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ORIGINAL RESEARCH ARTICLE

Characterization and selection of thin-shelled walnut (*Juglans regia* L.) genotypes of Mustang, Nepal

Asmita Khanal[1*], Sandip Timilsina[1], Tul Bahadur Poon[2] and Balkrishna Adhikari[3]

[1]Nepal Agricultural Research Council, Horticulture Research Station, Malepatan, Pokhara - 33700, Gandaki Province, NEPAL
[2]Retired Principal Scientist, Nepal Agricultural Research Council, NEPAL
[3]Agriculture Development Division, Ministry of Agriculture, Energy and Water Resources, Malepatan, Pokhara - 33700, Gandaki Province, NEPAL
[*]Corresponding author's E-mail: asmitakhanal47@gmail.com

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ABSTRACT

Walnut (*Juglans regia* L.) of seedling origin creates large variability within this crop. A research study was carried out at Directorate of Agricultural Research, Lumle, Kaski and Marpha, Mustang to characterize and deciphers the variability of thin-shelled walnut for further selection, conservation and variety registration. Walnut orchard of Mustang district was surveyed in March, 2018 and 50 walnut trees were labeled according to its flowering and flushing time. 36 accessions of thin-shelled walnut were characterized on 17 different parameters regarding growth habit, bearing habit, fruit and kernel characteristics. Around 88.89% trees exhibited terminal fruiting habit and remaining showed lateral fruiting habit. Three type of tree shape was noticed as spreading round, semi-erect and erect. Huge variation in nut shape was observed having 50% trees were with circular nuts. Four types of shell strength was recorded; 11.11% accessions having papery shell, 27.78% having weak shell, 47.22% having intermediate shell and 13.88 having strong shell strength. Average nut yield of trees ranged from 15-75 kg with an average of 26.67 kg. Nut weighted from 5.96-18.99 g with an average of 11.14 g. Kernel weight ranged from 2.8-8.92 g. More than 50% shelling was recorded in 13 accessions. The kernel quality of 14 accessions (out of 36) showed 5 rank (Excellent quality); and remaining 22 accessions showed 4 rank (Good quality). Based on this characterization, 13 accessions were selected and recommended for further multiplication and variety registration.

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INTRODUCTION

Walnut (*Juglans regia* L.) is one of the most important temperate fruit grown in Nepal, and it has great potential for utilization in mid-hill to Himalayan ranges (Weltz and Raizada, 2014). It is native to the mountain ranges of central Asia extending from Xinjiang province of western China, Kazakhstan, Uzbekistan, southern Kirghizia, Nepal, Tibet, northern India and Pakistan through Afghanistan, Turkmenistan and Iran to portions of Azerbaijan, Armenia, Georgia and eastern Turkey (Mir *et al.*, 2019). In these countries, there is a great genetic variability in particular ancestral form with lateral fruitfulness (Verma *et al.*, 2009). In Nepal, seedling trees of walnut are found growing in most parts of mid-hill, high-hill and Himalayan region at elevation scope of 1350-3000 masl which exhibits significant variability in vegetative development and fruit characters (Devkota, 1999). Seed propagated, indigenous walnut populations have a significant genetic diversity and as its result, their phenological and nut characteristics, such as fruit size and shape, kernel thickness and color, kernel flavor and oil content vary significantly (Zeneli *et al.*, 2004).

The total area, productive area, total production and productivity of walnut in Nepal are only 5889 ha, 2291 ha, 9162 tons and 4 tons/ha respectively. The Karnali province accounts for the

highest of all regions (2250 ha, 806 ha and 3341 tons and 4.15 t/ha respectively) whereas the Gandaki province accounts for (223 ha, 91 ha, 451mt and 4.98 mt/ha, respectively). Nepal has mainly 47 walnut growing districts and highest producing district was Rukum east. (1225 mt) (MoALD, 2022).Walnut is particularly an excellent example of under-utilization of existing plant genetic resources. The variability is crucial in selecting superior seedlings with desirable traits (superior nuts, adaptive to local climatic and edaphic condition) for the possible expansion of walnut cultivation in the country. Heterogeneous population allow us to select the superior walnut genotypes which is a simple and quick method of varietal improvement as breeding is a time consuming process in fruit crops, especially walnut that has long juvenile period.

