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Assessment of Morphological Diversity in Indigenous Ambri apple (*Malus × domestica* Borkh.)

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ABSTRACT: The present field work was done in order to study prevailing genetic diversity and to obtained information on the magnitude of variability of several morphological traits, predict heritability and genetic advance and estimate divergence in Doda and Kishtwar districts of Jammu region. A total of 50 Ambri apple trees were marked out of 150 trees explored in two districts situated at 1272 to 1798 above mean sea level. Out of fifty selected Ambri apple genotypes 70 per cent genotypes showed biennial, 24 per cent genotypes showed irregularity, 6 per cent genotypes were found regular and 24 per cent genotypes showed irregularity in flowering behaviour. In case of flower initiation, 32.00 per cent genotypes were early bloomers, 52.00 per cent genotypes were mid bloomers while rest 16.00 per cent genotypes were late bloomers. Regularity of flowering was categorised as regular (6 per cent), biennial (70 per cent), and irregular (24 per cent) among genotypes under study. On spur and mixed bearing habit were observed in 76 per cent and 24 per cent genotypes respectively. Fruit shapes varied as globose (38 per cent), globose conical (16 per cent), conical (20 per cent) and long conical (23 per cent). A remarkable variability was also exhibited with respect to fruit over colour (yellow and pink) and fruit ground colour (cream white yellow, yellow and green yellow) among selected genotypes of Ambri apple. Low fruit skin lenticels, were observed (50 per cent genotypes).

Keywords: Ambri apple, diversity, flowering, fruit, variability

INTRODUCTION

Apple (*Malus × domestica* Borkh.) is economically the most important tree fruit crop in the temperate zones, presenting a high diversity of commercial cultivars. In India apple is being cultivated on 307 thousand hectares area with the annual production of 2371 thousand metric tonnes (Anonymous, 2019). Apple varieties are grown throughout the world including Central and West Asia, India, Western provinces of China, Europe and parts of America and Africa (Juniper *et al.*, 1999). In India, apple is mainly grown in Jammu and Kashmir (the leading area), Himachal Pradesh, Uttarkhand, Arunachal Pradesh and Nagaland. Indian Himalayan region is very abundant in temperate fruit genetic diversity and extends from Jammu and Kashmir to the North-eastern hills and maintain broad genetic diversity of temperate fruits like apple, pear, peach, apricot, walnut, almond and other fruits and their wild relatives. *Ambri* covers minute area and acreage, this variety is diminishing fast due lo loss of its genome. Although *Ambri* plantations still subsist on elevated altitudes within unreachable areas which yield without any application of scientific package of practices. Due to its seedling origin and its highly cross pollinated nature, it has contributed towards the tremendous variability in shape and colour development which provide a platform for exploitation of vast gene pool of Ambri apple. Ambri apple is indigenous to Kashmir, and resumes its superiority by virtue of its crisp texture, sweet flesh and excellent aroma with prolonged storability. In spite of long gestation period, biennial bearing habit and susceptibility to scab disease, *Ambri* apple is in great demand because of unique flavour and prolonged shelf-life. Ambri apple is the choicest parent in Indian apple breeding programme for improving the quality and shelf-life of Delicious apple with good success. Fruit industry profile of Jammu and Kashmir has been dominated by Delicious varieties of apple. With the introduction of early maturing cultivars like Starkrimson and other Delicious group, there is decreased per capita consumption of this nutritious fruit. There is pressing need to diversify fruit industry with cultivation of other types and varieties of apple particularly indigenous *Ambri.* Hence, Ambri apple is an excellent alternative for the sustainability of Indian apple industry.

The maintenance of morphological and genetic diversity are important for future breeding programme

because diversity gives species the ability to adapt to changing environments and provide the raw material to breed new cultivars *via* hybridization or selection (Dhillon and Rana, 2004). Estimating genetic diversity and determining the relationships among germplasm collections enhance efficiency of its management and genetic improvement (Rana *et al*., 2012). Morphological characterization of trees and fruits is the first and the most important step for the description, classification and characterization of germplasm collections (Verma *et al.*, 2006). It is therefore important to characterize cultivars of each group so that well known cultivars are clearly distinguished from less known and commercially unsuccessful cultivars. In order to minimize genetic erosion of this special indigenous Ambri apple, there is a necessity for conserving this precious cultivar for its promotion to commercial level. In the present study, the efforts have been made to examine the existing morphological diversity in different traits of '*Ambri*' apple grown in temperate regions of Jammu. The affluent core set developed will be a valuable reserviour for future genetic studies and crop improvement strategies.

