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Floral Phenology and Pollination Studies in Exotic Cultivars under High Density Plantation of Apple under Kashmir Conditions

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ABSTRACT

Investigations on floral phenology and pollination study of three female (Gala Redlum, Fuji Zehn Aztec and Super Chief Sandidge) apple cultivars grafted on M9-T337 crossed with six pollinizer (Gala Redlum, Fuji Zehn Aztec, Super Chief Sandidge, Lal Ambri, Golden Clone-B and Red Gold) cultivars were carried out during the year 2018 using RCBD design with three replications comprising of eighteen cross combinations. Gala Redlum was earliest in all the flowering characters whereas Fuji Zehn Aztec performed late. Maximum pollen viability (94.99 %) and pollen germination (81.68 %) was observed in Red Gold. Cross compatibility studies revealed that Red Gold as a pollen source gave maximum fruit set in Gala Redlum (89.33 %) followed by Super Chief Sandidge (85.25 %) whereas Super Chief Sandidge and Fuji Zehn Aztec showed self-incompatibility. The other cross combinations also showed varied degrees of values for fruit set. Maximum fruit retention was recorded in Fuji Zehn Aztec (51.72%) when crossed with Red Gold whereas minimum was recorded in cross combination of Gala Redlum × Gala Redlum (37.50 %) with maximum fruit drop (62.50 %). Early fruit harvesting was recorded in Gala Redlum (123.03 days after full bloom) when crossed with Red Gold whereas Fuji Zehn Aztec took maximum number of days (173.39) after full bloom to reach maturity stage when Lal Ambri used as pollen source. Red Gold act as more effective pollen source for exotic cultivars under study in temperate conditions of Kashmir since it produce abundant number of viable and compatible pollens.

Keywords Pollination, Exotic, Cultivars, Floral phenology, High density plantation.

INTRODUCTION

Apple is most important temperate fruit crop and is the backbone of the UT's economy which is grown on an area of 164742 ha with an annual production of 1882319 MT (Anonymous 2019). Apart from widely grown in temperate zone now its cultivation is also expanding into subtropical and tropical zones of the country. As apple is the most popular and ubiquitous of all temperate fruits, therefore its production

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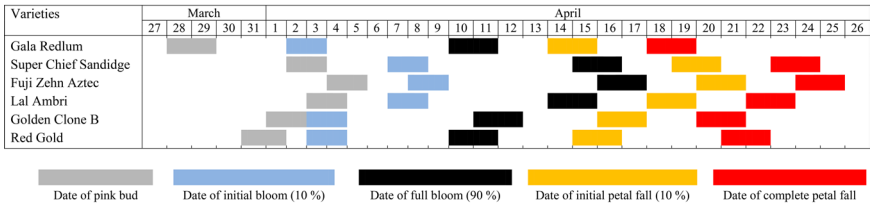

Fig. 1. Floral phenology of the cultivars involved in crossing plan.

has received a great deal of attention. It is therefore important to focus on all the factors which govern the yield and quality of apple. Apple production is a result of series of physiological events including fruit set (Sanzol and Herrero 2001). One of the pressing problems still is poor quality and low production of apple. There could be a number of reasons behind declined apple production in the state, but the most important factor which needs a quick attention is proper management of pollination in apples. Pollination is a very important and inseparable component in respect of regular and consistent production in a number of fruit crops, as apple cultivars are predominantly self-incompatible, therefore pollination is of utmost importance whose proportion and magnitude is primarily based upon appropriate selection of varieties. For cross-pollination to be effective, it is very important that the cultivars bloom at approximately the same time and produce the sufficient quantity of viable and compatible pollens. In the past few years, SKUAST-Kashmir had introduced some exotic cultivars of apple and these newly introduced varieties have been found to hold promise in terms of productivity, quality and performance under valley conditions. Although most of these apple varieties produce abundant bloom but their pollination status is still unknown as no systematic study has been conducted under the valley conditions so far. Keeping in view the effect of pollination on yield and fruit quality of apple, present study was conducted on floral phenology and pollination studies on exotic cultivars of apple.

