SEED SOURCE VARIATION IN TREE MORPHOLOGY AND OIL QUALITY OF *Prunus armeniaca* L.

Thesis

by

SWATI
(F-2021-33-M)

submitted to

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MASTER OF SCIENCE
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(FOREST BIOLOGY AND TREE IMPROVEMENT)

DEPARTMENT OF TREE IMPROVEMENT AND GENETIC RESOURCES
COLLEGE OF FORESTRY

2023

FRONTISPIECE

WILD APRICOT (*Prunus armeniaca* L.)

FAMILY - ROSACEAE

DEPARTMENT OF TREE IMPROVEMENT AND GENETIC RESOURCES
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CERTIFICATE-I

This is to certify that the thesis entitled **"Seed source variation in tree morphology and oil quality of *Prunus armeniaca* L."**, submitted in partial fulfilment of the requirements for the award of degree of **Master of Science** in the discipline of **Forestry (Forest Biology and Tree Improvement)** of Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan (H.P.) – 173230 is a bonafide research work carried out by **Ms. Swati (F-2021-33-M)** daughter of Shri Satish Kumar under my supervision and that no part of this thesis has been submitted for any other degree or diploma.

The assistance and help received during the course of investigations have been fully acknowledged.

Place : Nauni, Solan
Dated:

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CERTIFICATE - II

This is to certify that the thesis entitled, **"Seed source variation in tree morphology and oil quality of *Prunus armeniaca* L."** submitted by **Ms. Swati (F-2021-33-M)** daughter of Shri Satish Kumar to Dr.Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan (H.P.) – 173230 India in partial fulfilment of the requirements for the degree of **Master of Science** in the discipline of **Forestry (Forest Biology and Tree Improvement)** has been approved by the Advisory Committee after the Viva-Voce examination of the student in collaboration with the External Examiner.

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असंशयं महाबाहो मनो दुर्निग्रहं चलम् |
अभ्यासेन तु कौन्तेय वैराग्येण च गृह्यते|| (Bhagavad Gita 6.35)

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No one can claim to be flawless since we are all human. Therefore, I would want to take this opportunity to apologize for any accidental mistakes or omissions that may have occurred while writing this acknowledgment.

Place: Nauni **(SWATI)**
Date:

CONTENTS

ABBREVIATIONS USED

%	:	Per cent
^{o}C	:	Degree centigrade
amsl	:	above mean sea level
ANOVA	:	Analysis of variance
CD	:	Critical Difference
CV	:	Co-efficient of Variation
cm^2	:	square centimeter
CRD	:	Completely Randomized Design
D.B.H	:	Diameter at breast height
df	:	Degree of freedom
FAO	:	Food and Agriculture Organization
e.g.	:	for example
et al.	:	co-workers
Fig	:	Figure
g	:	grams
i.e	:	that is
m	:	meters
mg	:	mili grams
ml	:	millilitres
MT	:	Metric Ton
N	:	North
NS	:	Non-Significant

RBD	:	Randomized Block Design
SIG	:	Significant
SD	:	Standard Deviation
SE (d)	:	Deviation from standard mean
SE (m)	:	Standard error mean
Viz.	:	*Videlicet* (namely)

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Chapter-1

INTRODUCTION

Dynamic lifestyle, ever increasing population and the need to search for healthy and complete source of nutrition for subsistence compelled researchers to explore available resources, unexplored flora and fauna and ethnobotanically important assets.

The decrease in cultivated land area due to natural and anthropogenic causes such as floods, saline soils, pollution, population growth, increasing wastelands threatens the country's food security. The problems are numerous and vary geographically. To combat this, researchers and local communities are shifting to locally important native species or following modern or conventional breeding programmes.

In this tech savvy era, it has become easier to stay updated. With the expansion of knowledge and increased awareness individuals have become more conscious of their consumption choices. There is a recent trend of reverting back to traditional food grains, ayurvedic medicines and herbs, locally grown crops and wild fruits. These trends provide insights of their potential market and trade. Most of the item prepared from a variety of wild fruits have a promising economic potential. The total output and net return are high, and engaging in the production of quality food and other products from wild edible fruits can help minimize the threat of unemployment (Maikhuri *et al.*,1994).

One such internationally revered and nationally identified as cardinal species is *Prunus armeniaca* L. commonly known as chulli. It belongs to the family Rosaceae and order Rosales. The name "apricot" is believed to have originated from the Spanish words "apricock" and "abrecox," which came from the Latin word "*praecox"* or "*praecoquus,"* meaning "early." This likely refers to the fruit's tendency to ripen earlier in the summer than plums (Anonymous, 2008).

Prunus armeniaca L. is a small tree, reaching a height of 8-12 m with a trunk diameter of up to 40 cm (16 in). It has a thick, spreading canopy and oval shaped leaves with a rounded base, a pointed apex, and a coarsely serrated border. The blooms have five white to pinkish petals and appear singly or in pairs in early spring. The blooming period and duration of apricot vary depending on the cultivar, tree age, vigour and weather conditions in a specific agroclimatic zone. For example, under Indian conditions, flowering period varies from 11-14 days in New Castle cultivar of apricot (Sud *et al*., 1979).

The fruit of *Prunus armeniaca* L. is a drupe that resembles a small peach. It ranges in colour from yellow to orange, often tinged red on the side that receives the most sun. The fruit's surface can be smooth or velvety with very short hair. The flesh (mesocarp) is juicy and has a flavor that can be either sweet or sour. It contains a single seed protected by a hard, stony shell, commonly referred to as a "stone." The shell is grainy and smooth, except for three ridges along one side (Anonymous, 2022).

Prunus armeniaca L., is a representative fruit tree species that has two forms: one that is domesticated and widely cultivated and the other that is native to the Tian Shan Mountains in Central Asia (Decroocq *et al.*, 2016). Since apricot is thought to have its origins in Armenia, it is also known as armeniaca. However, according to Vavilov (1951) apricot has three main centres of origin: Chinese centre, the Central Asiatic centre, and the Near-Eastern centre. These centres include regions in China, Uzbekistan, Tajikistan, Afghanistan, North west India and Pakistan, Asia Minor, Iran, Transcaucasia and Turkmenistan.

A study done by Liu *et al*. (2019) inferred that there were at least three domestication events that led to the cultivation of apricots in Europe, South Central Asia and China. The domestication event in China likely resulted from hybridization between wild populations from Central and Eastern Asia. The authors also proposed that human transport along the Silk roads and modern breeding techniques are the probable reasons of admixture among cultivated apricots.

When considering the worldwide distribution of apricots, Turkey, Uzbekistan, Italy, Algeria and Iran emerge as the top five apricot producing countries (FAOSTAT, 2020). A recent study forecasting apricot production from 2018 to 2025 indicated that these five leading countries would account for 66% of apricot production, while the remaining countries would contribute 34%. The USSR will be the country with the highest production in international collaboration (26%) followed by Turkey (20%), Italy (7%), Algeria (7%), and Iran (6%) (Uzundumlu *et al*., 2021).

In India, apricots are grown in Western Himalayas including regions such as Himachal Pradesh, Jammu and Kashmir, Ladakh and Uttarakhand (Devrari, 2016). Apricot cultivation in

India requires a fairly cold winter and moderately high temperatures in the spring and early summer (Guclu *et al*., 2006).

Total apricot production in India was slightly over 14 thousand metric tonnes in 2020, slightly lower than the previous year's production of 16.1 thousand metric tonnes (Anonymous, 2022). In Himachal Pradesh, the total production during 2019-2020 was 5514 MT. Among the districts, Solan ranked first with the total production of 1851 MT, followed by Sirmaur (1653 MT) and Shimla (539 MT) (Anonymous, 2019). Amongst temperate fruits apricot commands considerable importance in the economy of the state.

Regions such as Kinnaur, Spiti valley, Kullu, Shimla, Solan, and parts of Sirmaur and Mandi districts are known for its production. Large populations of wild apricot trees are referred to as 'Zardalu,' 'Chulli,' 'Chir', 'Sarha' or 'Chuari'. Generally, apricot fruits are composed of 11.7-22.7% stones, which yield about 30.7-33.7% kernels (Yadav, 2015). There are two common divisions of kernels: sweet kernelled and bitter kernelled, each with its own specific usage.

Chulli is given a GI tag that makes is economically very important species for the local people. It can also be used as rootstocks for different varieties of plum, peach and apricots. Dried chulli has a high market value and is consumed widely as a dry fruit. Apricot fruits contain various macronutrients, including water, energy, protein, fat, carbohydrates and dietary fiber. Every 100 g of apricots contains up to 13 mg of calcium, iron (0.39 mg), magnesium (10 mg), phosphorus (23 mg), potassium (259 mg), sodium (1 mg), zinc (0.20 mg), copper (0.078), manganese (0.077 mg), and selenium (0.1 µg). Dried apricots have higher mineral levels compared to fresh apricots, particularly selenium, which reaches 2.2 µg/100 g (Xi and Lei, 2020).

