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SHORT COMMUNICATION

Effect of Different Pollen Sources on Fruit Set and Maturity of Exotic Pear (*Pyrus communis* L.) cvs. Carmen and Abate Fetel under Kashmir Conditions

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The cultivated pear (*Pyrus communis* L.) is an economically important fruit crop often showing gametophytic self-incompatibility. Therefore, this species needs to be pollinated by cross-compatible cultivars that bloom in the same time. Selection of appropriate pollinizers for pear cultivars is thus very important to produce commercial yield. The present study was undertaken on two exotic pear cultivars *viz*., Carmen and Abate Fetel used as maternal parents with seven pollinizer cultivars *viz.,* William Bartlett, Fertility, Clapp's Favorite, Chinese Sandy Pear, Max Red Bartlett, Kings Pear and Beurre d'Amanalis to assess the pollination behaviour, compatibility and effect of these pollen sources on fruit maturity. The treatments included self, open and cross pollination and the design of experiment was Randomized Complete Block Design (RCBD) with three replications per treatment. Among all the studied cultivars Chinese Sandy Pear was earliest (18^{th}-19^{th} March) in bud burst whereas, Abate Fetel was late in all the floral phenology parameters.Maximum flowering duration (17 days) was recorded in William Bartlett and Fertility whereas minimum (12 days) in Chinese Sandy Pear and Kings Pear.Highest compatibility in terms of fruit set (74.00%) was recorded with pollinizer "Fertility" followed by 72.83% with "William Bartlett" and 72.67% with "Max Red Bartlett. Likewise, highest mean fruit retention percentage (46.42%) was recorded with pollen source "Fertility" followed by 46.21% and 46.11% with "William Bartlett" and "Max Red Bartlett", respectively. Maximum days (127.10 days) from full bloom required to reach the harvestable stage were observed with pollinizer William Bartlett and minimum (123.49 days) with Clapp's Favourite. The pollinizer cultivars Fertility, William Bartlett and Max Red Bartlett proved to be best pollinizers for cvs. Carmen and Abate Fetel in terms of flowering duration, bloom synchronization and fruit set under Kashmir conditions.

Key Words: Fruit set, Flower phenology, Maturity, Pear, Pollination, Pollen compatibility

Introduction

Pear (*Pyrus communis* L.) cultivars are generally considered as self-unfruitful and do not set fruit by their own pollen due to the self-incompatibility. Self-fertilization in pear is prevented by a gametophytic self-incompatibility system (De-Nettancourt, 2001) and most of the pear cultivars are self-incompatible (Stern *et al*., 2004). This universal phenomenon of incompatibility averts the process of self-pollination. The transportation of pollen from flowers of one variety to those of another is probably the most critical single process in the series of events leading to the production of a good quality fruit. Pollination is the sexual portion of a tree's life cycle and involves the integration of several biological and physical factors comprising compatibility of different varieties, coincident blossoming periods, plenty of pollinators and suitable weather conditions. Absence of any of these factors may affect the crop yield and quality. Indeed, pollination management should be regarded as a production factor in its own right for the pear crop as it can affect the agronomic and economic yields and thereby many components such as fruit set, fruit quality (e.g. size, shape, colour and storability) and seed content. For effective cross pollination it is very important that the cultivars produce sufficient quantity of viable, compatible pollen and bloom approximately at the same time and the compatible pollinizers must be planted in the right proportion (Ershadi *et al*., 2010). Recently, two coloured pear cultivars Carmen and Abate Fetel were introduced by Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shalimar campus and under Kashmir conditions both

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these cultivars produce abundant bloom, however, bloom synchronization of these cultivars with the cultivars already grown in valley is not known. This necessitates the study on floral phenology and compatibility of different pollinizer cultivars with these varieties to ensure effective cross pollination with the ultimate aim of enhanced fruit set and yield in pear.