MATERIALS AND METHODS

The present field work was carried out during the year 2017 and 2018 in Doda and Kishtwar districts of Jammu (UT of Jand K). The sites viz. Bhaderwah, Thathri, Gandoh, Bhagwah, Kishtwar, Dool, Nagseni, Mughalmadain and Chatroo were located between 1272 m to 1798m above msl. Survey was done to select promising accession among the diverse Ambri apple genotypes and to assess variability. The department of Horticulture and local inhabitants were consulted to get first hand information so as to identify Ambri apple hotspots. Initially a total of 150 naturally growing seedling trees were marked and the data on various flowering and fruit morphological parameters were recorded to select the elite genotype. The sample of 100 trees were rejected and finally sample of 50 superior trees were selected to collect large sample size, for collection of data as per apple descriptor build by NBPGR-2002. Regularity of flowering was recorded on the basis of flowering flush as regular (1), biennial (2), and irregular (3). Initiation of flowering was recorded when 5 to 10 per cent per cent buds had opened and expressed as Day/Month/Year. End of flowering was recorded when 85 to 90 per cent buds have opened and expressed as Day/Month/Year. Bearing habit was recorded during flowering stage by the location and types of buds which produce flower and fruit and rated as on spur (1), on shoot tips (2) on old shoots (3) and mixed (4).

Fruit shape was recorded at maturity stage and rated as globose (1), globose conical (2), conical (6) and long conical (7). Fruit over colour was recorded as skin colour of fully mature fruit and rated as yellow (golden) (1), pink (2), green (3), orange (4), red (5), dark red (6), brown (7), purple (8), dark brown (9) and other (99). Fruit ground colour was recorded as skin colour of fully mature fruit and rated as cream white (1), yellow (2), green yellow (3), green(4), orange (5), red (6) and others (99). Fruit skin lenticels was recorded on mature fruit and rated as absent (0), low (3), medium (5) and high (7).

RESULTS AND DISCUSSION

In apple, the shape and colour influences the fruit quality and its marketability. Flower characteristics are equally important as far as diversity is concerned (Table 1, Table 2 and Plate 1). Duration of flowering ranged from 19-21 days. Out of fifty selected genotypes only 32.00 per cent started flowering from 7th April to 10th April (early bloomers), 52.00 per cent initiated flowering from 11th to 15th April (mid bloomers) while 16.00 per cent initiated flowering from 16th to 17th April (late bloomers). The flowering date and period may vary depending upon the cultivar aptitude as well as ecological and cultural conditions (Facteau *et al.*, 1986).

Our results are in close conformity with the results of Mratinic and Aksic (2011) who reported that the earliest initial bloom was recorded in some apple cultivars on 22nd April and lasted till 6th May and also reported an approximate 16 day of difference in full bloom between the earliest and latest cultivars. Similar results were obtained by Ahmed *et al*., (2016) who recorded the duration of flowering (11 to 24 days) in pear.

Kumar *et al.,* (1997) evaluated six apple cultivars and found that flowering time varied from the last week of March to the first week of April. They also revealed that percentage anthesis, dehiscence increased from 8.00 to 12.00 hrs, then it decreased slightly until 14.00 hrs and then declined rapidly. Elshihy *et al.,* (2004) also reported perfect flowers bloom on two years or older spurs between April and May in the south of Syria. Bhat (2012) also observed that variability in flowering time among the pear genotypes and it may be attributed to the difference in chilling hours required for breaking flower bud dormancy. However, most of the accessions in present study were mid bloomers but late bloomers should be favoured because of its possibility to avoid freezing injury. On the basis of regularity of flowering genotypes were categorized as regular, biennial and irregular (Table 1). Among the fifty selected genotypes 70 per cent were biennial, 24 per cent were irregular and rest 6 per cent were regular in flowering pattern. Fioravanco *et al*., (2018) studied biennial bearing in apple cultivars and reported Gala cultivars showed BBI (Biennial Bearing Indices) ranging from 0.28 to 0.35 and the Fuji from 0.26 to 0.38. Milatoviæ and Duroviæ (2012) also obtained indices of 0.17 and 0.26 for the cultivars Royal Gala and Gala Must of 0.49 and 0.55 for the Fuji Naga-fu 6 and Fuji Naga-fu 2. Similarly, Crassweller *et al*., (2005) estimated indices of 0.57 and 0.59 for Gala Supreme and Fuji. Flower and fruit thinning is considered a fundamental management practice to reduce the intensity of production alternation in apple trees (Bukovac *et al*., 2006), especially when carried out in the year of high production (Tromp, 2000). This is very important for assuring regular production every year and good sized fruits, and for avoiding unbalanced relationship between production