High Himalayan region of Nepal is rich in walnut genetic resources and superior walnut genotypes from seedlings origin are found in Mustang, Jumla and Dolpa districts. The seedling trees attain giant size and start bearing fruits of variable size and shape after 10-15 years. There are no regular orchards of walnuts in country because the existing plants are of seedling origin. Lack of quality planting materials and mineral fertilizers are the main constraints to walnut cultivation in Nepal. Till now, there was not any registered variety of walnut in the country and no any walnut breeding program was performed at past. Nepal Agriculture Research Council (NARC) is the sole agent responsible for fruit research. Several studies have been done in foreign countries to identify and introduce the superior walnut genotypes but in Nepal, it was the first initiation in walnut research to identify potential genotypes.

The development and maintenance of the most promising genotypes of thin shelled walnut within the country are the need of present years. By combining the desirable characteristics of improved cultivars with well-adapted cultivars (acclimatization, early fruiting, high productivity, disease tolerance, and quality fruit crop), it is possible to create new cultivars through hybridization (Cosmulescu and Botu, 2012). However, let alone the hybridization work, even systematic approach to survey and selection has not been carried out so far in this context. We focused our study in Mustang district and a systematic survey of the walnut genotypes was carried out. The main goal of this study was to characterize the genotypes of walnut so as to find superior genotypes for further multiplication and variety registration.

MATERIALS AND METHODS

The preliminary survey of walnut genotypes was conducted in different walnut orchards of Thasang and Gharapjhong Rural Municipality, Mustang, Gandaki Province, Nepal. Orchards of different farmers of Larjung, Kobang, Tukuche, and Marpha village and Temperate Horticulture Development Center, Marpha, were surveyed (elevation range: 2510-2685 m) during second fortnight of March 2018. At the time of survey, the parameters: flushing time, flowering time, fruiting habit and tree growth habit were observed and recorded accordingly. Unproductive trees and trees having less than 10 kg fruit/year were not taken in consideration. A total of 50 walnut trees were labeled as Extra Early (EE), Early (E), Medium (M), Late (L) and Very Late (VL), respectively by observing their flushing time, flowering time and flowering habit. The age of the selected trees was not same. All trees were tagged with respective tree number along with accession code. The layouts of each orchard with the selected trees were sketched in the register for easy access to working technicians. Out of 50 selected trees, harvesting of nut was done from 36 trees in September 2018 and yield was recorded. On the other hand, samples (15-25 nut fruits) were collected separately from 36 walnut trees in September, 2018. A manual, "Descriptors for Walnut" was followed for the morphological characterization procedure (IPGRI, 1994). Characterizations were done on different parameters; nut shape (circular, long circular, elliptic, broad elliptic, ovate and broad ovate, trapezium), structure of shell surface (slightly grooved, moderately grooved, strongly grooved and embossed), suture length (mm), cheek length (mm), shell thickness (mm), individual nut weight (g), individual kernel weight (g), shelling %, shell strength (papery, weak, intermediate and strong), kernel ground color intensity (light , medium and dark), kernel color (light brown, light yellow and white) and kernel quality (ranking 1-5) after thorough drying of the nuts. The suture length, cheek length and shell thickness were measured by using digital vernier caliper. Nut weight and kernel weight was measured by using an electronic balance (precision 0.01 g). Shelling percentage was calculated by using the formula "Kernel weight/ Nut weight × 100 ". The kernel quality was recorded based on the scoring procedure mentioned in Descriptors for Walnut (IPGRI, 1994).

The data generated in this study was entered into Microsoft excel-10 (MS-Excel) and analyzed using Statistical Tool for Agricultural Research (STAR-Package).