Materials and Methods

Healthy pear plants of uniform and full bearing age (6 years) and size growing under high density plantation were selected and tagged for the present study. The experiment was conducted at Experimental Farm of Division of Fruit Science, Sher-e-Kashmir University of Agricultural Science & Technology of Kashmir, Shalimar, Srinagar, Jammu and Kashmir during 2017-2018. The orchard soil was moderately deep with medium fertility status. Maternal parents *viz,* Carmen (M_1) and Abate Fetel (M_2) were crossed at balloon stage with male parents viz.,William Bartlett (P_1), Fertility (P_2), Clapp's Favourite (P_3), Chinese Sandy Pear (P_4), Max Red Bartlett (P_5), Kings Pear (P_6), Beurred'Amanalis (P_7) besides being self pollinated (P_8) and open pollinated (P_9). The female plants were planted at a spacing of 3m x 3m square system of planting on Quince C rootstock subjected to uniform cultural practices during the study. Pollination was carried out using three different modes *viz.,* self-pollination (bagging was done on unopened flowers and left as such for natural self-pollination), open pollination (three branches on all sides of every tagged tree were left unbagged for open pollination) and hand pollination (the emasculated flowers, covered with bags were pollinated 24 h after emasculation with the pollen of the parent as per crossing plan). Both maternal cultivars were pollinated with different pollen sources constituting the treatment combinations. The design of experiment was RCBD with nine treatments and three replications comprising of 54 cross combinations, number of flowers studied per replication were 25 and a total of 1,350 flowers were crossed.

Observations were recorded on date of swollen bud, date of bud burst, date of green cluster, date of balloon stage, date of initial bloom (10 %), date of full bloom (80 %) and date of complete petal fall. Flowering duration was calculated as the days from initial bloom to complete petal fall. The fruit set (%) was worked out after 21 days of pollination by dividing total number of fruit lets produced to the total number of flowers pollinated and multiplied by 100.

Fruit retention was calculated by dividing the number of fruits harvested to the number of fruits set after 21 days of pollination multiplied by 100. Per cent fruit drop was worked out by subtracting per cent fruit retention from 100 and average was worked out. The date of harvesting was recorded when fruits were harvested after attaining proper size and colour and converted into days which was counted from full bloom.The data recorded were subjected to statistical analysis as per the method of Snedecor and Cochran (1994). The significant difference of the means was tested at 5 % level.

Result and Discussion

Floral phenology

Floral phenology of different varieties involved in the crossing program is presented in Fig. 1. Considerable variations were exhibited by the varieties in attaining the different phenological stages from swollen bud stage to complete petal fall.Earliest swollen bud stage was observed in Clapp's Favourite and Chinese Sandy Pear (13th-14th March) followed by Kings Pear (14th-15th March) whereas Abate Fetel (21st-22nd March) was late in reaching swollen bud stage. Minimum number of days were taken by Chinese Sandy Pear to reach the bud burst stage (18th-19th March) and green cluster stage (21st-22nd March) closely followed by Clapp's Favourite and Kings Pear *i.e.* 19th-20th March and 23rd-24th March in bud burst and green cluster stage. Abate Fetel was late in the commencement of bud burst and green cluster stages *i.e.* 25th-26th March and 28th-29th March, respectively. Chinese Sandy Pear exhibited ballon stage earliest (25th-26th March) which was almost statistically at par with Kings Pear (26th-27th March), however, Abate Fetel variety was late to reach balloon stage (1st-2nd April) (Fig. 1). Earliest initial bloom was observed in Chinese Sandy Pear (29th-30th March) and Kings Pear (30th-31st March) the later variety was earliest to reach full bloom (2nd-3rd April) closely followed by Chinese Sandy Pear (3rd-4th April) whereas, late initial bloom (7th-8th April) and full bloom (11th-12th April) were recorded in Abate Fetel. Chinese Sandy Pear and Kings Pear were earliest in commencement of petal fall (10th-11th April) whereas, late complete petal fall was observed in Abate Fetel (20th-21st April) (Fig. 1). The differences in flower bud development period is due to varietal character which appears to be a principle factor in controlling flower bud development (Anand, 2003).