MATERIALS AND METHODS

The present investigation was conducted in the Experimental fields of Division of Fruit Science, Sher-e-Kashmir University of Agricultural Science and Technology of Kashmir, Shalimar, Srinagar, Jammu

Table 1. Effect of different pollen source on cultivars fruit set and fruit retention of exotic apple.

	Fruit set (%)				Fruit retention (%)			
Cultivars Pollen source	Gala Redlum	Super Chief Sandidge	Fuji Zehn Aztec	Mean	Gala Redlum	Super Chief Sandidge	Fuji Zehn Aztec	Mean
Gala Redlum	53.33	70.59	70.55	64.82	37.50	38.88	38.22	38.22
Super Chief Sandidge	67.93	-	73.26	70.59	37.59	-	37.54	37.56
Fuji Zehn Aztec	73.26	73.22	-	73.24	39.38	38.16	-	38.77
Lal Ambri	77.26	74.59	77.26	76.38	38.98	38.61	44.07	40.56
Golden Clone B	82.59	81.26	81.26	81.71	47.80	50.20	48.72	48.91
Red Gold	89.33	85.25	83.93	86.15	50.74	50.85	51.72	50.39
Mean	73.93	76.99	77.25		41.99	43.34	44.05	
$CD_{0.05}$								
Cultivars		1.25				1.34		
Pollen source		2.55				1.45		
M × P		3.60				2.68		

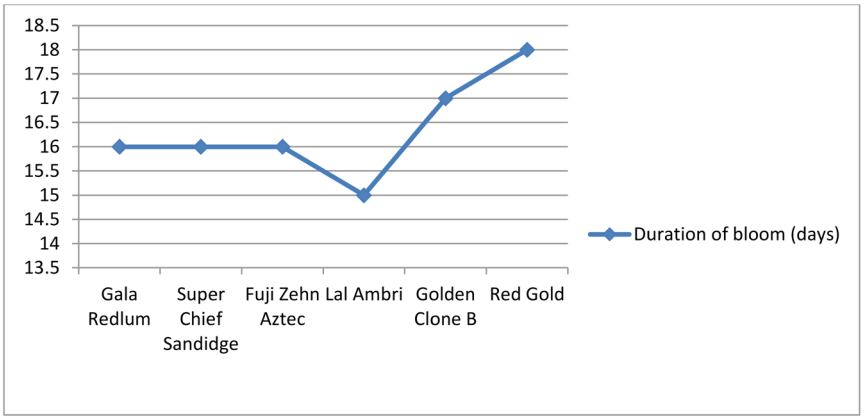

Fig. 2. Duration of bloom (days) of cultivars involved in crossing plan.

and Kashmir during the year 2018. Geographical features of the area lies between 35º North latitude and 74º East longitude and at an altitude of 1500 m above mean sea level. The experiment consisted of three exotic cultivars of apple grafted on M9-T337 clonal rootstock of uniform age and growth viz., Gala Redlum, Fuji Zehn Aztec and Super Chief Sandidge were taken as female parent. Female cultivars were cross pollinated with six compatible pollinizers viz. Gala Redlum, Fuji Zehn Aztec, Super Chief Sandidge, Lal Ambri, Golden Clone-B and Red Gold. The design of experiment was RCBD with three replications comprising of 18 cross combinations (Table 1).

Observations were recorded on date of advanced pink bud stage, initial bloom (10 %), full bloom (90 %), initial petal fall (10 %), complete petal fall (90 %), duration of bloom (days). Pollen viability and pollen germination were examined of the freshly collected pollen from the dehisced anthers and expressed in per cent. Fruit set (%) at pea stage, fruit retention (%) at one week before harvesting, fruit drop (%) 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 % significance.

