



Variation in Fruit and Seed Morphology of *Pyrus pashia* (Buch-Ham ex D. Don) in Alaknanda Valley of Garhwal Himalaya, India

Amreen, A.K. Negi and Himshikha Gusain

Department of Forestry and Natural Resources
H.N.B. Garhwal University, Srinagar, Garhwal-246 174, India
E-mail: amreenansari1990@gmail.com

Abstract: The study was conducted on fruit and seed morphology of *Pyrus pashia* populations. Seven characters (fruit length, width, thickness, seed length, width, thickness and seed number) were measured from 450 trees in 15 different locations at altitude ranging from 650 to 2190 metres. The altitudes were grouped as follows: the first group (650 m, 1790 m), third group (1260 m, 1460 m, 2100 m), and the second cluster containing the remaining altitude locations. The coefficient of variation confirmed significant difference of morphological characters. The correlation between morphological characteristics of fruits and seeds and geographic features showed a negative and weak correlation with altitude and latitude. Furthermore, altitude negatively correlates with fruit length, seed number and seed length morphological traits but positively with others, emphasizing the need to consider specific parameters when selecting germplasm collection sites. Among different locations, altitude of 1220 meter showed that the seed and fruit characteristics confirm it as the best germplasm collection site.

Keywords: *Pyrus pashia*, Himalaya, Fruits, Seeds, Morphology, Populations

Understanding the morphology of fruits and seeds is fundamental in identifying the Indian wild pear *P. pashia* (Buch-Ham ex D. Don), a highly valued deciduous tree species (Arya et al 2011). This significant intermediate species between the oriental and occidental groups of pears has played a crucial role in forming the *Pyrus* genus. The round, brown fruits are edible and have high nutritional and ethnomedicinal value. Depending on the topographic and climatic conditions, the fruit's colour changes from willow green to brown with light spots in the middle stage and eventually turns black when ripe (Prakash et al 2021a). Each fruit contains around five seeds, which are black in colour, tiny, light, and pyriform in shape. A mature tree may produce up to 45 kg of fruit per year, with a taste ranging from rigorous to sweet and gritty. Approximately 50 seeds are available per gram (Prakash et al 2021b). The oval, hairless and shiny leaves are accompanied by clusters of white flowers, adding to its aesthetic appeal. *Pyrus* species face threats worldwide that have caused the loss of 85% of numerous pear varieties in 19th century or even today (Sindelar 2002). Considering the variations in fruit and seed traits is difficult for determining the best geographic source of seeds (Mkwezalamba et al 2015). This study aimed to evaluate altitudinal variation in fruit and seed morphology of *Pyrus pashia* in Alaknanda valley of Garhwal Himalaya, India.

MATERIAL AND METHODS

Sampling location: The study was conducted during October to December 2020 and 2021 in the Alaknanda

Valley, covering an area of approximately 1400 km² in the Garhwal Himalayan region, India. Based on the altitudinal gradient, fifteen different locations (L1 to L15) ranged from 650 to 2190 m were randomly selected, all of which had wild populations (Table 1). Samples were collected from 30 randomly selected trees in each location, making a total of 450 trees.

The 5 kg of fully ripened fruits were collected from October to December 2020-21. Two to three branches per tree were harvested at mid-height to reduce individual variation and after the initial fruit screening, 100 ripened and undamaged fresh fruits were measured. After de-pulping, the seeds were extracted from the fruits and sun-dried for further tests. The comprehensive data on seven parameters, fruit length, width, and thickness, seed length, width, thickness, and number of seeds/fruits, were recorded.

Statistical analysis: The statistical was done using R.4.1.1 (Cluster analysis) and SPSS 4.9 (Correlation matrix). The Minitab-18 statistical software was used for one way analysis.

