

Phenological and Pomological Characteristics of Native Apple (*Malus domestica* Borkh.) Cultivars of Trans-Himalayan Ladakh, India

Tsetan Dolker[#], Deepak Kumar[#], Joginder S. Chandel[§],
Spalzin Angmo[#], O.P. Chaurasia[#] and Tsering Stobdan^{*,*}

[#]DRDO-Defence Institute of High Altitude Research (DIHAR), Leh Ladakh - 194 101, India

[§]Department of Fruit Science, Dr Y S Parmar University of Horticulture and Forestry, Solan- 173 230, India

*E-mail: stobdan@dihar.drdo.in

ABSTRACT

Seven local apple cultivars of the trans-Himalayan Ladakh region were studied for phenological and pomological characteristics. Early and extended flowering was observed. Flowering began 12 days earlier as compared to Royal Delicious, a popular introduced cultivar. The cultivars attained fruit maturity between mid-August to early September, which is one month earlier than Royal Delicious. Apples of the Ladakh region are soft (6.1 ± 1.1 kg cm⁻²) and small in size (60.1 ± 29.1 g). The unique characteristics observed in apples of the Ladakh region, such as early flowering and early fruit maturity offer an opportunity for exploring the native cultivars for future breeding programs for the development of early maturing cultivars.

Keywords: Apple germplasm; Early fruiting; Genetic variability; Native germplasm; Phenology

1. INTRODUCTION

Apple (*Malus domestica* Borkh.) is the most ubiquitous temperate fruit and has been cultivated in Asia and Europe from antiquity¹⁻². Orchards are now found in northern China and Siberia, where winter temperatures fall to -40°C, to high elevations in Indonesia and Colombia straddling the equator³. Apples have been introduced into tropical, subtropical and temperate environments globally. There are over 6000 regionally important landraces and cultivars across the world, but a few major cultivars dominate worldwide⁴.

The natural variation present in crop plants has been exploited since their domestication thousands of years ago by the genetic manipulation of developmental traits and physiological features related to adaptation⁵. Apple offers a clear prospect for the development of cultivars combining all the quality, horticultural and commercial traits, in a single genotype. Improving fruit quality and the development of disease-resistant cultivars are the two prime objectives of apple breeders worldwide. Developments of early maturing and winter-hardy cultivars are other important objectives the breeders seek to achieve⁶. The native cultivars serve as a valuable resource in breeding programs and therefore, the study of native germplasm in terms of early maturing and fruit quality has been considered both for breeding as well as for the selection of apple cultivars.

Apple is a traditional fruit crop of high altitude trans-Himalayan Ladakh region. It is the second most important fruit crop of the region, after apricot. Several native cultivars are

grown in the region, and *Thra*, *Mongol*, and *Karkechu* are the three most popular cultivars. However, little is known about the native apple cultivars of Ladakh, to date, there is a single report by Dwivedi⁷ *et al.* on preliminary description of the local cultivars. Native apple cultivars of the region exhibit unique and wide variations and thus offer prospects for exploring the native germplasm for crop improvement programs. Accordingly, this study was carried to contribute to the pomological and phenological characteristics of seven native cultivars and highlight the important and unique characteristics of trans-Himalayan Ladakh apple germplasm that can be used for future apple improvement programs globally.

2. MATERIALS AND METHODS

2.1 Study Area and Plant Material

The study was carried out at an experimental orchard (34°08.2'N; 77°34.3'E, elevation 3331 m) which is located on flat ground with abundant direct sunshine at Defence Institute of High altitude research in trans-Himalayan Ladakh, India. The mean maximum temperature recorded daily during the cropping season (April-September) were 21.0 ± 4.7 and 20.4 ± 4.8 °C, while the minimum temperatures were 8.3 ± 4.9 and 6.9 ± 3.7 °C, respectively in 2018 and 2019. The orchard contains 10 rows, having 8 trees per row of cultivars representing important germplasm from the Ladakh region. Trees were planted at a spacing of 4m×4m and trained to the modified central leader system. Standard cultural practices were performed and all trees were of the same age. The soil texture of the orchard was silty loam with pH 7.8 ± 0.2 . Royal Delicious, a popular introduced cultivar grown in an adjacent orchard, was used for comparison. The date of fruit harvesting of each cultivar

was determined by a panel of four assessors who identified the best-maturing stage for fresh consumption based on firmness, taste and fruit colour.