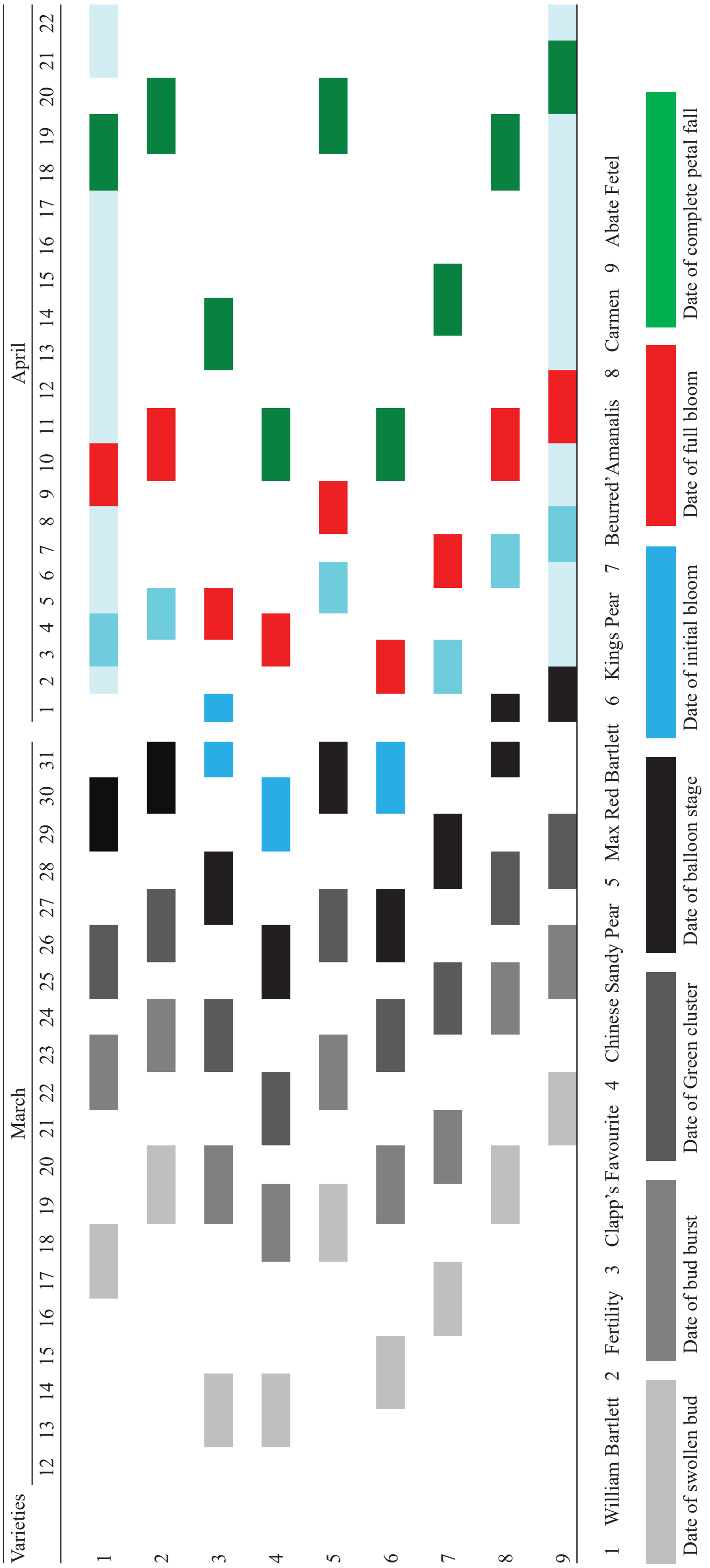

Fig. 1. Floral phenology of pear cultivars involved in crossing plan

The complex mechanisms of chilling requirements and subsequent heat unit accumulation, may affect flowering date and duration of anthesis differently in different cultivars (Malgarejo, 1996). Arzani (2004) supported this concept and stated that different genotypes of Asian pear showed different flowering times and periods. Besides environmental factors like temperature, rainfall and relative humidity may directly or indirectly, singly or collectively play an important role during flower bud development period. Dhillon and Gill (2013) also reported the affect of climatic conditions especially temperature on flowering of hard pear (*Pyrus pyrifolia*).

