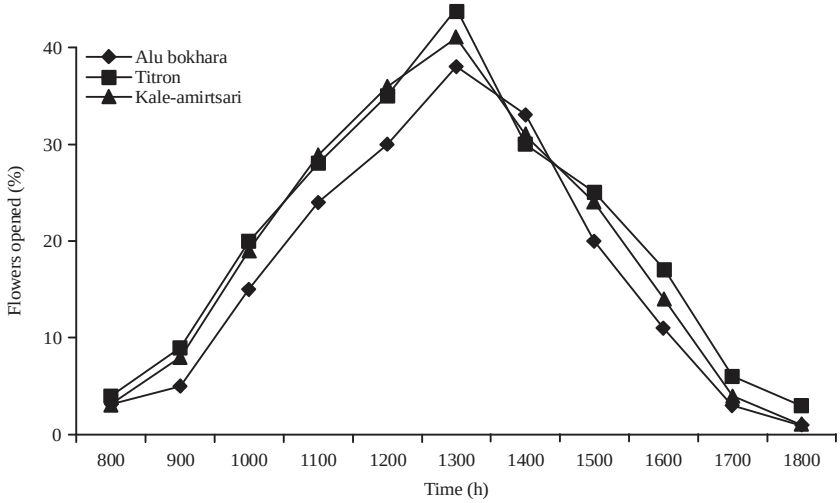

Fig. 3: Time of anthesis in different varieties of plum in 2009

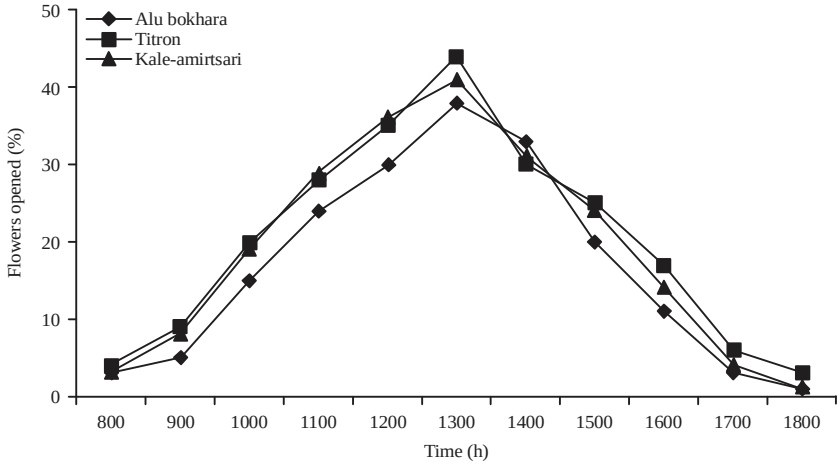

Fig. 4: Time of anthesis in different varieties of plum in 2010

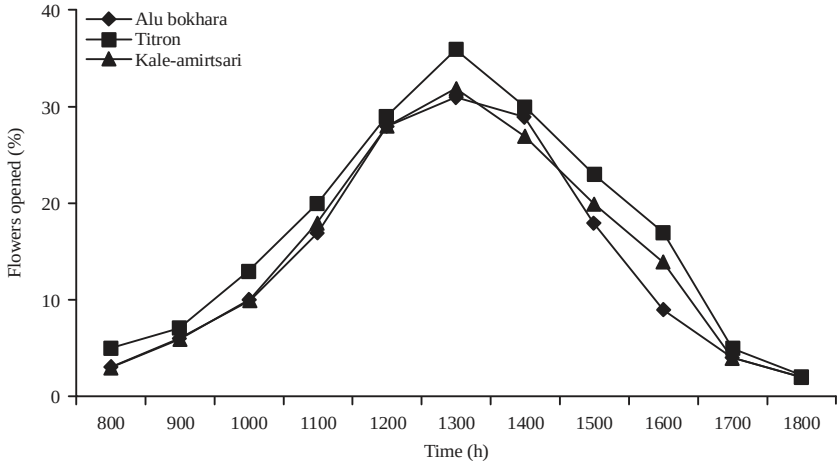

Fig. 5: Time of anther dehiscence in different varieties of plum in 2009

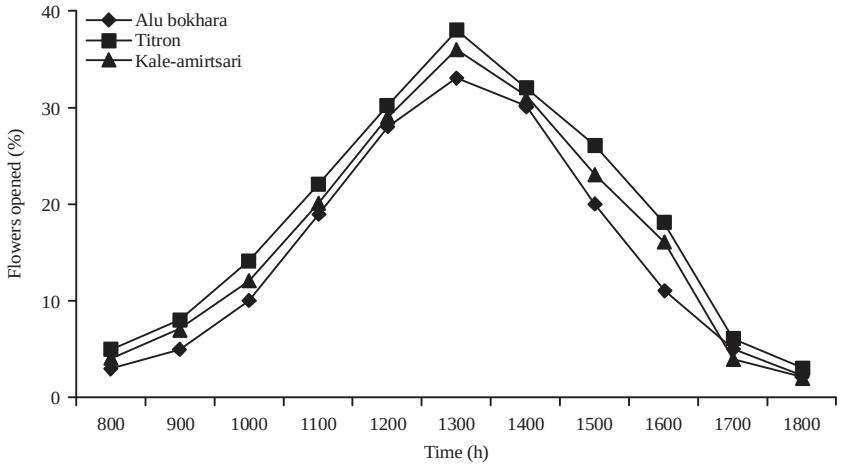

Fig. 6: Time of anther dehiscence in different varieties of plum in 2010

Table 3: Different floral attributes of three varieties of plum

	Floral attributes*			
Varieties	Flower diameter (cm)	Number of stamens	Umbel cluster	Longevity (h)
Alu bokhara	2.5±1.29	28.29±8.38	2.62±0.92	59.07 ±1.87
Titron	2.4±1.37	30.11±3.18	2.83±1.31	59.79 ±1.65
Kala-amritsari	2.7±1.14	29.21±3.95	2.56±0.95	59.65 ±1.31

*Mean±SD of 350 observations. Differences between varieties were non-significant (p>0.05, ANOVA, F-test)

relation to climatic condition. Phenology has been principally concerned with the dates of first occurrence of natural events in their annual cycle. The flowering habits of all the three varieties of plum viz. Alu-Bokhara, Kala-Amritsari and Titron under the semi-arid environment of Hisar were found to be similar. In this study, three varieties of plum viz Alu-Bokhara, Kala-Amritsari and Titron were found to flower once a year i.e., (January-March) when the weather matched the temperate conditions (Table 1, 2). Similar pattern of flowering was observed by Stinson[38] in *Potentilla pulcherrima* (Rosaceae) a high altitude plant, flowering quickly ensures reproductive success within a short snow-free period but limits maturation time and fecundity. Natural selection on prefloration intervals may, therefore, vary in contrasting snow-melt environments and could influence the outcome of phenological responses to climatic change.

The pattern of anthesis was same in all the varieties of plum under study. After full opening, the flower remains in an open condition for about 2-3 days till the petals shed. Maximum anthesis in these varieties took place between 12:00 h and 14:00 h with the increase of daily temperature, the time of anthesis was hastened. Anthesis started at 800 h and continues till 1800 h (Fig. 3, 4). Dehiscence of anthers first started in inner whorl of anthers. Dehiscence starts only after complete opening of flower and goes on for a day. It took more than a day to complete the dehiscence of all the anthers in a single flower. These results were at par with the findings of Ansari and