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Full Length Research Paper

Influence of diverse pollen source on compatibility reaction and subsequent effect on quality attributes of sweet cherry

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Sweet cherry is self incompatible due to having a gametophytic self – incompatibility system. S alleles in the style and pollen determine possible crossing relationship and ultimate fruit set. Complete knowledge of the s allele constitution of cultivars is import out for sweet cherry growers and breeders. Natural pollination in cultivar Van resulted in high fruit set as compared to controlled crossing but fruit size recorded high in crossed than natural pollinated. However, cultivar Stella recorded high fruit set in controlled crossing. In Lapinus also, very few crosses set fruits. Furthermore, the fruit set percent are also low and diverse pollen source has no effect on the fruit weight but total soluble solids (T.S.S) was recorded higher in crossed fruits. Similarly, Lambert in controlled pollination resulted in poor fruit set as compared to natural pollination. Guigne Pourpera Precoca exhibited high fruit set with pollen of Lambert and Bing; but other combinations resulted in poor compatibility. Bigarreau Noir Grossa with all the pollen resulted in poor compatibility, whereas fruit set in natural (controlled) pollination recorded high fruit set. Bigarreau Napoleon with Guigne Pourpera Precoca and Lapinus showed good cross compatibility; when used as male with Bigarreau Napoleon, Lapinus exhibited increased fruit weight and T.S.S. as compared to natural pollinated fruits.

Key words: Cherry, pollen, compatibility, quality attributes, fruit set.

INTRODUCTION

The sweet cherry botanically known as *Prunus avium* L., belongs to Family Rosaceous, a deciduous tree of large stature, occasionally reaching almost 20 m in height with attractive peeling bark. Primary centre of origin of cherry is Caspian and Black seas from where it spread by birds Westwood (1993). Cherries are cultivated almost continuous of the world, offering suitable congenial conditions. Hungary consume almost twice of cherry than Germany and sour cherries are consumed most in the Yugoslavs, Germans etc. Turkey ranks first accounts, 59751.00 ha area and 338361.0 tones production with 5.66 t/ha, productivity (Anonymous, 2009). Since most major cherry cultivars are self incompatible, require cross pollinations to obtain fruits. Maximum pollinating efficiency in sweet cherry can be achieved by planting equal numbers of each cultivars and alternating their location down the rows. Each tree should be surrounded by compatible pollinizer. For good orchard pollination, three to five strong beehives per hectare is ideal, comprising of 20,000 to 30,000 adult' bees per beehives. In sweet cherry flower remain open for 7 to 8 days and stigma is receptive at the opening of flowers. Anther starts dehiscing shortly after flower open and continues the second day (Srivastava and Singh, 1970). Ovule longevity is of 4 of 5 days (Roversi, 1994). Maximum stigma receptivity exhibits for five days after anthesis and few ovules remain functioning even after 13 days of

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anthesis. Most varieties of sweet cherries are self sterile and need cross pollination. All commercial cultivar have viable pollen, but all varietal combinations are not useful. In cherry upto 25 different S-alleles (Boskovic and Tobutt, 1996, 2001; Boskovic et al., 1997; De Cuper et al., 2005; Sonneveld et al., 2001, 2003; Taq et al., 1996; Vaughan et al., 2008) and 40 incompatibility groups have been reported so far in sweet cherry using different methods (Marchese et al., 2007; Schuster et al., 2007; Tobutt et al., 2004). There are many incompatible cross groups of sweet cherry; hence, the cultivars within a group should not be planted together without a pollinizer (Childers, 1995). Incompatibility in sweet cherry is gametophytic type, results in the inhibition of pollen tube growth in the style (Hurter et al., 1979; Vasilakakis and Porlingis, 1985). Mechanism of incompatibility is genetically controlled by multiple alleles at a single locus. The sweet cherry cultivars with sterility alleles were reported by Crane and Brown (1937), Tehrani and Brown (1992). Black Heart, Van, Venus, Winds have S1, S3 alleles, Bing, Lambert, Napoleon, S3, S4 alleles, whereas Vic, Stella, Vista cultivars are universal doner (Tao et al., 1999b). In sweet cherry cultivars, RFLP profiles have been used to assign self incompatibility alleles in sweet cherry genotypes (Hauck et al., 2002). The introduction of molecular methods for determining self incompatibility alleles in sweet cherry led to the rapid confirmation of the S-allele, on this basis incompatibility groups of many cultivars were reported previously. Self and cross (in) compatibility between cultivars have traditionally been determined by monitoring the fruit set percentage under field condition. The only disadvantage of this method is that fruit set varies from year to year, depending on weather condition. In order to establish high yielding sweet cherry orchards it is essentially required to have the knowledge of incompatibility relationship of the varietal profile available in India. In cherry orchardists are not aware about the incompatibility reactions resulting poor orchard yield. In order to find out best pollen source for most of the commercially grown varieties, this present experiment was initiated. Hence, this present experiment has been designed to determine compatibility relationship among the sweet cherry cultivars.