2.2 Analysis of Phenological, Pomological and Quality Traits

The time of the beginning of flowering was considered when 10 per cent of the flowers were fully open⁸ and expressed in Julian days (JD) (natural days from January 1). Full bloom was considered when 90 per cent of the floral buds were fully open. Standard fruit quality parameters and pomological traits (Annexure I, Annexure II) were determined on the day of harvest. Fruit and seed weight were measured with an electronic balance. Dimensional properties were measured with a digimatic caliper (CD-6"CS, Mitutoya, Japan) to an accuracy of 0.01 mm. Total soluble solids (TSS) were measured with a refractometer (ATAGO, Tokyo) and values were corrected at 20°C. Total acid (TA) was determined by titration using 0.1N NaOH and values expressed as % malic acid⁹. Fruit firmness was determined with a hand penetrometer (FT-327, Effegi, Italy).

2.3 Statistical Analysis

All the experimental data were recorded in triplicates, with each replication being an average of ten samples. The experimental results were expressed as mean \pm standard deviation (SD) using statistical analysis with SPSS (Statistical Program for Social Sciences, SPSS Corporation, Chicago, Illinois, USA). One way analysis of variance (ANOVA) and post hoc analysis with 2-sided Tukey's HSD at $p \leq 0.05$ level were performed. Hierarchical clustering along with Dendrogram using UPGMA (unweighted pair group method with arithmetic mean) was constructed using SPSS software to determine the relatedness among the cultivars. The data collected for all the characters were used as variables for clustering.

3. RESULTS AND DISCUSSION

3.1 Flowering Phenology

Significant variability in the bud burst time was observed between the native cultivars (Annexure I). The cultivars reached the bud burst stage much earlier than Royal Delicious. Similarly, a wide variation at the beginning of blooming was observed. The amplitude of the variation between the earliest and the latest flowering cultivars was 8.7 and 8.3 in 2018 and 2019, respectively. Flowering began in native cultivars 12 days earlier as compared to Royal Delicious. The native cultivars came into the full bloom stage in early to mid-May (124-135 JD). In comparison, Royal Delicious came into full bloom 9-16 days after the native cultivars under the same environmental condition. Early flowering in the native cultivars may be an adaptive mechanism for the early completion of the fruit development stages before the onset of cold weather in the region. The flowering

duration (number of days from beginning to end of flowering) ranged from 9 to 17.7 days depending on cultivar and year. In comparison, the flowering duration of native apple trees is 7.0-12.3 with a mean of 9.11 days in Serbia¹⁰.

3.2 Maturity Date

Fruits of all the cultivars were harvested between 253 to 273 JD (mid-August to early September) in 2018 and 261 to 283 JD in 2019 (Annexure I). *Karkechu* matures much later as compared to other cultivars. Overall, the native cultivars were early maturing and ripening one month before Royal Delicious under the same environmental condition. Therefore, the native cultivars of Ladakh may be exploited in future breeding programs for development of early maturing cultivars. The difference in harvesting dates between the earliest and the late cultivar was 20 to 22 days. Significant variations in fruit maturity period between the cultivars may be an adaptive mechanism to extend the seed dispersal period. A similar observation was recorded in apricots¹¹. The variation in fruit maturity in these cultivars may be due to the genetic makeup of the cultivars.

3.3 Pomological Traits

Tables 1 & 2 presents pomological attributes of the seven native cultivars. Fruit weight ranged from 21-107.5 g with a mean weight of 60.1 ± 29.1 g. Except for one cultivar that weighs more than 100 g, fruit weight from all other cultivars was determined < 85.0 g. In comparison, the fruit weight of Royal Delicious was 180.8 ± 23.5 g, which was significantly higher than all the native cultivars. Therefore, it could be commented that apples of the trans-Himalayan Ladakh region are small