Wild apricots are primarily valued for their oil, which has a high nutritional value and commands a high market price. The oil derived from kernels is rich in essential fatty acids such as oleic acid and linoleic acid, as well as antioxidants and vitamins. A retrospective study conducted at the Beni Mellal regional oncology centre found that 39% of patients reported positive effects from conventional treatment with *Prunus armeniaca* L. seeds, with 100% of consumers reporting favourable outcomes, followed by *Curcuma longa* L. (Aboufaras *et al*., 2022).

The bitter kernels of apricots are used for oil extraction, while the sweet kernels are used as a substitute for almonds and culturally significant for making garlands, particularly during festivals in district Kinnaur. Wild apricot oil has a wide range of applications, including cosmetics, aromatherapies, massage, hair oil, joint pain relief and as well as for cooking purposes. It is widely renowned for its anti-aging, nourishing and anti- inflammatory benefits. Additionally, a decoction of apricot bark is used to soothe inflamed and irritated skin conditions (Chevallier, 1996).

One popular dish made from dried apricots and jaggery is "Chull-faanting," which is highly cherished by the residents, especially during the winter season. It is considered extremely nutritious and excellent source of energy. In some regions, apricot powder is mixed with roasted barley flour, known as "Chulphey," and consumed during travel or trekking (Tiwari, 2021). Locally made chulli liquor is also very popular among the residents. It is prized for its high quality and being an integral component of each function, it is extracted extensively. Furthermore, the leftover oilcakes are used as feed for cattles, and hard shell or seed coat is used as a substitute of wood by the villagers.

Thus, wild apricots are blessing to the people as nothing goes waste and being provided with Geographic Indication tag, it has created wide economic opportunities. However, due to being site-specific plant and lower conservation practice, wild apricots have become endangered species. The seedlings of wild apricots found in hilly regions are cold-hardy and disease resistant making them suitable for further improvement in breeding programs (Kashyap and Negi, 2006). Wild plant species offer a diverse supply of germplasm, which can contain desirable and sometimes unidentified beneficial genes. The high genetic variability allows for the production of progeny with more adaptive traits. Therefore, to optimize production and enhance social and economic well-being, it is essential to identify superior phenotypes, study their growth in different altitudinal ranges, and evaluate the quality of fruit, oil and other parameters.

Chulli holds enormous market potential both domestically and internationally. Therefore, it is crucial to increase its production sustainably to meet future demands, generate employment and serve as a source of revenue. Considering the conservation status of wild apricots, it is necessary to conduct a study on **"Seed source variation in tree morphology and oil quality of *Prunus armeniaca* L."** at different altitudinal zones. The present investigation was undertaken under the following objectives:

Objectives

1. To study the seed source variation in tree morphological characteristics at altitudinal gradient in *Prunus armeniaca* L.

2. To study altitudinal variation in fruit, seed and oil quality attributes of *Prunus armeniaca* L. in different seed sources.

Chapter-2

REVIEW OF LITERATURE

The natural variations as a result of continuous environmental selection have resulted in creation of broad genetic diversity which can lead to the chances of selecting superior genotypes. Successful breeding programmes can be ensured by making the correct genotype selection. Therefore, it becomes essential to explore these untapped resources.

The present investigation **"Seed source variation in tree morphology and oil quality of *Prunus armeniaca* L."** was aimed to assess the variation in morphometric traits, flowering season, leaf, fruit, seed, physical and chemical characteristics of oil along the altitudinal range in wild apricot. The pertinent literature collected on various aspects of study has been reviewed under the following heads:

2.1 Morphometric traits
2.2 Foliage characters
2.3 Flower characters
2.4 Fruit characters
2.5 Variation in oil content
2.6 Physico-chemical characteristics of kernel oil

2.1 MORPHOMETRIC TRAITS

Plant breeders place high emphasis on morphological and agronomic trait-based characterization of germplasm since it is the first step in starting breeding programmes and identifying superior accessions to diversify local output (Pereira *et al*., 2012). Morphometric traits are important as they help to evaluate the growth and development of a tree easily. The following is a review of the literature on morphometric traits:

Sharma (1991) evaluated apricot and its wild relatives under Kandaghat, Solan conditions of Himachal Pradesh. He found that trees were of spreading growth habit with average trunk girth of 55.59 cm. The bark had a reddish-brown colour.

Sankhyan *et al*. (2004) studied the differences in morphometric traits among the many seabuckthorn species found in the frigid deserts of H.P. Significant differences between species were found in the branch, thorn, leaf, and fruit features. The age of nine years was found to be the ideal age for fruits harvesting after which the productivity starts declining.

Yilmaz *et al*. (2012) studied 93 apricot accessions and one apricot X plum hybrid which were collected from different regions in Turkey. The results showed that tree habitus of apricot has been clustered under the UPOV (International Union for the Protection of New Varieties of Plants) classes of "Upright to spreading" (25.5%), "Spreading" (41.5%) and "drooping" (13.8%). The Turkish apricot fruits mostly have a "Strong branching degree" (89.4%).

Li *et al*. (2013) studied the genetic variability of 14 wild apricots (*Prunus armeniaca* L.) using morphological analysis and ISSR (Inter Simple Sequence Repeat Markers). Ten morphological characters revealed a high level of variation particularly in fruit number, fruit weight, seed weight and tree height.

Kumar *et al*. (2015) studied 49 wild apricots (*Prunus armeniaca* L.) genotypes collected from NBPGR, New Delhi and North Western Himalayas. The findings showed that all genotypes varied (60-1957.33) significantly in relation to number of fruits per plant which actually enhances economic output. Maximum number of fruits/plants was recorded in Afghani (1957.33) followed by CITH-AP-1(1868.33) and CITH-AP-3(1656.67) the values were least for Viva Gold (60).

The evaluation of the genetic variability of 22 wild apricots genotypes by Wani and Mughal (2017) in Kashmir and Ladakh region revealed that tree height varied from 5m (CPT 74/075) -15m (CPT 64/075). Trunk girth was reported to be maximum 145 cm in CPT 20/075 and minimum 42 cm in CPT 74/075.

Chauhan (2018) assessed magnitude of variability in wild apricots growing in district Kinnaur and Shimla. Marked trees were observed to be upright to spreading in growth habit whereas, trunk girth in Shimla ranged between 18.72-78.84 cm and in Kinnaur it ranged between 35.10-106.17 cm. Yield and yield efficiency were ranged between 36.00-54.00 kg/tree and 38.00-57.00 kg/tree and 0.09-1.47 kg/cm^2 and 0.05-0.45 kg/cm^2 in Shimla and Kinnaur, respectively.

Aukta (2022) conducted a study about *Quercus floribunda* which revealed that morphometric traits varied significantly among nine study sites for the traits eg., tree height, DBH, clean bole height, crown length, crown width, number of primary branches, leaf width and leaf area. The only trait which exhibited non-significant variations among the sites was leaf length. Significant variations were also observed in two diameter classes for same parameters.

2.2 FOLIAGE CHARACTERS

In order to identify and distinguish the species, leaf characteristics are significant traits. According to a study by Eisensmith *et al*. (1980), the number of leaves on spur and terminal shoots were strongly connected with degree-day. The study used a model that predicts the emergence of terminal and spur leaves on sour cherry (*Prunus cerasus* L.cv. Montmorency) trees. It also showed that, regardless of location, terminal buds set for spur and terminal shoots, respectively, about 350- and 380-degree days after the first leaf appeared. Until full leaf growth, leaf size rose linearly with degree day accumulation and at maturity terminal leaves were about 50% larger in area than spur leaves.

Sharma (1994) studied the variation in local apricots growing in district Kinnaur of Himachal Pradesh. The leaf area varied from 8.2-39.9 cm^2, whereas commercial cultivars grown in the same region had 35.4 -43.9 cm^2 leaf area.

Rana and Verma (2011) studied the foliar traits of various accessions of wild apricots. The leaves of the wild apricot were large, cordate, dark green, petiolated, alternating, with reticulate pinnate venation, and had serrate margins. They were 5–6 cm long and 5–6 cm wide.

At the Seed and Plant Improvement Research Institute of Karaj (Iran) Kamrani and Bouzari (2013) studied some Iranian apricots and their leaf characteristics. The leaf blades varied in length from 6.17 to 8.92 mm and in width from 3.52 to 7.9 mm. Petiole length ranged from minimum (2.5 mm) in Shahrood 49 to maximum (5.17 mm) in BN-KB 31.