and vegetative growth of the plant. The flowering date and period may also vary depending upon the altitude at which cultivar is growing as well as its ecological and cultural condition (Facteau *et al.*, 1989).

(a) Recording observations on different morphological traits.

(b) Blooming in Ambri apple

Plate 1: (a) Recording observations on different morphological traits (b) Blooming in Ambri apple.

Inflorescence bearing habit were categorized as on spurs, on shoot tips, on old shoots and mixed among different Ambri apple genotypes (Table 1). Majority of genotypes 76 per cent showed bearing on spurs and 24 per cent exhibited mixed bearing habit. Whereas on shoot tips and on old shoot tip bearing habit were not observed among fifty selected Ambri apple genotypes. These results are in agreement with the results of Hassan *et al.*, (2017) who reported that the bearing habit of apple was categorised as on long shoots, on spurs and on spurs and long shoots in 6.06 per cent, 18.18 per cent and 75.75 per cent genotypes respectively.

Table 1: Flowering characteristics of Ambri apple (*Malus* × *domestica* Borkh.) genotypes.

Sr. No.	Genotype number	Regularity of flowering	Date of start of flowering (dd/mm/yy)	Date of end of flowering (dd/mm/yy)	Bearing Habit
1.	SKJAB -01	2	10th April, 2017	17th April, 2017	1
2.	SKJAB -02	2	9th April, 2017	18th April, 2017	1
3.	SKJAB -03	2	11th April, 2017	16th April, 2017	1
4.	SKJAB -04	2	10th April, 2017	15th April, 2017	1
5.	SKJAB -05	3	9th April, 2017	15th April, 2017	1
6.	SKJAT -06	3	12th April, 2017	18th April, 2017	4
7.	SKJAT -07	3	15th April, 2017	20th April, 2017	4
8.	SKJAT -08	3	11th April, 2017	16th April, 2017	1
9.	SKJAT -09	2	11th April, 2017	17th April, 2017	1
10.	SKJAG -10	2	9th April, 2017	15th April, 2017	4
11.	SKJAG -11	1	8th April, 2017	16th April, 2017	1
12.	SKJAG -12	1	9th April, 2017	15th April, 2017	4
13.	SKJAG -13	2	8th April, 2017	18th April, 2017	1
14.	SKJAG -14	2	8th April, 2017	15th April, 2017	1
15.	SKJAG -15	2	7th April, 2017	15th April, 2017	1
16.	SKJAG -16	3	10th April, 2017	19th April, 2017	4

