



Physico-chemical parameters of some exotic cultivars of apple affected by pollen source

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ABSTRACT

The present experiment was conducted in the Experimental fields of Division of Fruit Science, SKUAST-Kashmir, Shalimar, Srinagar, UT of J&K during the year 2018. 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. Observations were recorded on physical and biochemical parameters of the fruits. Cross combinations of Super Chief Sandidge x Red Gold registered maximum fruit length (7.24 cm), fruit weight (195.33 g), fruit volume (180.79 cm³), seed number (9.26), total soluble solids (14.10°B), reducing sugar (10.48 %), total sugar (12.54 %) and minimum acidity (0.15 %) whereas maximum fruit diameter (7.44 cm) and fruit firmness (8.79 kg/cm²) was recorded in Fuji Zehn Aztec x Red Gold. No effect of pollen source was observed on female varieties and Gala Redlum and Super Chief Sandidge showed conical and Fuji Zehn Aztec was Globose in fruit shape. Red Gold and Golden Clone B proved to be the best pollen source for all the cultivars under study in terms of physico-chemical parameters.

1. Introduction

Pollination is a very important and inseparable component in respect of regular and consistent production in a number of fruit crops. Pollination is essential and preliminary step for the sexual reproduction of flowering and fruiting plants including apple. 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 (Inouye, 2013). Successful pollination and the formation of many healthy seeds contribute to the eventual size and quality of that fruit and its failure can result in reduced yield, poor fruit set, pre-harvest fruit drop, lower fruit weight, misshapen fruit, thereby reducing fruit quality and finally the output (yield). Therefore, it is important to select a pollinizer variety which has compatible pollen and an overlapping flowering period.

As apple is the most popular and ubiquitous of all temperate fruits, therefore its production has received a great deal of attention and a good number of scientists have worked on apple pollination (Sharma and Bashir, 2007; Javid *et al.*,

2017). Apple varieties are generally self-unfruitful and do not set fruit by their own pollen due to the antagonism nature that prevents pollen grains from growing onto stigmas of the same variety. Commercial pollination is of utmost significance and its proportion and magnitude is primarily based upon appropriate selection of varieties. In the decade, apple cultivation has totally revolutionized the status of the farming community. Apple industry has become back bone of rural economy of UT and majority of the people are directly or indirectly involved with this industry, but due to the monoculture, lack of pollinizing variety, economic returns of the growers have not grown as per expectations (Pandit *et al.*, 2018). Therefore, stress is being laid on increasing the compatible varietal spectrum of apple. 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. Keeping in view the facts the present study was conducted with recently

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introduced varieties of apple to evaluate them for quality attributes in relation to source of pollen.

2. Materials and Methods

The present investigation was conducted in the Experimental fields of Division of Fruit Science, Sher-e-Kashmir University of Agricultural Science & Technology of Kashmir, Shalimar, Srinagar, Jammu & Kashmir during the year 2018. Geographical features of the area lies between 35° North latitude and 74° East longitude and at an altitude of 1500 meters 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.

Ten fruits were randomly taken for all the physio-chemical characters and observations were recorded. Ten fruits were weighed on digital weighing balance, averaged and fruit weight was expressed in grams. Fruit length and diameter were determined using a digital Vernier caliper, averaged and expressed in cm. Fruit volume was measured by water displacement method and expressed in cm³. Fruit firmness was determined with the help of a digital Effegi pressure tester plunger and expressed in kg/cm². Fruit shape was observed according to the apple descriptor (UPOV, 2004). Fruit colour was observed under Hunter colour Lab depicting with L, a and b, where L indicates lightness, a and b indicate colour directions, + a is the red direction, - a is the green direction, + b is the yellow direction and - b is the blue direction. Seed count was assessed by slicing the apples horizontally through the equatorial plane and the number of fully developed seeds were counted. Total soluble solids were determined by using digital hand refractometer whereas acidity was measured in terms of malic acid. Reducing sugar and total sugar was determined as per the standard procedures (AOAC, 2012). Data generated from these investigations were appropriately computed, tabulated and statistically analyzed as per the procedure given by Snedecor and Cochran (1994). The level of significance was tested for different variable at 5 per cent level of significance.

