



Flowering and pollination studies plum (*Prunus domestica* L.) under temperate conditions of India

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ABSTRACT

The present investigations were carried out under temperate conditions on six-year-old bearing plants of different plum cultivars (Burbank, Satsuma, Wickson, Sharps Early and Santa Rosa) having synchronization in their flowering period. Among the studied cultivars, earliest full bloom and end of the bloom was also recorded in Sharp's Early i.e. 19-20th March and 25-26th March, respectively whereas Wickson was late. The duration of blooming varied from 11 days (Burbank, Sharp's Early and Wickson) and 15 (Santa Rosa) days. Maximum pollen viability and pollen germination was recorded in Burbank (87.14 %) and Wickson (81.44 %). Under open and self-pollination, maximum fruit set (65.6 % and 41.6 %) and fruit retention (28.0 % and 21.6 %) was recorded in Wickson, respectively. Cross combination of Wickson x Satsuma observed maximum fruit set (64.8 %) whereas maximum fruit retention was recorded in cross combination Santa Rosa x Burbank (28.00 %). From the present study, it is clear that Santa Rosa and Burbank would be the best choices as both the cultivars whereas Burbank and Wickson are considered as good pollinizers.

1. Introduction

Plum is one of the most important stone fruit of the world belongs to the family Rosaceae and the commercially cultivated plum belong to two species viz., *Prunus domestica* and *Prunus salicana* which is commonly known as the European and Japanese plum, respectively (Okie and Hancock, 2008). *Prunus domestica* L. being a high chill type and has been reported to have originated from Asia Minor whereas, *Prunus salicana* is a low chill type and native to China, although it was the commercial fruit of Japan and America. In India, plum is cultivated mainly in the northern hemisphere ranking fourth after apple, pear and peach (Vishnu *et al.*, 2012). *Prunus domestica* is mostly grown in temperate region of the country viz., Jammu and Kashmir and Himachal Pradesh, whereas *Prunus salicana* is grown in sub-tropical states viz., Punjab, Haryana, Uttarakhand, hills of Uttar Pradesh and sub-temperate regions of North Eastern states like Sikkim and Arunachal Pradesh. In India, Jammu and Kashmir is the leading state in area and production of the plum followed by Himachal Pradesh. European plums are consumed fresh as well as dry, while Japanese plums are mostly consumed as fresh (Ertekin *et al.*, 2006). The dried plums are known as prunes.

Plum fruits are borne laterally on short and thick spurs which have viability for more than five to seven years. In a single spur, there are three to five flowers that arise from the axil of the leaf bud. Plum flowers profusely and densely but fruit set percentage is low to very low (12-18 %). Plums are mostly are self-unfruitful and require proper pollination to ensure fertilization for a good fruit set. Self-unfruitful cultivars produce fruit only when pollinated with compatible pollen grains of other cultivars (Chung *et al.* 1998). Successful pollination depends not only on the compatible pollen but also on the synchronization of flowering period of the pollinizer variety. In cross-pollination, different varieties of nearly the same blossom period are planted for the transfer of pollen to the stigma. Good pollinators for plum produce 50,000 pollen per flower (Hartman and Neumullar, 2006). Thus, for a successful breeding programme, detailed knowledge of the floral morphology of the existing germplasm is a pre-requisite. Hence, there is a direct need to derive information on the floral behaviour of varieties before any recommendation given to the farmers. This study includes various aspects of flowering viz; floral biology, pollen morphology, pollen viability, pollen germination and ovary size which will be useful for taking up plum

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improvement programme.

2. Materials and Methods

The experiment was carried out at the experimental field of Division of Fruit Science, SKUAST-K, Shalimar, Srinagar during the years 2018. Six-year-old bearing plants of different plum cultivars (Burbank, Satsuma, Wickson, Sharps Early and Santa Rosa) having good vigour, health and bearing were selected. The trees were spaced 3 x 3 meters in a square system of planting and uniform cultural practices as per package and practices were followed during the period of study. The design of experiment was RCBD with three replications with a single plant in each replication.

