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Selection of Homogamous Walnut from Seedling Plantation in South Kashmir

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Thirty two homogamous walnut trees were pre-selected from a total of four hundred and eighty two trees grown naturally in fourteen villages of district Pulwama of South Kashmir. In most of the trees flowering periods of male and female are overlapping at least for six days and recorded less than 25 per cent degree of dichogamy. The quality characteristics of nuts of these selected walnut types are quite valuable. Out of these homogamous trees, more than 80 per cent varied considerably in terms of yield, nut and kernel quality. Their nut and kernel weight varied between 10.23 g to 17.73 g and 5.20 g to 9.55 g, respectively. However, kernel percentage ranged between 44.83 and 56.35 per cent. These selected walnut types are adequate for commercial growth and can be utilized in genetic improvement programmes.

Key Words: Homogamous, Pollen shedding, Seedling, Selection, Stigma receptivity, Walnut

Introduction

Owing to favourable ecological conditions, to the existence of a valuable fund of germplasm which is adapted to these conditions and to a tradition of many centuries for growing this species, Kashmir is one of the regions in the whole world with an important production of walnut. The common walnut is considered to be indigenous to the region from Persia to Kashmir (Ford, 1975) which further extends to Himachal Pradesh, Uttaranchal (Hayes, 1957). Walnut is important in terms of enormous export potential and has a scope of diversification with suitable high value crop in an otherwise apple dominating region. Walnut becomes a viable alternative for commercial cultivation in hilly states. Presently the major walnut production comes from seedling trees of primitive population grown under natural forests and farmers backyards without any cultural operation. *Juglans regia* L. is heterodichogamous species i.e. having dichogamous and homogamous genotypes. Dichogamous includes protandrous and protogynous genotypes and causing outcrossing (Sutyemez, 2006). Persian walnut exhibits varying degrees of dichogamy with protandry more pronounced than protogyny in most of the genotypes (Majackaja, 1969; Germain *et al*., 1981). On the other hand, homogamy i.e. overlapping pollen shedding period and stigma receptivity periods results in good pollination and consequent higher yield, however homogamy in walnut is quite rare (Solar *et al*., 1997; Sharma and Sharma, 2000; Sutyemez, 2001; Beyhan and Ozatar, 2008; Verma *et al*., 2009) as compared to protandry and protogyny. Homogamous types of walnuts are generally more productive than the protogynous and protandrous walnuts because of synchronized blooming of male and female flowers. The present study aims in highlighting the walnut accessions with high degree of homogamy, to achieve optimum fruit set and for getting higher yields with desirable nut and kernel characters.

Materials and Methods

In a preliminary survey four hundred and eighty two walnut trees were marked in fourteen villages of district Pulwama during 2010 and 2011. All the marked trees are of seedling origin ranging an age of between 20 to 60 years. The trees were marked on the basis of health, plant vigour, regular bearing and desirable nut and kernel characters and out of them 32 trees were pre-selected for further studies on the basis of their homogamous nature. The weather and geographical features of the studied location are represented in Figure 1.

Observations on flowering characters were recorded as per IPGRI walnut descriptors (IPGRI, 1994). Four branches on each side of the tree were selected and marked. Bearing habit of each tree was observed on the basis of terminal and lateral habit. Time of the leaf bud burst was taken on the four selected branches and noted. Number of catkins/bud was observed on four selected branches and average value was calculated. Ten catkins were randomly taken from the selected branches and

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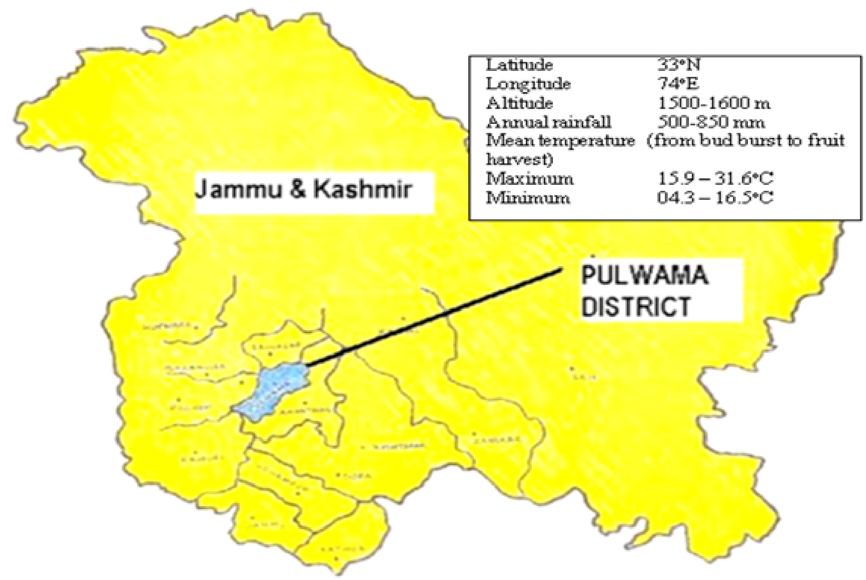