Krichen *et al*. (2014) evaluated the variation in morphological traits across 112 apricot accessions in Tunisian apricot germplasm. According to their research, leaf width varied from 4.09 cm to 9.41 cm and leaf length ranged from 4.28 cm to 9.33 cm. The length and thickness of the leaf petiole varied from 1.69 to 4.78 cm and 0.78 to 2.19 cm, respectively.

Wani (2017) conducted a study on floral biology of *Prunus armeniaca* L. Maximum leaf emergence was recorded in diameter class 15-20 cm and minimum in diameter class 0-5 cm. The study also showed that maximum number of fully expanded leaves were observed on northern direction for diameter class (10-15cm) and minimum number of fully expanded leaves were recorded on eastern direction.

Yaman and Turan (2021) conducted a study on 9 different apricot varieties, examining the leaf and fruit properties. The study's findings showed that there was significant diversity in the leaf parameters. Leaf width data ranged from 46.42 mm to 75.02 mm, while leaf length values ranged from 64.77 mm to 82.79 mm. The values for both criteria were lowest and greatest for the Castle Bright and SEO types, respectively. Like leaf breadth and length, Seo was the most notable variety in terms of petiole length, measuring 35.99 mm. Palstein cultivar has the smallest petiole measurement at 21.54 mm.

Zargar *et al*. (2021) investigated 68 apricot accessions collected from Jamu and Kashmir, India. Among all the accessions, leaf length ranged from 4.86 to 10.65 cm with an average of 7.37 cm, whereas leaf width varied from 3.65 to 8.81 cm with an average of 5.97 cm. Similarly, the leaf area ranged from 12.61 to 68.05 cm^2. In addition, petiole length ranged from 1.26 to 4.54 cm.

2.3 FLOWER CHARACTERS

The flowering period plays a vital role in the cultivation of commercial fruit trees as it is crucial to prevent early flowering varieties from being harmed by late frosts that negatively impact production. The assessment of this intricate characteristic requires a considerable amount of time due to the extended period of immaturity in trees and the impact of external factors that affect genetic manifestation on an annual basis. The study of flowering time necessitates several years of analysis to attain a statistically significant outcome (Del Cueto and Dicenta, 2014). The following literature has been reviewed in light of the importance of the blooming time and traits.

Sharma (1991) examined the differences in local apricots growing in Kandaghat, Solan, H.P., and reported that flowering time was from March 16 to March 28; average flower colour was white with a pink tinge, and diameter was 2.90 cm. 1.24 cm and 1.13 cm, respectively, were the length and breadth of the petals.

Nuzzo *et al*. (1999) studied an apricot cultivar "Tirynthos," and it was discovered that light had a favourable impact on flower bud number and fruit set per fruiting branch.

Szalay and Szabo (1999) stated that apricot flowering begins at a different time every year, varying by approximately a month, although it often starts around the middle of April, or in nations with a warmer temperature.

Guirao *et al*. (2000) examined fourteen apricot cultivars and it was discovered that flowering began in Palstein, Lambertin no.1, Beliana and Modesto between 26th February and ^{2nd} March, while in other cultivars like Hargrand, Beato, Pepito del Rubio, Bebeco, Carrascal, Moniqui, Bulida, and Guillermos, the flower initiation period varied between 7th March and 10th March and in Bergeron and Stark Early Orange, it was between 15th March- 18th March.

Time and duration of flowering in different apricot cultivars in the mid -hills of Uttaranchal was observed by Kaur (2004). The results indicated that cultivar New Castle bloomed earliest (23rd Feb.) while Moorepark showed delayed blooming (6th March). The cultivar Turkey had the longest flowering duration (22 days).

Mratinic *et al*. (2011) evaluated the output of 19 apricot genotypes grown as seedlings in FYR Macedonia over the course of two years (2003 and 2004). Their flowering period was contrasted with Hungarian Best. Flowering started two days earlier in both years in all genotypes than in the control. In both years, flowering started on March 13th and March 20th in T-9/03 and on March 24 and March 28 in N-2/03. In 2003 and 2004, the lengths of flowering were 8–13 and 7–12 days, respectively.

Polat and Caliskan (2013) studied different flowering stages of apricot cultivars under sub-tropical climatic conditions and found that the earliest maturing cultivars were "Beliana" and "Feriana" (maturing on May 20th), while "Precoce de Colomer" and "Macar" (ripening on June 7th) were the latest.

Bartolini *et al*. (2013) studied the effect of summer shading on flower bud morphogenesis in apricot and as evidenced by uneven floral morphogenesis and xylogenesis, it was found that shadings had a deleterious influence on the progression of flower bud development. A greater bud drops just prior to blooming demonstrated the irregular growth of flower buds from shade trees, resulting in a sensible reduction in flowering and fruit set rates.

Kumar *et al*. (2016) studied the productivity of various apricot genotypes from 2010–11 to 2014–15 at ICAR's Central Institute of Temperate Horticulture in Srinagar. They stated that Erani had the earliest first blossom opening on March 25th while CITH-AP-02 and

Chinese Apricot had the latest on March 29^{th}. Full bloom occurred between March 3^{rd} and March 7^{th}. Flowering lasted a maximum of 12 days in Erani and CITH-AP-09 and a minimum of 7 days in CITH-AP-03.

Angmo *et al*. (2017) studied apricot genotypes in Ladakh and found that they showed a large variation in blooming times. White seed coat genotypes bloom before brown seed coat genotypes. Apricots of Ladakh bloom in late April to late May (111–144 JD).

Chauhan (2018) studied time and season of flowering in genotypes of district Shimla and Kinnaur and found that initiation of flowering in district Shimla was observed from 4th week of February and it extended up to 1st week of April. Whereas, in district Kinnaur it was from 2nd week of March to 3rd week of April. Full bloom in district Shimla was observed from 2^{nd} week of March and extended up to 3^{rd} week of April. In district Kinnaur full bloom was observed from 4^{th} week of March to 4^{th} week of April.

A study on the flowering penology in wild apricot by Avilekh (2019) suggested that flowering phenology is substantially influenced by altitude. There is a linear association (R^2=0.914) between the timing of flowering and the increase in height. Flowering was postponed by 3.3 days for every 100 m of height increase. Flowering dates varied significantly, from 104.0 Julian days at 3006 m to 116 Julian days at 3346 m above sea level.

Peavey *et al*. (2020) studied the effect of canopy height and bud light exposure on early stages of flower development in *Prunus persica* (L.) Batsch and found that there is a favourable correlation between the amount of sunshine and floral initiation and differentiation, as seen by the improved transition to floral nodes within these zones and the better daily light penetration at higher canopy heights.

2.4 FRUIT CHARACTERS

2.4.1 Physical characters

The physical characteristics of the fruit must be taken into account for the industry's mechanisation and value addition (Demir and Kalyoncu, 2003). The firmness, appearance, and flavour of an apricot fruit all contribute to its overall excellence. This suggests that improving the physical characteristics and flavour of the fruits, which may be accomplished by propagating the finest cultivars-should be the major focus of efforts to boost the economy of the apricot market.

Sofi *et al*. (2001) in their study found that apricot cultivars in Ladakh varied in average fruit weight from 19.07 g to 7.06 to 40.60 g, average fruit length from 2.62 to 4.95 cm, and average fruit diameter from 1.97 to 4.65 cm.

Dwivedi *et al*. (2003) surveyed the cold, dry Ladakh region and collected wild apricot fruit samples. The fruits' physicochemical characteristics were examined. The fruit's weight ranged from 8.7 to 35.5 g and its length, breadth and thickness were found to be between 26.5 and 44.0 mm, 24.9 and 41.8 mm and 22.9 and 38.8 mm, respectively. Pulp weight varied between 2.5 to 31.2 g.

Vachun (2003) evaluated weight, diameter, height and width of fruits in 21 apricot cultivars. The results showed that the mean values for fruit weight, diameter, height and width were 42.44±4.76 g, 39.40±1.77 mm, 23.60±1.75 mm, 41.99±1.77 mm, respectively.

Asma and Ozturk (2005) examined 128 apricot genotypes at Malatya Fruit Research Institute in Turkey. According to their analysis fruit sizes ranged from 17 to 68 g, with most genotypes having yellow fruit skin and very few having orange. The tint of flesh ranged from yellow to cream.

