



Research Article

Xenia studies in exotic and indigenous almond (*Prunus amygdalus* L.) varieties of Kashmir, India

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Article Info

<https://doi.org/10.31018/jans.v12i2.2266>

Received: April 29, 2020

Revised: May 31, 2020

Accepted: June 9, 2020

How to Cite

Majid, S. *et al.* (2020). Xenia studies in exotic and indigenous almond (*Prunus amygdalus* L.) varieties of Kashmir, India. *Journal of Applied and Natural Science*, 12(2): 244 - 251 <https://doi.org/10.31018/jans.v12i2.2266>

Abstract

Pollination is very important to obtain an economic yield, and the selection of pollinizer with suitable quality and quantity of pollen is an essential practice in different fruit plants. The effects of pollen parent on kernel and nut characters are known to occur in several nut crops and to determine the best pollinizer and effect of pollen source on the nut and kernel quality of almond (*Prunus amygdalus* L.). The present investigation was carried out at the experiment farm of Dryland Agriculture Research Station (DARS), SKUAST-Kashmir for two consecutive years, i.e. 2008 and 2009. Various cross combinations were made among nine almond (three exotic and six indigenous) varieties/selections which are compatible with each other. Their nut and kernel characteristics were determined and observed maximum nut weight (2.21 g), nut length (39.78 mm) and nut breadth (20.33 mm), kernel weight (1.28 g), kernel length (28.63 mm) and kernel breadth (12.61 mm) and shelling percentage (57.99 %). In the present study it has been observed that the parent with big nut and kernel size and weight influenced the nut and kernel size; nut and kernel weight of the recipient parent significantly ($p \leq 0.05$).

Keywords: Almond, Exotic, Indigenous, Selections, Varieties, Xenia

INTRODUCTION

Almond, one of the most important nut fruit in the world, is mainly grown on sloppy land and under rain-fed conditions in India with very low productivity (Sharma and Joolka, 2000) mainly in Jammu and Kashmir and Himachal Pradesh. Grown on an area of about 5588 hectares, the production of almond in the state of Jammu and Kashmir is about 10,326 MT (Anonymous, 2019). Out of the total production of the country (13.69 thousand tonnes), more than 90 per cent of the produce comes from Kashmir with low productivity as com-

pared to global production. In Indian conditions almonds are mostly grown on marginal lands with inadequate fertilizers and use other plant protection chemicals is far below the minimum requirements for sustained production. Most of the cultivars are self-incompatible, and nearly 30 per cent pollinizers are required in almond to have an economical crop (Connell, 2000). Some cultivar combinations also exhibit cross-incompatibility, and such cross incompatibility groups have been recognized (Kester *et al.*, 1994a; Sharafi *et al.*, 2010). Owing to these complications in almond, it necessitates the planting of more than one culti-

var with sufficient overlapping of flowering periods to ensure adequate cross-pollination and fruit set. Fertilization is an important factor in almond production because the commercial part is a seed that results from fertilized ovule. Effects of a particular pollen parent on seed (xenia) or fruit (metaxenia) characteristics are known to occur in several nut crops. Xenia and metaxenia effect have been observed in a chestnut (Crane and Iwakiri, 1980), pecan (Marquard, 1988) and almond (Vezvaie and Jackson, 1995; Kumar and Das, 1996). Cross-pollination increases nut and kernel weight and decreases blank percentage in different nut crops (Rahemi and Javadi, 2001). Thus maximum orchard efficiency depends on the proper combination of compatible cultivars, favourable weather and proper pollinator management. Considering this, it was felt imperative to study whether or not the pollen parent affects economically important nut and kernel characters in almond. The present study was conducted with cross-compatible combinations with various almond introduced varieties from abroad and SKU-AST, Kashmir released selections.