MATERIALS AND METHODS

This present studies were carried over a period of three years in 2009, 2010 and 2011 on eight cherry varieties buded on *Prunus cerasus* (sour cherry) root stock and planted at 3 × 3 m spacing. The cherry varieties used for this study was Van, Stella, Lapinus, Lambert, Guigne Purpera Precoca, Bigarreau Napoleon, CITH-Cherry-01, Bing and Bigarreau Noir Grossa. The experimental site is located at Karewa Belt of Kashmir situated at latitude 34°, 45°N and longitude of 74°50 E, and elevation is 1649 m masl, area experienced average minimum and maximum temperate 6.52 19.63°C. Area receives the amount of rainfall 650 to 1000 mm with relative humidity 58.35%. The specified branches were tagged and covered with muslin cloth bags to prevent any contamination from the foreign pollen well in advance. To collect the pollen from the designated male parents for the pollination, the flowers were collected at balloon stage just before the petals expand and before anther dehisce. Before crossing the flowers of the seed parents were emasculated at balloon stage by flicking off the sepals, petals and stamens with scissors and pollination was done immediately. In cherry orchardists are not aware about the incompatibility reactions resulting poor orchard yield. In order to find out best pollen source for most of the commercially grown varieties, this present experiment was initiated. In case of bad weather re-pollination was done.

All possible crosses were made during this study including di-allele crosses. The specified branches were tagged and covered with net bag to prevent infection from foreign pollen. To collect pollen, flowers from the netted branch were collected at the balloon stage just before the petals expand and anther dehiscence though receptivity remains for five days. After 30 days of hand pollination fruit set per cent was recorded and calculated by total fruit set divided by total flowers pollinated multiplied by 100. The same crossing was done on three different branches to replicate the treatment. The data were recorded on fruit set percent, fruit diameter, fruit length, fruit height, pulp weight, stone weight and TSS. The Digital Vernier Caliper (*Mitutoyo, Japan*), Hand refractometer (*Atago*) and electronic balance was used to record the observations. The impact of diverse pollen source on compatibility reaction as well as on fruit quality attributes was recorded. In order to compare the quality attributes of crossed fruits, one tree of each variety was left to set fruits through natural pollination for check.

RESULTS

The fruit set percent and quality attributes of cherry from cross combinations are presented in Table 1. Fruit set and quality attributes were recorded in cultivar Van. Highest fruit set 80.74, 68.32 and 61.30% were recorded during 2009, 2010 and 2011, respectively under naturally pollinated condition, however, fruit set percent from the specific pollen source were poor. Van and Guigne Pourpera Precoca resulted in poor fruit set in all the years; Van X Lambert resulted in high fruit set in three years (Figure 1). Similar trend in fruit diameter was also observed. Fruit diameter obtained from crossing was higher than the fruits obtained from the control. Fruit diameter registered highest 23.4, 22.26, 23.59 mm in Van × Guigne Pourera Precoca and lowest in Van × Lambert. Fruit length was recorded highest (22.10 mm) in Van × Guigne Pourpera Precoca (Table 1). Significant variations in TSS were obtained in different cross combinations, highest TSS. (17.46%) was noted in Van × Stella, followed by Van × Guigne Pourpera Precoca, whereas lowest (11.2% in Van × Lapinus during 2011, while fruits obtained from control (natural) pollination had low TSS (11.26%) during 2009 and 2010 (Figure 3).

The cultivar Stella exhibited high fruit set as compared to natural pollination. Fruit set 54.10%, 61.99 and 66.40% during 2009, 2010 and 2011, respectively were recorded. Stella × Bigarreau Napoleon recorded highest fruit set 75.73, 82.23 and 74.83%, respectively for the 3 studied years, Stella with all the pollen source resulted high fruit set except Stella and Lambert (Figure 1). Significant difference of pollen source on the fruit weight was noted.