17.	SKJAG -17	3	8th April, 2017	17th April, 2017	4
18.	SKJABh -18	3	9th April, 2017	15th April, 2017	4
19.	SKJABh -19	3	10th April, 2017	18th April, 2017	1
20.	SKJABh -20	3	10th April, 2017	15th April, 2017	1
21	SKJAK -21	2	15th April, 2017	21st April, 2017	1
22	SKJAK -22	2	16th April, 2017	22nd April, 2017	1
23	SKJAK -23	2	17th April, 2017	23rd April, 2017	1
24	SKJAK -24	2	16th April, 2017	23rd April, 2017	1
25	SKJAK -25	2	15th April, 2017	22nd April, 2017	1
26	SKJAK -26	2	17th April, 2017	23rd April, 2017	1
27	SKJAK -27	2	15th April, 2017	21th April, 2017	1
28	SKJAD -28	2	15th April, 2017	19th April, 2017	1
29	SKJAD -29	2	15th April, 2017	22nd April, 2017	1
30	SKJAD -30	2	16th April, 2017	20th April, 2017	1
31	SKJAD -31	2	15th April, 2017	21st April, 2017	1
32	SKJAD -32	2	14th April, 2017	19th April, 2017	1
33	SKJAD -33	2	15th April, 2017	20th April, 2017	1
34	SKJAD -34	2	16th April, 2017	21st April, 2017	1
35	SKJAD -35	1	15th April, 2017	20th April, 2017	1
36	SKJAD -36	3	15th April, 2017	23rdApril, 2017	1
37	SKJAN -37	2	13th April, 2017	19th April, 2017	4
38	SKJAN -38	2	14th April, 2017	19th April, 2017	4
39	SKJAN -39	2	15th April, 2017	20th April, 2017	1
40	SKJAN -40	2	14th April, 2017	19th April, 2017	1
41	SKJAN -41	2	14th April, 2017	20th April, 2017	1
42	SKJAN -42	2	13th April, 2017	19th April, 2017	1
43	SKJAM-43	2	12th April, 2017	18th April, 2017	1
44	SKJAM-44	3	12th April, 2017	18th April, 2017	1
45	SKJAM-45	3	11th April, 2017	17th April, 2017	1
46	SKJAM -46	2	12th April, 2017	19th April, 2017	4
47	SKJAM -47	2	13th April, 2017	18th April, 2017	1
48	SKJAC -48	2	15th April, 2017	21st April, 2017	1
49	SKJAC -49	2	16th April, 2017	25th April, 2017	4
50	SKJAC -50	2	17th April, 2017	27rd April, 2017	4

Legend

Regularity of flowering	Note	Bearing Habit	Note
Regular	1	On spurs	1
Biennial	2	On shoot tips	2
Irregular	3	On old shoots	3
		Mixed	4

Table 2: Summary of frequency of flowering characteristics of Ambri apple (*Malus* × *domestica* Borkh.). genotypes.

Trait	Category	Number of Genotypes	Percentage
Regularity of flowering	Regular	3	6
	Biennial	35	70
	Irregular	12	24
Initiation flowering	1st week of April	16	32
	2nd week of April	26	52
	3rd week of April	8	16
End of flowering	3rd week of April	41	82
	4th week of April	9	18
Bearing Habit	On spurs	38	76
	On shoot tips	-	-
	On old shoots	-	-
	Mixed	12	24

Table 3: Fruit characteristics of Ambri apple (*Malus* × *domestica* Borkh.) genotypes.

Sr. No.	Selection number	Fruit shape	Fruit over colour	Fruit ground colour	Fruit skin lenticels
1.	SKJAB -01	1	2	3	0
2.	SKJAB -02	1	2	3	0
3.	SKJAB -03	1	1	3	0
4.	SKJAB -04	1	2	2	3
5.	SKJAB -05	7	2	3	3
6.	SKJAT -06	1	1	2	3
7.	SKJAT -07	7	1	2	3
8.	SKJAT -08	7	1	2	3
9.	SKJAT -09	7	1	2	0
10.	SKJAG -10	2	2	4	0
11.	SKJAG -11	2	2	4	0
12.	SKJAG -12	2	2	4	0
13.	SKJAG -13	2	2	4	0
14.	SKJAG -14	2	2	4	0
15.	SKJAG -15	2	2	4	0
16.	SKJAG -16	2	2	4	0
17.	SKJAG -17	2	2	4	0
18.	SKJABh -18	1	1	2	3
19.	SKJABh -19	6	2	4	3
20.	SKJABh -20	6	2	4	3
21.	SKJAK -21	7	2	2	3
22.	SKJAK -22	7	1	4	3
23.	SKJAK -23	7	1	2	3
24.	SKJAK -24	7	2	4	0
25.	SKJAK -25	7	1	4	3
26.	SKJAK -26	7	2	4	0
27.	SKJAK -27	1	2	2	0
28.	SKJAD -28	1	1	4	3
29.	SKJAD -29	7	1	3	3
30.	SKJAD -30	1	2	2	3
31.	SKJAD -31	1	2	4	3
32.	SKJAD -32	1	1	4	3
33.	SKJAD -33	1	2	2	3
34.	SKJAD -34	1	1	3	3
35.	SKJAD -35	1	1	3	3
36.	SKJAD -36	1	1	4	3
37.	SKJAN -37	6	2	2	0
38.	SKJAN -38	6	2	2	0
39.	SKJAN -39	6	2	4	0
40.	SKJAN -40	6	2	4	3
41.	SKJAN -41	6	2	4	0
42.	SKJAN -42	6	2	4	0
43.	SKJAM-43	1	1	4	0
44.	SKJAM-44	1	1	4	0
45.	SKAM-45	6	2	2	3
46.	SKJAM -46	7	2	4	0
47.	SKJAM -47	1	1	4	3
48.	SKJAC -48	6	2	3	0
49.	SKJAC -49	1	1	4	3
50.	SKJAC -50	1	2	2	0