MATERIALS AND METHODS

Experimental material and location: The present investigation was carried out with cross combinations of nine almond (three exotic and six indigenous) varieties/selections at experiment farm of Dryland Agriculture Research Station (DARS), SKUAST-Kashmir, Jammu and Kashmir for two consecutive years, i.e. 2008 and 2009. The experimental farm is situated at a latitude of 34°05'N and longitude of 74°50' E and at an altitude of 1640 m amsl with the temperate region having cold conditions from November to February. The experimental was comprised of nine almond varieties viz. Pranyaj (V₁), Merced (V₂), Primorskij (V₃), Mukhdoom (V₄), Waris (V₅), Shalimar (V₆), KD-03 (V₇), KD-05 (V₈) and KD-06 (V₉) planted in 1988. Plants of uniform size and vigour were selected randomly, and all the trees were kept under similar cultural practices to ensure uniform growth as

per package and practices (Anonymous, 2018). Samples were collected from mature nuts and kernels obtained from the cross combinations given in Table 1.

Observation recorded and data analysis: Observations were recorded on nut and kernel characters. Nut weight and kernel weight of fifteen nuts were taken with the help of top pan balance, the averaged value was worked out and expressed in grams. Nut (length and breadth) and kernel (length and breadth) were measured of fifteen nuts and kernels, the average was worked out and expressed in mm. The shelling percentage was worked out by multiplying the ratio of kernel weight and nut weight with 100 and expressed in percentage.

Data collected on various parameters were computed and statistically analyzed as per the procedure given by Snedecor and Cochran (1994). The level of significance was tested for the different variables at 5 percent.

RESULTS AND DISCUSSION

The immediate effect of pollen on the tissues of nuts and kernel has received much attention in several plants of horticultural importance (Denney, 1992). Most of the cultivars are self-incompatible in almond. Therefore some other pollinizer cultivars were used for commercial fruit production.

Effect of pollen source on nut weight and nut size: Data on the effect of pollen source on nut weight and nut size of different female varieties are shown in Table 2.

Cross combinations with Pranyaj of different pollen source depicted that maximum nut weight was with Primorskij (2.21 g and 2.17 g, respectively) as a pollen donor during the year 2008 and 2009, respectively, which was significantly ($p \leq 0.05$) different than other pollen sources followed by Waris (2.08 g) and KD-06 (2.07 g) in the first year and KD-06 (2.10 g) and Waris (2.09 g) in the second year. Minimum nut weight (2.00 g) in the first year was recorded when Merced and Mukhdoom were used as pollen donors whereas in the se-

Table 1. Crossing plan among different almond varieties/selections.

♂ \ ♀	V ₁	V ₂	V ₃	V ₄	V ₅	V ₆	V ₇	V ₈	V ₉
V ₁	V ₁ V ₁	V ₁ V ₂	V ₁ V ₃	V ₁ V ₄	V ₁ V ₅	V ₁ V ₆	V ₁ V ₇	V ₁ V ₈	V ₁ V ₉
V ₂		V ₂ V ₂	V ₂ V ₃	V ₂ V ₄	V ₂ V ₅	V ₂ V ₆	V ₂ V ₇	V ₂ V ₈	V ₂ V ₉
V ₃			V ₃ V ₃	V ₃ V ₄	V ₃ V ₅	V ₃ V ₆	V ₃ V ₇	V ₃ V ₈	V ₃ V ₉
V ₄				V ₄ V ₄	V ₄ V ₅	V ₄ V ₆	V ₄ V ₇	V ₄ V ₈	V ₄ V ₉
V ₅					V ₅ V ₅	V ₅ V ₆	V ₅ V ₇	V ₅ V ₈	V ₅ V ₉
V ₆						V ₆ V ₆	V ₆ V ₇	V ₆ V ₈	V ₆ V ₉
V ₇							V ₇ V ₇	V ₇ V ₈	V ₇ V ₉
V ₈								V ₈ V ₈	V ₈ V ₉
V ₉									V ₉ V ₉

cond year minimum nut weight (2.05 g) was recorded with KD-03 and KD-05 used as pollen donors. Maximum nut length during both the years of study was recorded in Pranyaj x Primorskij (39.23 mm and 39.78 mm, respectively) which was significantly higher than other varieties/selections. In contrast, minimum nut length was recorded in

Pranyaj x KD-03 (36.81 mm) and Pranyaj x KD-05 (36.81 mm) in the first year and in Pranyaj x Shalimar (37.17 mm) in the second year of study. Pranyaj x Waris (20.22 mm and 20.12 mm) noticed maximum nut breadth during both the years of study which differed significantly ($p \leq 0.05$) from other cross combinations. In contrast, minimum

Table 2. Effect of pollen sources on nut weight and nut size in almond.