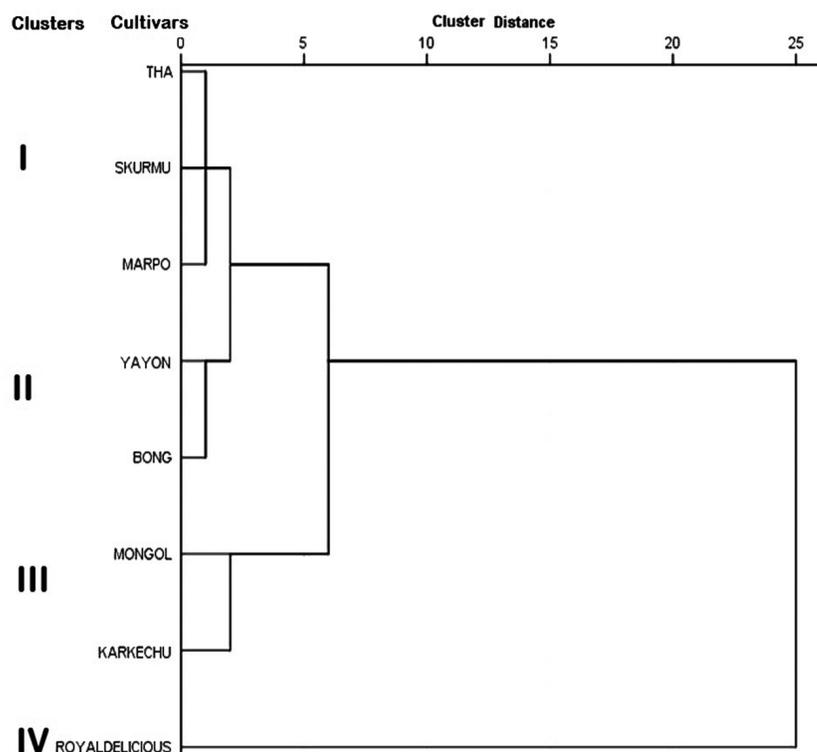


Figure 1. Dendrogram showing the similarity between the cultivars.

in size, which could be due to high altitude environmental conditions and genetic factors. Mratinić & Akšić¹⁰ reported fruit weight of 70-193 g with a mean weight of 129 g in 18 native apple cultivars from Serbia. Kaya¹² *et al.* reported 43.04-310.99 g fruit in 35 promising genotypes of Turkey. The fruit weight of 79 native cultivars and germplasm from Iran ranged between 9-165 g with a mean weight of 84.79±4.66 g¹³. The fruit weight of five local cultivars of Syria ranged between 36-68 g¹⁴.

The fruit of native cultivars was soft with a mean firmness value of 6.1±1.1 kg cm⁻², which was significantly low as compared to Royal Delicious (8.8±0.9 kg cm⁻²). In comparison, Farrokhi¹⁵ *et al.* reported fruit firmness of 3.2-17.1 kg cm⁻² with a mean value of 8.35±1.4 kg/cm² in the 56 native apple germplasm of Iran. Kaya¹² *et al.* reported that the fruit firmness of 35 promising genotypes collected from Turkey ranged between 3.99-14.05 kg cm⁻² with a mean value of 7.86 kg/cm⁻².

The number of seeds per fruit ranged from 5.7-8.6 with mean value of 7.1±1.4, and each seed weighed 52-76 mg. Low fruit weight with a high number of seeds may be an adaptive mechanism for plant reproduction in high altitude conditions by producing a higher number of seeds per plant.

3.4 Fruit Total Soluble Solids and Acidity

The native cultivars showed a wide range of TSS content (11.8-15.5°Brix) with mean value of 13.2±1.6°Brix. The highest TSS was observed in *Marpo* cultivar. In comparison, the value ranged from 6.7-16.3°Brix among 33 apple accessions from Kashmir valley¹⁶, 11.8-15.6°Brix in five local cultivars in Syria¹⁴, 9-18°Brix in 56 native apple germplasm of Iran¹⁵, 9.0%-14.4% in 35 promising genotypes from Turkey¹², and 12.55-19.24°Brix in 18 native cultivars from Serbia¹⁰. The acidity was between 0.25 % - 0.71%. High acidity in *Skurmo* relates well to the name of the cultivar. *Skurmo* in local dialect means sour.