RESULTS AND DISCUSSION

Morphological characteristics of fruits of *P. pashia*: There was high degree of variation in its phenotypic characteristics. The fruit length varied among locations, ranged from 16.29 mm for L6 to 24.93 mm for L2 (1220 m). Similarly, the mean fruit width varied from 25.97 mm for L2 to 17.86 mm for L6 (1420 m). However, the fruit thickness ranged from 26.01 mm for L8 (1465 m) to 17.94 mm for L6.

The length and width of the fruit were lower at both higher elevations (2190 m) and the lowest elevation (650 m). The L2 (1220 m) has shown superior fruit size of 24.93 mm and maintained its superiority over other locations. L3 (1260 m) consistently underperformed in all traits of *P. pashia* fruit. Kishore et al (2017) also observed the smallest fruit size of *P. pashia* at 1350 m. The shape of the fruit (Round, oblong and pyriform) varied, with the maximum fruit length (24.93 mm) and fruit width (25.97 mm) at an elevation of 1220 m. These

findings suggest that the population from this area can be utilized for genetic and tree breeding programs (Table 2). Lone et al (2000) observed significant variation in fruit traits in temperate fruits. These findings suggest that the quantity of *P. pashia* fruit seeds tend to decrease with altitude. Shankar et al (2012) also observed considerable variation in the morphological traits of fruits and seeds of *P. nepaulensis* among different locations. The lowest diameter in the fruit at the middle altitude of 1420 m might be due to the fruit's

Table 1. Geographical coordinates of study sites in Alaknanda valley, Garhwal Himalaya

Location code	Name	Altitude (m)	Latitude	Longitude
L1	Luneta	650	30°12'32.39" N	78°40' 35.04" E
L2	Kund	1220	30°30'20.11" N	79°05' 29.87" E
L3	Silyara	1260	30°27'14.01" N	78°38' 56.62" E
L4	Kuhed	1300	30°22'35.51" N	79°19' 37.98" E
L5	Gadora	1400	30°24'56.35" N	79°25' 50.34" E
L6	Kauliyadhar	1420	30°17'37.18" N	78°50' 22.17" E
L7	Kandikhal	1460	30°20'41.71" N	78°37' 50.67" E
L8	Barsori	1465	30°09'26.68" N	78°48' 31.57" E
L9	Chunikhal	1630	30°18'10.75" N	78°48' 43.70" E
L10	Agroda	1700	30°07'08.46" N	78°47' 49.84" E
L11	Chandrabadni	1780	30°18'20.90" N	78°37' 38.93" E
L12	Gopeshwar	1790	30°25'12.53" N	79°19' 16.41" E
L13	Tapowan	1970	30°30'02.40" N	79°37' 31.34" E
L14	Nauti	2100	30°12'43.59" N	79°12' 26.96" E
L15	Tala	2190	30°30'32.69" N	79°10' 14.24" E

Table 2. Variation in morphological characteristics (Length, width and thickness) of fruits of *Pyrus pashia* (Mean \pm SD)

Location code	Altitude (m)	Fruit length (mm)	Fruit width (mm)	Fruit thickness (mm)
L1	650	17.94 \pm 0.48	18.75 \pm 0.53	18.70 \pm 0.59
L2	1220	24.93 \pm 0.79	25.97 \pm 0.78	25.76 \pm 0.69
L3	1260	17.81 \pm 0.50	19.01 \pm 0.49	19.19 \pm 0.50
L4	1300	20.89 \pm 0.05	23.86 \pm 0.39	23.83 \pm 0.34
L5	1400	22.62 \pm 0.37	19.82 \pm 0.34	19.53 \pm 0.43
L6	1420	16.29 \pm 0.78	17.86 \pm 0.70	17.94 \pm 0.72
L7	1460	19.39 \pm 0.21	20.07 \pm 0.29	21.95 \pm 0.00
L8	1465	20.70 \pm 0.02	24.12 \pm 0.44	26.01 \pm 0.74
L9	1630	20.89 \pm 0.05	23.41 \pm 0.31	23.42 \pm 0.27
L10	1700	20.19 \pm 0.07	21.94 \pm 0.04	21.95 \pm 0.00
L11	1780	20.07 \pm 0.09	21.46 \pm 0.04	21.42 \pm 0.09
L12	1790	22.06 \pm 0.26	20.83 \pm 0.15	20.64 \pm 0.23
L13	1970	22.10 \pm 0.27	22.07 \pm 0.06	22.10 \pm 0.03
L14	2100	21.90 \pm 0.24	23.87 \pm 0.39	23.68 \pm 0.31
L15	2190	21.07 \pm 0.08	22.43 \pm 0.13	22.84 \pm 0.16
F		56.43**	63.45**	62.78**