RESULTS AND DISCUSSION

Floral phenology

The days taken from pink bud to complete petal fall by the different cultivars which are involved in the crossing plan is presented in Fig. 1. Considerable variations were exhibited by the different genotypes in attaining the different phenological stages from pink bud stage to complete petal fall stage and the data presented in the Fig. 1 depicts that earliest pink bud stage (28th-29th March) was recorded in Gala Redlum followed by Red Gold (31st March-1st April) and Golden Clone B (1st-2nd April) whereas Fuji Zehn Aztec came late into pink bud stage (4th-5th April). Initial bloom (10%) and full bloom (90 %) was commenced early in Gala Redlum i.e., on 2nd-3rd April and 10th-11th April, respectively followed by Red Gold (3rd-4th April and 10th-11th April, respectively), however Fuji Zehn Aztec was late in initial bloom and full bloom i.e., on 8th-9th April and 16th-17th April, respectively. Similar results were noticed among the cultivars studied for initial petal fall (10 %) and complete petal fall (90 %). Phenological studies indicated synchronization of blooming period among studied cultivars which is a prerequisite for effective pollination. The differences in the phenological stages may be due to their genetic differences or the differential chilling requirements of these varieties may be the reason for such variations. Further these varieties may be different in their photo sensitivity and response to temperature resulting in such variations. Pandit *et*

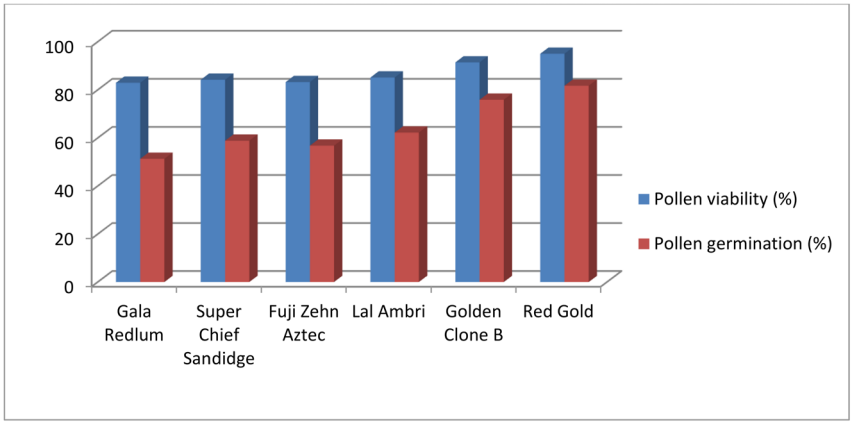

Fig. 3. Pollen viability and pollen germination in different apple cultivars.

al. (2017) also reported similar results with respect to different flowering stages of apple cultivars. Duration of flowering of various studied cultivars ranges between 15 days (Lal Ambri) to 18 days (Red Gold) genotypes (Fig. 2). Earlier Sharma *et al.* (2005) and Sharma *et al.* (2006) also reported flowering duration in ranged from 10 to 17 days.

Pollen studies

Fig. 3 depicts significant differences among studied cultivars for pollen viability and pollen germination and maximum pollen viability (94.99 %) and pollen germination (81.68%) was recorded in Red Gold followed by Golden Clone B (91.39 % and 75.89 %, respectively) which was statistically higher among all the studied cultivars however minimum pollen viability (82.93 %) and pollen germination (51.31 %) was recorded in Gala Redlum. which was statistically higher among all the studied cultivars however minimum pollen viability (82.93 %) and pollen germination (51.31 %) was recorded in Gala Redlum. which was statistically higher among all the studied cultivars however minimum pollen viability (82.93 %) and pollen germination (51.31 %) was recorded in Gala Redlum. Variation in pollen viability and pollen germination is attributed to the genetic differences among thevarious genotypes (Nogueira *et al.* 2016). Present result are corroborated with the earlier results of Sharma *et al.* (2005) and Rather *et al*. (2018) working on different cultivars of apple.