Observations were recorded on initial bloom (10 %), full (80 %) and end of the bloom (petal fall) was recorded in all the cultivars visually. Duration of bloom was worked out by difference between initial bloom and end of flowering. Pollen size (length and breadth) was determined on an average of ten pollen grains with the help of an ocular micrometre adjusting it with stage micrometre and expressed in micrometre (μm). The pollen shape was determined by recording the length/breadth ratio of pollen grains and which was expressed as P/E (polar axis/equatorial diameter) ratio was determined by using a formula. According to this formula, when the ratio is 0.75 to 0.88 then the pollen shape is sub-oblate, similarly when the ratio 1.14-1.33, 1.33-2.00 and more than 2.00 they correspond to shapes sub-prolate, prolate and per-prolate (Erdtman, 1943). Ovary size was determined by measuring the length and breadth of excise ovary under the ocular micrometre and expressed in μm . Pollen viability and pollen germination were examined of the freshly collected pollen from the dehisced anthers and expressed in per cent.

Twenty five flowers in each pollination (open, self and cross pollination) methods were selected separately and observations were recorded. In cross pollination, all possible cross combinations of cultivars selected for the study were made which showed synchronized flowering times. Flowers at balloon stage were emasculated, bagged and tagged and the pollen of the desired pollinizers was applied with the help of brush in each cultivar. The pollinated flowers were covered with the muslin cloth bags. Care was taken so as to avoid any contamination in pollen grains. Fruit set (%) after 21 days and 45 days was calculated, fruit retention (%) at the time of harvesting and days to harvest was recorded when fruit has attained proper size and developed coloration and converted into days after full bloom. The observations recorded were subjected to statistical analysis as per the method Snedecor and Cochran (1994). The significant difference on the means was tested against the critical difference at 5 per cent significance.

3. Results and Discussion

Flowering behavior

Data on the flowering behaviour of some plum cultivars is presented in Fig. 3. Among the cultivar studied, the cultivar Sharp's Early was earliest to bloom and the initial bloom was observed on 14-15th March followed by cultivars Santa Rosa and Satsuma on 17-18th March and whereas late initial bloom stage was recorded in cultivar Wickson on 21st-22nd March. Earliest full bloom and end of the bloom was also recorded in Sharp's Early i.e. 19-20th March and 25-26th March, respectively followed by Satsuma 23rd-24th March and 30th-31st March, respectively whereas Wickson was late in attaining the full bloom (26-27th March) and end of the bloom stage (1st-2nd March). The duration of blooming varied from 11 days (Burbank, Sharp's Early and Wickson) and 15 (Santa Rosa) days (Fig 2). Sundouri *et al.* (2017) and Sharma *et al.* (2018) also reported 9-11 days and 12-16 days of duration of flowering while studying exotic plum cultivars, respectively however Bajwa *et al.* (1991) reported that time of flowering in plum cultivars varied from first week of February to the first week of March and observed a duration from 14 days to 31 days under sub temperate conditions. Kour (2018) also observed flowering duration ranging between 19 to 29 days in sub-tropical cultivars of plum. The overall bloom of fruit plant depends on climatic conditions like temperature, sunshine, humidity, rainfall and location which vary from place to place, time to time and year to year (Liverani *et al.*, 2010; Kang *et al.*, 2005).

Significant results were obtained among the studied plum cultivars for their reproductive parameters. The pollen grains of the cultivars studied significantly differs for their polar (length) and equatorial (width) dimensions (Table 1) and ranged from 34.54 μm (Sharp's Early) to 39.85 μm (Wickson) and from 20.48 μm (Santa Rosa) to 23.67 μm (Wickson), respectively. Santa Rosa (1.94) and Sharp's Early (1.53) registered maximum and minimum L/B ratio and all the studied cultivars exhibit prolate shape of pollens. The equatorial dimension of the pollen grains was generally lesser than the polar dimensions among studied cultivars, which could be due to variability in their genetic background. Sotonyi *et al.* (2000) and Josan *et al.* (1999) also reported similar observations in plum cultivars with respect to pollen size and shape and concluded that variation in pollen grain size may be attributed to the genetic makeup of the cultivar taken and moisture content. Maximum ovary length (polar) and width (equatorial) was observed in cultivars Satsuma (3253.09 μm and 2573.84 μm) which was statistically higher among all the studied cultivars whereas minimum ovary length (polar) was recorded in cultivar Burbank (2449.21 μm) and minimum ovary width (equatorial) was recorded in Sharp's Early (2029.39 μm), respectively. Likewise in pollen

grains, the equatorial dimension of the ovary was lesser than the polar dimension which might also be due to the genetic constitution of the particular cultivar and the prevailing climatic conditions of the particular place.