Sharma *et al*. (2005) in their study found that maximum fruit length (38.14 cm) and breadth (36.02 cm) were measured in Australian apricot cultivar fruits, which were much larger than those of all other cultivars but on level with Lari selections in terms of fruit breadth. Additionally, they noticed that the Australian cultivar's maximum fruit weight (30.0 g) was comparable to Charmagz but much larger than the remainder of the cultivars under evaluation.

Ruiz *et al*. (2007) studied 43 apricot cultivars for two years in a row and selections cultivated in a Mediterranean climate were investigated for fruit quality features. Physical characteristics (such as weight, size, flesh and skin colour, blush percentage, firmness, and dry matter percentage), chemical characteristics (such as total soluble solids content and acidity), and sensory characteristics (such as attractiveness, flavour, aroma, and texture) were all assessed. The set of analysed apricot genotypes showed great variability, and significant variations in all examined quality parameters were discovered between them. Some pomological parameters, including as harvest date, flesh colour, fruit weight, hardness, and soluble solids content, showed year-to-year variability.

Haciseferogullari *et al*. (2007) studied physical and chemical characteristics of six samples of apricot fruits (*Prunus armeniaca* L.). The measurements of the length, mass, geometric mean diameter, and sphericity of six distinct apricot fruits ranged from 29.26 mm to 46.98 mm, 14.35 g to 41.48 g, 28.99 mm to 41.15 mm, and 0.876-0.991%, respectively. Investigations were also conducted on the dry matter, ash, crude protein, crude fibre, pH, acidity, water soluble extract, and mineral contents of fully matured fruits. Crude protein, crude oil, crude fibre, ash, water-soluble extract, alcohol-soluble extract, dry matter, pH, and acidity contents of all fruits were determined to be between 2.8% and 4.29%, 0.55-3.12%, 0.77-2.41%, 2.72-5.34%, 48.3-74.7%, 19.9-25.9%, 16.73-22.63%, 4.16-5.23%, and 0.17-0.79 (% malic), respectively. All fruits had high levels of potassium (20 791-33 364), phosphorus (1436.49-2643.42), calcium (843.28-1896.53), sodium (773.95-1129.74 ppm), and magnesium (402.82-765.62 ppm).

Jannatizadeh *et al*. (2008) studied some Iranian apricot fruits *i.e*., Shams, Sefide Damavand, Nakhjavan, Shahroud-8, Djahangiri and Gheysi-2, which were obtained from Agricultural Research Centre of Shahroud, Iran. The samples were dried at 78^{o} Celsius for 48 hours. The results obtained showed that the length of an apricot fruit ranged from 35.6 to 70.8 mm, with a CV (coefficient of variation) of 8.68%. The fruit's breadth and thickness varied from 32.2 to 50.4, from 28.9 to 49.1, with CVs of 9.69% and 10.48%, respectively. The geometric mean diameter had a CV of 8.64% and varied from 32.98 to 50.84. The criterion predicted area of each apricot cultivar produced varied means, ranging from 1117.34 to 1643.81 mm^2. Djahangiri and Nakhjavan cultivars had the largest and lowest volume and mass, with means of 49.99 cm^3 and 49.69 g and 27.39 cm^3 and 27.55 g, respectively.

Drogoudi *et al*. (2008) studied physical and chemical characteristics of 29 apricot cultivars of Greek and American origin and found that the hybrid 309/99 (38.5 g) produced the lightest fruit, while the cultivars Bebecou (105.3 g) and Nostos (91.3 g) produced the heaviest. A weak positive correlation was found between fruit weight and harvest date (r=0.500).

Milosevic *et al*. (2010) studied fruit quality of promising apricot in Central Serbia region and found that the weight of the fruit varied from 41.34 $\pm$ 0.8 g to 81.50 $\pm$ 4.1 g on average, with T-5 being the only genotype to have fruit that weighed less than Hungarian Best (49.07$\pm$2.2 g). Fruit weight exceeded 60.0 g in more than 78.5% of genotypes. Stone weight varied from 2.98$\pm$0.4 (T-5) to 5.01$\pm$0.8 g (T-1), with 3.37 $\pm$ 0.6 g in Hungarian Best.

Lo Bianco *et al*. (2010) in their trial studied 16 apricot cultivars, which included five early ripening, 9 intermediate ripening and two late ripening. Average fruit weight and diameter ranged widely, from 32.9 to 77.4 g and 37 to 50 mm, respectively. Early cultivars showed above-average fruit size (weight and diameter) for Silvercot and below-average fruit size for Pinkot. Orange Red and Palummella exhibited below-average fruit size (all below 40 g), Bulida, Alba, and Fracasso had above-average fruit size (all over 60 g). The only late cultivar with below-average fruit size was Pellecchiella.

An examination of the physico-chemical properties of wild apricot seedling trees from the Kinnaur district of Himachal Pradesh by Kumar and Bhan (2010) suggested that the fruit size, weight, and pulp recovery were greater in the genotypes Le-02, Le-06, and Le-26. Le-06 had the heaviest fruit (24.20 g) and the lightest (5.70 g); La-02 had the largest fruit (37.51 mm), breadth (39.28 mm), and thickness (38.76 mm); and Le-22 had the smallest fruit (22.04 mm), breadth (20.08 mm), and thickness (18.87 mm). Le-06 recorded the highest pulp recovery (94.65%), followed by Yg-03 (92.76%), while Le-26 recorded the lowest (81.31%).

Malik *et al*. (2010) conducted research on the genetic diversity of wild apricots in India's high-altitude northwest Himalayas. Tachu had the highest average fruit weight (19.80 g), followed by Rakchey Karpo (19.61 g), while Laila Tilli had the lowest average fruit weight (9.36 g), followed by Khakhe (9.89 g). Margulam had the longest fruits (3.66 cm), followed by Rakchey Karpo (3.48 cm), while Khakhe and Narmo had the shortest fruits (2.39 cm and 2.52 cm, respectively). Rakchey Karpo had the widest fruit (3.24 cm), followed by Lodi, while Khakhe had the narrowest fruit (2.25 cm), followed by Laila Tilli (2.33 cm). Most cultivars have fruit with a creamy-light yellow to yellow fruit ground colour and a light orange to deep orange fruit overcolour. Fruit shapes were elliptical in four genotypes, round in six genotypes, ovate in nine genotypes, and oblong in nine genotypes. Folk varieties of wild apricots have a variety of fruit tastes, from extremely sweet to sour.

Padder (2011), studied about fruits of apricot and the investigation revealed that fruit shape, size and density at harvest varied significantly. Fruit length, fruit diameter, fruit weight and fruit volume varied from 30.63 to 37.06mm, 29.00 to 38.19mm, 24.00 to 34.50 g and 22.96 to 33.82 cm^3 respectively. Fruit shape varied from flattish-round to oval or heart shaped and density from highest of 1.04 g/cm^3 in cultivar 'Quetta' to lowest value of 0.96 g/cm^3 'Charmagz'.

A trial conducted by Roussos *et al*. (2011) during 2009–2010 gave insights into the effect of thinning on fruit quality characteristics. The results showed that yield efficiency was low under heavy thinning, whereas fruit thinning significantly increased the fruit weight in two cultivars, *i.e*., Nafsika and Niove. Fruit diameter due to heavy thinning increased only in Nafsika, whereas fruit length remained unaffected. Pulp weight increased under heavy thinning. Fruit colour characteristics did not show any notable variations as a result of different treatments.

Gupta *et al*. (2012) investigated the physico-chemical characteristics of wild apricots chosen from several regions in Himachal Pradesh. In the Mandi and Shimla districts of Himachal Pradesh, the average fruit weight of genotypes chosen from various regions varied from 8 to 15 g, while the average pulp weight ranged from 6.2 to 13.2 g.

At the Division of Fruit Science, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shalimar, Srinagar, Bhat *et al*. (2013) examined the physical and chemical characteristics of six apricot cultivars, including Australian Sweet, Kaisha, Conan Italy, Roundel, Quetta, and Charmagz. Conan Italy was the cultivar with the highest documented fruit length (37.06 mm) and diameter (38.19 mm). Australian Sweet, Charmagz, and Roundel were oval- or heart-shaped fruits, whereas Conan Italy and Kaisha were roundish but rather flat. Quetta had the smallest fruit weight (24.00 g), whereas Conian, Italy, had the largest (35.5 g).

Onal (2014) assessed and categorised the wild apricot materials gathered in Turkey's Southeast Anatolia Region. They noted that the weight of the fruit varied from 15.4 (2243) to 44.6 g (2239). Three genotypes had cream-colored skin, two had light yellow skin, nine had yellow skin, five had orange skin, and four had red skin. Yellow to dark orange were the hues of the flesh. The range of the flesh's firmness was tender to firm. Approximately 73% of the fruits were firm, with the remainder fruits being soft or moderately firm.