Statistically significant difference, **=P<0.05

maturity. Altitude and other local factors cause a net decline in the variation between day and night temperatures, thus modifying the characteristics of inland growing areas. However, it is suggested that altitude alone is not the only factor affecting these variations.

Morphological characteristics of seeds of *P. pashia*: The variation in the seed size and number can affect a species reproductive ability. In wild fruits, the mean seed length ranged from 1260 m to 1630 m. The maximum seed width was in L11 (1780 m- 3.83 mm), while the minimum seed width was in L9 (1630 m- 2.92 mm), followed by L1 and L14. The average number of seeds/fruits differed from 5.97 for L2 (1220 m) to 4.76 for L3 (1260 m). This confirmed a significant change in altitude-wise seed morphology in terms of mean seed width and thickness (Table 3). The increasing trend in the morphological values of seeds up to the middle elevation (1420 m) was observed except for 1220 m. This variation in seed morphology may also be due resources, which change from season to season. The observed variations in seed characteristics of wild pear accessions could also be due to hybridization, sexual reproduction, bud mutation, and diverse agroecological conditions. Similar observations were observed wild, primitive varieties and landraces of other temperate fruits (Zafar et al 2004).

Correlation between the morphological features of *P. Pashia* to geographical distribution: The size of the fruit and seed mass of *P. pashia* increased as longitude increased

which differed from Baker's rule. The sample locations show a strong correlation between altitude and longitude, which suggesting that the fruit of *P. pashia* has evolved to adapt to different latitudes and longitudes. Fruit length showed positive linear regression coefficient associated with fruit width, thickness and number of seeds/fruits. Fruit length displayed a weak correlation with the length, width and thickness of seeds. The width of the fruits was highly significant with fruit thickness and seed width the correlation between morphological characteristics of fruits and seeds and geographic characteristics showed a negative and weak correlation with altitude and latitude. Fruit thickness, however, significantly positively correlated with altitude and longitude and was negatively correlated with latitude. Number of seeds/fruits did not relate to seed length, width, and thickness but showed a significant correlation with longitude and latitude. There is no linear relationship, either increasing or decreasing, of selected morphological characters of fruits and seeds of *P. pashia* to its distribution along all gradients (Table 4). The differences in the physical characteristics of seeds and fruits may be due to natural limitations in their location. Environmental factors resulting from variations in latitude and altitude, including soil type, human activity, and wind patterns, along with different communities of dispersers separately and together might be responsible for the differences in fruit size in *P. Pashia* across or between species.

Table 3. Variation in morphological characteristics (Length, width, thickness and number of seeds/fruits) of seeds of *Pyrus pashia* (Mean \pm SD)