3.5 Cluster Analysis

The dendrogram constructed using UPGMA of variables of the characters studied separated the seven native cultivars into three groups (Fig. 1). Three cultivars were placed in cluster I, while two cultivars each formed cluster II and -III. However, Royal Delicious formed a separate cluster.

4. CONCLUSIONS

Native apple cultivars of the trans-Himalayan Ladakh possess a considerable diversity. Early flowering was observed as compared to the introduced cultivar. The native cultivars were early maturing and ripe one month before Royal Delicious. Apples of the Ladakh region are soft and small in size with mean weight of 60.1±29.1 g. The unique characteristics observed in apples of Ladakh region, such as early flowering and early fruit maturity offer opportunity for exploring the native cultivars for future breeding programs for development of early maturing cultivars. The flowering duration of the native cultivars was also high, which ranged from 9 days to 17.7 days depending on cultivar and year.

REFERENCES

1. Janick, J.; Cummins, J.N.; Brown, S.K. & Hemmat, M. Apples. *In* Fruit Breed, Volume I: Tree and Tropical Fruits edited by Janick, J. & Moore, J.N. John Wiley & Sons, New York, 1996. pp. 1-77.
2. Adachi, Y.; Komori, S.; Hoshikawa, Y.; Tanaka, N.; Abe, K.; Bessho, H.; Watanabe, M. & Suzuki, A. Characteristics of fruiting and pollen tube growth of apple autotetraploid cultivars showing self-compatibility. *J. Jpn. Soc. Hortic. Sci.*, 2009, **78**, 402-9. doi: 10.2503/jjshs1.78.402.
3. Janick, J. The apple in Java. *HortScience*, 1974, **9**, 13-5.
4. Ramirez, F. & Davenport, T.L. Apple pollination: A review. *Sci. Hortic.*, 2013, **162**, 188-203. doi: 10.1016/j.scienta.2013.08.007.
5. Alonso-Blanco, C.; Aarts, M.G.M.; Bentsink, L.; Keurentjes, J.J.B.; Reymond, M.; Vreugdenhil, D. & Koornneef, M. What has natural variation taught us about plant development, physiology, and adaptation? *Plant Cell*, 2009, **21**, 1877-96. doi: 10.1105/tpc.109.068114.
6. Laurens, F. Review of the current apple breeding programmes in the world: objectives for scion cultivar improvement. *Acta Hortic.*, 1999, **484**, 163-70. doi: 10.17660/ActaHortic.1998.484.26.
7. Dwivedi, S.K.; Kareem, A. & Raut, B. Some fruit characteristics of apple varieties indigenous to Ladakh, India. *Acta Hortic.*, 2005, **696**, 53-4. doi: 10.17660/ActaHortic.2005.696.7.
8. UPOV. Apple Descriptor. Guidelines for the conduct of tests for Distinctness, Uniformity and Stability, International union for the protection of new varieties of plants, Geneva. Switzerland. 2005
9. Rangana, S. Handbook of Analysis and Quality Control for Fruit and Vegetable Products. Tata McGraw-Hill Pub Co., New Delhi, India, 1986. p.1112.
10. Mratinić, E. & Akšić, M.F. Phenotypic diversity of apple (*Malus* sp.) germplasm in south Serbia. *Braz. Arch. Biol. Techn.*, 2012, **55**(3), 349-58. doi: 10.1590/S1516-89132012000300004.
11. Angmo, P.; Angmo, S.; Upadhyay, S.S.; Targais, K.; Kumar, B. & Stobdan, T. Apricots (*Prunus armeniaca* L.) of trans-Himalayan Ladakh: Potential candidate for fruit quality breeding programs. *Sci. Hortic.*, 2017, **218**, 187-92. doi: 10.1016/j.scienta.2017.02.032.
12. Kaya, T.; Balta, F. & Şensoy, S. Fruit quality parameters and molecular analysis of apple germplasm resources from Van Lake Basin, Turkey. *Turk. J. Agric. For.*, 2015, **39**, 864-75. doi: 10.3906/tar-1406-24.
13. Damyar, S.; Hassani, D.; Dastjerdi, R.; Hajnajari, H.; Zeinanloo, A.A. & Fallahi, E. Evaluation of Iranian native apple cultivars and genotypes. *J. Food Agr. Environ.*, 2007, **5**(3&4), 211-5. doi: 10.1234/4.2007.1158.
14. Al-Halabi, O. & Muzher, B. Genetic diversity of some apple cultivars in the south of Syria based on morphological

characters. *Int. J Environ.*, 2015, 4(4), 86-99.

doi: 10.3126/ije.v4i4.14105.