Kumar *et al*. (2015) studied forty-nine apricot (*Prunus armeniaca* L.) genotypes collected from NBPGR, New Delhi, and North West Himalayan region of India. They found that fruit length and diameter ranged from 31.47 mm to 50.52 mm and 31.68 mm to 53.89 mm, respectively; the maximum length was found in Erani (49.74 mm), followed by CITH-AP 1 (49), and the minimum length was found in CITH-AP 36 (31.47 mm); meanwhile, the maximum fruit diameter was found in CITH-AP 1 (53.89 mm), followed by CITH-AP 2 (53.71mm).

Angmo *et al*. (2017) studied sixty-five apricot genotypes of trans-Himalayan Ladakh region for phenological and pomological traits. Fruit averaged 21.6 $\pm$ 9.3 g in weight, with a weight range of 7.1 to 53.7 g. Fruit weights from all other genotypes were calculated to be less than 40.0 g, with the exception of two genotypes that weigh more than 40.0 g. In Ladakh, genotypes with white seed coats (Group-III) exhibited noticeably larger seeds and kernels than genotypes with brown seed coats.

A study by Naryal *et al*. (2019) intends to assess how altitude affects the sugar profile and content of dried apricots. Fruits from 108 genotypes were gathered in trans-Himalaya at six sites between 3006 and 3346 metres above sea level. The fruit's sugar content was significantly impacted by the area's elevation. Total sugar concentrations were found to increase linearly with elevation (R^2 = 0.877, $p \leq 0.01$). Total sugar rose by 64.8 mg/g DW every 100 m of elevation gain. The amount of sucrose in the total sugar was the largest (57.8%), followed by glucose (19.4%), fructose (14.3%), and sorbitol (8.4%).

Rezaei *et al*. (2020) in their study determined that fruit sizes varied in length from 40.0 mm to 62.0 mm and ranged in weight from 35.70 g to 69.90 g.

Yaman and Turan (2021) in their study detected wide variations among the fruit parameters. Fruit length varied between 33.08mm - 49.89 mm. In terms of fruit width, the values ranged between 31.40 mm-43.50 mm. The Seo and Rakowsky cultivar outperformed other cultivars in terms of fruit length and fruit width.

An evaluation of six commercial apricot genotypes cultivated in India for different nutritional and nutraceutical traits by Alajil *et al*. (2021) showed that the varieties studied were CITH-A-1, CITH-A-2, CITH-A-3, Gold cot, Roxana and Shakarpara. The results showed that the fruit and stone weights varied from 20.13 to 38.18 g and 1.62 to 2.96 g, respectively. The genotype 'Gold Cot' had the most weight of fruit and stones, whereas 'Shakarpara' had the least.

Lachkar *et al*. (2021) assessed the organic fruit quality of local and introduced apricot cultivars in Tunisia. For each of the physical characteristics of the fruit (weight, height, lateral width, ventral width, proportion of flesh and stone), a very significant difference ($p \leq 0.01$) was found between the several apricot varieties. The weight of organic fruit ranged between 32.44 and 41.64 g, where 'Oud Aouicha' produced the biggest fruits and 'Ninfa' were the smallest ones. The values for lateral width varied from 31.30 mm ('Ninfa') to 40.50 mm ('Oud Aouicha'). The maximum value for ventral breadth (thickness) of organic fruit was discovered in ‘Oud Aouicha’ and ‘Oud Hmida’. 'Ninfa' was found to have the lowest ventral breadth (thickness) of all organic fruits. The longest fruits were of the variety "Mogador" (38.61 mm).

Wu *et al*. (2021) studied high-quality, very early-ripening prunus cultivars called “Jinyu” and “jinhe”. The fruit of "Jinyu" is oval, with an average weight of 55.4±1.1 g and a maximum weight of 75.0 g, according to observations performed over three years (2015–17). The values of average stone weight were 2.11 ± 0.06 g, comprising up 3.8% of the fruit weight. The fruit has typical sizes of 4.89±0.55 cm in the vertical direction, 4.47±0.48 cm in the transverse direction, and 5.02±0.62 cm in the lateral direction. The fruit features an elongated, flat top, shallow but noticeable sutures, and unevenly shaped flesh. Mature fruit skin is orange in colour, with no additional colouring. The fruit has bright and clean surface. The flesh is orange in colour and has a delicate texture with less fibre and more juice. In contrast, the fruit of "Jinhe" was spherical, weighing a maximum of 115.0 g and an average of 66.0 ±1.4 g. It has average diameters of 4.81±0.39 cm in the vertical direction, 4.80±0.52 cm in the horizontal direction, and 4.85±0.33 cm in the lateral direction. On the sunny side, a little crimson blush is added to the fruit's yellow base colour. Fruit flesh has a bright colour and a smooth, delicate texture. The flesh is delicious, low in fibre, and has a rich fruit scent.

Mashhadi and Khadivi (2022) studied different apricot genotypes and concluded that fruit colour varied strongly. The colors noted were white, yellow, yellow green, light orange, orange and dark orange. Fruit dimensions were 34.99–38.20 mm in length, 31.32–36.88 mm in width, 27.37–33.99 g in weight, and 11.16–13.47 mm in fruit flesh thickness.

Cirillo *et al*. (2023) analyzed 12 Vesuvian apricot accessions for their chemical-physical and nutraceutical properties. They were namely ‘Vincenzo e Maria’, ‘Fracasso’, ‘Piciona’, ‘Boccuccia di Eboli’, ‘Scassulillo grande’, ‘Palummella’,’ Paolona’, ‘Puscia’, ‘Panzona’, ‘Pellecchiella’, ‘Portici 2’, and ‘Vitillo’. The investigation of fruit weight revealed that accession 'VI' had the most weight 88.33 g, while accessions 'BE' and 'PE' had the lightest weights 36.98 g and 42.37 g, respectively.

2.4.2 Stone characters

Dwivedi *et al*. (2003) collected fruit samples from the cold, arid Ladakh area and evaluated the fruits' physico-chemical characters. Stone weight was discovered to be between 1.0 and 20.0 g, while the ratio of pulp to stone was between 1.5 and 17.86. Kernel oil recovery ranged from 27.0 to 45.0 percent, while the measured average kernel weight was between 0.3 and 0.5 g.

21 apricot varieties' stone weight, diameter, height, and breadth were assessed by Vachun (2003). The findings of the study showed that the mean value for stone weight was 2.96±0.25 g, for stone height it was 26.35 ± 0.89 mm. The values for stone width and diameter were 20.29 ± 0.72 mm, 11.93 ± 0.49 mm, respectively.

Alpaslan and Hayta (2006) in their study concluded that apricot kernels typically measure 14.0–19.17 mm in length, 9.99–10.20 mm in width, 3.3-6.27 mm in thickness, 9.89–10.31 mm in geometric mean diameter, and 0.47–0.48 g in mass. The weight range for 100 kernels was 28.7–65.1 g.

In the districts of Shimla and Kinnaur, Kashyap and Negi (2006) investigated the biodiversity of wild apricots. For 16 distinct fruit traits, a broad range of variability was observed in order to determine the degree of divergence from various vegetative and pomological characters. Tree No. 34 had the stones with the highest weight (1.99 g) and volume (1840 ml) and Tree No. 24 has the largest kernel weight (0.74 g) and kernel percentage (84.65 %).

According to Rana *et al*. (2007), the wild apricot's stone weight varied from 1.0 to 20.0 g, its kernel weight was between 0.3 and 0.5 g, and its kernel yielded excellent oil in the range of 40% to 70%.

Milosevic *et al*. (2010) stated that the weights of the stones varied between 2.98 and 5.01 g. Stone weight was greatest in T-1 genotype (5.01±0.8g) followed by T-6 (4.08±0.7g) whereas lowest value was recorded for T-5 (2.98±0.4g).

A study conducted by Kan *et al*. (2014) revealed that the seeds of *Prunus armeniaca* L. generally produce 27% of the kernels, while the kernels produce around 44.3% of the oil and due to the presence of the cyanogenic glycoside amygdalin, kernels have a bitter taste.

Kumar *et al*. (2015) in their study found that the germplasm tested had substantial variations in stone length (21.03 - 28.54 mm) stone diameter (17.73-24.36 mm) and stone weight (2.17-4.34 g). The genotype CITH-AP 2 had the largest stone diameter and weight (24.36 and 4.34 mm) followed by CITH-AP 1 (23.69 and 3.71 mm) while the genotype CITH-AP 24 had the smallest stone diameter and weight (17.73 and 2.17 mm). Also, the ranges for kernel weight and diameter were 0.78–1.72 and 10.79–15.07, respectively. Afghani recorded the lowest kernel weight (1.78 g) while Erani recorded the most (15.07 g) and CITH-AP 6 recorded the highest (10.79 g) in terms of kernel diameter. The largest kernel length (20.61) and the smallest kernel length (12.96) were found in CITH-AP 25 and CITH-AP 6, respectively.