Female parent	Pollen source	Nut weight (g)		Nut size (mm)			
		1 st year	2 nd year	Length		Breadth	
				1 st year	2 nd year	1 st year	2 nd year
Pranyaj x	Merced	2.00	2.07	36.82	37.20	19.49	19.27
	Primorskij	2.21	2.17	39.23	39.78	19.01	19.20
	Mukhdoom	2.00	2.07	36.84	37.22	19.50	19.52
	Waris	2.08	2.09	36.84	37.18	20.22	20.12
	Shalimar	2.03	2.07	36.89	37.17	19.48	19.21
	KD-03	2.02	2.05	36.81	37.19	19.46	19.23
	KD-05	2.03	2.05	36.81	37.20	19.47	19.19
	KD-06	2.07	2.10	36.83	37.21	19.48	19.25
CD _{0.05}		0.11	0.05	0.032	0.02	0.01	0.012
Merced x	Primorskij	-	-	-	-	-	-
	Mukhdoom	1.96	1.98	35.98	35.05	19.28	19.39
	Waris	2.06	2.04	35.82	34.87	20.33	20.08
	Shalimar	1.84	1.83	35.88	35.00	17.93	18.10
	KD-03	1.85	1.86	35.96	35.02	18.26	18.12
	KD-05	1.82	1.81	35.92	34.96	18.06	18.20
	KD-06	1.80	1.80	35.94	34.94	19.08	18.66
	CD _{0.05}		0.09	0.05	0.29	0.21	0.14
Primorskij x	Mukhdoom	2.21	2.15	39.78	40.12	19.12	19.33
	Waris	2.20	2.17	39.77	40.12	20.11	20.01
	Shalimar	2.19	2.16	39.77	40.13	18.76	18.78
	KD-03	2.20	2.17	39.77	40.12	18.77	18.80
	KD-05	2.21	2.16	39.78	40.12	18.77	18.87
	KD-06	2.23	2.19	39.76	40.10	19.08	19.00
	CD _{0.05}		0.01	0.01	NS	NS	0.14
Mukhdoom x	Waris	2.00	2.07	32.33	32.87	20.38	20.12
	Shalimar	1.96	2.10	34.29	35.68	19.44	19.55
	KD-03	1.97	2.08	30.32	31.24	19.43	19.44
	KD-05	1.95	2.06	30.30	31.10	19.40	19.38
	KD-06	1.96	2.08	30.31	31.13	19.41	19.40
	CD _{0.05}		0.013	0.013	0.015	0.01	0.01
Waris x	Shalimar	2.11	2.06	34.10	35.01	20.34	20.16
	KD-03	2.10	2.06	32.31	31.11	20.35	20.16
	KD-05	2.11	2.07	32.30	31.41	20.36	20.17
	KD-06	2.12	2.07	32.31	31.10	20.35	20.15
	CD _{0.05}		0.013	NS	NS	0.47	0.014
Shalimar x	KD-03	1.82	1.79	34.58	35.17	17.14	17.13
	KD-05	1.83	1.80	34.57	35.16	17.17	17.87
	KD-06	1.81	1.81	34.55	35.19	17.10	17.57
CD _{0.05}		NS	NS	NS	NS	NS	NS

nut breadth in the first year was obtained in Pranyaj x Primorskij (19.01 mm) and in the second year in Pranyaj x KD-06 (19.19 mm).