Location code	Altitude (m)	Seed length (mm)	Seed width (mm)	Seed thickness (mm)	Number of seeds/fruits
L1	650	6.03 \pm 0.03	3.05 \pm 0.06	2.11 \pm 0.02	5.20 \pm 2.19
L2	1220	6.53 \pm 0.05	3.74 \pm 0.06	2.39 \pm 0.08	5.97 \pm 2.12
L3	1260	6.88 \pm 0.1	3.78 \pm 0.06	2.02 \pm 0.01	4.76 \pm 2.27
L4	1300	5.96 \pm 0.05	3.52 \pm 0.02	2.01 \pm 0.01	5.57 \pm 2.51
L5	1400	5.98 \pm 0.04	3.56 \pm 0.03	2.19 \pm 0.04	5.32 \pm 2.56
L6	1420	6.20 \pm 0.00	3.64 \pm 0.04	1.78 \pm 0.03	5.48 \pm 2.21
L7	1460	6.25 \pm 0.00	3.29 \pm 0.02	1.83 \pm 0.02	5.69 \pm 2.27
L8	1465	6.24 \pm 0.00	3.27 \pm 0.02	1.99 \pm 0.00	5.46 \pm 2.32
L9	1630	5.38 \pm 0.15	2.92 \pm 0.08	1.54 \pm 0.07	5.62 \pm 1.57
L10	1700	6.30 \pm 0.01	3.55 \pm 0.02	1.90 \pm 0.00	5.71 \pm 1.77
L11	1780	6.46 \pm 0.03	3.83 \pm 0.08	1.97 \pm 0.00	5.50 \pm 2.50
L12	1790	5.68 \pm 0.10	3.25 \pm 0.02	2.12 \pm 0.03	5.69 \pm 2.07
L13	1970	6.45 \pm 0.03	3.18 \pm 0.03	2.09 \pm 0.02	5.76 \pm 2.97
L14	2100	6.75 \pm 0.09	3.06 \pm 0.06	1.68 \pm 0.04	5.59 \pm 2.25
L15	2190	6.61 \pm 0.06	3.27 \pm 0.0	1.61 \pm 0.06	5.55 \pm 2.36
F		43.95*	30.32**	246.47**	219.99**

Statistically significant difference, *= $P < 0.01$, **= $P < 0.05$

Principal component analysis (PCA) and hierarchical cluster analysis between morphological traits and locations:

The populations were classified into three main groups, with group 3 being the largest, consisting of 10 populations. The first three principal components (PC1, PC2, and PC3) explained 73.6% of the location changes. PC1's first component accounted for 37.91% of the total variation, followed by the second component which accounted for 19.52%. Through hierarchical cluster analysis, three primary groups of locations were identified based on their similarity. The first group consisted of L1 and L12 (650 m, 1790 m) and the third cluster comprised L3, L7, and L14 (1260 m, 1460 m, 2100 m) and the remaining 10 location formed the second cluster.

The lowest fruit length, weight, and thickness values were recorded at middle elevations around 1440-1600 meters. However, these findings partially contradict earlier observations that fruit size increases with elevation (Dinis et

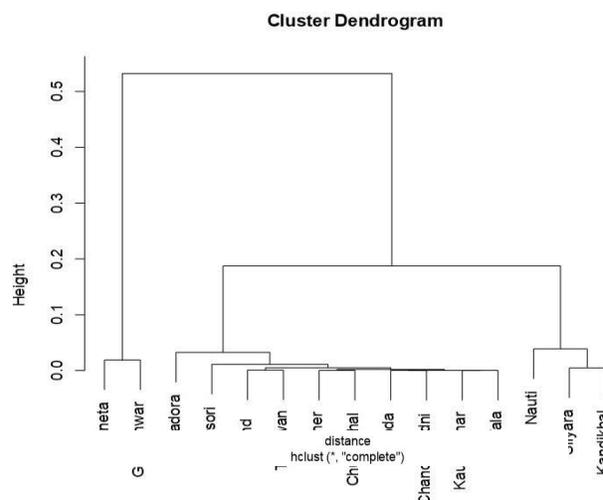


Fig. 2. Dendrogram (Hierarchical clustering) of 15 locations of *Pyrus pashia* based on fruits and seeds morphological characters