3. Result and Discussion

Significant differences were observed for fruit length, fruit breadth and fruit weight among different cross combinations in the study (Table 1). Maximum fruit length was observed in cross combinations of Super Chief Sandidge x Red Gold (7.24 cm) which was significantly at par with Super Chief Sandidge x Golden Clone-B (7.20 cm), Super

Chief Sandidge x Gala Redlum (7.15 cm), Super Chief Sandidge x Lal Ambri (7.09 cm) and Super Chief Sandidge x Fuji Zehn Aztec (7.01 cm) however minimum fruit length was observed in cross combinations of Fuji Zehn Aztec x Gala Redlum (5.15 cm). Cross combinations of Fuji Zehn Aztec x Red Gold (7.44 cm) recorded maximum fruit diameter which was significantly at par with Fuji Zehn Aztec x Golden Clone B (7.14 cm) whereas minimum fruit diameter was observed in Gala Redlum x Lal Ambri (4.08 cm). Maximum fruit weight was recorded in Super Chief Sandidge x Red Gold (195.33 g) which was statistically higher among all other cross combinations and followed by Super Chief Sandidge x Golden Clone B (190.51 g) and Fuji Zehn Aztec x Red Gold (190.17 g) however minimum fruit weight was recorded in Gala Redlum x Lal Ambri (130.27 g). The difference in these results obtained may be due to varietal characters and presence of seeds in the fertilized fruits, as the fruits containing seeds with endosperm are the sites of gibberellic acid synthesis (Jain, 2013) where growth substances are produced. In earlier reports, bad developed of fruits are the result of an unequal seed distribution inside the fruit also noticed. In a well-pollinated flower occurs a rapid development of ovary, and the fecundated seeds produce plant growth hormones, leading to good fruit development (Tuan and Chung-Ruey, 2013). Increase in fruit weight by using the different pollinizers was also reported by Javid *et al.* (2017).

Fruit volume, fruit firmness and seed number were significantly influenced by different cross combinations (Table 2). Super Chief Sandidge as female parent and Red Gold as pollen source registered maximum fruit volume (180.79 cm³) which was statistically at par with Super Chief Sandidge x Gala Redlum (179.63 cm³), Super Chief Sandidge x Golden Clone B (178.56 cm³) and Fuji Zehn Aztec x Red Gold (178.19 cm³) whereas minimum fruit volume was recorded in the cross combinations of Gala Redlum x Lal Ambri (122.78cm³). Among various cross combinations, maximum fruit firmness was recorded with Fuji Zehn Aztec x Red Gold (8.79 kg/cm²) which was statistically at par with Fuji Zehn Aztec x Lal Ambri (8.52 kg/cm²) and Fuji Zehn Aztec x Golden Clone B (8.39 kg/cm²) however cross combination of Gala Redlum x Lal Ambri registered minimum fruit firmness (6.11 kg/cm²). This could be explained by the fact that higher seed content is related with higher calcium concentration (Parray *et al.*, 2017) and thus increased firmness. Enhancement in fruit firmness is due to the fact that calcium is an important constituent of the cell wall (Rashid *et al.*, 2009).

Remarkable differences in mean seed number of pollinated fruits were observed (Table 2). Cross combination of Super Chief Sandidge x Red Gold (9.26) registered maximum seed number which was statistically at par with

Super Chief Sandidge x Golden Clone B (9.22), Gala Redlum x Red Gold (9.21), Fuji Zehn Aztec x Red Gold (9.19) and Fuji Zehn Aztec x Red Gold (9.12) whereas Gala Redlum x Lal Ambri (7.59). The significant difference in the number of seeds per fruit may be due to difference in fruit size specific to each variety, number of seeds peculiar to each cultivar, poor/successful pollination, cross compatibility of varieties, stage of maturity of cultivars. The finding of present study is also in consonance with the earlier reports of Tuan and Chung Ruey (2013) who reported that pollen sources effect the seed number per fruit. Kron and Husband (2006) stated that by increasing the diversity of compatible pollen, seed number enhanced and reduced seed abortion resulting in increased number of fruits.