Fig. 1. Weather and geographical features of the area surveyed

measured with the help of digital vernier's caliper and expressed in cm. To determine the nature and degree of dichogamy, observations were recorded at the time of maturation of male catkins and female flower by selecting four branches on each tree. Degree of dichogamy was calculated as per methods of Solar *et al*. (1997).

$$\text{Degree of dichogamy (\%)} = 1 - \frac{\text{Number of days when male and female flowering coincides}}{\text{Number of days of female flowering}} \times 100$$

The selected trees showing less than 25 per cent degree of dichogamy (Kumar, 2000; Kumar *et al*., 2005) were categorized as homogamous. The homogamous selections were further evaluated for their nut, kernel and yield characteristics for two consecutive years. Nut yield (kg/tree) was calculated on the basis of total weight of all the nuts harvested after dehulling and drying. Yield efficiency and trunk cross sectional area was calculated as per Westwood (1993)

$$\text{Yield efficiency (kg/cm}^2\text{)} = \frac{\text{Yield}}{\text{Trunk cross sectional area}}$$

Trunk cross sectional area (TCSA) = r^2 where 'r' is the radius of the tree. For recording observations on nut and kernel characters, 20 randomly selected nuts from each selected tree were taken. Nut length and width was measured with the help of digital vernier's caliper and expressed in mm. Nut weight and kernel weight were weighed on digital balance whereas kernel percentage was calculated as:

$$\text{Kernel (\%)} = \frac{\text{Kernel weight}}{\text{Nut weight}} \times 100$$

Shell thickness was measured at near centre of half shell with the help of digital vernier's caliper. The pooled data of two year were analyzed as per method suggested by Gomez and Gomez (1985) using randomized block design.

Results and Discussion

In the present study, the experimental trees were selected among > 1200 hundred seedling trees grown in 14 villages of district Pulwama. Out of these trees, 482 were selected as promising types from the stand point of quality of nuts, yield, disease resistance etc., according to walnut descriptors. During the selection works it was noticed that thirty two superior trees have homogamous flowering characters. All the genotypes presented in Table 1 showed terminal bearing habit, however, nature of dichogamy was homogamous. Time of leaf bud burst extended from 28th March (HJ-46) to 9th April (MD-03 and KL-29). Duration of male flowering ranges from 8 days (MD-09) to 15 days (SI-05, PA-34, MD-38, KL-29 and TL-13). However, duration of female flowering ranges from 7 days (MD-09) to 16 days (KL-29). Out of all the studied selections evaluated, thirty two trees recorded less than 25 per cent dichogamy (Table 1) ranging between

0.00 per cent (HJ-46) to 25.00 (BT-07, NO-42, PA-29, RJ-02, BS-12 and TL-12). Earlier Kumar *et al*. (2005) and Kumar and Sharma (2013) also reported less than 25 per cent dichogamy in nine selections and in three cultivars for three respective years out of 19 studied cultivars, respectively. Out of thirty two genetically diverse walnut accessions Verma *et al*. (2009) reported 13 accessions of homogamous nature, while Ghasemi *et al*. (2012) observed two genotypes, out of seventy (MS 27 and MS 29) completely homogamous.