Table 1. Fruit set and quality attributes as influenced by diverse pollen source in cherry.

Cross combinations	Fruit dia. (mm)	Fruit length (mm)	Fruit pulp weight (g)	Stone weight (g)	Fruit dia. (mm)	Fruit length mm)	Fruit pulp weight (g)	Stone weight (g)	Fruit dia. (mm)	Fruit length mm)	Fruit pulp weight (g)	Stone weight (g)
	2009				2010				2011			
Van x Stella	21.3	20.9	4.90	0.4	20.83	20.6	4.26	0.36	21.13	21.45	4.36	0.33
Van x Lapinus	20.53	20.0	4.86	0.5	19.93	21.84	4.5	0.36	20.77	23.90	5.16	0.26
Van x Lambert	16.92	17.33	2.70	0.3	19.58	20.18	4.1	0.26	20.64	21.83	4.53	0.26
Van x Guigne Pourpera Precoca	23.4	22.1	5.63	0.53	22.26	21.66	5.0	0.4	23.59	22.38	5.76	0.46
Van	20.00	21.91	4.8	0.5	20.28	19.57	4.6	0.4	19.41	21.57	3.9	0.26
CD (P = 0.05)	1.21	1.10	0.53	0.11	1.13	1.75	0.97	0.33	1.85	1.91	6.53	0.45
Stella x van	21.46	21.56	5.26	0.26	21.87	22.13	4.64	0.6	22.68	22.47	6.3	0.36
Stella X Lapinus	21.5	19.93	3.93	0.4	20.21	19.33	4.70	0.26	21.87	20.43	4.03	0.36
Steela x Guigne Pourpera Precoca	21.36	21.6	5.63	0.73	22.00	20.16	5.66	0.5	21.81	22.74	6.1	0.36
Stella x Bigarreau Napoleon	20.6	21.5	5.6	0.46	20.63	20.65	4.96	0.26	20.88	21.95	5.83	0.36
Stella x Biggareau Napoleon	20.53	21.26	5.03	0.5	19.98	20.3	5.13	0.5	21.29	22.41	5.36	0.36
Stella x Bigarreau Noir Grossa	20.83	20.46	4.4	0.56	19.5	20.26	4.33	0.46	21.08	21.32	4.93	0.26
Stella x Lembert	18.56	17.6	2.23	0.16	18.5	18.56	3.20	0.4	19.71	18.9	3.5	0.26
Stella	19.90	20.85	4.0	0.5	19.99	17.61	4.13	0.36	19.99	20.94	4.2	0.36
CD (P = 0.05)	1.72	1.15	0.57	0.23	1.72	1.81	1.02	0.45	1.73	1.83	0.51	0.71
Lapinus x Van	21.16	20.33	4.66	0.53	20.53	19.33	5.1	0.4	21.52	20.29	4.43	0.5
Lapinus x Guigne Pourpera Precoca	21.26	21.63	3.96	0.6	19.68	19.57	4.13	0.36	21.20	21.31	4.2	0.5
Lapinus x Bigarreau Napoleon	21.66	20.76	5.16	0.5	21.16	20.63	4.83	0.4	21.75	22.13	5.26	0.43
Lapinus	19.89	20.80	4.3	0.5	19.35	20.45	5.36	0.46	20.73	22.04	4.1	0.53
CD (P = 0.05)	1.25	1.17	0.49	0.13	1.11	1.20	0.43	0.13	1.30	1.18	0.33	0.21
Lambert x Van	18.4	17.03	3.03	0.36	23.75	21.21	5.76	0.5	18.93	17.63	3.06	0.33
Lambert x Stella	20.43	20.26	4.76	0.46	21.16	21.76	4.03	0.43	21.25	20.56	4.8	0.43
Lambert x Lapinus	18.53	18	3.9	0.5	19.06	17.50	3.9	0.36	20.77	19.29	3.96	0.26
Lambert x Bigarreau Noir Grossa	18.96	18.42	3.6	0.53	21.28	20.02	4.35	0.47	20.37	20.50	4.06	0.53
Lambert	19.85	21.00	4.6	0.4	23.16	21.21	5.63	0.5	21.7	21.61	4.7	0.4
CD (P = 0.05)	0.92	1.11	0.38	0.12	1.20	1.80	0.82	0.21	2.30	2.17	0.51	0.32
Guigne Pourpera Precoca. x Lambert	21.15	18.6	3.96	0.4	20.27	16.71	4.00	0.43	21.39	19.10	3.83	0.63
Guigne Pourpera Precoca. x Bing	22.36	18.76	4.4	0.5	19.16	15.87	2.99	0.4	22.58	19.25	4.33	0.76
Guigne Pourpera Precoca. x Biggareau Napoleon	21.2	16.66	3.9	0.5	22.24	17.86	3.97	0.47	21.06	17.73	3.8	0.73
Guigne Pourpera Precoca. x Bigarreau Noir Grossa	21.8	17.83	4.03	0.6	22.1	18.2	4.03	0.46	21.43	17.35	3.66	0.73
Guigne Pourpera Precoca. x Van	21.86	18.33	4.56	0.53	19.3	16.52	2.99	0.4	22.11	19.11	4.86	0.43
Guigne Pourpera Precoca x Steela	21.43	18.4	4.16	0.6	21.15	16.76	3.18	0.41	21.86	19.15	4.3	0.5
Guigire Pourpera Precoca	18.03	19.05	5.1	0.5	20.79	17.9	5.5	0.53	19.87	17.87	3.2	0.63