RESULTS AND DISCUSSION

Considerable variations were recorded on the 36 surveyed trees of walnut for various morphological characters. Variation across the genotypes was observed with respect to growth habit, fruiting habit and kernel characteristics that are presented in Table 1. The frequency distributions of each character are given in Figure 1. Table 1 shows the nine phenological characters (accession code, flushing time, fruiting habit, tree shape, nut shape, shell groove structure, shell strength, kernel ground color and kernel color). Out of 36 walnut trees, 2 trees were extra early (EE)-type (flushing between February 3rd week – February 4th week), 19 trees were early (E)-type (flushing between February 4th week – March 2nd week), 9 trees were medium (M)-type (flushing from March 3rd week - March 4th week), 4 trees were late (L)-type (flushing from April 1st week- April 2nd week) and 2 trees were very late (VL)- type (flushing between April 3rd week-April 4th week). Walnut plants typically begin to flower in the beginning of spring and fruits mature from the beginning to mid fall. Walnut flower induction and initiation in Iran occurred in early June and late September, respectively. After meeting

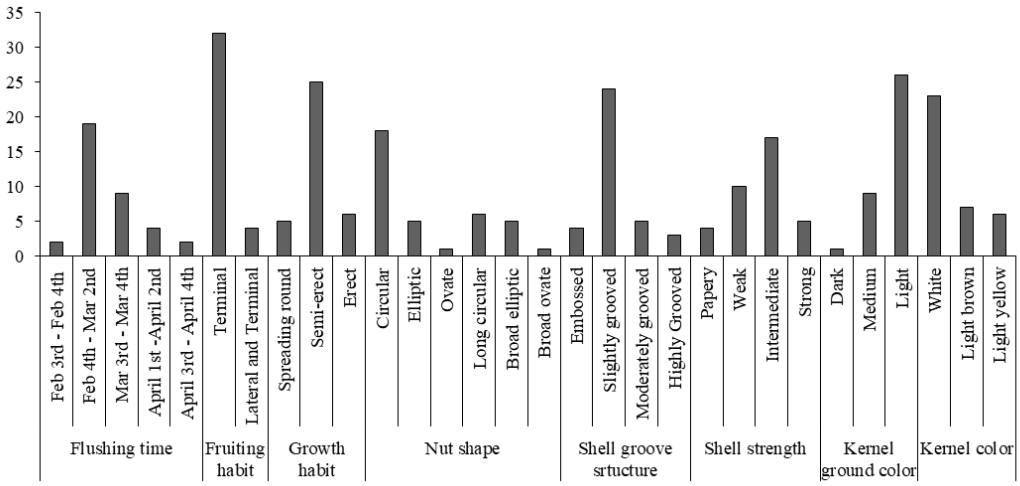

Figure 1. *Frequency distribution of plant characteristics of 36 walnut accessions.*

Table 1. Characterizations of thin-shelled walnuts collected from Mustang in 2018.