Data in Table 2 depicted the significant results on the effect of pollen source on various nut characters of Merced. No fruit set was obtained in a cross combination of Merced x Primorskij in both the year of study. Merced x Waris recorded maximum nut weight (2.01 g and 2.00 g), nut breadth (20.33 mm and 20.08 mm) and kernel weight (1.03 g and 1.02 g) during both the years of study which differed significantly from other varieties/selections. Maximum nut length was observed in Merced x Mukhdoom (35.98 mm and 35.05 mm, respectively) in both the years, which was statistically at par with all the varieties. Minimum nut weight (1.80 g and 1.80 g), nut length (35.82 mm and 34.87 mm), nut breadth (17.93 mm and 18.10 mm) and kernel weight (0.98 g and 0.99 g) in Merced was recorded when KD-06, Waris, Shalimar and KD-05 were used as a pollen source during both the years, respectively.

Effect of different pollen source on nut characters of Primorskij is presented in Table 2. Cross combination of Primorskij x KD-06 (2.23 g and 2.19 g) recorded highest nut weight in both the years of study which differed significantly from others whereas lowest nut weight was observed with Primorskij x Shalimar (2.19 g) in the first year and Primorskij x Mukhdoom (2.15 g) in the second year. Maximum nut length (39.78 mm) in Primorskij was recorded with Mukhdoom and KD-05 used as pollen source in the first year and in the second year with Shalimar (40.13 mm) as pollen source. Minimum nut length was recorded in Primorskij x KD-06 (39.76 mm and 40.10 mm) in both the year, respectively. Maximum and minimum nut breadth was recorded in Primorskij x Waris (20.11 mm and 20.01 mm) and Primorskij x Shalimar (18.76 mm and 18.78 mm) during both the years of study.

Data in Table 2 revealed that there was a significant effect of cross combinations on nut weight, nut size, kernel size, shelling percentage of Mukhdoom however, kernel weight and organoleptic evaluation was non-significant ($p \leq 0.05$). Maximum and minimum nut weight was recorded in Mukhdoom x Waris (2.00 g) and Mukhdoom x KD-05 (1.95 g) during the first year whereas in the second year Mukhdoom x Shalimar (2.10 g) recorded maximum and Mukhdoom x KD-05 (2.06 g) recorded minimum nut weight. Maximum nut length and nut breadth were recorded in Mukhdoom x Shalimar (34.29 mm and 35.68 mm) and Mukhdoom x Waris (20.38 mm and 20.12 mm) during both the year of study whereas minimum nut length (30.30 mm and 31.10 mm) and nut breadth (19.40 mm and 19.38 mm) was obtained in Mukhdoom x KD-05, respectively during both the years.

Effect of different pollen source showed significant results on nut breadth, kernel length, shelling percentage during both the years and for nut weight in the first year and for nut length in the second year (Table 2). Nut weight ranged from 2.10 g (Waris x KD-03) to 2.12 g (Waris x KD-06) during the first year and in the second year 2.06 g (Waris x Shalimar and Waris x KD-03) to 2.07 g (Waris x KD-06 and Waris x KD-5). Maximum nut length with Shalimar (34.10 mm and 35.01 mm) used as a pollen source for Waris during both the years which differed significantly from other pollen sources. In contrast, minimum nut length was recorded with KD-05 (32.30 mm) in the first year and with KD-06 (31.10 mm) in the second year, when used as a pollen source. Waris x KD-05 measured maximum nut breadth (20.36 mm and 20.17 mm) during both the years whereas minimum nut breadth in Waris x Shalimar (20.34 mm) in the first year and in Waris x KD-06 (20.15 mm) in the second year.

Non-significant results were obtained for all the nut characters of Shalimar with different pollen source. Nut weight ranged between 1.81 g (Shalimar x KD-06) to 1.83 g (Shalimar x KD-05) and 1.79 g (Shalimar x KD-03) to 1.81 g (Shalimar x KD-06) during both the years, respectively. Nut length ranges between 34.55 mm (Shalimar x KD-06) to 34.58 mm (Shalimar x KD-03) and 35.16 mm (Shalimar x KD-05) to 35.19 (Shalimar x KD-06) whereas nut breadth ranges between 17.10 (Shalimar x KD-06) to 17.17 (Shalimar x KD-05) and 17.13 (Shalimar x KD-03) to 17.87 (Shalimar x KD-05) during both the years of study.