Fruiting characters

Perusal of data presented in Table 1 revealed significant results for fruit set and fruit retention and among maternal parent Fuji Zehn Aztec recorded maximum mean fruit set (77.25 %) which was statistically at par with Super Chief Sandidge (76.99 %) however Gala Redlum (73.93 %) recorded minimum fruit set. Regarding pollen source, significant results were obtained and maximum fruit set was recorded with pollinizer Red Gold (86.15 %) followed by Golden Clone B (81.71 %) however Red Gold was significantly higher among the entire pollen source. Minimum fruit set was registered with Gala Redlum (64.82 %). Interaction studies between pollen source and maternal parents the data reveals that the maximum fruit set was observed in Gala Redlum × Red Gold (89.33 %) followed by Super Chief Sandidge × Red Gold (85.25 %) however Gala Redlum × Red Gold was significantly higher among all the cross made. Minimum fruit set was recorded between crosses of Gala Redlum × Gala Redlum (53.33 %) however Fuji Zehn Aztec Fuji Zehn Aztec and Super Chief Sandidge × Super Chief Sandidge showed full self-incompatibility. In earlier reports Self-incompatibility was also reported by Bashir (2006) in Royal Gala and Fuji and Pandit *et al*. (2018) in Royal Gala, Early Red One, Scarlet Spur, Ginger Gold and Red Gravenstein which failed to set fruit when pollinated with their own pollen. Difference in fruit set within the same variety using different pollinizers is attribut-

Table 2. Effect of different pollen source on fruit drop and days to harvest of exotic apple cultivars.

Cultivars Pollen source	Fruit drop (%) Gala redlum	Super Chief Sandidge	Fuji Zehn Aztec	Mean	Days to harvest (days from full bloom) Gala Redlum	Super Chief Sandidge	Fuji Zehn Aztec	Mean
Gala Redlum	62.50	60.38	61.04	61.26	124.26	151.59	168.26	148.04
Super Chief Sandidge	62.41	-	61.72	62.06	123.59	-	170.59	147.09
Fuji Zehn Aztec	59.88	61.84	-	60.86	123.10	154.26	-	138.68
Lal Ambri	60.28	60.65	55.19	58.71	124.93	153.93	173.59	149.82
Golden Clone B	51.44	49.06	50.64	50.38	124.26	154.59	171.93	150.26
Red Gold	49.25	48.41	47.54	48.87	123.03	157.59	169.26	149.96
Mean	57.63	56.07	55.23		123.59	154.39	170.72	
$CD_{0.05}$								
Cultivars	1.53				3.05			
Pollen source	2.10				1.49			
M × P	3.53				4.53			

ed to degree of compatibility within combinations, the higher compatibility resulted in higher fruit set (Tatari *et al.* 2017). Sharma *et al*. (2005) obtained mean fruit set from different pollinizers ranged between 34.52 % (Spartan) to 42.88 % (Jonadel). Pandit *et al.* (2018) observed 66.74 % (Red Gravenstein) to 87.35 % (Red Gold) fruit set under open pollination in apple.

Fuji Zehn Aztec recorded on maximum fruit retention (44.05 %) which was statistically at par with Super Chief Sandidge with a mean value of 43.34 % whereas minimum fruit retention was recorded in Gala Redlum (41.99 %) (Table 1). As per the overall mean of the pollen source, the maximum fruit set was obtained with the pollen of Red Gold (50.39 %) followed by Golden Clone-B (48.91 %) however Red Gold was significantly higher among the entire pollen source. Minimum fruit set was registered with Super Chief Sandidge (37.56 %). The interaction data of pollen source and maternal parent reflect that fruit retention differed significantly between both the applied pollen source and the varieties under study. Red Gold showed highest compatibility as pollen source with maternal parent Fuji Zehn Aztec and observed maximum fruit retention (51.72 %) which was statistically at par with Super Chief Sandidge × Red Gold (50.85 %), Gala Redlum × Red Gold (50.74 %) and Super Chief Sandidge × Golden Clone B (50.20 %) however minimum fruit retention was recorded between crosses of Gala Redlum × Gala Redlum (37.50 %). Sharma and Bashir (2007) and Pandit *et al.* (2018) reported 3.08 (Extercross) to 16.00 (Arlet) and 15.78 % (Ginger Gold) to 33.86 % (Red Gold) of fruit retention, respectively in apple.