Legend

Fruit shape	Note	Fruit over colour	Note	Fruit ground colour	Note	Fruit skin lenticels	Note
Globose	1	Yellow	1	Cream white	1	Absent	0
Globose conical	2	Pink	2	Yellow	2	Low	3
Flat	4	Green	3	Green yellow	3	Medium	5
Conical	6	Orange	4	Green	4	High	7
Long conical	7	Red	5	Orange	5		
Intermediate conical	8	Dark red	6	Red	6		
Others	99	Brown	7	Others	99		
		Purple	8				
		Dark brown	9				
		Others	99				

Variability in fruit attributes such as fruit shape, fruit over colour, fruit ground colour and fruit skin lenticels are considered to be important for identification and characterization of any fruit crop germplasm. Among the selected genotypes none of the genotypes showed flat fruit shape and intermediate conical fruit shape, while 38 per cent exhibited globose fruit shape, 16 per cent had globose conical fruit shape, 20 per cent had conical fruit shape and rest 26 per cent had long conical fruit shape (Table 4). Fruit shape was controlled by climatic and non-climatic factors, and varied greatly.

Our results are in conformity with the results of Ganopoulos *et al.,* (2018) who reported conical fruit shape (Forlady, Ozark gold, Scarlet spur, and Super chief), was predominant followed by ellipsoid (Fuji zhen Aztec, Fuji kiku 8) and globose (Delicious and Mutsu) in 19 apple cultivars. Mratinic *et al.,* (2012) recorded fruit shapes of apple and classified them in eight groups stretching from short globose to conical, conical, ellipsoid to conical and ellipsoid (all 5.56 per cent, respectively) to flat-gobose (16.67per cent), globose (27.78 per cent) and intermediated conical (33.33 per cent).

Table 4: Summary of frequency of fruit characteristics of Ambri apple (*Malus* × *domestica* Borkh.) genotypes.

Trait	Category	Number of Selections	Percentage
Fruit shape	Globose	19	38
	Globose conical	8	16
	Flat	-	-
	Conical	10	20
	Long conical	13	26
	Intermediate conical	-	-
Fruit over colour	Yellow	19	38
	Pink	31	62
	Green	-	-
	Orange	-	-
Fruit ground colour	Yellow	15	30
	Green yellow	8	16
	Green	27	54
Fruit skin lenticels	Absent	25	50
	Low	25	50

Similar results were obtained by Hofer *et al.,* (2012) in apple who reported that majority of apple accessions possessed fruit shape as flat globose (65 per cent), flat globose in (14 per cent) and globose (11 per cent) accessions. Fruit skin lenticels of Ambri apple genotypes studied were not found in 50 genotypes (50 per cent) and rest 50 genotypes (50 per cent) were observed low in fruit skin lenticels. Our results are in close conformity with the Hassan *et al.* (2017) who reported few numbers of lenticels (42.42 per cent), medium numbers of lenticels (30.30 per cent) and many number of lenticels (27.27 per cent) in selected accessions of apple under study. Variation in fruit size might be under control of genetic factors involving their phylogenic behaviours.

The mechanisms of fruit development are influenced by cultural and genetic factors (Cowan *et al.,* 2001 and Harada *et al.,* 2005).