Table 1. Contd.

CD (P = 0.05)	2.11	1.02	0.52	0.21	2.10	0.70	0.71	0.21	2.11	2.02	0.87	0.17
CITH-Cherry-01 x Stella	21.3	20.43	5.53	0.4	20.93	21.66	5.36	0.5	21.25	22.35	5.86	0.43
CITH-Cherry-01 x Lambert	19.6	18.1	3.7	0.4	18.83	19.66	3.66	0.43	17.47	20.53	4.2	0.23
CITH-Cherry-01 X Bing	20.23	22.43	4.96	0.56	20.13	22.33	4.86	0.43	20.8	22.50	5.23	0.26
CITH-Cherry-01 x Bigarreau Noir Grossa	20.33	21.3	5.23	0.6	19.43	20.66	4.76	0.43	20.74	21.88	5.53	0.26
CITH-Cherry-01 x Lapinus	19.4	21.5	4.5	0.5	20.5	20.83	4.23	0.53	20.78	21.57	4.86	0.23
CITH – Cherry- 01	19.20	20.01	4.2	0.5	14.55	20.20	4.1	0.5	20.04	21.64	4.33	0.6
CD (P = 0.05)	1.12	1.51	0.51	0.11	2.20	0.79	0.79	0.24	2.30	2.05	0.91	0.21
Bing x Stella	21.5	24.66	6.73	0.43	21.7	22.92	5.04	0.31	22.13	26.7	6.96	0.33
Bing x Lambert	21.86	21.5	6.13	0.53	22.65	25.00	6.31	0.47	21.41	22.68	6.26	0.33
Bing x Guigne Pourpera Precoca	20.76	23.83	5.63	0.5	22.88	24.07	5.95	0.48	20.89	24.13	6.0	0.43
Bing x Bigarreau Napoleon	20.43	19.66	4.7	0.53	23.15	24.41	5.35	0.37	24.37	26.15	7.6	0.43
Bing	20.00	21.10	4.8	0.5	20.84	21.14	5.03	0.43	22.01	23.4	5.10	0.5
CD (P = 0.05)	1.82	2.01	0.58	0.31	2.00	0.68	0.19	0.90	1.91	2.02	0.91	0.27
Bigarreau Noir Grossa x Van	23.52	21.54	6.26	0.6	23.47	22.73	4.63	0.46	21.32	21.61	5.53	0.26
Bigarreau Noir Grossa x Stella	20.86	23.16	4.1	0.56	20.14	20.76	3.27	0.37	21.39	23.6	4.5	0.26
Bigarreau Noir Grossa x Lambert	22.43	23.06	6.43	0.53	19.23	19.50	4.36	0.5	23.15	23.63	6.7	0.33
Bigarreau Noir Grossa x Guigne Pourpera Precoca	19.33	18.83	3.86	0.36	18.5	19.83	4.3	0.53	19.59	21.06	4.33	0.36
Bigarreau Noir Grossa x Bigarreau Napoleon	19.55	19.5	3.8	0.4	26.47	24.24	6.83	0.5	19.61	20.14	3.76	0.33
Bigarreau Noir Grossa x Bing	18.16	18.66	3.56	0.43	18.5	19.0	3.3	0.4	19.4	19.66	3.63	0.3
Bigarreau Noir Grossa x Bigarreau Noir Grossa	17.5	18.7	3.06	0.43	20.33	20.06	3.3	0.3	18.17	18.19	3.43	0.43
Bigarreau Noir Grossa	21.80	22.51	4.4	0.4	22.53	22.99	5.83	0.43	20.26	22.50	3.6	0.36
CD (P=0.05)	1.00	1.91	0.51	0.31	3.01	0.71	0.18	0.89	1.81	2.03	1.12	0.31
Bigarreau Napoleon x Lapinus	20.86	22.43	5.73	0.6	19.99	18.71	3.63	0.56	22.31	22.84	6.06	0.23
Bigarreau Napoleon x Guigne Pourpera Precoca	19.87	17.45	4.3	0.5	20.81	18.42	4.0	0.46	19.02	19.80	3.36	0.33
Bigarreau Napoleon x Van	18.73	20.93	3.63	0.46	18.26	20.43	4.06	0.4	20.46	23.06	4.33	0.26
Bigarreau Napoleon	16.62	17.30	4.1	0.5	20.44	19.44	4.4	0.53	19.61	21.86	4.9	0.4
CD (P = 0.05)	1.61	1.18	0.45	0.11	1.36	0.54	0.71	0.11	1.64	1.17	0.43	0.11