S.N.	Accession code*	Flush time (week)	Fruiting habit	Tree Shape	Nut shape	Shell groove structure	Shell strength	Kernel ground color	Kernel color
1	EE-1	Feb 3rd- Feb 4th	T	SE	BE	SG	P	M	LY
2	EE-2	Feb 3rd- Feb 4th	T	SE	BO	MG	I	D	LB
3	E-1	Feb 4th - Mar 2nd	T	SE	BE	SG	S	L	W
4	E-2	Feb 4th - Mar 2nd	T	SE	C	SG	I	M	LY
5	E-3	Feb 4th - Mar 2nd	T	E	C	E	I	L	W
6	E-4	Feb 4th - Mar 2nd	T	E	C	HG	I	L	W
7	E-5	Feb 4th - Mar 2nd	T	E	E	MG	S	L	W
8	E-6	Feb 4th - Mar 2nd	T	SR	C	SG	W	L	W
9	E-7	Feb 4th - Mar 2nd	T	SR	C	E	W	L	W
10	E-8	Feb 4th - Mar 2nd	T	SR	C	SG	I	L	W
11	E-9	Feb 4th - Mar 2nd	90% T, 10% L	SE	E	SG	I	L	W
12	E-10	Feb 4th - Mar 2nd	T	SE	BE	SG	I	L	W
13	E-11	Feb 4th - Mar 2nd	T	SE	LC	SG	I	L	W
14	E-12	Feb 4th - Mar 2nd	T	SE	C	SG	I	L	W
15	E-13	Feb 4th - Mar 2nd	T	SE	C	E	S	L	W
16	E-14	Feb 4th - Mar 2nd	T	SE	E	SG	W	M	LB
17	E-15	Feb 4th - Mar 2nd	T	SE	E	SG	S	L	LB
18	E-16	Feb 4th - Mar 2nd	85%T, 15% L	SE	LC	E	I	L	LY
19	M-1	Mar 3rd - Mar 4th	T	E	C	MG	I	M	W
20	M-2	Mar 3rd - Mar 4th	85% T, 15% L	SE	C	SG	W	L	LY
21	M-3	Mar 3rd - Mar 4th	T	SE	C	SG	W	L	W
22	M-4	Mar 3rd - Mar 4th	T	SE	C	SG	P	L	LY
23	M-5	Mar 3rd - Mar 4th	T	SR	C	SG	I	M	W
24	M-6	Mar 3rd - Mar 4th	T	SE	0	SG	S	L	W
25	M-7	Mar 3rd - Mar 4th	T	SE	BE	SG	W	L	W
26	M-8	Mar 3rd - Mar 4th	T	SE	C	SG	I	L	W
27	M-9	Mar 3rd - Mar 4th	T	SE	C	SG	I	M	W
28	L-1	Apr 1st - Apr 2nd	80% T, 20% L	E	LC	HG	W	L	W
29	L-2	Apr 1st - Apr 2nd	T	SE	C	SG	P	L	W
30	L-3	Apr 1st - Apr 2nd	T	SR	LC	MG	W	D	LB
31	L-4	Apr 1st - Apr 2nd	T	SE	C	SG	W	M	LB
32	VL-1	Apr 3rd - Apr 4th	T	E	LC	SG	I	L	W
33	VL-2	Apr 3rd - Apr 4th	T	SE	BE	SG	I	L	W
34	ASHLEY	Feb 4th - Mar 2nd	T	SE	C	HG	P	L	LB
35	HARTLEY	Feb 4th - Mar 2nd	T	SE	E	SG	I	M	LB
36	PAYNE	Feb 4th - Mar 2nd	T	SE	LC	MG	W	L	LY

Fruiting habit: T = Terminal, L = Lateral;
Tree Shape: E = Erect, SE = Semi-Erect, SR = Spreading Round
Nut Shapes: C=Circular, LC=Long Circular, E=Elliptic, BE=Broad Elliptic, O=Ovate, BO=Broad Ovate
Shell Groove Structure; HG=Highly Grooved, MG=Moderately Grooved, E=-Embossed, SG=Slightly Grooved
Shell Strength; S=Strong, I=Intermediate, W=Weak, P=Papery
Kernel Ground Color; L=Light, M=Medium, D=Dark
Kernel Color; W-White, LB-Light Brown, LY-Light Yellow

Table 2. Characterizations of thin-shelled walnuts collected from Mustang in 2018.