In the present study fruit over colour fruit was found to vary from yellow (golden), pink, green, orange, red, dark red, brown, purple, dark brown and other. Selected Ambri apple genotypes showed that 19 genotypes (38 per cent) had yellow and 31 genotypes (62 per cent) possessed pink fruit over. Fruit ground colour was observed as yellow in 15 genotypes (30 per cent), green yellow in 8 genotypes (16 per cent) and green in 27 genotypes (54 per cent) (Table 4). Our results are supported by Mratinic and Aksic (2012) they reported that background colour varies from cream white (38.89 per cent), over yellow (16.67 per cent) to green yellow (44.44 per cent), while over colour ranged from red (50.0 per cent) to dark red or purple (5.56 per cent) in some *Malus* species in South Serbia. Similar results were obtained by Ganopoulos *et al.,* (2018) in 19 apple cultivars who reported fruit over colour was orange in (Gala Buckeye, Gala, Brookfield, Gold Chief, Golden Reinders, Golden Delicious, Granny Smith, Mutsu, Mirto, Ozark Gold and Florina). They further observed that two cultivars had hue of over color, FuJi Kiku 8 was pink and Delicious was brown.

Difference of color among the cultivars is an important indicator of varietal identification. It makes the fruit attractive and good looking for the consumer choice and is the most easily assessable parameter while determining the freshness and ripeness of the fruit within a variety. Fruit colour also evaluate fruit characters which directly correlate with environmental conditions in prevailing localities. Fruit colour is significantly influenced by temperature, location of plant, light penetration and growth habit of tree. Sunlight is main factor responsible for synthesis of anthocyanin in fruit skin (Erez and Flore, 1986) and responsible for fruit colour (Marini *et al.*, 1991). When the apple fruit gains optimum size, ground colour of skin changes from green to green yellow or yellow on the tree then it is ready for harvesting. Beginning of fruit ripening was evaluated on the basis of fruit size, change in colour and overall visual observations. Fruit skin lenticels were categorized into absent, low, medium and high. As per the fruit skin lenticels are concerned, only 50 per cent genotypes showed low fruit skin lenticels. Similar results were obtained by Hassan *et al.,* (2017) who reported few numbers of lenticels (42.42 per cent), medium numbers of lenticels (30.30 per cent) and many number of lenticels (27.27 per cent) in apple. Wide range of morphological and genetic variability was observed in seedling origin Ambri apple growing in the North-Western Himalayan region of

India. This offers great scope for indigenous Ambri apple improvement. The genotypes SKAJK-29 and SKAJK-30 are rated as most outstanding in the present work with respect to morphological characters would of immense use not only to develop variety but will also serve as useful in apple breeding programme.

CONCLUSION

The present study highlights the presence of significant morphological variability among the Ambri apple accessions in Jammu region. All the observations made in this study will provide valuable evidence for decision making in characterization of Ambri apple germplasm and its management.

REFERENCES

Anonymous, (2019). Indian Horticulture Database. National Horticulture Board, Gurgoan.

Ahmed, M., Akbar Anjum, M., Hussain, S., Ejaz, Shaqhef., Ahmad, S. and Ercisli, S. (2016). Biodiversity in indigenous germplasm of *Pyrus* from Pakistan based on phenotypical and morphological traits. *Springer*, *59*: 19-27.

Bhat, Z. A. (2012). Molecular characterization and hybridization studies in pear. Ph. D. Thesis submitted to Division of Pomology, Punjab Agriculture University, Ludhiana.

Bukovac, M., Sabbatini, P. and Schwallier, P. (2006). Modifying alternate bearing of spur-type Delicious apple with ethephon. *Hort Science*, *41*(7): 1606-1611.

Cowan, A. K., Cripps, R. F., Richings, E. W. and Taylor, N. J. (2001). Fruit size: towards an understanding of the metabolic control of fruit growth using avocado as a model system. *Physiologia Plantarum*, *111*(2): 127-136.

Crassweller, R., Clemens, J., Brown, S., Cowgill, W., Cline, J., Berkett, L., Azarenko, A., McNew, R., Belding, R. and Barritt B. (2005). Performance of apple cultivars in the 1995 NE-183 regional project planting: I growth and yield characteristics. *Journal of the American Pomological Society*, *59*(1): 18-27.