Arora (2018) conducted research and the findings revealed highest stone weight for genotypes in Champawat and Narkanda (1.32g) while the lowest values were attributed to genotypes in Kanasar (1.28g). Kernel length raged from 19.65mm to 20.70mm while the kernel width was recorded maximum for Thatyur(16.09mm) and minimum for Narkanda (14.75mm).

Kumar and Bhan (2020) studied 167 selected wild apricot trees for their stone and kernel characteristics. The results revealed that the stone dimensions ranged from 14.64 to 26.48 mm in length, 12.26 to 21.49 mm in width, and 8.63 to 14.65 mm in thickness. Stone and kernel weight ranged between 66.60–295.10 g and 18.20–68.18 g, respectively.

Rezaei *et al*. (2020) in their study found that stone length and breadth values varied from 16.60 to 37.50 mm and 10.00 to 23.00 mm, respectively and stone weight was between 6 and 5.5 g.

Yaman and Turan (2021) found significant variations between varieties in the values of stone weight, stone length and stone width. The greatest statistical figures in terms of stone weight values were obtained by the Seo and Rakowsy cultivars, each with a weight of 3.99 and 4.21 g, respectively. The Castle Bright variety has the lowest stone weight 1.93 g. Stone width values for the cultivars ranged from 7.83 to 16.05 mm, whereas stone length values varied between 15.50 and 27.44 mm.

Mashhadiet and Khadivi (2022) studied seeds of apricot and found that stone dimensions ranged from 28.13 to 30.92 mm in length, 20.65 to 24.37 mm in breadth, 10.40 to 11.78 mm in thickness and 1.48 to 2.71 g in weight. Kernel dimensions were as follows: 18.27–20.19 mm in length, 13.62–17.51 mm in width, 6.6–7.41 mm in thickness and 0.7–0.81 g in weight. The flavour of the kernel was bitter in 17 genotypes, moderate in 24 genotypes and sweet in 7.

Pawar *et al*. (2023) studied the effect of moisture content on engineering characteristics of apricot (*Prunus armeniaca* L.) kernel. This study analyses the relationships between the engineering properties of apricot kernels with varied moisture contents, from 5.66% to 26.47% wet basis. Engineered properties like linear dimension length (13.26-14.47 mm), breadth (8.69-9.97 mm), thickness (5.36-6.50 mm), arithmetic mean diameter (9.11-10.32 mm), geometric mean diameter (8.48-9.77 mm), surface area (227.91-302.68 mm^2), projected area (91.99-114.95 mm^2), 1000 kernel mass (0.317-0.403 kg), true density (881.23-973) and porosity (33.74%–43.68%) increased with increase in moisture content.

2.5 VARIATION IN OIL CONTENT

Parmar *et al*. (1992) reported an oil yield of 48.6% in wild apricots kernels found in district Kinnaur and Chamba of Himachal Pradesh.

Kodad and Socias I Company (2008) studied variation on oil content of *Prunus amygdalus* Batsch. Oil content was constant throughout the course of the two years, ranging from 48% to 67% of the total dry weight of the kernel. Oil content readings in 2002 varied from 50.7% to 67.5%, with a mean value of 57.9% for all genotypes. In 2003, it ranged from 48.3% to 65%, with a mean of 58.15%.

Matthaus and Ozcan (2009) investigated the oil content, fatty acid composition, and tocopherol composition of kernels from 15 *Prunus species* cultivars in Turkey. The oil content in the samples ranged from 46.3% (*Prunus armeniaca* [Doganhisar-Konya]) to 55.5% (*Prunus amygdalus* [Sekerpare, GülnarMersin]) on a dry weight basis (d.b.%). The oil content of *Prunus armeniaca* was generally higher than that of the other Prunus species' kernels, but overall, there was not much variation in oil content between different species, let alone within them (*Prunus amygdalus* [47.1-55.5%]; *Prunus armeniaca* [47.6-55.4%]). This demonstrates that the oil content is a characteristic that is mostly independent of the varieties studied.

Gupta and Sharma (2009) evaluated the suitability of apricot stone for oil extraction and its suitability for both edible and pharmaceutical purposes at a semi- pilot scale. Wild bitter apricot kernel oil yield, as determined by solvent extraction, varied from 45.6-46.3%. The average amount of oil from apricot kernels extracted using a table oil expeller was between 37.5 and 38.5%, whereas the average amounts of oil recovered using a baby oil expeller and an oil press (power ghani) were between 31.5 and 32.0% and 28.5-29.0%, respectively.

Wu *et al*. (2011) extracted peach kernel oil using Soxhlet extraction with different solvents *i.e*., Petroleum ether, Chloroform, Ethyl ether and Hexane. The solvent ethyl ether substantially produced the greatest total oil yield during soxhlet extraction (0.38±0.07 g/g d.b), followed by chloroform extraction (0.35 ± 0.06 g/g d.b). The total oil yields obtained with petroleum ether (0.25±0.04 g/g d.b) and hexane (0.26 ± 0.04 g/g d.b) did not differ significantly.

Mughal *et al*. (2015) conducted an experiment to study variation in oil content percent among 25 accessions of *Prunus armeniaca* L. collected from different locations of Jammu and Kashmir, India. The results showed that the oil content ranged between 47.20% for CPT 116 to 50.79% (maximum value) for CPT 110 followed by CPT 117 (50.40%), yet there was a big difference between the two. Over 50% of oil content was reported by six sources.

Sorkheh *et al*. (2016) analysed 40 wild almonds (*Prunus scoparia* L.) and found that oleic and linoleic fatty acids showed high variability ranging from sss232.4 to 359.6 g/kg oil and from 190.7 to 348.8 g/kg oil, respectively.

Gayas *et al*. (2016) conducted ultrasound-assisted extraction (UAE) of apricot kernel oil. According to studies, oil extraction is increased by ultrasound-assisted extraction. The UAE-treated apricot kernels had an oil production that varied from 40.86 to 46.01%. The kernels treated with UAE at a temperature of 60 °C for 50 minutes with a solvent/solute ratio of 20:01 produced the best oil yield.

Yildirim *et al*. (2016) undertook research to identify the total oil content of a few marketed almond cultivars. The oil content of the cultivars varied significantly. Over the course of two years, the average oil content changed from 52.51% in Picantili to 61.92% in Cristomorto. The mean oil content was greater than 60% in the cultivars Cristomorto, Supernova, and Ferragnes. In 2008, Supernova (62.01%) was found to have the greatest total oil content, followed by the cultivars Ferragnes (60.92%) and Cristomorto (60.66%). On the other side, Picantili (50.90%) had the lowest overall oil content.

Arora (2018) evaluated the variation of oil content in four natural populations viz., Champawat, Narkanda, Thatyur and Kanasar. He found that the stones gathered from Thatyur had the highest oil concentration (46.02%), followed by Kanasar (45.52%). Both populations had the same amount of oil. Champawat had the least oil content (42.34%), which was comparable to Narkanda's oil level of 43.67%.

Stryjecka *et al*. (2019) analysed five cultivars of apricot (*Prunus armeniaca* L.) for its chemical composition and antioxidant properties. They found that the oil content of the apricot seeds produced in Poland was found to be high (37% on average), although there were significant variations across varieties. The 'Somo' cultivar, which had the lowest moisture percentage of the defatted seeds, had the highest oil content (44.2%). The 'Harcot' cultivar was determined to have the least oil.

Kumar and Bhan (2020) studied 167 selected wild apricot trees for their oil content and found that it ranged between 50.05 - 57.97%. Bg-02 had the highest oil content (57.97%), closely followed by Bg-05 (57.23%), Sc-19 (57.49%), Sc-15 (57.05%), Sc-14 (57.87%), Sc-13 (57.32%) and Ku-11 (57.18%), whereas La-09 had the lowest oil content (50.05%). Oil content was shown to be significantly correlated with both stone thickness (0.211) and kernel weight (0.236) as well as positively and extremely significantly correlated with kernel thickness (0.292).

2.6 PHYSICO-CHEMICAL CHARACTERISTICS OF KERNEL OIL

Gupta (2006) in his research, found that the acid value of kernel oil from bitter apricot kernels was lower than that of sweet apricot kernel oil, which had a higher acid value of 4.27–4.35 mg KOH/g oil. Additionally, compared to sweet kernelled apricot oil (4.32-4.40 meq/kg oil), the kernel oil from bitter apricots had a greater peroxide value (5.12-5.26 meq/kg oil).