In the earlier reports, it has been observed that size of nuts (different nut crops) produced was always in the direction of the pollen parent (Crane and Iwakiri, 1980, Golzari *et al.*, 2016). In the present study also pollen from the cultivar that produced relatively large nuts when applied to a cultivar normally producing small nuts brought about an increase in the size of a nut of the recipient parent. The present findings are in the agreements with Vezvaei and Jackson (1995), where they obtained heavier and bigger nuts from Price variety of almond when Keane variety was used as donor parents. Kumar and Das (1996) also reported that nut size index was significantly increased in a small nut parent 'Drake' on pollination with large nut parents 'Nonpareil'.

Effect of pollen source on kernel weight and kernel size: Highest kernel weight was observed with Primorskij (1.26 g and 1.25 g, respectively) as a pollen donor during both the year, which significantly differed than other varieties. In contrast, the lowest kernel weight was obtained with Merced (1.13 g and 1.16 g, respectively) as a pollen donor during both the year of study (Table 3). Maximum kernel length and kernel breadth during both the year of study were obtained from the

cross combinations of Pranyaj x Primorskij (28.60 mm and 28.77 mm) and Pranyaj x Waris (12.61 mm and 12.43 mm), respectively which differs significantly from other varieties/selections whereas minimum kernel length and kernel breadth were recorded in Pranyaj x KD-05 (26.81 mm and 26.83 mm) and Pranyaj x Merced (12.09 mm and 11.92 mm) during both the years, respectively.

Maximum kernel length and kernel breadth were recorded in cross combinations of Merced x Mukhdoom (26.67 mm and 26.28 mm) and Merced x Waris (12.60 mm and 12.42 mm) whereas minimum kernel length and kernel breadth were obtained from Merced x Waris (26.59 mm and 26.22 mm) and Merced x KD-06 (11.55 mm and 11.31 mm) during both the years

Table 3. Effect of pollen sources on kernel weight and kernel size in almond.

Female parent	Pollen source	Kernel weight (g)		Kernel size (mm)			
		1 st year	2 nd year	Length		Breadth	
				1 st year	2 nd year	1 st year	2 nd year
Pranyaj x	Merced	1.13	1.16	26.85	26.88	12.09	11.92
	Primorskij	1.26	1.25	28.60	28.77	12.10	11.96
	Mukhdoom	1.15	1.21	26.83	26.86	12.10	11.95
	Waris	1.14	1.18	26.83	26.87	12.61	12.43
	Shalimar	1.15	1.18	26.84	26.85	12.10	11.98
	KD-03	1.16	1.18	26.83	26.87	12.12	11.98
	KD-05	1.15	1.17	26.81	26.83	12.11	11.98
	KD-06	1.15	1.17	26.85	26.87	12.11	11.96
CD _{0.05}		0.011	0.01	0.014	0.03	0.012	0.048
Merced x	Primorskij	-	-	-	-	-	-
	Mukhdoom	1.01	1.01	26.67	26.28	11.58	11.32
	Waris	1.08	1.06	26.59	26.22	12.60	12.42
	Shalimar	1.00	1.00	26.60	26.27	11.57	11.33
	KD-03	1.02	1.00	26.66	26.24	11.56	11.32
	KD-05	0.98	0.99	26.61	26.25	11.58	11.32
	KD-06	1.01	1.01	26.64	26.24	11.55	11.31
CD _{0.05}		0.016	0.010	NS	NS	0.04	0.04
Primorskij x	Mukhdoom	1.25	1.22	28.60	29.02	11.75	11.62
	Waris	1.27	1.26	28.60	28.99	12.60	12.32
	Shalimar	1.28	1.24	28.63	28.99	11.78	11.59
	KD-03	1.27	1.23	28.60	29.01	11.77	11.59
	KD-05	1.27	1.24	28.58	29.00	11.74	11.56
	KD-06	1.26	1.23	28.63	28.98	11.76	11.60
CD _{0.05}		NS	NS	NS	NS	0.013	0.022
Mukhdoom x	Waris	0.94	0.95	22.40	22.52	12.40	12.31
	Shalimar	0.85	0.89	24.90	25.11	11.01	11.12
	KD-03	0.86	0.90	22.04	22.45	11.24	11.11
	KD-05	0.86	0.93	22.05	22.50	10.97	11.09
	KD-06	0.86	0.92	22.08	22.47	11.22	11.24
CD _{0.05}		NS	NS	0.04	0.015	0.01	0.014
Waris x	Shalimar	1.02	1.02	25.76	26.02	12.67	12.43
	KD-03	1.02	1.02	22.77	22.98	12.60	12.41
	KD-05	1.00	1.01	22.74	22.97	12.59	12.39
	KD-06	1.00	1.01	22.76	22.99	12.58	12.40
CD _{0.05}		NS	NS	0.01	0.01	NS	NS
Shalimar x	KD-03	0.90	0.91	25.77	26.27	11.33	11.11
	KD-05	0.88	0.90	25.77	26.28	10.86	10.99
	KD-06	0.87	0.89	25.77	26.26	11.13	11.23
CD _{0.05}		NS	NS	NS	NS	NS	NS