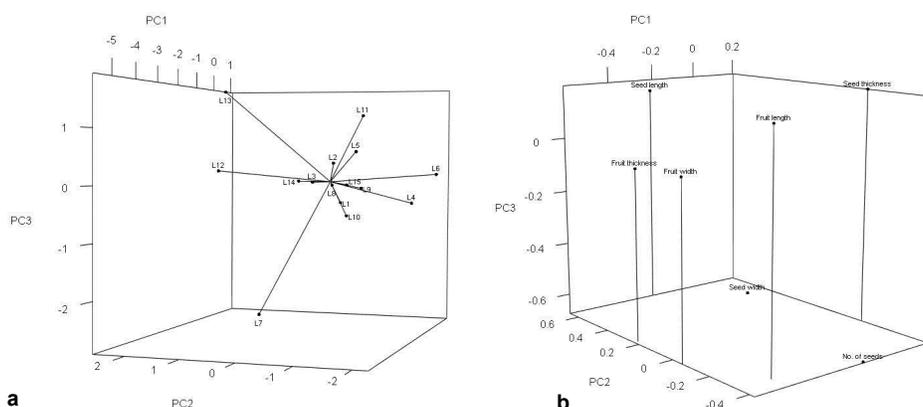


Fig. 1. Principal component analysis (PCA) of fruits and seed characteristics at different locations (a) and projection of morphological characters (b) on the space formed by the first three axes

Table 4. Pearson's correlation coefficient relationship between locations parameters concerning fruit and seed morphological traits of *Pyrus pashia*

Characters	1	2	3	4	5	6	7	8	9
Fruit length 1	1								
Fruit width 2	0.621**	1							
Fruit thickness 3	0.444*	0.521**	1						
Number of seeds/fruits 4	0.837**	0.317	0.151	1					
Seed length 5	0.134	0.207	0.315	0.205	1				
Seed width 6	0.165	0.403*	0.426*	0.232	0.028	1			
Seed thickness 7	0.041	0.079	0.683	0.304	0.149	-0.538	1		
Altitude 8	-0.328	0.373	0.725*	-0.726*	-0.261	0.628*	0.564	1	
Latitude 9	0.514	0.417	0.801**	0.768*	0.703*	-0.508	0.650	0.416	1
Longitude 10	-0.458	0.137	-0.780**	0.805*	0.695	0.255	-0.634	-0.380	-0.840*

Statistically significant difference, *= $P < 0.01$, **= $P < 0.05$

al 2011, Trad et al 2013, Silvanini et al 2014, Maro et al 2014). This can be ascribed to the different climatic and soil conditions at the three monitored altitudes. Contrasting results in previous studies could be due to differences in the altitude of the studied areas. The results demonstrate considerable morphological diversity in fruit and seed characteristics. This was evident from the PCA and hierarchical clustering trends. However, despite being geographically distant, populations belonging to the same group were morphologically similar (PCA and Cluster dendrogram). This highlights the importance of considering location and geographical origins when analysing such data. These findings indicate that location is crucial in determining the physical features of fruits and seeds. Brenes-Gamboa (2017) observed the need to consider the specific characteristics of each site, such as soil slope, acidity, organic matter content, and the impact of climatic factors, when comparing different altitudes. Furthermore, optimal environmental conditions are necessary to achieve the highest possible yields and qualities from fruit plantations, conditions that are linked to the genetic potential of the species (Perez and Melgarejo 2015).

CONCLUSIONS

The altitude of 1220 m exhibited the most considerable fruit length, width, and seed thickness, making the ideal location for collecting germplasm for propagation and germination to achieve the best fruit quality. Correlation coefficient, PCA, and hierarchical clustering analyses confirmed that fruit width, thickness, altitude, and number of seeds/fruits are crucial factors in determining the optimal altitude for germplasm collection, especially when fruit quality is the primary consideration. The study found a negative and weak correlation between the morphological characteristics of fruits and seeds and geographic features (latitude and longitude). Despite the altitude, seed morphology varied widely and irregularly, indicating that specific morphological parameters should be considered when selecting suitable germplasm of *P. pashia* from different location.