Turan *et al*. (2007) studied the kernel oil of Malatya apricots from Turkey. The names of the apricot cultivars studied were Alyanak (ALY), Çatalogˇlu (CAT), Çölogˇlu (COL), Hacıhalilogˇlu (HAC), Hacıkız (HKI), Hasanbey (HSB), Kabaas (KAB), Sogˇancı (SOG), and Tokalogˇlu (TOK). Apricot kernels vary in total oil content from 40.23 to 53.19%. Linoleic (21.96%), palmitic (4.92%), and stearic (1.21%) acids were next in contribution to the total fatty acids, with oleic acid making up 70.83%. Significant variations in total saturated fatty acids (SFAs), total monounsaturated fatty acids (MUFAs), and total polyunsaturated fatty acids (PUFAs) were also discovered across the kinds. The fatty acids in apricot kernel oils were primarily made up of MUFAs (ranged from 67.41 to 76.69%), with modest amounts of total SFAs (5.77 to 7.13%).

A study about oil composition and some physical and chemical characteristics of wild apricot grown in Turkey by Kaya *et al*. (2008) revealed that the apricot kernel contained about 48-50% crude oil of total dry matter. The oil consisted of 93% of unsaturated fatty acids and the main fatty acids were oleic (75%), linoleic (17.5%), palmitic (4.5%) and stearic (2%) acids. Wild apricot kernel's physical features and fatty acid content analysis showed that it is relatively similar to other edible oils.

Kodad and Socias I Company (2008) investigated eight cultivars and 47 advanced self-compatible genotypes of almonds developed in an almond breeding programme that were examined for oil content and fatty acid composition during a two-year period. In 2002, the values for palmitic acid, palmitoleic acid, stearic acid, oleic acid, and linoleic acid were 5.4-6.9%, 0.3-0.8%, 1.2-2.8%, 63.1-78%, and 12.2-25.7%, respectively, of the total kernel oil. In 2003, the values for palmitic acid, palmitoleic acid, Stearic acid, Oleic acid and Linoleic acid were 5-7.1%, 0.3-0.7%, 1.1-2.7%, 63.4-78.7% and 12.1- 27.1 %, respectively. The analysis of the fatty acid composition of the kernel oil for these genotypes revealed that almond oil has a low concentration of the group of saturated fatty acids (SFA) (palmitic and stearic), an intermediate concentration of polyunsaturated fatty acids (PUFA) (linoleic), and a high concentration of MUFAs, particularly oleic acid.

Matthaus and Ozcan (2009) in their study investigated the fatty acid and tocopherol composition of 15 *Prunus spp.* Varieties from Turkey. The oil has a high concentration of monounsaturated oleic acid (ranging from 43.9% in *Prunus spinosa* to 78.5% in *Prunus domestica* "William") and a very low concentration of saturated fatty acids like palmitic acid (4.9% in *Prunus armeniaca* "Hachaliloglu") to 7.3% (*Prunus domestica* “William”) and stearic acid (0.8% (*Prunus armeniaca* “Sekerpare”, “Alyanak”, “Cataloglu”) to 2.1% (*Prunus armeniaca* “Sultan”; *Prunus spinosa*). Linoleic acid, which ranges in concentration from 9.7% (in *Prunus domestica* “William”) to 28.0% (in *Prunus armeniaca* “Alyanak”), is another significant fatty acid found in *Prunus species*. Vaccenic acid concentration ranges from 0.6% (*Prunus spinosa*) to 1.5% (*Prunus armeniaca* “Alyanak”), which is similar to other widely used edible oils. The overall amount and composition of vitamin-E-active components varied greatly among the oils from various species and varieties. It ranged from 62.9 (*Prunus persica*) to 439.9 mg/kg (*Prunus armeniaca* “Sultan”).

Gupta and Sharma (2009) evaluated the extracted oil for their physico-chemical properties and found that the extracted oil was seen to have a light to deep yellow tint. Additionally, the oil obtained using solvent extraction and an oil press had an iodine value of 100.2-100.4 g I_2/100g as opposed to 100.2-100.8 g I_2/100g obtained using a table oil expeller. The oil obtained using the solvent extraction technique ranged in molecular weight from 189.5 to 191.1, the oil produced using the oil press ranged in molecular weight from 190.9 to 191.9, and the oil obtained using the table oil expeller ranged in molecular weight from 191.5 to 192.7.

An analysis of the fatty acid profile of wild apricot kernel oil was done by Singh *et al*. (2010). They found that the wild apricot oil has a high refractive index of 1.468, a saponification value of 123.4, an iodine value of 96.39, and an acid value of 38.6. High iodine and saponification levels signify the presence of many fatty acids and are thus of major commercial significance. There were found to be fourteen distinct fatty acids, the majority of which were myristic acid (25.63%), oleic acid (24.75%), stearic acid 12.91%, linolenic acid 16.41%, and linoleic acid 9.50%, as well as trace amounts of archidic, archidnoic, behenic, and erucic acids (less than 1%).

Korepar *et al*. (2011) studied 14 apricot genotypes grown in Trans-Himalayan Ladakh region. The study was conducted to find out the effect of genotype on antioxidant capacity and total phenolic content (TPC) of apricot kernel. TPC concentrations in the kernels were observed to range from 92.2 to 162.1 mg gallic acid equivalent/100g. According to the results of principal component analysis, the genotypic influence is more evident when it comes to the TPC and total antioxidant capacity (TAC) content of apricot kernels, whereas the physical characteristics of the seed and kernel are not a significant contributor.

Wu *et al*. (2011) in their investigation found that the ethyl ether extract had the greatest acid value (1.099 mg KOH/g oil), followed by the hexane extract (0.895 mg KOH/g oil), and the chloroform extract (0.608 mg KOH/g oil). According to the findings, the extracts' peroxide levels differed greatly, ranging from 0.256 mg/g oil for the petroleum ether extract to 2.366 mg/g oil for the ethyl ether extract. Iodine levels in the peach kernel oil ranged from 36.328 to 75.726 mg per 100 g of oil, making it non-drying oil. Oil extracted using petroleum ether has a higher concentration of monounsaturated fatty acids than oil extracted with hexane, which has a higher concentration of polyunsaturated fatty acids. The petroleum ether extract had the greatest saponification index (165.701 mg KOH/g oil), followed by the chloroform extract (156.599 mg KOH/g oil), and the hexane extract (101.836 mg KOH/g oil).

Bachheti *et al*. (2012) studied the physico-chemical properties of apricot oil and also compared it to the conventional food oils. Gas chromatography (GC) of seed oil revealed that it contains oleic acid (73.58%), linoleic acid (19.26%), palmitic acid (3.31%), myristic acid (1.18%) and stearic acid (2.68%). The study also suggested that wild apricot oil may be utilised for edible purposes, according to approximate values of the protein, fibre, oil, and carbohydrate content of the wild apricot seed oil and their comparability to other food grade oil.

Gupta *et al*. (2012) studied physico-chemical characteristics and fatty acid composition of wild apricot oil. They found that the specific gravity of the oil ranged 0.914-0.915, refractive index and butyro- refractrometer reading at 40^o C were 1.4720-1.4729 ad 69.6-70.3, respectively. The apricot oil had a low acid content (2.27-2.78 mg KOH/g); peroxide value (5.12-5.27 meq/kg); iodine value (100.2-100.4 g I_2/100 g) and saponification value of 189.8-191.3 mg KOH/g oil. The vitamin E contents in oil ranged between 72-93.7 mg/100g.

Wang and Yu (2012) investigated Siberian apricot (*Prunus Sibirica* L.) seed kernel oil for preparation of biodiesel. They found that the Siberian apricot seed kernels has high oil content (50.18$\pm$3.92%), with low acid value (0.46 mg g^{-1}) and low water content (0.17%). Oleic and linoleic acids make up a significant portion of the Siberian apricot seed kernel oil's fatty acid content (65.23$\pm$4.97%, respectively).

Zhou *et al*. (2015) studied quality of apricot kernel oil prepared by different oil producing processes *i.e*., old pressing, heat pressing, and refining of sun-dried and baked apricot kernels. Peroxide value, acid value, fatty acids, and UV absorbance were among the quality criteria that were determined. The examined oils had absorbance values of 0.70-0.85 and 0.20-0.38 at 232 and 268 nm, respectively; peroxide values ranged from 2.09-5.62 mmol O2/kg, and acid values ranged from 0.36-1.40 mg KOH/g. The largest fatty acid identified in the oils was oleic acid (70.29-71.25%), which was followed by linoleic (22.31-23.00%), palmitic (4.57-4.87%), stearic acids (4.57-4.87%), palmitoleic acid (0.62-0.71%), and a-linolenic acid (0.15-0.18%). The investigation's findings also showed that the volatile profiles of apricot kernel oil were significantly impacted by the oil-producing method. More specifically, the baked-pretreatment procedure may improve the scent of apricot kernel oil by enhancing the quantity and variety of volatile components.