Pollen studies

Significant difference was observed for pollen viability and pollen germination among studied plum cultivars (Fig 1). Maximum pollen viability was observed in cultivar Burbank (87.14 %) which was statistically at par with cultivar Wickson (86.73 %) whereas minimum pollen viability was recorded cultivar Sharp's Early (68.63 %). From the study, it was observed that pollen germination was highest (81.44 %) in cultivar Wickson which was statistically at par with Burbank (79.61 %) however, minimum pollen germination was recorded in cultivar Sharp's Early (63.80 %). Pollen germination is considered to more reliable and more convenient method to assess the level of viability. The result obtained in the present study, for the pollen fertility (viability and germination) are in accordance with the results of Sharma and Bist (2003), Koskela *et al.* (2010) and Nencetti *et al.* (2010).

Pollination studies

The observations on fruit set and retention percentage under open pollination and self-pollination are presented in Table 3. Significant variation was observed in with respect to all the studied parameters among different plum cultivars. The average maximum fruit set under open pollination after 21 days (65.6 %) and 45 days (38.8 %) of full bloom was recorded in cultivar Wickson which was statistically higher among all the studied cultivars whereas cultivars Sharp's Early recorded minimum fruit set after 21 days (50.4 %) and 45 days (29.6 %) of full bloom. Under open pollination, maximum and minimum fruit retention at harvesting time was observed in Wickson (28.0) and Sharp's Early (20.0 %). Gravite and Kaufmane (2013) reported 37.7 per cent (Lotte) to 53.3 per cent (Sonora) fruit set under open pollination after June drop in plum cultivars. Minimum number of days from full bloom to harvest i.e. early maturity was registered in Sharp's Early (96 days) whereas maximum number of days from full bloom to harvest i.e. late maturity was observed in Satsuma (116 days) under open pollination method.

Under self-pollinated, maximum fruit set after 21 days (65.6 %) and 45 days (37.6 %) of full bloom was recorded in cultivar Wickson which was statistically higher among all the studied cultivars whereas cultivars Sharp's Early recorded minimum fruit set after 21 days (41.6 %) and 45 days (27.2 %) of full bloom (Table 3). Maximum and minimum fruit retention at harvesting time under self-pollination was observed in Wickson (21.6 %) and Burbank

(16.0 %), respectively. Under self-pollination studies, Koskela *et al.* (2010) reported 0.0 per cent to 56 per cent fruit set. Among five cultivars during a study Gravite and Kaufmane (2013) reported that only Sonora showed self-fertility (33.5 %) in self-pollination experiment. Minimum number of days from full bloom to harvest i.e. early maturity was registered in Burbank (98 days) whereas maximum number of days from full bloom to harvest i.e. late maturity was observed in Satsuma (115 days) under self-pollination method.

Significant variation was observed for percentage of fruit set and fruit retention in different cross combinations (Table 2). Maximum fruit set after 21 days of pollination was observed in cross combination of Wickson x Satsuma (64.8 %) closely followed and statistically at par with the cross combination of Burbank x Satsuma (63.2 %) and Santa Rosa x Burbank (62.4 %) whereas minimum fruit set was recorded in Satsuma x Sharp's Early (55.2 %). After 45 days of fruit set, maximum fruit set was recorded in cross combination of cultivar Santa Rosa x Burbank (39.2 %) and Wickson x Satsuma (39.2 %) closely followed and statistically at par with Santa Rosa x Sharp's Early (39.00 %) whereas minimum fruit set was recorded in cross combination of Satsuma x Sharp's Early (34.4 %). Maximum fruit retention at harvest was recorded in combination Santa Rosa x Burbank (28.00 %) closely followed and statistically at par with Santa Rosa x Wickson (26.4 %) and Burbank x Satsuma (25.6 %) whereas minimum fruit retention at harvest was recorded in cross combinations of Santa Rosa x Sharp's Early (21.6 %). In a study with five pollinizers, Gravite and Kaufmane (2013) showed best combination results among Adelyn x Victoria (66.5 %), however least suitable pollinizer in all the crosses was cv. Julius. Among different cross combinations, best cross combination was observed among Angeleno x Santa Rosa (Nencetti *et al.*, 2010). Cross-combination of Santa Rosa x Wickson (108 days) took maximum number of days from full bloom to harvest which was statistically higher among all other cross combinations whereas minimum number of days was taken by cross combination of Burbank x Satsuma (97 days).