of study, respectively however results were non-significant for kernel length in both the years (Table 3). Different pollen parents crossed with Primorskij depicts non-significant for kernel weight (Table 3). In the first year, kernel weight ranged from 1.25 g (Primorskij x Mukhdoom) and 1.28 g (Primorskij x Shalimar) whereas in the second year ranged from 1.22 g (Primorskij x Mukhdoom) to 1.26 g (Primorskij x Waris). Non-significant results were observed for kernel length where maximum kernel length (28.63 mm) in the first year was recorded in Primorskij x Shalimar and Primorskij x KD-06 and minimum in Primorskij x KD-05 (28.58 mm). Maximum and minimum kernel length in the second year was recorded in Primorskij x Mukhdoom (29.02 mm) and Primorskij x KD-06 (28.98 mm). Primorskij x Waris recorded maximum (12.60 mm and 12.32 mm) kernel breadth during both the year whereas the minimum was recorded in Primorskij x KD-05 (11.74 mm and 11.56 mm) during both the years.

Non-significant effect ($p \leq 0.05$) on kernel weight in both the years of study was noticed. However, the maximum kernel weight was recorded in Mukhdoom x Waris (0.94 g and 0.95 g) in both the years whereas minimum kernel weight was recorded in Mukhdoom x Shalimar (0.85 g and 0.89 g, respectively) during both the years (Table 3). Maximum and minimum kernel length was recorded in Mukhdoom x Shalimar (24.90 mm and 25.11 mm) and Mukhdoom x KD-03 (22.04 mm and 22.45 mm) during both the year of study whereas maximum and minimum kernel breadth was recorded in Mukhdoom x waris (12.40 mm and 12.31 mm) and Mukhdoom x KD-05 (10.97 mm and 11.09 mm) in both the years.

The non-significant effect of pollen source was obtained on Waris for kernel weight which ranges between 1.00 g (Waris x KD-06 and Waris x KD-05) to 1.02 g (Waris x Shalimar and Waris x KD-03) in the first year and 1.01 g (Waris x KD-06 and Waris x KD-05) to 1.02 g (Waris x Shalimar and Waris x KD-03) in the second year of study (Table 3). Maximum and minimum kernel length was recorded in Waris x Shalimar (25.06 mm and 26.02 mm) and Waris x KD-05 (22.74 mm and 22.97 mm), respectively during both the years. Non-significant results of kernel breadth depicted that in the first year Waris x Shalimar (12.67 mm) scored maximum values and Waris x KD-06 (12.58 mm) scored minimum values for kernel breadth whereas in the second year kernel breadth ranges between 12.39 mm (Waris x KD-05) to 12.43 (Waris x Shalimar).