With respect to fruit shape no effect of pollen source was observed in all the combinations (Table 3). All the pollen source for Gala Redlum and Super Chief Sandidge showed conical fruit shape whereas in Fuji Zehn Aztec the shape is Globose. The cultivars which develop regular and symmetrical fruits contain good number of seeds hence, seeds play an important role in shaping of fruits. The fruit shape obtained in present investigation was identical in all the combinations, which may be attributed to the fact that none of the fruits contained less than five number of seeds in all the treatment combination and moreover, seed number was sufficient to contribute to Apple shape (Balaguera-Lopez *et al.*, 2020).

Interaction effect of pollen source and maternal parent showed significant results for total soluble solids, total sugar and reducing sugars, however titratable acidity was non-significant. Maximum TSS was recorded in cross combination of Super Chief Sandidge x Red Gold (14.10°B) which was statistically at par with Super Chief Sandidge x Red Gold (14.01°B) and Super Chief Sandidge x Red Gold (13.76°B) whereas minimum total soluble solids was recorded in Fuji Zehn Aztec x Super Chief Sandidge (11.20°B). Minimum and maximum acidity was recorded in Super Chief Sandidge x Red Gold (0.15 %) and Fuji Zehn Aztec x Gala Redlum (0.36 %), respectively (Table 4). These variations may be due to the effect of pollen donors on recipients or it could be due to low temperature conditions or due to varietal characters of the cultivars under study. The increase or decrease in acidity observed with some of the pollinizers is similar to the observations of Sulusoglu and Cavusoglu (2014) who reported metaxenic effect of pollen source on fruit titratable acidity in cherry laurel.

Cross combinations of Super Chief Sandidge x Red Gold (12.54 % and 10.48 %) registered maximum total sugars and reducing sugar which was statistically at par with Super Chief Sandidge x Golden Clone B (12.51 % and 10.28 %) however minimum total sugars was recorded in Fuji Zehn Aztec x Gala Redlum (9.47 % and 7.10 %), respectively

(Table 4 and Fig 1). These variations in soluble solid content, total sugars and reducing sugars may be due to the varietal characteristics or it could be due to activities of the enzyme systems initiated by the metaxenic effect and later on passed into extra cellular sites, get dissolve readily into water and invert the sugar. Metaxenic effect of pollen source on fruit soluble solid content and total sugars was also reported by many scientists (Militaru *et al.*, 2015; Majid *et al.*, 2020).

Perusal of the data recorded with respect to fruit color under hand pollination of apple cultivars under study is presented in Table 5. Fruit color is determined on the basis of value of 'a', the best (a = 16.35) colored fruit is noticed in 'Gala Redlum' when 'Super Chief Sandidge' was used as the pollen parent, however the value of 'a' was not recorded as negative in any of the fruit samples. The apple skin colour plays an important role in apple fruit trading because customers prefer red coloured apples and thus the cost effectiveness of red skin apples is greater. The red colour is conditioned by anthocyanin, green and yellow colour is controlled by the quantity and the ratio of carotenoids and chlorophyll (Khoo *et al.*, 2017).

4. Conclusion

From the present study it is concluded that Red Gold and Golden Clone B proved to be the best pollen source for all the cultivars under study in terms of physical parameters, seed number, TSS, acidity and total sugars. It is therefore suggested from this study that Red Gold and Golden Clone B act as more effective pollen source for exotic cultivars under study in temperate conditions of Kashmir since it produce compatible pollens.