4. Conclusion

A long anthesis period, abundant viable and fertile pollen is the pre-requisite for good fruit set and high productivity. In the light of current study, Santa Rosa and Burbank would be the best choices as both the cultivars are good and productive. Burbank and Wickson are considered as good pollinizers as the flowering period of these two cultivars synchronize with the other cultivars and both the cultivars have the highest pollen viability and germination.

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Table 1. Reproductive character of different plum cultivars

Cultivars	Pollen size		L/B ratio	Pollen shape	Ovary size		L/B ratio
	Pollen length (µm)	Pollen breadth (µm)			Ovary length (µm)	Ovary breadth (µm)	
Burbank	37.02	22.37	1.65	Prolate	2449.21	2079.56	1.17
Santa Rosa	39.81	20.48	1.94	Prolate	2977.07	2244.59	1.32
Satsuma	39.53	22.33	1.77	Prolate	3253.09	2573.84	1.26
Sharp's Early	34.54	22.47	1.53	Prolate	3108.63	2029.39	1.53
Wickson	39.85	23.67	1.68	Prolate	2755.58	2167.87	1.27
CD _{0.05}	2.22	4.50	0.11	-	111.42	119.58	0.06

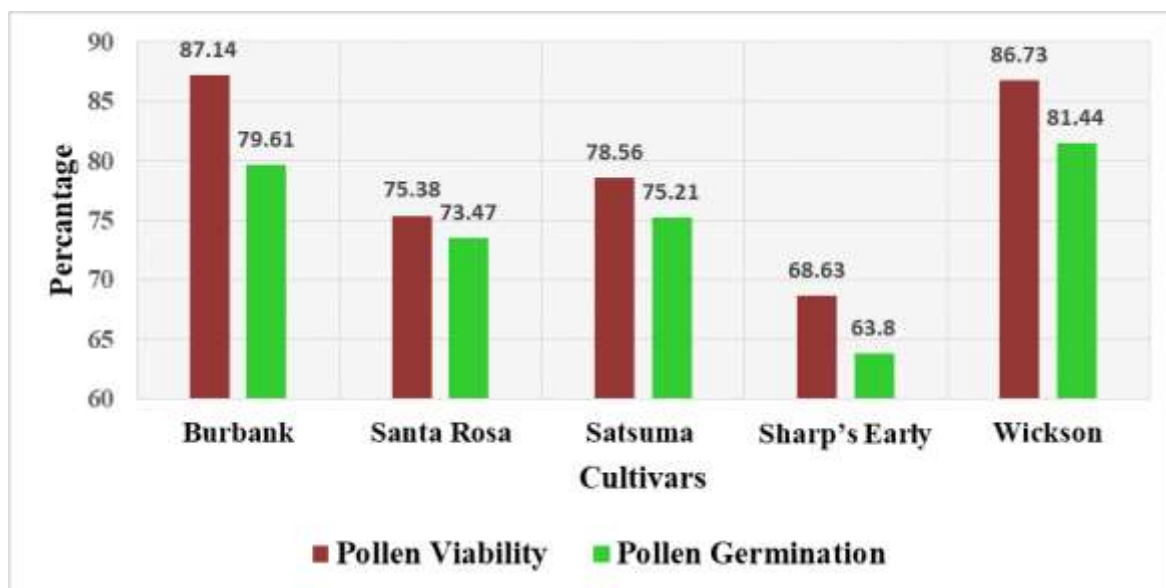


Figure 1. Pollen viability and pollen germination of various plum cultivars

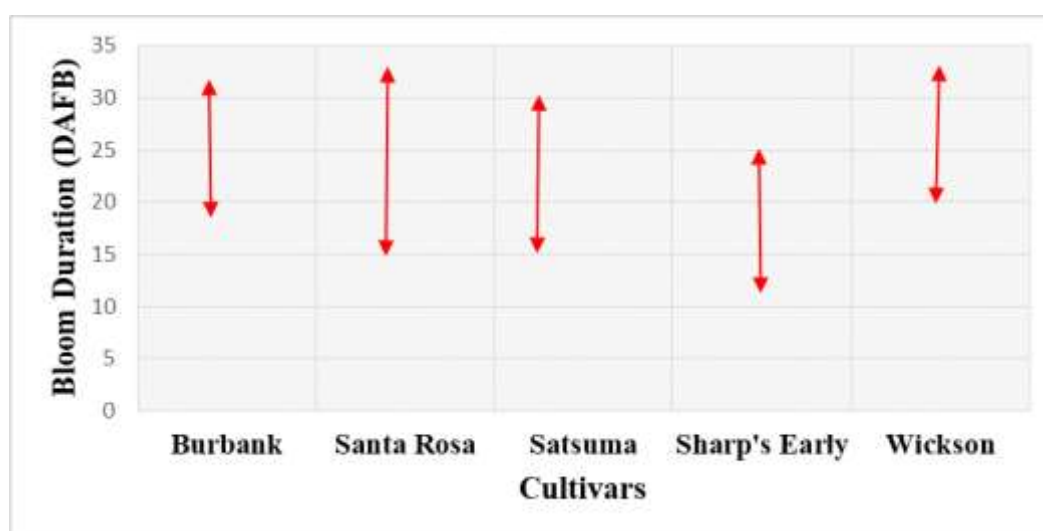


Figure 2. Synchronization of bloom period in various plum cultivars