Davarynejad[39] in sour cherry cultivars who reported that the stigma viability was 2-3 days. This process was intensive between 9:00-2:00 h clock and reached the maximum at 11:00 h clock. During 2 years of experiment, anther dehiscence started only a few min after flower opening. Maximum anther dehiscence occurred at 11:00-1:00 h clock in rather high temperature (Fig. 5, 6). Verma and Jindal[40] also reported that plum took about 2 days for completion of anthesis. Anthesis started at 800 h in the morning, continued till 1800 h while peak stigma receptivity staggered 1 day before and a day after anthesis. Bajwa *et al.*[41] and Randhawa and Nair[42] also reported that the dehiscence of the anthers in different plum varieties was completed in 2 days after the opening of the flower. The period when maximum anthers dehisced varied from 12:00 to 13:00 h depending upon the temperature of the day. In the present study, floral longevity was found to be 2.5-3 days. These results were at par with the findings of various earlier workers, for example, Verma and Jindal[40] and Randhawa and Nair[42] reported that the flowers of plum varieties shed their petals normally after 2-3 days and rarely after 1 or 3 days. Nectar concentration was found

to be at peak in the afternoon from 1:00 to 3:00 h as compared to rest of the day. These finding were found to be in agreement with the present study. Horvath and Orosz-Kovacs[43] studied the nectar production in plum. Flowers attracted bees both for their nectar and pollen. Nectar was secreted at 09.00-10.00 h and 18.00 h, its amount varied. The findings of present study are broadly in agreement with the previous ones (Fig. 3-6).

CONCLUSION

The flowering phenology of plum in the semi-arid environment of northwest India reveals that this is a winter flowering fruit plant in this region. The flowering season takes 40-42 days, the peak anthesis and dehiscence takes place around noon time. The flower remains alive for about 3 days. The knowledge of these findings would be useful in deciding the pollination management strategy of plum in the semi-arid environments of northwest India.

SIGNIFICANCE STATEMENT

European plum is a new introduction in the semi-arid environment of north-west India. Its establishment would depend upon the availability of basic knowledge on the reproduction and ecology of this plant under such conditions. This study is the first step and effort in this direction.

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