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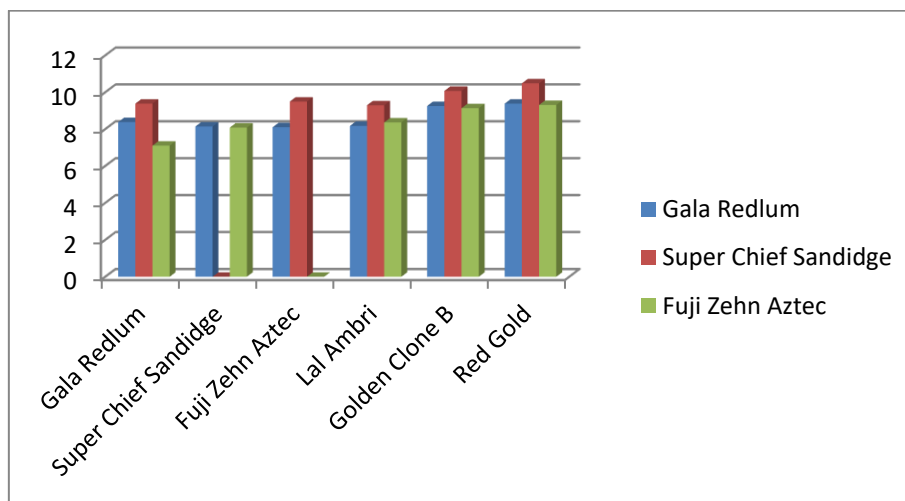


Figure 1. Effect of pollen source on reducing sugars (%) of fruit of exotic apple cultivars

Table 3. Effect of pollen source on fruit shape of exotic apple cultivars

Cultivars Pollen Source	Gala Redlum	Super Chief Sandidge	Fuji Zehn Aztec
Gala Redlum	Conic	Conic	Globose
Super Chief Sandidge	Conic	-	Globose
Fuji Zehn Aztec	Conic	Conic	-
Lal Ambri	Conic	Conic	Globose
Golden Clone B	Conic	Conic	Globose
Red Gold	Conic	Conic	Globose

Table 1. Effect of pollen source on physical parameters of fruit of exotic apple cultivars

Cultivars Pollen source	Fruit length (cm)				Fruit breadth (cm)				Fruit weight (g)			
	Gala Redlum	Super Chief Sandidge	Fuji Zehn Aztec	Mean	Gala Redlum	Super Chief Sandidge	Fuji Zehn Aztec	Mean	Gala Redlum	Super Chief Sandidge	Fuji Zehn Aztec	Mean
Gala Redlum	5.96	7.15	5.15	6.08	5.05	6.39	6.80	6.08	138.83	188.38	178.32	168.51
Super Chief Sandidge	6.06	-	5.68	5.83	5.18	-	6.75	5.96	143.89	-	182.57	163.23
Fuji Zehn Aztec	6.27	7.01	-	6.64	5.46	6.01	-	5.73	150.88	179.93	-	165.40
Lal Ambri	5.16	7.09	5.28	5.84	4.08	6.25	6.55	5.63	130.27	183.94	183.51	165.90
Golden Clone B	6.31	7.20	5.76	6.42	5.51	6.46	7.14	6.37	154.24	190.51	185.50	176.75
Red Gold	6.35	7.24	5.85	6.48	5.60	6.86	7.44	6.63	158.72	195.33	190.17	181.41
Mean	6.02	7.14	5.54		5.15	6.39	6.94		146.14	187.62	184.01	
CD _{0.05}												
Cultivar (M)	0.70				0.25				2.61			
Pollen source (P)	0.11				0.10				1.09			
M x P	0.89				0.35				3.68			

Table 2. Effect of pollen source on physical parameters of fruit of exotic apple cultivars