Dhillon, B. S. and Rana, J. C. (2004). Temperate fruits genetic resources management in India -Issues and strategies. *Acta Horticulturae*, *662*(2): 139-146.

Elshihy, O. M., Sharaf, A. N. and Muzher, B. M. (2004). Morphological, anatomical and biochemical characterization of Syrian Pear (*Pyrus syriaca* Boiss) genotypes. *Arabian Journal of Biotechnology*, *7*(2): 209- 218.

Erez, A. and J.A. Flore (1986). The quantitative effect of solar radiation on "Redhaven" peach fruit skin colour. *Hort Science*, **21**: 1424-1426.

Facteau, T., K. Rove and Chestnut, N. (1986). Firmness of sweet cherry fruit following grow in New York. *Proceedings in American Society of Horticulture Science*, *57*: 169-178.

Facteau, T.J., Rowe, K.E. and Chestnut, N.E. (1989). Flowering in sweet cherry in response to application of gibberllic acid. *Scientia Horticulture*, *38*(2): 39-245.

Fioravanco, J. and Czermainsk, B.C. (2018). Biennial bearing in apple cultivars. *Revista Ceres*, *65*(2): 144-149.

Ganopoulos, I., Tourvas, N., Xanthopoulou, A., Aravanopoulos, F.A., Avramidou, E., Zambounis, A., Tsaftaris A., Madesis, P., Sotiropoulos, T. and Koutinas, N. (2018). Phenotypic and molecular characterization of apple (*Malus* × *domestica* Borkh) genetic resources in Greece. *Scientia Agricola*, *75*(6): 509-518.

Harada, T., Kurahashi, W., Yanai, M., Wakasa, Y. and Satoh, T. (2005). Involvement of cell proliferation and cell enlargement in increasing the fruit size of *Malus* species. *Scientia Horticultura, 105* (4): 447-456.

Hassan, S., Bhat, K. M. and Rehman, H. U. (2017). Assessment of Genetic Variability of Wild Apple (*Malus* sp.) Genotypes in Kashmir Valley. *International Journal of Plant and Soil Science*, *14*(5): 1-12.

Hofer, M., H. Flachowsky, M. Hanke, V. Semenov, A. Lavas, V. Bandurko, A. Sorokin and S. Alexanian (2012). Assessment of phenotypic variation of *Malus orientalis* in the North Caucasus region. *Genetic Resource in Crop Evolution*, 1-15.

Juniper, B. E., Watkins, R. and Harris, S. A. (1999). The origin of the apple. *Acta Horticultura, 484*: 27-33.

Kumar, R., Sharma, R. L. and Best, H.S. (1997). Studies on flowering behaviour of some scab resistant and susceptible apple cultivars. *Horticulture Journal, 10* (2): 37-41.

Marini, R. P., D. Sowers, and M. C. Marini (1991). Peach fruit quality is affected by shade during final swell of fruit growth. *Journal* of *American Society* for *Horticultural Science*, *116* (3): 383-389.

Milatoviæ, D. and Duroviæ, D. (2012). Growth and yield characteristics of new apple cultivars. *Journal of Pomology, 46*: 77-82.

Mratinic, E. and M. F. Aksic. (2012). Phenotypic diversity of apple (*Malus* sp.) germplasm in South Serbia. *Brazilian Archives of Biology and Technology*, *55*: 349-358.

Mratinic, E. and M. F. Aksic. (2011). Evaluation of phenotypic diversity of apple (*Malus* sp.) germplasm through the principle component analysis. *Genetic*, *43*(2): 331-340.

NBPGR, (2002). National Bureau of Plant Genetic Resource. Apple (*Malus* × *domestica* Borkh.) pp. 201-206.

Rana, J.C., Dutta, M. and Rathi, R.S. (2012). Plant genetic resources of the Indian Himalayan region- an overview. *Indian Journal of Genetics and Plant Breeding*, *72*: 115-129.

Tromp, J. (2000). Flower-bud formation in pome fruits affected by fruit thinning. *Plant Growth Regulation*, *31*:27-34.

Verma, V.D., Pradheep, K., Yadav, S. K., Rana, J.C. and Chander, R. (2006). Characterization of apple germplasm. *Indian Journal of Plant Genetic and Resources*, *19*: 276-278.

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