Overlapping of pollen shedding and stigma receptivity periods in the above thirty two selections extended from 6 (MD-09) to 13 (GP-32, KL-29) i.e. the number of days which actually coincided (Table 1). Figure 2 shows that synchronization of pollen shedding and stigma receptivity was maximum (13 days) in GP-32 and KL-29 which starts from 7th April and end on 19th April, however, in accession MD-09 the synchronization

Table 1. Bearing and flowering behaviour of selected homogamous walnut selections

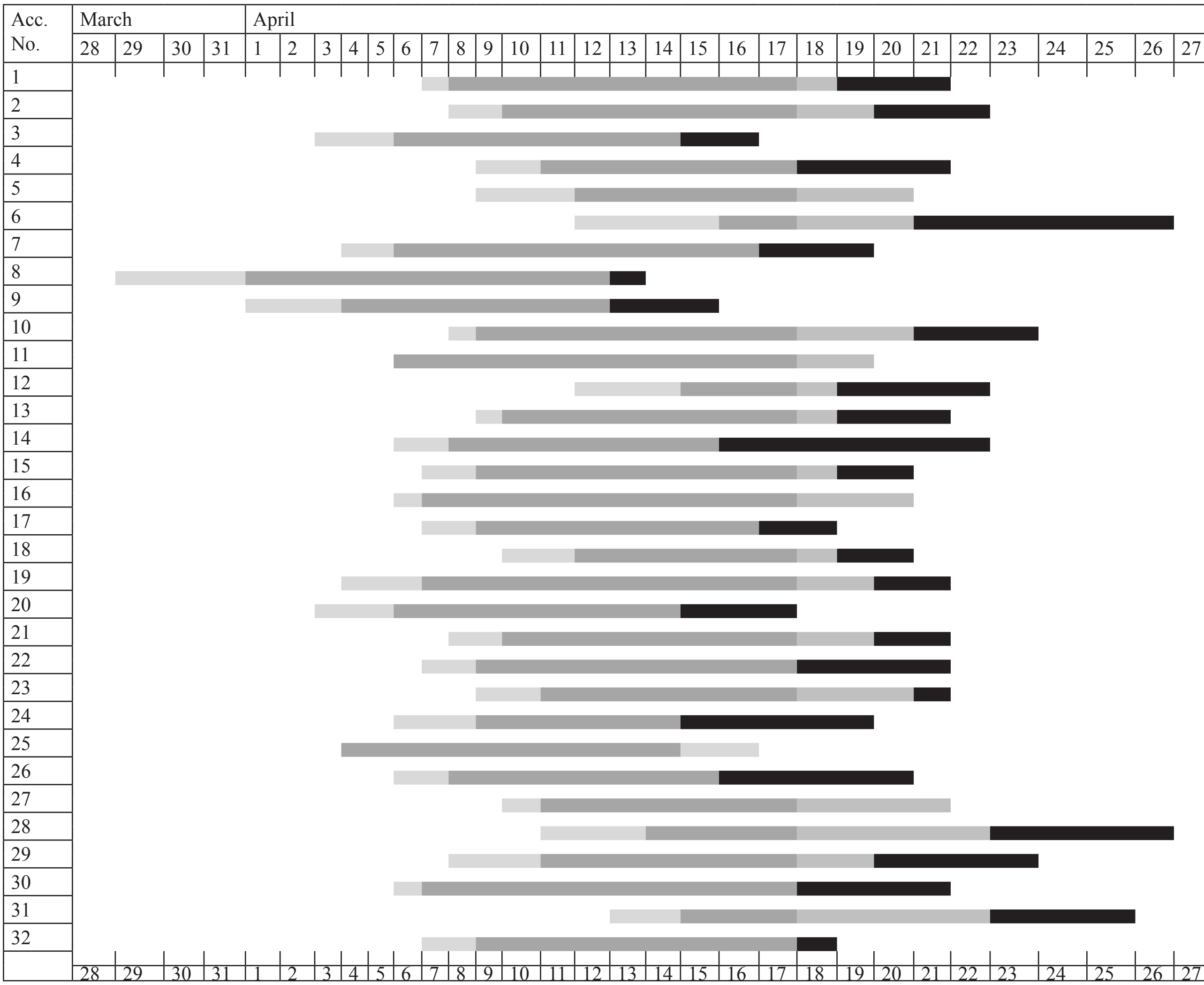
Accession No.	Bearing habit	Date of leaf bud burst	Duration of male flowering (days)	Duration of female flowering (days)	No. of days synchronized	Degree of dichogamy	No. of catkins /bud	Catkin length (cm)	Nature of dichogamy
SI-05	Terminal	5th April	15	12	11	8.33	4.36	9.64	Homogamous
SI-19	Terminal	4th April	13	12	10	16.67	3.85	9.90	Homogamous
BT-07	Terminal	29th Mar	11	12	9	25.00	4.14	10.08	Homogamous
NO-35	Terminal	31st March	11	9	7	22.22	4.10	7.16	Homogamous
NO-42	Terminal	8th April	9	12	9	25.00	5.44	7.65	Homogamous
PA-12	Terminal	6th April	11	9	7	22.22	5.18	7.52	Homogamous
PA-17	Terminal	31st March	14	13	11	15.38	3.40	8.10	Homogamous
PA-18	Terminal	29th March	13	15	12	20.00	3.85	7.32	Homogamous
PA-29	Terminal	5th April	12	12	9	25.00	4.80	8.44	Homogamous
PA-34	Terminal	4th April	15	13	12	7.69	5.80	7.50	Homogamous
MD-03	Terminal	9th April	12	14	12	14.28	4.32	7.00	Homogamous