15. Farrokhi, J.; Darvishzadeh, R.; Maleki, H.H. & Naseri, L. Evaluation of Iranian native apple (*Malus x domestica* Borkh) germplasm using biochemical and morphological characteristics. *Agric. Conspec. Sci.*, 2013, 78(4), 307-13.
16. Hassan, S.; Bhat, K.M.; Dar, Z.A.; Mir, M.A.; Pandith, A.H.; Wani, W.M. & Jan, A. Morphological characterisation of apple accessions in Kashmir region. *Plant Arch.*, 2017, 17, 1071-7.

CONTRIBUTORS

Ms. Tsetan Dolker is a Senior Research Fellow at DRDO-DIHAR, Leh. She holds M.Sc in Botany from Bangalore University.

She conducted the study, analysed the data, and contributed towards literature collection and manuscript preparation.

Mr. Deepak Kumar received MSc in Plant Breeding and Genetics from Bihar Agriculture University. Currently working as a Senior Technical Assistant in DRDO-DIHAR, Leh.

He contributed in data analysis and manuscript preparation.

Dr. Joginder S. Chandel received Ph.D in Horticulture from Dr Y S Parmar University of Horticulture and Forestry with specialisation in plant propagation and orchard management. Currently working as Principal Scientist in Fruit Science Department of Univ. of Hort & Forestry.

He contributed towards cultivar description and manuscript preparation.

Ms. Spalzin Angmo is a Senior Research Fellow at DRDO-DIHAR, Leh. She holds M.Sc in Zoology from Garhwal University, Uttarakhand.

She conducted the study, and contributed towards literature collection.

Dr. O.P. Chaurasia obtained his Ph.D. (Botany) from Magadh University Bodh Gaya, Bihar, in 1992. Currently working as Scientist 'G' and Director, DRDO-DIHAR, Leh.

He contributed in manuscript preparation.

Dr. Tsering Stobdan received his Ph.D. from Indian Agricultural Research Institute, New Delhi. Currently working as Scientist 'F' at DRDO-DIHAR, Leh.

He conceived the study and contributed in manuscript preparation.

Annexure I
Phenological and pomological characteristics of local apples cultivars of trans-Himalayan Ladakh