Figure 2 depicts that maximum flowering duration (17 days) was recorded in William Bartlett and Fertility followed by Max Red Bartlett (16 days) whereas minimum (12 days) duration of flowering was recorded in Chinese Sandy Pear and Kings Pear.Flowering duration a highly variable character primarily is regarded as a varietal character, but temperature has a great effect on duration of flowering. The time of flowering in pear is influenced by chilling requirement for breaking the rest period and heat requirement to develop flower buds to bloom.Variation in duration of flowering between different cultivars may be attributed to differential development of floral parts in various cultivars which is greatly attributed to their genetic difference. Similar variations in flowering duration of different genotypes of pear were also reported by Aulakh *et al.* (1981) who stated that the duration of flowering varied from 21 days in Baggugosha to 29 days in Smith. Dhillon and Gill (2013) also reported flowering duration in hard pear ranging between 14 to21 days in the first year and 9 to11 days in the following year.

Fruit set and retention

Perusal of data presented in Table 1 reveals that maximum mean fruit set (74.00%) was recorded with pollinizer cultivar Fertility followed by William Bartlett (72.83 %) and Max Red Bartlett (72.67 %), while under open pollination mean fruit set of 68.66 % was recorded. Under self-pollination and with the pollinizer cultivar Beurre de Amanalis, zero per cent fruit set was recorded. Interaction combination of 'Carmen × William Bartlett'(81.33 %) recorded the maximum fruit set percentage followed by 'Carmen × Max Red Bartlett' (80.00%) and 'Carmen × Fertility' (78.67%) which was higher than open pollination (74.66 %) whereas, minimum fruit set (54.67%) was recorded in 'Abate Fetel × Kings Pear' combination. It is evident from the Table 1 that pollen source proved a major factor in retaining fruits and number of fruits harvested in both the exotic cultivars. Maximum fruit retention (46.42 %) was recorded with pollen source Fertility followed by William Bartlett (46.21 %) and Max Red Bartlett (46.11 %) and minimum fruit retention percentage (29.80 %) was observed with Kings Pear irrespective of cultivars which was even lower than that obtained from open pollination (38.56%). Maximum fruit retention was obtained in the cross combinations of Carmen × William Bartlett (50.79 %) followed by Carmen × Max Red Bartlett (48.24 %)

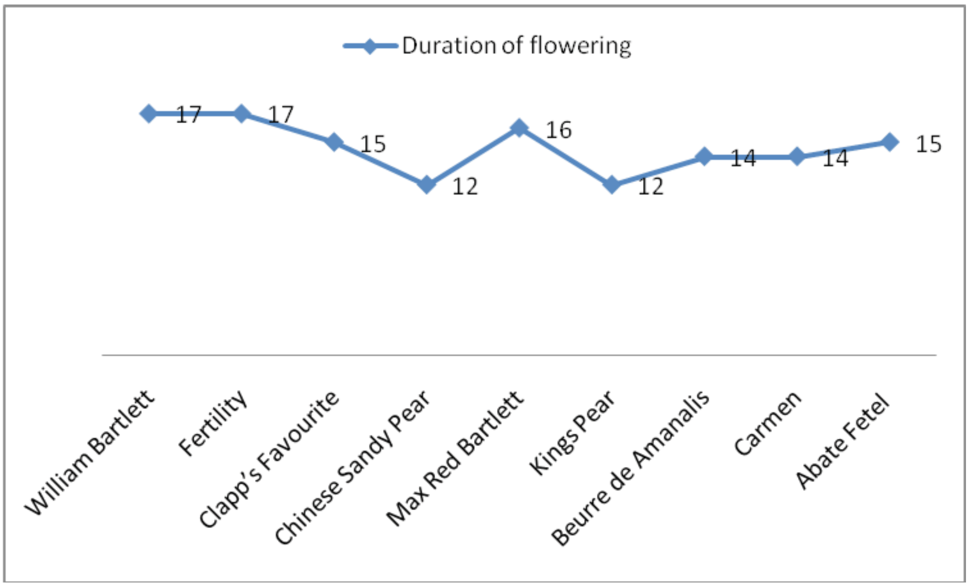

Fig. 2. Flowering duration of different pear cultivars involved in crossing plan

Table 1. Effect of pollen source on fruit set and fruit retention in Carmen and Abate Fetelpears