S.N.	Accession code*	Tree Age (Yr)	Average Nut yield (kg / tree)	Cheek length (cm)	Suture length (cm)	Shell thickness (mm)	Nut weight (gm)	Kernel weight (gm)	Shelling %	Kernel quality (1-5)
1	EE-1	22	15	3.81	3.55	1.04	13.51	6.81	50.51	4
2	EE-2	25	15	3.63	3.83	3.9	13	6.6	50.76	4
3	E-1	25	20	2.86	3.53	4.8	11.2	5.2	46.42	4
4	E-2	55	40	2.81	2.6	2	7.19	2.8	38.94	4
5	E-3	15	15	2.52	3.07	3.9	7.4	3.8	51.35	5
6	E-4	55	75	3.65	3.4	2.3	11.82	4.28	36.21	4
7	E-5	55	50	3.71	3.44	2.5	11.99	5.24	43.7	4
8	E-6	13	25	3.09	2.88	1.3	10.47	5.57	53.22	5
9	E-7	16	15	3.15	2.94	1.64	10.83	4.96	45.8	5
10	E-8	16	25	3.94	3.73	2.05	18.99	8.25	43.44	4
11	E-9	16	20	2.94	2.7	1.66	7.17	3.36	46.86	4
12	E-10	16	20	3.66	2.88	1.74	14.36	7.37	51.32	4
13	E-11	16	20	2.87	2.73	2.27	5.96	3.21	59.33	4
14	E-12	16	30	3.01	2.81	2.31	9.72	4.06	41.77	5
15	E-13	16	15	3.46	3.39	4	13.6	6.2	45.58	5
16	E-14	16	15	3.28	3.18	1.11	8.6	4.39	51.05	4
17	E-15	16	20	3.3	3.09	2.66	9.57	4.12	43.05	5
18	E-16	16	30	3.25	3.58	3.9	8.4	4.2	50	4
19	M-1	50	25	3.94	3.62	1.73	11.11	4.56	41	5
20	M-2	35	50	3.79	3.43	2.04	12.26	3.974	35.92	5
21	M-3	16	30	2.83	2.63	1.36	10.18	4.75	46.66	4
22	M-4	16	35	3.16	2.97	1.37	8.894	4.108	46.19	4
23	M-5	16	15	3.11	2.94	1.66	13.25	6.64	50.11	4
24	M-6	16	25	3.05	3.69	3.8	11.4	6	52.63	5
25	M-7	16	15	3.66	3.5	1.34	11.81	6.54	55.38	5
26	M-8	16	20	2.71	2.58	1.87	11.52	5.47	47.48	4
27	M-9	16	15	3.31	3.11	1.6	11.6	5.67	48.9	4
28	L-1	55	50	3.54	3.34	1.41	10.74	4.85	45.16	4
29	L-2	16	20	3.13	2.95	0.9	8.47	4	47.33	5
30	L-3	16	15	4.14	3.84	1.86	17.36	8.92	51.38	5
31	L-4	16	20	3.33	3.11	1.66	11	4.858	43.66	5
32	VL-1	16	30	3.58	3.82	2.6	9.8	5	51.02	4
33	VL-2	16	25	3.67	3.44	2.06	12.402	5.166	42.01	4
34	ASHLEY	20	50	2.79	2.56	1.07	12.25	6.07	49.55	4
35	HARTLEY	20	35	3.81	3.38	1.8	11.91	5.18	43.49	4
36	PAYNE	20	20	3.56	3.11	1.36	11.42	5.56	48.69	5
	Mean	22.69	26.67	3.33	3.20	2.13	11.14	5.21	47.11	4.39
	Maximum	55	75	4.14	3.84	4.8	18.99	8.92	59.33	5
	Minimum	13	15	2.52	2.56	0.9	5.96	2.8	35.92	4

Kernel quality: 1=Very poor, 2= Poor, 3=Medium, 4= Good, 5= Excellent.

chilling and heat requirement, flower differentiation and anthesis occurred in late-March and mid-April to early-May respectively (Hassankhah *et al.*, 2020). The walnut tree species have shown a wide range of morphological characteristics along with shape and size of nuts, depending on the region. (Germain, 2004). Around 88.89% trees exhibited terminal fruiting habit and remaining showed lateral fruiting habit. Three types of tree shape were noticed among 36 sampled trees. They were recorded as spreading round in 5(16.67%) trees, semi-erect in 25 (69.44%) trees and erect tree shape in 6(13.89%) trees. A study reported the highest number of trees (196) with semi-erect shape followed by 111 trees with erect shape and 55 trees with spreading shape (Mirmahdi and Khadivi, 2021). The results of present study were nearly in agreement with the results of their study. Nut shape varied greatly: 18 trees with circular nuts, 6 trees with long circular nuts, 5 trees with elliptic nuts, 5 trees with broad elliptic nuts, 1 tree with ovate nuts, and 1 tree with broad ovate nut shape. As regards to the nut shell surface, the nuts collected from 4 trees were embossed, 24 trees as slightly grooved, 5 trees as moderately grooved and 3 trees as highly grooved shell surface structure. In terms of shell-strength, 11.11% accessions were with papery shell, 27.78% accessions were with weak shell, 47.22% accessions were with intermediate shell and 13.88 % accessions were with strong shell. Kernel ground color was found to be dark colored in 2.78% accessions, medium colored in 25% accessions and light colored in 72.22% accessions. Kernel color differed from dark brown (in 5.479% of accessions) to light brown color (in 41.096 % accessions) among four categories of kernel color (Light brown, light yellow, dark brown and white). Mir *et al.* (2018) in their study has found 3 different leaf shape; narrow elliptic, elliptical and broad elliptic as well as five different nut shape; round, cordate, ovate, long trapezoid and elliptic. The shell colors of the genotypes they have studied were of light shell color having shell surface smooth, moderately smooth to rough.