Parameters	Unit/ year	Native cultivars of Ladakh								Mean±SD	Royal Deliculous
		Mongol	Thra	Karkechu	Marpo	Yayon	Bong	Skjurno			
Bud burst	JD 2018	109.7±1.5 ^a	105.7±4.0 ^a	113.3±3.1 ^{ab}	106.3±4.0 ^a	111.3±3.5 ^a	113.7±3.5 ^{ab}	110.7±4.5 ^a	110.1±3.1	121.3±3.1 ^b	
	JD 2019	115.7±1.2 ^{ab}	111.0±2.0 ^a	121.0±4.6 ^{bc}	117.0±3.6 ^{ab}	117.3±4.9 ^{ab}	118.7±2.5 ^{ab}	118.3±3.5 ^{ab}	117.0±3.1	128.3±2.1 ^c	
Beginning of flowering	JD 2018	122.0±2.0 ^{ab}	115.3±3.5 ^a	124.0±2.7 ^b	115.3±3.1 ^a	121.7±2.5 ^{ab}	123.3±3.1 ^{ab}	122.0±4.0 ^{ab}	120.5±3.6	132.7±2.5 ^b	
	JD 2019	125.7±3.6 ^a	122.7±3.2 ^a	131.0±2.7 ^{ab}	127.0±4.0 ^a	129.3±4.2 ^a	130.3±5.5 ^{ab}	130.0±2.0 ^{ab}	128±3.0	140.0±4.0 ^b	
Full bloom	JD 2018	124.3±2.1 ^a	124.0±3.6 ^a	128.0±2.7 ^a	125.7±3.5 ^a	128.7±3.5 ^a	131.3±2.3 ^a	126.0±2.7 ^a	126.9±2.6	140.0±4.0 ^b	
	JD 2019	132.0±4.6 ^a	132.7±5.0 ^a	133.7±3.2 ^a	133.0±2.7 ^a	133.7±3.2 ^a	135.3±3.8 ^{ab}	135.0±2.7 ^{ab}	133.9±1.4	145.3±3.1 ^b	
End of bloom	JD 2018	131.7±0.6 ^a	133.0±3.0 ^a	136.0±3.0 ^a	133.7±2.1 ^a	134.0±1.0 ^a	134.7±2.5 ^a	132.0±3.0 ^a	133.6±1.5	146.0±2.0 ^b	
	JD 2019	137.7±2.5 ^a	138.7±4.0 ^a	141.0±4.6 ^a	137.3±3.2 ^a	141.0±4.4 ^a	139.7±3.2 ^a	139.0±5.3 ^a	139.2±1.5	152.7±2.5 ^b	
Flowering duration	Day 2018	9.7±1.5 ^a	17.7±0.6 ^a	12.0±1.0 ^a	15.0±1.0 ^a	12.3±2.1 ^a	11.3±5.5 ^a	13.3±0.6 ^a	12.6±2.8	13.3±0.6 ^a	
	Day 2019	12.0±2.7 ^a	16.0±3.0 ^a	10±7.2 ^a	10.3±5.5 ^a	11.7±8.0 ^a	9.3±2.5 ^a	9.0±5.3 ^a	11.2±4.9	12.7±6.5 ^a	
Time for harvest	JD 2018	254.3±4.0 ^a	253.3±2.5 ^a	273.3±3.1 ^c	258.3±3.5 ^{ab}	259.0±3.6 ^{ab}	265.0±2.7 ^{bc}	262.0±3.6 ^{ab}	260.8±6.9	292.0±4.0 ^d	
	JD 2019	264.7±1.5 ^a	261.3.1±3.1 ^a	283.7±4.2 ^b	264.7±4.0 ^a	266.7±1.5 ^b	273.3±1.5 ^a	270.0±2.7 ^a	268.0±7.4	296.0±2.0 ^c	
Fruit weight	g	84.0±14.3 ^d	48.9±9.6 ^b	107.5±20.1 ^e	21.0±4.5 ^a	53.0±4.6 ^{bc}	68.6±7.8 ^{cd}	37.4±4.6 ^{ab}	60.06±29.1	180.8±23.5 ^f	
Fruit length	mm	55.7±2.3 ^c	44.8±2.5 ^{bc}	52.3±8.5 ^{de}	31.9±3.4 ^a	45.1±1.1 ^{bc}	49.2±3.3 ^{cd}	41.2±2.5 ^{bc}	45.7±8.3	65.9±4.4 ^f	
Fruit diameter	mm	57.3±3.4 ^{de}	49.1±4.0 ^{cd}	60.1±5.7 ^e	37.2±2.7 ^b	26.3±2.8 ^a	36.2±7.9 ^b	46.9±2.4 ^c	44.7±12.1	90.4±11.8 ^f	
Fruit stalk length	mm	29.3±3.1 ^d	14.1±3.4 ^a	18.7±3.3 ^{ab}	27.3±3.2 ^d	21.0±2.3 ^{bc}	20.4±2.9 ^{bc}	29.0±5.1 ^d	22.8±6.3	25.3±4.1 ^{cd}	
Fruit stalk thickness	mm	1.9±0.2 ^{abc}	3.0±1.4 ^c	2.2±0.1 ^{abcd}	1.3±0.1 ^a	2.4±0.5 ^{bcde}	2.7±0.6 ^{cde}	1.6±0.1 ^{ab}	2.2±0.8	2.8±0.5 ^{de}	
Fruit stalk cavity depth	mm	17.9±0.2 ^{de}	16.6±0.2 ^{cd}	17.1±0.2 ^{cde}	10.7±0.1 ^a	15.8±0.2 ^{cd}	14.7±0.2 ^{bc}	13.1±0.2 ^{ab}	15.13±2.52	19.4±0.3 ^c	
Fruit stalk cavity width	mm	31.4±0.3 ^c	27.7±0.2 ^{bc}	26.0±0.6 ^b	20.0±0.2 ^a	27.8±0.2 ^{bc}	25.7±0.2 ^b	19.8±0.5 ^a	25.49±4.24	29.6±0.2 ^{bc}	
Fruit firmness	kg cm ⁻²	5.9±0.9 ^a	6.4±1.2 ^a	7.0±0.4 ^b	5.7±0.7 ^a	5.8±0.8 ^a	7.8±1.3 ^b	5.5±0.6 ^a	6.1±1.1	8.8±0.9 ^b	
TSS	°Brix	11.8±0.4 ^a	12.4±1.1 ^{ab}	13.5±1.1 ^b	15.5±1.9 ^c	13.2±1.3 ^{ab}	13.9±1.0 ^{bc}	12.3±0.9 ^{ab}	13.2±1.6	13.0±1.3 ^{ab}	
Acidity	%	0.3±0.01 ^{bc}	0.28±0.0 ^b	0.29±0.01 ^{bc}	0.29±0.01 ^{bc}	0.25±0.01 ^a	0.31±0.01 ^c	0.71±0.02 ^d	0.35±0.01	0.31±0.01 ^{bc}	
No. of seeds	nos.	7.8±1.0 ^{bc}	5.8±0.4 ^a	8.6±1.1 ^c	7.2±1.6 ^{ab}	5.7±1.0 ^a	7.0±0.8 ^{ab}	7.8±1.1 ^{bc}	7.1±1.4	7.4±1.1 ^{bc}	
Seed length	mm	7.9±0.2 ^d	7.4±0.4 ^{bcd}	7.8±0.4 ^{cd}	7.0±0.5 ^{abc}	7.8±0.2 ^{cd}	6.4±1.6 ^a	6.6±0.2 ^{ab}	7.3±0.9	7.4±0.3 ^{bcd}	
Seed width	mm	4.4±0.2 ^{cd}	4.1±0.2 ^{ab}	4.2±0.2 ^{abc}	4.5±0.2 ^d	4.3±0.2 ^{bcd}	4.6±0.1 ^d	4.0±0.1 ^a	4.3±0.3	4.2±0.3 ^{abc}	
Seed thickness	mm	2.4±0.1 ^{ab}	2.4±0.2 ^{ab}	2.5±0.2 ^{bc}	2.2±0.1 ^a	2.6±0.3 ^{bc}	2.4±0.3 ^{abc}	2.7±0.2 ^c	2.5±0.3	2.7±0.1 ^{bc}	
Single seed weight	mg	67.5±9.5 ^{cd}	52.1±16.9 ^{ab}	76.4±15.1 ^d	56.6±7.7 ^{abc}	59.6±8.1 ^{abcd}	64.7±10.5 ^{bcd}	61.3±7.0 ^{ab}	62.6±7.91	60.82±6.29 ^{ab}	