High fruit weight were recorded in combination of Stella × Guigne Pourpera Precoca, Stella × Bigarreau Napoleon and Steel × Van with low in Stella × Lambert was recorded during all the three years (Figure 2). TSS was recorded at par with natural pollination among the entire cross combinations except Stella × Guigne Pourpera Precoca (14.1, 13.76 and 14.2% during 2009, 2010 and 2011, respectively. However, during 2010, TSS in Control was significantly higher than fruits obtained from cross combinations (Figure 3). In poor fruit set. Bigarreau Noir Grossa with all the

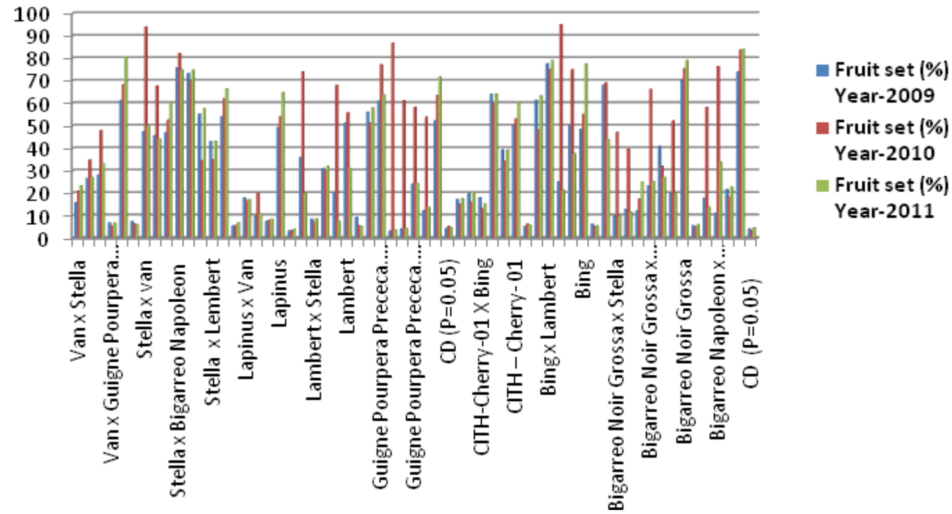

Figure 1. Impact of diverse pollen source on fruit set of sweet cherry.