REFERENCES

Arya V, Gupta R and Gupta VK 2011. Pharmacognostic and

- phytochemical investigations on *Pyrus pashia* Buch. - Ham. ex D. Don stem bark. *Journal of Chemical Pharmaceutical Research* **3**(3): 447-456.
- Brenes-Gamboa S 2017. Parámetros de producción y calidad de los cultivos de banana FHIA-17, FHIA-25 y Yangambi. *Agronomía Mesoamericana* **28**(3): 719-733.
- Dinis LT, Peixoto F, Pinto T, Costa R, Bennett RN and Gomes-Laranjo J 2011. Study of morphological and phenological diversity in chestnut trees ('Judia' variety) as a function of temperature sum. *Environmental and Experimental Botany* **70**: 110-120.
- Kishor Arun, Verma SK, Brijwal Manoj, Kumar Anil, Attri BL, Narayan Raj and Debnath Sovan 2017. Evaluation of Genetic Diversity in Wild Pear (*Pyrus pashia*) under Kumaon Hills of Uttarakhand. *Environment & Ecology* **35**(1B): 524-529.
- Lone AF and Wafal BA 2000. Varietal diversity in the germplasm of cherries under cultivation in Kashmir. In: Khan MA, Farooq S. (eds). *Environmental Biodiversity and Conservation* 319-340.
- Maro LAC, Pio R, Guedes MNS, Abreu CMP and Moura PHA 2014. Environmental and genetic variation in the post-harvest quality of raspberries in subtropical areas in Brazil. *Acta Scientiarum Agronomy* **36**(3): 323-328.
- Mkwezalamba Idah, Munthali RV Chimuleke and Missanjo Edward 2015. Phenotypic Variation in Fruit Morphology among Provenances of *Sclerocarya birrea* (A. Rich.) Hochst. *International Journal of Forestry Research*, [Doi.org/10.1155/2015/735418](https://doi.org/10.1155/2015/735418)
- Perez LV and Melgarejo LM 2015. Photosynthetic performance and leaf water potential of gulupa (*Passiflora edulis* Sims, Passifloraceae) in the reproductive phase in three locations in the Colombian Andes. *Acta Biológica Colombiana* **20**(1): 183-194.
- Prakash Om, Chauhan AT and Kudachikar VB 2021a. Traditional uses, nutrition, phytochemistry and various pharmacological properties of Indian wild pear (Review), *International Journal of functional nutrition* **2**:9.
- Prakash Om, Selvi Karthika Moorthy, Vijayaraj Panneerselvam and Kudachikar VB 2021b. Lipidome, nutraceuticals and nutritional profiling of *Pyrus pashia* Buch-Ham ex D. Don (Kainth) seeds oil and its antioxidant potential. *Food chemistry* **338**.
- Shankar Uma and Synrem L Idaiarilin 2012. Variation in morphometric traits of fruits and seeds of *Prunus nepaulensis* Steud. in Meghalaya, India. *Tropical Ecology* **53**(3): 273-286.
- Silvanini Annalisa, Dall'Asta Chiara, Morrone Lucia, Cirlini Martina, Beghe Deborah, Fabbri Andrea, Ganini Tommaso 2014. Altitude effects on fruit morphology and flour composition of two chestnut cultivars. *Scientia Horticulturae* **176**: 311-318.
- Sindelar J 2002. Toward threatened forest tree species preservation on the example of crab apple (*Malus sylvestris* L.) and wild pear (*Pyrus pyraeaster* L. [Burgsdorf]). *Zprav Lesnik Vyzk* **47**: 199-203.
- Trad M, Gaaliche B, Renard CMGC and Mars M 2013. Inter and intra-tree variability in quality of figs. Influence of altitude leaf area and fruit position in the canopy. *Scientia Horticulturae* **162**: 49-54.
- Zafar G, Mir MS and Sofi AA 2004. Genetic divergence among apricot (*Prunus armeniaca* L.) genotypes of Kargil, Ladakh. *Indian Journal of Horticulture* **61**: 6-9.