Table 2. Fruit set, fruit retention and number of days taken from full bloom to fruit harvest in different plum cultivars under cross pollination

Cross combinations	Fruit set (%)		Fruit retention (%)	Number of days from full bloom to harvest
	21 days	45 days		
Burbank x Satsuma	63.2	36.8	25.6	97
Santa Rosa x Burbank	62.4	39.2	28.0	105
Santa Rosa x Sharp's Early	57.6	39.0	21.6	105
Santa Rosa x Wickson	57.6	35.2	26.4	108
Satsuma x Sharp's Early	55.2	34.4	24.0	101
Wickson x Satsuma	64.8	39.2	22.0	107
CD _{0.05}	3.51	2.59	2.41	0.86

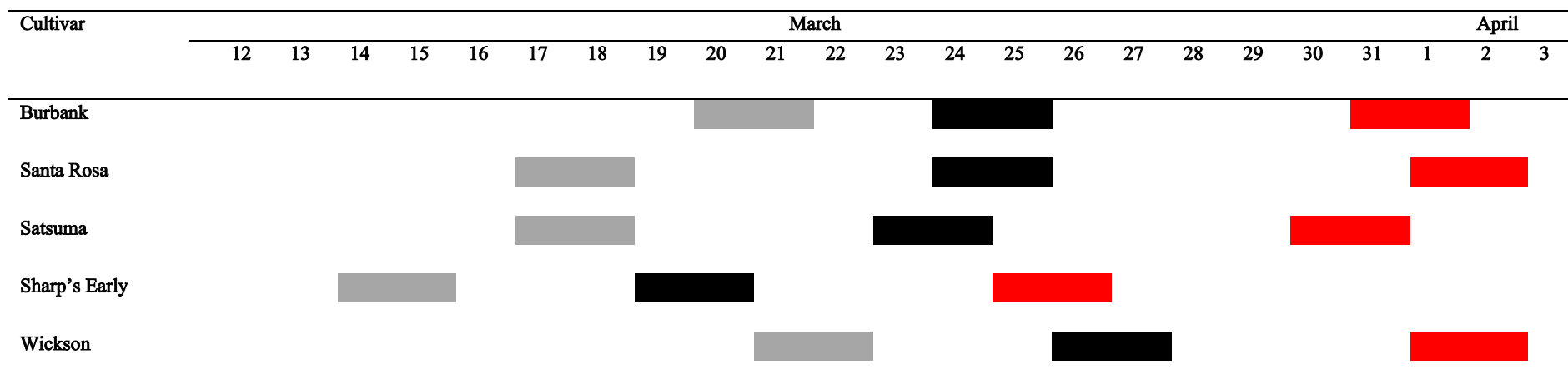


Figure 3. Flowering behaviour of different plum cultivars

Table 3. Fruit set, fruit retention and number of days taken from full bloom to fruit harvest in different plum cultivars under open and self-pollination

Cultivars	Open pollination				Self-pollination			
	Fruit set (%)		Fruit retention (%)	Number of days from full bloom to harvest	Fruit set (%)		Fruit retention (%)	Number of days from full bloom to harvest
	21 days	45 days			21 days	45 days		
Burbank	60.0	36.8	24.0	99	56.8	34.4	21.6	98
Santa Rosa	55.2	36.0	23.2	111	51.2	31.2	19.2	112
Satsuma	59.2	37.1	21.6	116	56.8	30.4	19.2	115
Sharp's Early	50.4	29.6	20.0	96	41.6	27.2	16.0	100
Wickson	65.6	38.8	28.0	107	65.6	37.6	20.8	109
CD _{0.05}	2.18	1.52	2.07	3.34	3.12	2.90	1.98	4.54