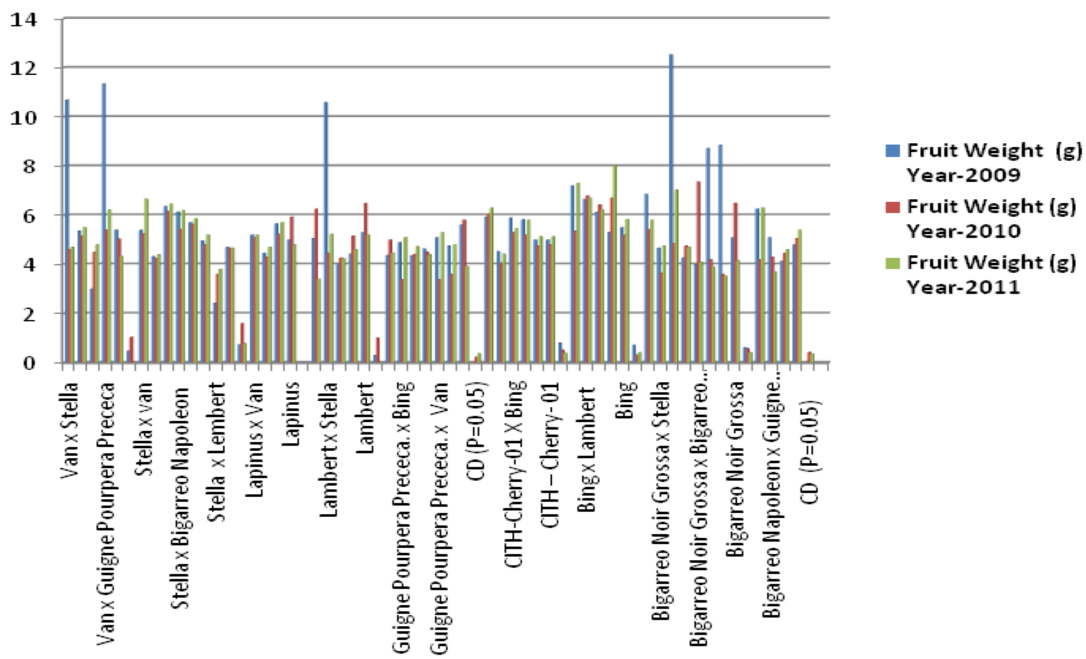

Figure 2. Impact of diverse pollen source on fruit weight of sweet cherry.

combinations resulted poor fruit set as compare to control, higher fruit set 70.50, 75.43 and 79.07% recorded during 2009, 2010 and 2011, respectively in control. However, Bigarreau Noir Grossa with Van, Bing in 2009 and with Van, Stella and Bigarreau Napoleon in 2010 resulted in high fruit set, where as all the combinations resulted in poor fruit set during 2011 except with Van (Figure 1). When Lambert was used as pollen source with Bigarreau Noir Grossa resulted high TSS (Figure 3). Bigarreau Napoleon with all the cross combinations resulted in low fruit set as compared to control except Bigarreau Napoleon with Guigne Pourpera Precoca and Lapinus, 76.34 and 58.19%, respectively, similarly pollen of Lapinus resulted increased in fruit weight and TSS case of Lapinus, very few cross combinations set fruits, further, the fruit set percent were also found lowest in comparison to control (49.25%) (Figure 1). No significant variations in fruit weight was recorded however, Lapinus × Bigarreau Napoleon and Lapinus × Van recorded comparatively higher fruit weight, but during 2010, fruit weight among crossed fruits were found less than control (Figure 2). TSS recorded

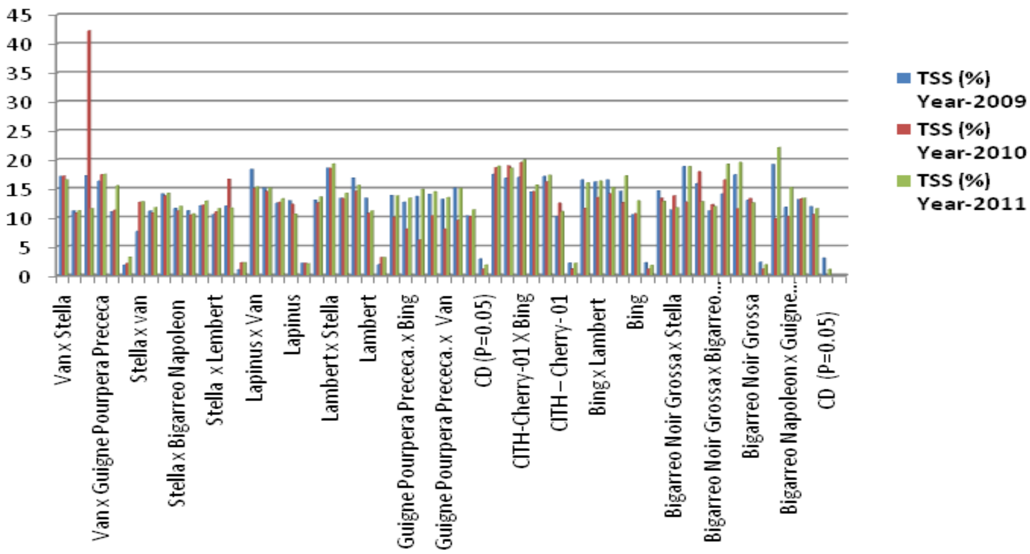

Figure 3. Impact of diverse pollen source on quality of resultant fruits.