MD-09	Terminal	7th April	8	7	6	14.28	5.39	8.82	Homogamous
MD-15	Terminal	1st April	12	10	9	10.00	5.60	9.36	Homogamous
MD-38	Terminal	6th April	15	10	8	20.00	4.98	10.34	Homogamous
GP-19	Terminal	4th April	12	12	10	16.67	6.04	11.16	Homogamous
GP-32	Terminal	5th April	13	15	13	13.33	3.20	7.25	Homogamous
ML-01	Terminal	6th April	10	10	8	20.00	6.84	9.15	Homogamous
ML-26	Terminal	3rd April	9	9	7	22.22	5.51	7.20	Homogamous
KL-29	Terminal	9th April	15	16	13	18.75	4.59	8.80	Homogamous
RJ-02	Terminal	3rd April	12	12	9	25.00	7.50	7.37	Homogamous
RJ-24	Terminal	2nd April	12	12	10	16.67	5.54	8.12	Homogamous
RJ-38	Terminal	31st March	13	11	9	18.18	7.28	9.49	Homogamous
LP-03	Terminal	8th April	11	12	10	16.67	6.54	10.72	Homogamous
HJ-02	Terminal	6th April	11	9	7	22.22	7.18	7.32	Homogamous
HJ-46	Terminal	28th March	11	11	11	0.00	7.12	8.79	Homogamous
BS-05	Terminal	2nd April	13	10	8	20.00	6.25	10.64	Homogamous
BS-11	Terminal	8th April	10	12	10	16.67	5.68	11.75	Homogamous
BS-12	Terminal	5th April	13	12	9	25.00	6.14	7.44	Homogamous
TL-12	Terminal	31st March	13	12	9	25.00	6.46	9.18	Homogamous
TL-13	Terminal	2nd April	15	12	11	8.33	6.06	10.89	Homogamous
TL-15	Terminal	7th April	11	10	8	20.00	5.62	8.17	Homogamous
TL-28	Terminal	1st April	10	11	10	9.09	6.52	10.39	Homogamous
Mean			12.03	11.50	9.50	17.50	5.48	8.84	
SD			1.87	1.93	1.81	6.23	1.71	1.38	
CoV			15.54	16.78	19.05	35.60	31.21	27.93	