Table 2 shows 9 phenological characters of 36 walnut accessions. The age of the surveyed trees ranged from 13-55 years. Out of which, 24 (66.66%) were 13-16 years old, six (16.67%) were 20- 25 years old and remaining six (16.67%) were estimated 35-55 years old. The average nut yield of the trees varied from 15-75 kg/tree. As per the surveyed trees, the production of nuts was higher in older tree than in the younger ones.

The cheek length of the nuts varied between 2.52 (cm) and 4.14 (cm) with the mean value of 3.33. The cheek of the nuts was maximally long in three accessions viz.; L-3 (4.14 cm) ensued by E-8 (3.94 cm) and M-1 (3.94 cm). In contrast, the cheek of the nuts was minimally short in three accessions viz., E-3 (2.52 cm) followed by M-8 (2.71 cm) and Ashley (2.79 cm). Suture lengths (cm) varied from 2.56 cm to 3.84 cm (mean- 3.20 cm). The sutures were maximally long in three accessions viz., L-3 (3.84cm), EE-3 (3.83 cm) and VL-1 (3.82 cm).). In contrast, it was minimally short in three accessions viz., Ashley (2.56 cm), E -2/Tree-6 (2.60 cm and M-8 (2.58 cm). Nut- shell- thickness differed from 0.9 mm (L-2) to 4.8 mm (E-1) with mean 2.13 mm. The Nut shell- thickness was > 2.00 mm in sixteen accessions namely (EE-2, E-1, E-2, E-3, E-4, E-5, E-8, E-11, E-12, E-13, E15, E-16, M-2, M-6, VL-1 and VL-2). In 10 accessions viz., EE-1, E-6, E-14, M-3, M-4, M-7, L-1, L-2, Ashley and Payne, the shell thickness was <1.5 mm. The remaining 10 accessions had the nut-shell-thickness of 1.5 - 2.00 mm. Khadivi *et al.* (2019) has selected 329 superior walnut genotypes of seedling origin based on the fruit traits. That study reported the nut diameter ranged from 20.00 to 43.35 mm, while nut length ranged from 22.20 to 47.42 mm.