Maternal parents Pollen source	Fruit set (%)			Fruit retention (%)		
	Carmen	Abate Fetel	Mean	Carmen	Abate Fetel	Mean
William Bartlett	81.33 (64.40)	64.33 (53.12)	72.83 (58.76)	50.79	41.64	46.21
Fertility	78.67 (62.48)	69.33 (56.36)	74.00 (59.42)	47.54	45.31	46.42
Clapp's Favourite	66.67 (54.72)	60.00 (50.76)	63.33 (52.74)	35.90	33.43	34.66
Chinese Sandy Pear	65.33 (53.91)	56.33 (49.20)	60.83 (51.55)	34.72	30.31	32.51
Max Red Bartlett	80.00 (63.48)	65.33 (53.91)	72.67 (58.69)	48.24	43.99	46.11
Kings Pear	57.33 (49.20)	54.67 (47.66)	56.00 (48.43)	30.31	29.30	29.80
Beurred' Amanalis	0.00 (0.01)	0.00 (0.01)	0.00 (0.01)	0.00	0.00	0.00
Self-pollination	0.00 (0.01)	0.00 (0.01)	0.00 (0.01)	0.00	0.00	0.00
Open Pollination	74.66 (59.78)	62.67 (52.32)	68.66 (59.78)	41.02	36.11	38.56
Mean	56.00 (45.33)	48.03 (40.37)		32.06	28.89	
$CD_{0.05}$						
Maternal parent		2.11			0.60	
Pollen source		0.98			1.13	
M × P		2.98			1.60	

Values in the parenthesis are arc sine transformed values

and Carmen × Fertility (47.54 %) whereas, minimum fruit retention was recorded in Abate Fetel × Kings Pear (29.30 %). Under open pollination Carmen and Abate Fetel recorded 41.02 per cent and 36.11 per cent fruit retention, respectively. Conducive climatic conditions during flowering play a vital role in achieving successful pollination and fruit set. Bee activity which is necessary for fruit set may be affected by unfavorable weather conditions during blooming under temperate conditions. Tatari *et al.* (2017) and Cerovic *et al.* (2020) also worked on fruit set and fruit retention using different pollinizers in pear. Difference in fruit set within the same variety using different pollinizers is attributed to degree of compatibility within combinations; the higher compatibility resulted in higher fruit set (Tatari *et al.*, 2017). Bashir *et al.* (2010) also reported differences in fruit retention in apple with different pollinizers and varieties. In addition to the genetic variances, there could be numerous factors responsible for differential fruit set and fruit retention between the varieties. These factors include temperature and other climatic conditions, effective pollination period of varieties, stigmatic receptiveness, ovule longevity, pollen germination, ploidy level of cultivars, post blossom temperatures, time of hand pollination, skill of emasculation and fertilization process (Verma, 1997).

Furthermore, in case of self-pollination in both the cultivars *viz.,* Carmen and Abate Fetel, no fruit set was observed which proves full self-incompatibility. Earlier reports in different pear varieties (Gent Drouard and Fertility) also recorded full self-incompatibility (Qadir, 2007). No fruit set recorded in cvs. Carmen and Abate Fetel under self-pollination and hand cross pollination with Beurred' Amanalis could be due to self-incompatibilityand cross incompatibility. Growth of pollen tube is essential for its entry into the viable ovules for the process of fertilization needed for sufficient fruit set (Sanzol and Herrero, 2001).No fruit set in both the cvs. Carmen and Abate Fetel by pollen source Beurred' Amanalis may be attributed to its triploid nature resulting in production of sterile pollen.

Minimum fruit drop was recorded with pollinizer cultivars Fertility (53.77 %), William Bartlett (53.78%) and Max Red Bartlett (53.88%) being statistically at par with each other (Table 2). Maximum fruit drop (70.19 %) was observed with pollinizer cultivar Kings Pear which was statistically different from other pollinizer cultivars followed by Chinese Sandy Pear (67.48 %) and Clapp's Favourite (54.33 %). Under open pollination the fruit drop of 61.43 per cent was registered. Among different cross combinations minimum fruit drop was registered in Carmen × Max Red Bartlett (51.75 %) which was statistically at par with Carmen × Fertility (52.45 %) whereas maximum fruit drop was recorded in Abate Fetel × Kings Pear (70.70 %) which was statistically at par with Carmen × Kings Pear (69.68 %) and Abate Fetel × Chinese Sandy Pear (69.68 %). In the earlier reports, Pandit (2014) in apple and Singh *et al.* (2004) in pear reported differences in fruit drop using different pollinizers. Fruit bearing species containing greater than one seed (apple, pear and quince) ideally drop fruits which possess lesser number of seeds. These fruits cannot tolerate the harsh environmental conditions i.e. drought, reduced fertility etc. and hence, more susceptible to fruit drop (Racsko *et al.*, 2007).