Table 2. Yield, nut and kernel characters of selected homogamous walnut selections

Accession No.	Nut yield (Kg/tree)	Trunk girth (cm)	TCSA (cm2)	Yield efficiency (kg/cm2)	Nut weight (g)	Nut length (mm)	Nut width (mm)	Kernel weight (g)	Shell thickness (mm)	Kernel (%)
SI-05	56	239	4543.06	0.0123	12.04	31.86	29.83	6.29	0.87	52.24
SI-19	65	248	4891.24	0.0133	11.50	32.00	28.26	5.70	0.90	49.57
BT-07	66	265	5586.32	0.0118	13.28	34.45	30.89	6.67	1.26	50.23
NO-35	65	275	6015.63	0.0108	16.54	39.69	31.24	8.62	1.21	52.12
NO-42	62	271	5840.91	0.0106	15.12	37.65	32.44	8.08	1.14	53.44
PA-12	72	270	5797.64	0.0124	12.98	31.29	27.25	7.00	1.25	53.93
PA-17	70	270	5797.64	0.0121	12.09	31.75	27.29	6.32	0.88	52.27
PA-18	64	218	3779.92	0.0169	14.80	35.09	27.77	7.42	1.25	50.14
PA-29	60	240	4581.38	0.0131	14.24	33.62	32.50	7.07	1.11	49.65
PA-34	77	290	6690.83	0.0115	15.38	38.79	33.20	7.65	1.22	49.74
MD-03	79	298	7064.23	0.0112	14.00	32.24	29.16	6.40	0.92	45.71
MD-09	68	280	6237.64	0.0109	15.31	39.36	33.14	7.52	1.20	49.12
MD-15	70	284	6415.30	0.0109	13.13	32.71	30.39	6.93	0.96	52.78
MD-38	75	295	6921.91	0.0108	12.24	32.01	30.28	6.16	1.18	50.33
GP-19	48	172	2352.65	0.0204	15.30	36.62	31.86	7.82	1.16	51.11
GP-32	60	208	3441.27	0.0174	11.60	30.45	29.97	5.20	1.11	44.83
ML-01	65	244	4736.26	0.0137	17.73	40.88	34.92	9.55	1.14	53.86
ML-26	78	282	6324.75	0.0123	13.84	33.53	29.64	6.85	1.21	49.49
KL-29	50	195	3024.18	0.0165	16.07	37.57	36.84	8.12	1.09	50.53
RJ-02	45	192	2933.24	0.0153	13.24	32.71	30.39	6.53	1.20	49.32
RJ-24	48	190	2872.11	0.0167	15.59	36.76	33.61	7.74	0.92	49.65
RJ-38	65	215	3676.01	0.0177	14.50	34.27	32.14	7.64	1.30	52.69
LP-03	62	204	3309.44	0.0187	11.84	31.70	26.12	6.41	0.92	54.14
HJ-02	50	230	4207.75	0.0119	14.22	36.12	31.89	7.01	0.93	49.30
HJ-46	72	268	5714.25	0.0126	12.10	31.18	28.41	5.60	0.99	46.28
BS-05	65	270	5797.64	0.0112	15.16	38.09	32.52	7.92	1.15	52.24
BS-11	66	262	5459.84	0.0121	12.28	31.93	30.16	6.92	1.11	56.35
BS-12	72	285	6460.82	0.0111	14.28	34.39	31.34	7.13	1.26	49.93
TL-12	70	277	6103.95	0.0115	10.23	29.26	26.71	5.73	1.34	56.01
TL-13	62	232	4281.67	0.0145	14.45	35.21	32.50	7.66	1.14	53.01
TL-15	58	212	3575.67	0.0165	13.56	33.72	29.92	6.72	1.29	49.56
TL-28	64	226	4061.84	0.0158	13.58	33.95	29.25	6.90	1.12	50.81
Mean	64.03	247.09	4953.03	0.0136	13.82	34.40	30.68	7.04	1.12	50.95
SD	8.89	35.40	1354.29	0.003	1.67	3.06	3.06	2.54	0.92	2.63
CoV	13.88	14.33	27.34	22.09	12.08	8.93	9.93	36.08	82.40	5.16

was only for 6 days i.e. from 14th April to 19th April. In earlier reports, Lonnie *et al*. (1998) stated that the pollen shedding period coincides well with the period of pistillate flower receptivity. In their study chart of relationship of pollen shedding period and peak pistillate bloom period, it was observed that the overlapping period was more than 7 days. Sutyemez (2001) and Kumar *et al*. (2005) also reported overlapping of male and female flower between 6 to 11 days and 8 to 13 days in their respective studies. Due to this fact their self pollination occurs in a desired manner without necessity of another pollinators. With the mean values of 5.48 and 8.84, number of catkin per bud and catkin length ranges between 3.20 (GP-32) to 7.50 (RJ-02) and 7.16 cm (NO-35) to 11.75 cm (BS-11), respectively.