Individual nut weight (g) also varied from 5.96 g (E-11) to 18.99 g (E-8) with the mean value of 11.14 g. The highest nut weight of E-8 (18.99 g) was followed by L-3 (17.36 g) and E-10 (14.36 g) while the lowest nut weight of E-11 (5.96) was followed by E-9 (7.17 g) and E-2 (7.19g). Individual kernel weight (g) also varied between 2.8 g (E-2) and 8.92 g (L-3) with the mean value of 5.18 g. The highest kernel weight (8.92 g) from L-3 was followed by E-8 (8.25 g); while the lowest kernel weight (2.8 g) from E-5 was followed by E-11 (3.21g). Shelling (%) was observed to vary from 35.92% (M-2) to 59.33 % (E-11) with mean of 47.11%. 232 genotypes were evaluated using 30 phenological and pomological characteristics in Iran. Variability was found in nut weight (8-23 g), kernel weight (4-14 g), shell thickness (0.10-3.0 mm) and in kernel percentage (40- 72.22 %) (Khadivi-Khub *et al.*, 2015). Kernel weight and nut weight, were the important traits that determines the kernel percentage (Khadivi-Khub and Ebrahimi, 2015). More than 50% shelling was recorded in 13 accessions viz., EE-1 (50.51 %), EE-2 (50.76 %), E-3 (51.35 %), E-6 (53.22 %), E-10 (51.32 %), E-11 (59.33 %), E-14 (51.05 %), E-16 (50%), M-5 (50.11 %), M-6 (52.63 %), M-7 (55.38 %), L-3 (51.38 %) and VL-2 (42.01 %). Less than 45 % shelling was recorded in 11 accessions viz., E-2 (38.94 %), E-4 (36.21 %), E-5 (43.7 %), E-8 (43.44 %), E-12 (41.77 %), E-15 (43.05 %), M-1 (41 %), M-2 (35.92 %), L-4 (43.66 %), VL-2 (42.01 %) and Hartley (43.49 %). The remaining 12 accessions exhibited the 45-50% shelling. Fourteen accessions (out of 36) have ranked 5 (Excellent quality) for the kernel quality and remaining 22 accessions have ranked 4 (Good quality) for the kernel quality. Nut weight ranged from 5.42 to 23.00 g, kernel weight varied from 2.30 to 14.00 g and kernel percentage ranged from 24.66 to 75.10% (Khadivi *et al.*, 2019). Eskandari *et al.* (2005) also selected superior walnut genotypes according to yield and nut characteristics from natural populations in different provinces of India.

High variability in nut traits has been reported in walnut trees in different countries. Many countries have adopted the method of simple selection in natural seedling populations with high quality walnuts. Sharma *et al.* (2010) found the great range of variability on various nut and kernel characters of 23 bearing seedling trees of Walnut in Ladakh region of India. Same study was done at ICAR-Central Institute of Temperate Horticulture, Srinagar and worked on identification and development of superior walnut varieties through selection and hybridization (Mir *et al.*, 2019). Arzani *et al.* (2008) investigated the phonological traits viz., nut weight, kernel weight, shelling percentage/kernel ratio and shell thickness of fifty-eight variants of Persian walnut. The findings of these traits varied greater than those of recent study as their investigation showed the range of differences in nut weight between 6.0 g and 15.2 g; kernel weight between 2.6g and 9.1 g; shelling percentage between 38.4 and 79.6 g and shell thickness between o.4 mm and 1.4 mm. Casal *et al.* (2004) and Khan *et al.* (2010) in their study reported that walnut trees of different region has high variability in nut traits e.g. nut sizes, nut shape, shell thickness, kernel percent, color of kernels and taste of kernels. The variability found in the present study is in agreement with that reported for the Eurasian walnut distribution range from Iran (Atefi, 1993) and India (Sharma and Sharma, 2001). Enormous variability has been reported in different traits of walnut. A total of thirteen accessions of walnut were selected based on the phenological characters. Thirteen selected accessions from Mustang were: EE-1, EE-2, E-3, E-6, E-10, E-11, E-14, E-16, M-5, M-6, M-7, L-3 and VL-1. The data generated in this study shows that there was huge phenotypic diversity among the selected accessions which can be a valuable gene pool.

Conclusion

Despite the numerous obstacles in developing a superior walnut cultivar with all characteristics and a short juvenile period, the availability of plant genetic resources and evaluation are essential tools for selection of superior genotypes. Many walnut accessions surveyed, evaluated and selected from unexplored areas of Mustang district revealed a great diversity in respect of tree shape, growth habits, leafing/flushing, flowering, and nut characteristics. The genotypes were preliminarily selected based on yield potential, nut weight and kernel percentage. Thirteen superior accessions / genotypes viz., EE-1, EE-2, E-3, E-6, E-10, E-11, E-14, E-16, M-5, M-6, M-7, L-3 and VL-1 selected in this study was promising ones to pave the way to further utilize, conserve and develop suitable cultivars for different agro-ecological regions of the country. In terms of early fruiting, higher nut yield, bearing habit, high nut quality, and adaptability to various ecological regions, the superior genotypes selected from this study must be confirmed. Although walnut consumption appears to be on the rise and genetic resources are readily available in Nepal, this study helps to multiplication of superior genotypes and varietal development.

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