Cultivars Pollen source	Fruit volume (cm ³)				Fruit firmness (kg/cm ²)				Seed number			
	Gala Redlum	Super Chief Sandidge	Fuji Zehn Aztec	Mean	Gala Redlum	Super Chief Sandidge	Fuji Zehn Aztec	Mean	Gala Redlum	Super Chief Sandidge	Fuji Zehn Aztec	Mean
Gala Redlum	128.71	179.63	172.80	160.38	6.37	6.96	7.24	6.84	8.22	8.93	8.26	8.47
Super Chief Sandidge	131.47	-	171.92	151.69	6.79	-	6.99	6.89	8.93	-	8.11	8.52
Fuji Zehn Aztec	138.59	168.43	-	153.51	7.19	7.82	-	7.50	8.58	8.20	-	8.39
Lal Ambri	122.78	172.41	168.16	154.45	6.11	7.23	8.52	7.29	7.59	8.26	7.89	7.91
Golden Clone B	140.17	178.56	175.50	164.74	7.27	7.13	8.39	7.59	9.01	9.22	9.12	9.12
Red Gold	145.37	180.79	178.19	168.17	7.07	7.61	8.79	7.82	9.21	9.26	9.19	9.14
Mean	134.51	175.96	173.31		6.80	7.35	7.99		8.59	8.77	8.51	
CD _{0.05}												
Cultivar (M)	1.52				0.48				0.12			
Pollen source (P)	2.43				0.17				0.08			
M x P	3.92				0.64				0.22			

Table 4. Effect of pollen source on chemical parameters of fruit of exotic apple cultivars

Cultivars Pollen source	TSS (°B)				Acidity (%)				Total sugars (%)			
	Gala Redlum	Super Chief Sandidge	Fuji Zehn Aztec	Mean	Gala Redlum	Super Chief Sandidge	Fuji Zehn Aztec	Mean	Gala Redlum	Super Chief Sandidge	Fuji Zehn Aztec	Mean
Gala Redlum	11.88	13.37	11.46	12.24	0.31	0.20	0.36	0.29	10.11	11.30	9.47	10.29
Super Chief Sandidge	12.26	-	11.20	11.73	0.28	-	0.35	0.31	10.88	-	10.14	10.51
Fuji Zehn Aztec	12.44	13.76	-	13.10	0.26	0.22	-	0.24	10.54	11.19	-	10.86
Lal Ambri	12.87	13.56	11.26	12.56	0.29	0.23	0.30	0.27	10.25	12.05	9.83	10.71
Golden Clone B	13.32	14.01	12.27	13.20	0.27	0.19	0.34	0.26	11.00	12.51	10.44	11.32
Red Gold	13.39	14.10	12.43	13.31	0.25	0.15	0.29	0.23	11.15	12.54	10.58	11.42
Mean	12.70	13.76	11.72		0.28	0.19	0.33		10.65	11.92	10.09	
CD _{0.05}												
Cultivar (M)	0.21				0.01				0.22			
Pollen source (P)	0.12				0.01				0.09			
M x P	0.44				NS				0.32			

Table 5. Effect of pollen source on fruit colour of exotic apple cultivars

Cross combinations	Gala Redlum			Cross combinations	Super Chief Sandidge			Cross combinations	Fuji Zehn Aztec		
	L*	a*	b*		L*	a*	b*		L*	a*	b*
GRL x GRL	18.75	16.25	12.05	SCS x GRL	3.55	12.35	2.79	FZA x GRL	26.72	2.59	15.85
GRL x SCS	28.42	16.35	14.99	SCS x SCS	-	-	-	FZA x SCS	28.39	3.75	12.59
GRL x FZA	18.29	10.11	7.92	SCS x FZA	4.12	10.62	2.19	FZA x FZA	-	-	-
GRL x LA	19.49	14.25	11.14	SCS x LA	3.24	11.79	4.19	FZA x LA	28.85	1.42	15.92
GRL x GC	18.82	8.02	5.22	SCS x GC	3.99	11.01	5.39	FZA x GC	29.09	1.12	15.12
GRL x RG	23.02	12.01	10.12	SCS x RG	3.14	12.42	3.22	FZA x RG	26.55	1.99	16.75
CD _{0.05}	0.28	0.20	1.03		0.90	0.81	1.89		0.55	0.12	0.41

GRL: Gala Redlum,
LA: Lal Ambri,

SCS: Super Chief Sandidge,
GC: Golden Clone B,

FZA: Fuji Zehn Aztec,
RG: Red Gold