Data on various yield, nut and kernel characters of the selected homogamous selections are presented in Table 2. Nut yield varies from 45 kg (RJ-02) to 79 kg (MD-03) however, trunk girth and TCSA registered maximum (298 cm and 7064.23 cm^2) in MD-03 and minimum (172 cm and 2352.65) in GP-19. Yield efficiency in various accessions ranged from 0.0106 (NO-42) to 0.0204 kg/cm^2 (GP-19). The dimensions of in-shelled nuts representing selections were based on nut weight, nut length and



S. No.	Accession No.	S. No.	Accession No.	S. No.	Accession No.	S.No.	Accession No.
1	SI-05	9	PA-29	17	ML-01	25	HJ-46
2	SI-19	10	PA-34	18	ML-26	26	BS-05
3	BT-07	11	MD-03	19	KL-29	27	BS-11
4	NO-35	12	MD-09	20	RJ-02	28	BS-12
5	NO-42	13	MD-15	21	RJ-24	29	TL-12
6	PA-12	14	MD-38	22	RJ-38	30	TL-13
7	PA-17	15	GP-19	23	LP-03	31	TL-15
8	PA-18	16	GP-32	24	HJ-02	32	TL-28

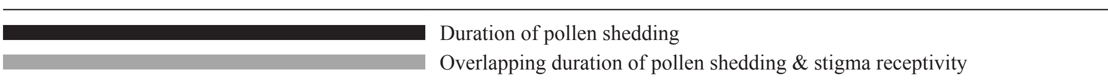


Fig. 2. Duration of pollen shedding and stigma receptivity in different walnut selections

nut width. The average in-shell nut weight varied from 10.23 to 17.73 g being lowest in the accessions no. TL-12 and highest in the accessions no. ML-01. In-shell nut weight can serve as good parameter for selection provided coupled with high shelling percentage and creamish kernel colour as reported by Gautam (2000). Goughen and Weichang (1990) reported nut weight of 5.8 g as the smallest and 25-27 g as largest size in

China. Minimum standard for shell nut weight is above 12 g and all the accessions (except three) in the present study confirmed these criteria. Accession ML-01 scored maximum (40.88 mm) nut length however, minimum (29.26 mm) was of TL-12. Maximum (36.84 mm) and minimum (26.12 mm) nut width was registered in the accession KL-29 and LP-03, respectively. Most of the accessions in the present study confirmed the standard diameter laid out by Serr and Ford (1956). Pandey *et al*. (2004) and Verma *et al*. (2009) also reported similar reports with respect to various nut characters.

Kernel weight ranges from 5.20 (GP-32) to 9.55 g (ML-01); however, minimum and maximum shell thickness was registered in accession SI-05 (0.87 mm) and TL-12 (1.34 mm), respectively. Kernel percentage in various accessions ranged from 44.83 to 56.35 per cent. The highest kernel percentage (56.35 %) was obtained in accessions BS-11 followed by TL-12 (56.01 %) and LP-03 (54.14 %). Serr and Ford (1956) suggested that any accessions should have above 50 per cent shelling percentage have a reasonable goal. In the present study out of homogamous selection, nineteen selections achieved the standard along with good in-shell nut weight and kernel characteristics. Earlier Bhat *et al*. (1992) reported highest percentage ranging from 54.2 to 63.2 per cent in two indigenous selected cultivars. The extent of variations in observed nut and kernel characters is largely due to their seedling origin and varying age and is in accordance with previous studies (Sharma and Sharma, 2000; Attar, 2001; Pandey *et al*., 2004) and even in homogamous types reported (Rouskas and Zakynthinos, 2001; Sutyemez, 2001; Kumar, 2000; Kumar, *et al*., 2005). Nearly similar findings have been obtained in the present study, only thirty two selections were found to be homogamous. Homogamous types are however more productive than either protandrous or protogynous cultivars (Sutyemez, 2001). Likewise the selections made in the present study having sufficient overlapping pollen shedding and stigma receptivity yielded higher as compared to most of the remaining selections screened in the present study.

In Himalayas, most walnuts are protandrous, the inclusion of homogamous types in a walnut orchard would ensure optimum pollination to obtain higher fruit set and nut yield. The identification of homogamous walnut types indicates the possibility of developing homogamous varieties to obtain higher yield in walnut and these selections have been conserved *ex situ* in a field repository for future use in germplasm exchange, genetic improvement and commercial exploitation as direct cultivars.

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