significantly higher in the crossed fruits than naturally set fruits. High TSS 15.13 and 18.3, 14.53 and 15.3 and 15.1 and 15.33 were noted in Lapinus × Van, Lapinus × Guigne Pourpera Precoca during 2009, 2010 and 2011 respectively (Figure 3).

Lambert cultivar were crossed with different male parents, the fruit set were recorded less than control with 51.20, 55.76 and 30.98% during 2009, 2010 and 2011 respectively except Lambert x Van (74.0%) and Lambert X Bigarreau Noir Grossa. When Lambert crossed with Stella resulted high fruit weight and TSS for the three consecutive years.

Fruit set pattern among the cross combinations of Guigne Pourpera Precoca with cross combination were found poor except with Lambert and Bing which were recorded higher as compared to other combinations.

Guigne Pourpera Precoca recorded high fruit set during 2010 with Bigarreau Napoleon and Van (86.9, 61.17 and 58.27%), however, other cross combinations resulted in poor fruit set for the two years, that is, 2009 and 2011(Figure 1). Diverse pollen source had significant impact on quality attributes of fruits, fruit length, fruit diameter and TSS (Table 1).

Fruit set pattern was recorded low as compared to control, except CITH-Cherry - 01 × Bigarreau Noir Grossa, 64.16, 60.03 and 64.13% during 2009, 2010 and 2011 respectively (Figure1). Similarly, fruit weight and TSS also recorded high in CITH-Cherry-01 × Bing during three consecutive years.

Fruit set was recorded significantly higher as compare to control during three consecutive years, Bing with Stella and Lambert resulted in high fruit set (Figure 1), TSS and fruit weight constantly. However, Bing × Guigne Pourpera Precoca resulted 95.0% during 2010, rest two years, this combination resulted constantly.

DISCUSSION

Most of the cherry varieties are self sterile and need cross pollination. All commercial cultivars have viable pollen, but not all varietal combinations are useful. Childers (1995) suggested 18 cross compatible groups of sweet cherries. Incompatibility in sweet cherries is gametophytic in nature. The incompatibility in cherry and pear appears to function via glycoprotein's which correlate with the incompatibility alleles (Raff et al., 1981) for Bing, Lambert and Napoleon the suitable polinizers are Van, Black Republican, Corum, Stella and Black Tartarian . The poor fruit set among the crossed combinations might be due to incompatibility group cultivars have same geographical origin and are genetically closely related which showed incompatibility reaction. In cherry, stigma of all species and varieties are receptive as soon as flower open, but maximum receptivity of sweet cherry has been recorded for 4 to 5 days after anthesis (Stosser and Anvari, 1982; Guerrero et al., 1985). Ganopoulos et al. (2010) recorded same trends in cross compatibility in sweet cherry at Greece, Similarly at Himachal Pradesh, Ananda and Verma (1992), recorded that 75 crosses of almond, 53 were cross compatible, 12 crosses partially cross compatible and 10 crosses fully cross incompatible. Reciprocal combinations gave a good amount of fruit set and were partially to completely cross compatible. Stella is a self compatible cultivar has S_3 S_4 alleles but the S_4 is mutated to the 4^1 type. Ganopoulos et al. (2010) reported most frequent genotypes were S_3 S_4 (51%) and S_4 S_9 (9%) alleles. Hence, in order to increase the potential for cross fertilization in Kashmir, it is essential that additional cross compatible cultivars should be planted for obtaining high yield in cherry.

Based on this findings, we concluded that in sweat cherry, self and cross incompatibility are both prevalent. Hence, cultivars of same group should not be planted together. Cultivars Bigarreau Noir Grossa, Lambert and Lapinus exhibited poor cross compatibility, however, Stella, Guigne Pourpera Precoca and CITH Cherry 01 showed good cross compatible relation with crossed parents in this study.

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