Significant effect of pollen source was observed on fruit drop of maternal parents and is presented in Table 2. Minimum fruit drop was recorded in Fuji Zehn Aztec (55.23%) which was statistically at par with Super Chief Sandidge (56.07 %) however Gala Redlum (57.63 %) recorded maximum fruit drop. Considering the pollen source significantly minimum fruit drop was observed with pollinizer Red Gold (48.87 %) which was statistically at par with Golden Clone B (50.38 %) however Super Chief Sandidge (62.06 %) recorded maximum fruit drop. Crosses between maternal parent and pollen source depicts significant results for fruit drop and minimum fruit drop was recorded in crosses of Fuji Zehn Aztec × Red Gold (47.54 %) and was statistically at par with Super Chief Sandidge × Red Gold (48.41 %), Super Chief Sandidge × Golden Clone B (49.06 %), Gala Redlum × Red Gold (49.25 %) and Fuji Zehn Aztec × Golden Clone B (50.64 %) whereas Gala Redlum × Gala Redlum (62.50 %) recorded maximum fruit drop. Fruit species producing fruits containing more than one seed (apple, pear and quince) drop preferably those fruits which contain the

less number of seeds. Such fruits are genuinely more susceptible to environmental adversities i.e., water stress, poor nutrition.Therefore more prone to fruit drop (Stosser 2002). Racsko *et al.* (2007) argued in favor of the effect of preceding temperature as an important factor responsible for June drop of apple. Pandit *et al.* (2018) reported 61.37 % (Red Gold) and 75.52 % (Scarlet Spur) fruit drop in apple.

Analyzed data on number of days to harvest reveals that fruit maturity was influenced by different pollen source (Table 2) and had a direct effect on the number of days required by a cultivar to reach its harvest stage. Among maternal parent Gala Redlum took significantly minimum number of days (123.59) to reach the harvest maturity followed by compared to Super Chief Sandidge (154.39) and Fuji Zehn Aztec (170.72) which took maximum number of days to reach harvest stage. Regarding pollen source the mean maximum (150.26) number of days required to reach the harvest stage were observed with pollen source Golden Clone B closely followed and statistically at par with Red Gold (149.96) and Lal Ambri (149.82) whereas minimum number of days was registered in Fuji Zehn Aztec (138.68). As per the maternal parent × pollen source combinations the maximum number of days to harvest was recorded in Fuji Zehn Aztec × Lal Ambri (173.59) followed by Fuji Zehn Aztec × Golden Clone B (171.93) whereas minimum days to harvest was recorded in Gala Redlum × Red Gold (123.03). In the present study different varieties attained fruit maturity in span of four to six months period exhibiting characters of early, mid and late season maturation under open pollination conditions. The variation among cultivars in the date of maturity may be due to the difference in their genetic makeup and inherent parental characters of these varieties. Karacali (2004) reported that most important criteria in maturity of apple cultivars are duration between full bloom and harvest date, which depends upon cultivar, place, year, rootstock and ecological conditions. The present results are in consonance with Pandit *et al.* (2018) who also reported 95.50 days (Red Gravenstein) to 184.00 days (Golden Delicious) taken by different cultivars from full bloom to fruit maturity in apple. 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

From the above study it is clear that Red Gold and Golden Clone B proved to be the best pollen source for all the female cultivars under study as the blooming period of these cultivars synchronizes with the blooming period of almost all the cultivars under study, which is a prerequisite for effective pollination.

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