Annexure II

Pomological description of local apples of trans-Himalayan Ladakh as per UPOV descriptor⁸

Parameters	Cultivars						
	<i>Mongol</i>	<i>Thra</i>	<i>Karkechu</i>	<i>Marpo</i>	<i>Yayon</i>	<i>Bong</i>	<i>Skyurmo</i>
Fruit: size	Small medium	Small	Medium	Very small	Small	Small	Small
Fruit: general shape	Flat globose	Flat globose	Globose	Flat	Globose	Flat globose	Globose
Fruit: ribbing	Weak	Weak	Weak	Absent	Weak	Absent	Absent
Fruit: greasiness of skin	Moderate	Medium	Medium	Moderate	Absent	Weak	Weak
Fruit: ground colour	Red	Yellow	Green	Yellow orange	Yellow green	Yellow green	Yellow green
Fruit: intensity of over colour	Strong	Medium	Medium	Light	Light	Light	Light
Fruit: width of stripes	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Fruit: area of russet around stalk attachment	Absent	Medium	Absent	Absent	Absent	Absent	Absent
Fruit: area of russet on cheeks	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Fruit: size of lenticels	Absent	Absent	Small	Absent	Small	Small	Absent
Fruit: colour of flesh	White	Yellowish	White	Pinkish	Yellowish	White	White