During both the years of study, kernel weight ranges between 0.87 g (Shalimar x KD-06) to 0.90 g (Shalimar x KD-03) and 0.89 g (Shalimar x KD-06) to 0.91 g (Shalimar x KD-03). Data reveals kernel length of 25.77 mm recorded for all cross combination in the first year as compared to maximum

kernel length of 26.28 mm recorded in Shalimar x KD-05 (26.28 mm) and minimum recorded in Shalimar x KD-06 (26.26 mm) in the second year. The kernel breadth ranged from 10.86 mm (Shalimar x KD-05) to 11.33 (Shalimar x KD-03) in the first year and ranges from 10.99 mm (Shalimar x KD-05) to 11.23 mm (Shalimar x KD-06) in the second year.

In the earlier studies, Kumar and Das (1996), Acar *et al.* (2016) on almond and Golzari *et al.* (2016) on walnut also reported big kernel size of the recipient parent when crossed with the bigger kernel size of the pollen parent.

Effect of pollen source on shelling percentage : Figure 1 depicts that during the first year of study, the highest shelling percentage was observed in Pranyaj x Mukhdoom (57.83 %) as compared to lowest shelling percentage recorded in Pranyaj x KD-06 (55.71 %) whereas, in the second year, maximum shelling percentage was observed in Pranyaj x Mukhdoom (57.50 %) and minimum recorded in Pranyaj x Waris (54.87 %) (Fig. 2). Merced x KD-06 (56.12 % and 55.80 %) scored maximum values for shelling percentage during both the years which was statistically at par with Merced x KD-05 (55.68 % and 55.02 %) whereas minimum shelling percentage was recorded in Merced x Waris (51.31 % and 50.98 %) during both the years, respectively.

Different cross combinations Primorskij with pollen source depicts that maximum shelling percentage in the first year was scored in Primorskij x Shalimar (57.99 %) which was statistically at par with Primorskij x Waris (57.72 %) and minimum in Primorskij x Mukhdoom (57.01 %) (Fig. 1). In the second year, results were non-significant however, maximum and minimum shelling percentage was obtained in Primorskij x Waris (57.60 %) and Primorskij x KD-05 (56.94 %), respectively (Fig. 2). Mukhdoom x Waris revealed maximum shelling percentage (47.12 % and 45.89 %) during both the years which differs significantly from other varieties whereas minimum shelling percentage was recorded in Mukhdoom x Shalimar (43.87 % and 42.85 %) in both the years.

Shelling percentage showed significant results when different pollen source was applied on Waris during both the years (Fig. 1 and 2). Maximum shelling percentage was recorded in Waris x KD-03 (48.81 % and 49.75 %) during both the years whereas minimum shelling percentage was recorded in Waris x KD-06 (47.29 % and 48.81 %) in both the years.

Shelling percentage of different cross combinations with Shalimar shows significant results. Shalimar x KD-06 (49.86 %) reveals maximum shelling percentage as compared to a minimum in Shalimar x KD-03 (48.35 %) in the first year whereas in the second year maximum and minimum shelling percentage was recorded with the