The analyzed data regarding fruit maturity as influenced by different pollen source presented in Table 2 reveal that pollen source had a direct effect on number of days required by a variety to reach its harvestable stage. Carmen was earliest in maturation of fruits which took significantly lesser number of days (108.07) after full bloom to reach the harvest maturity compared to Abate Fetel which took 142.42 days after full bloom to reach maturity. Maximum days (127.10) after full bloom required to reach the harvestable stage were observed with pollinizer cultivar William Bartlett followed by Max Red Bartlett (126.88 days) whereas minimum days to harvest were registered in Clapp's Favourite (123.49 days) as pollen source .Maximum numbers of days (145.00) to maturity were recorded in Abate Fetel under open pollination and minimum number of days (105.21) were taken by Carmen under open pollination to reach maturity. Among cross combinations the maximum number of days (143.55) were taken by Abate Fetel × William Bartlett and minimum number of days (106.66) were recorded in Carmen × Clapp's Favourite combination to attain the harvest maturity. The remarkable difference between cultivars in days taken to maturity may be due to their distinct genetic makeup and intrinsicpaternal character. Present results are in agreement with the results of Pandit (2014) who reported difference in fruit maturity of apple using different pollinizers. Moreover, the variation among the different treatment combinations is due to metaxenic effect of pollen as it is clearly evident from the data that some pollinizers hastened the maturity while others delayed it (Ghnaim and Al-Muhtaseb, 2006).

Conclusion

For getting higher yields, high fruit set is required which is achieved by managing successful pollination and fertilization, at the right time. In the present study both pear cultivars Carmen and Abate Fetel exhibited gametophytic self-incompatibility, however, cross compatibility with different pollinizer cultivars was evidenced by fruit set. All the pollinizer cultivars used in present study were found to be the effective for pollination of both the cultivars (Carmen and Abate Fetel) except Beurre de Amanalis which showed cross

Table 2. Effect of pollen source on fruit drop and days to fruit maturity in Carmen and Abate Fetel pears

Maternal parents Pollen source	Fruit drop (%)			Days to fruit maturity (%)		
	Carmen	Abate Fetel	Mean	Carmen	Abate Fetel	Mean
William Bartlett	49.20	58.36	53.78	110.66	143.55	127.10
Fertility	52.45	54.69	53.57	107.21	141.00	124.10
Clapp's Favourite	64.09	66.57	65.33	106.66	140.33	123.49
Chinese Sandy Pear	65.28	69.68	67.48	107.66	141.33	124.49
Max Red Bartlett	51.75	56.01	53.88	110.66	143.10	126.88
Kings Pear	69.68	70.70	70.19	108.44	142.66	125.55
Beurred' Amanalis	0.00	0.00	0.00	0.00	0.00	0.00
Self pollination	0.00	0.00	0.00	0.00	0.00	0.00
Open Pollination	58.97	63.89	61.43	105.21	145.00	125.10
Mean	45.71	48.87		108.07	142.42	
$CD_{0.05}$						
Maternal parent		0.54			0.40	
Pollen source		1.01			0.71	
M × P		1.40			1.00	

incompatibility with both the cultivars due to triploid genotypic constitution nature (pollen sterility). However, best pollinizer cultivars in terms of flowering duration andcompatibility were Fertility, William Bartlett and Max Red Bartlett. These pollinizer cultivars proved efficient for both the cultivars under study as the blooming period of these synchronizes with the blooming period of the cultivars under study, which is a prerequisite for effective pollination and also improved fruit set and retention and ultimately fruit yield.

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