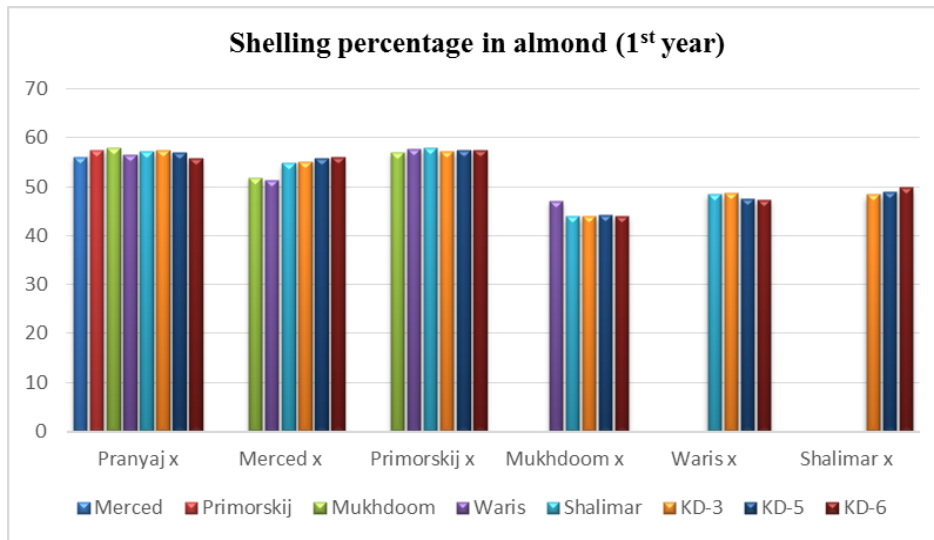


Fig. 1. Effect of pollen sources on shelling percentage in almond (1st year).

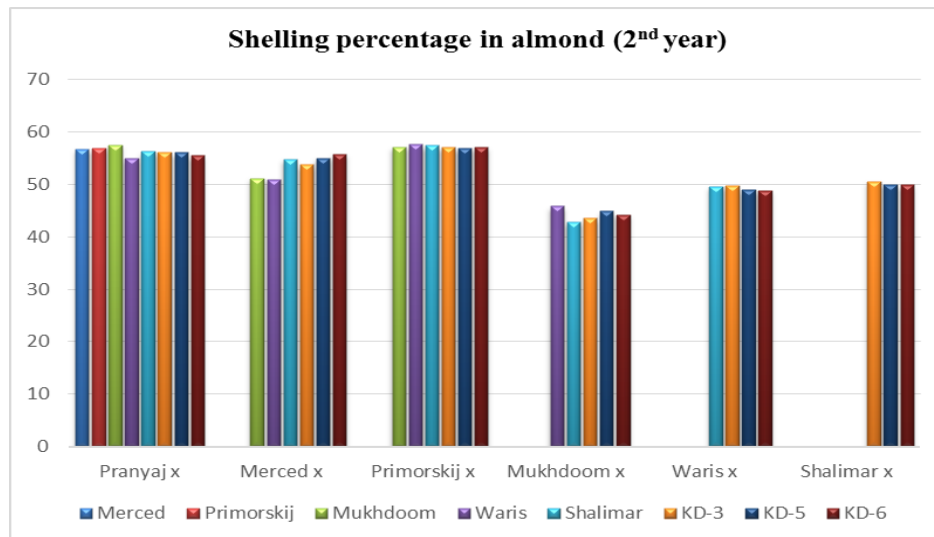


Fig. 2. Effect of pollen sources on shelling percentage in almond (2nd year).

pollen source of KD-03 (50.55 %) and KD-06 (49.86 %), respectively (Fig. 1 and 2).

Bahmani *et al.* (2003) also reported that pollination of almond with pollen of the cultivars with higher shelling percentage significantly increased shelling percentage in the recipient parent. The effect of pollen type on shelling percentage was in agreement with results previously reported in almond (Kumar and Das, 1996; Acar *et al.*, 2016), in pistachio (Crane and Iwakiri, 1980), in hazelnut (Javadi and Gheshlaghi, 2006) and in walnut (Golzari *et al.*, 2016).

The effects of pollen source on nut and kernel characteristics are known in several nut crops. In the present study, our results confirmed the effect of pollen on the physical characteristics of the nut and kernel of almond (*P. amygdalus*). At the same time, further research could clarify the effect of pollen on the chemical composition of the nut.

Conclusion

From the present study, it was concluded that the pollen source on the nut and kernel characteristics of recipient varieties/selections of almond (*P. amygdalus*) revealed that the characters like nut weight, kernel weight, nut size, kernel size and shelling percentage were significantly ($p \leq 0.05$) influenced by the donor parent. The paternal effect in the present study exhibited by differences among fruits borne on the same cultivar but developed from a different source of pollen.

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