Gayas *et al*. (2016) conducted ultrasound-assisted extraction of apricot kernel oil. The following were the ideal extraction parameters: the extraction took place for 43.95 minutes at a fixed ultrasonic frequency of 40 kHz, a temperature of 51.72 °C, and a solvent/sample ratio of 19.8:01. The oil had an acid value of 2.27 to 2.69 mg KOH/g and a free fatty acid content of 0.1418 to 1.3581, respectively. Specific gravity and iodine value of apricot kernel oil ranged from 0.9115 to 0.9138 and 98.86 to 100.35, respectively.

Yildirim *et al*. (2016) undertook research to identify the total oil content of a few marketed almond cultivars. Oleic and linoleic acids were the most common unsaturated fatty acids, and palmitic acid was the most common saturated fatty acid. Glorieta recorded the greatest oleic acid yields in 2008 (83.35%) and 2009 (72.74%). The greatest levels of linoleic acid were found in Picantili (26.08%) in 2008 and Yaltinski (30.01%) in 2009. Cultivar Sonora had the highest levels of palmitic acid in both years, 7.76% in 2008 and 10.11% in 2009.

Shariatifar *et al*. (2017) investigated the the physicochemical properties of wild apricot kernel oil. The wild apricot kernel oil has the following meanings for peroxide value (meq/kg), acid value, iodine value, and saponification number, respectively: 0.67375, 0.48625, 100.27, and 1089.06. The range of the oil content in wild apricot kernels was 38 to 55.3% on average. Wild apricot kernel oil contains the major fatty acids oleic acid (60.01-70.56%), linoleic acid (19.74-23.52%), and palmitic acid (2.35-5.97%).

Stryjecka *et al*. (2019) analysed five cultivars of apricot (*Prunus armeniaca* L.) for its chemical composition and antioxidant properties. The results showed that the extracted oils had an average iodine value (g of I/100 g of oil) of 99.2, a saponification value of 189 mg of KOH/g of oil, and 0.68% unsaponifiable materials. Oil also contained palmitic, stearic, oleic, palmitoleic, linoleic and linolenic acids. The most linolenic acid was noted in ‘Early Orange’ and ‘Goldrich Sungiant’, and the least in ‘Somo’ and ‘Hargrand’. Additionally, the oil has antioxidant characteristics.

Aurtherson *et al*. (2021) worked on biofuel production from *Prunus domestica* kernel oil. They also studied the fatty oil composition of oil and found the following composition percentage *i.e*., Oleic acid (63.9%), Linoleic acid (23.9%), Stearic acid (1.5%), Palmitoleic acid (1.3%), Linolenic acid (0.9%), Palmitic acid (8.1%). They added that the overall amount of saturated and unsaturated fatty acids was 4.7% and 99.5%, respectively. Using the isopropyl alcohol procedure, the FFA value of the kernel oil was calibrated and determined to be 11.63 mg KOH/g. They also concluded that the ideal conditions for obtaining the most amount of biodiesel from *Prunus domestica* kernel oil were 55°C, an 8:1 ratio, 120 minutes, and 1wt% NaOH.

Chapter-3

MATERIALS AND METHODS

The present study entitled **“Seed source variation in tree morphology and oil quality of *Prunus armeniaca* L.”** was carried out with a view to examine the variation in morphological traits, fruit, seed, and oil quality of wild apricot in various seed sources with altitudinal range. The details of experimental methodology followed for the present study was as under:

3.1 STUDY AREA

The study was conducted on existing wild populations of apricots in Kinnaur and Lahaul and Spiti districts of Himachal Pradesh and as well as in the laboratory of Department of Tree Improvement and Genetic Resources, College of Forestry, Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan (H.P.) during the years 2021-2023. The area selected for research falls under temperate and dry temperate (cold desert) zone with elevation ranging from 2100-3280 m amsl. The broad locations surveyed are depicted in Fig.1a and b. Geographical location of selected apricot trees is detailed in Appendix I. The only wild apricots that were chosen and subsequently assessed were those that were healthy and bearing.

3.2 EXPERIMENTAL DETAILS

For the research purpose, the distribution range of *Prunus armeniaca* L. *i.e.*, 2000-3500 m amsl was classified into three altitudinal zones viz. A1 (2000-2500 m amsl), A2 (2500-3000m amsl) and A3 (3000-3500 m amsl). Total three sites from each altitudinal range and five trees from each site were selected which means total 15 trees from each altitudinal gradient and total forty-five trees for the study were selected. The selected trees were studied for their morphometric traits and fruit quality. These trees were marked properly for studying morphometric variations and fruits were collected and studied from the same marked trees. The seeds and kernels of these fruits were then measured and assessed for various traits and parameters. The oil characteristics for the three altitudinal ranges were studied for their various properties.

Fig 1a: Locations surveyed in Kinnaur district

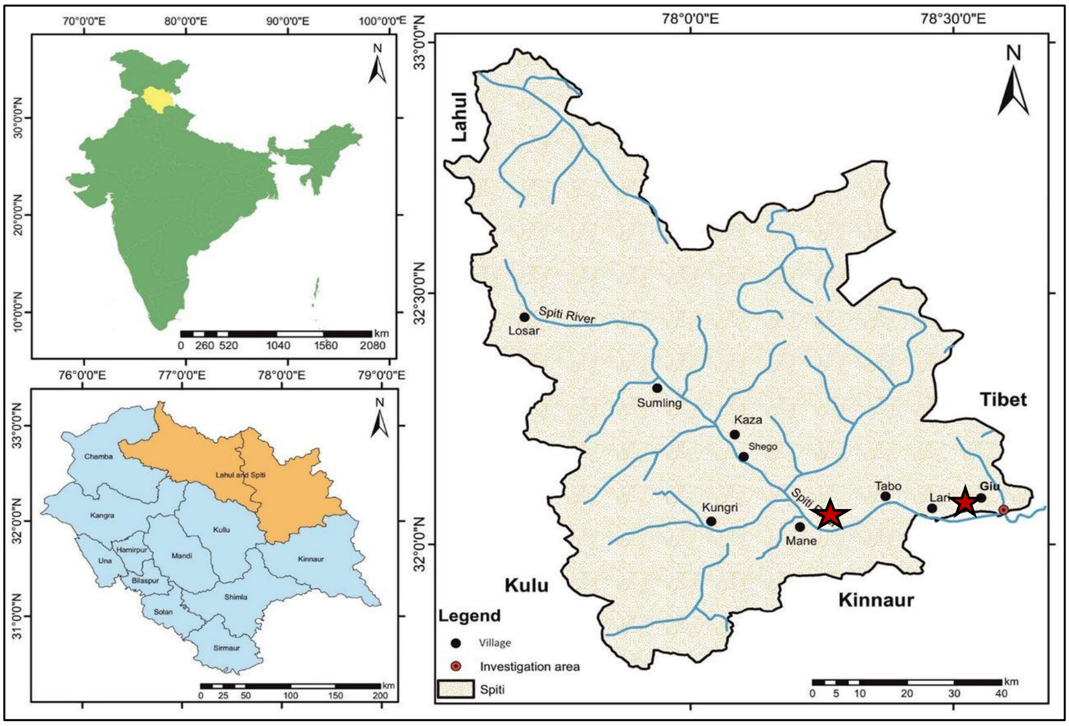


Fig 1b: Locations surveyed in Lahaul and Spiti district

Table 3.1 Sites selected from three altitudinal zones

Altitudinal zone (A)	Site (S)	Altitude (m amsl)	District
2000-2500 m amsl (A1)	Nichar (S1)	2100 m amsl	Kinnaur
	Katgaon (S2)	2086 m amsl	Kinnaur
	Chagaon (S3)	2265 m amsl	Kinnaur
2500-3000 m amsl (A2)	Sangla (S4)	2621 m amsl	Kinnaur
	Kanai (S5)	2674 m amsl	Kinnaur
	Pooh (S6)	2662 m amsl	Kinnaur
3000-3500 m amsl (A3)	Chango(S7)	3058 m amsl	Kinnaur
	Hurling (S8)	3120 m amsl	Lahaul and Spiti
	Poh(S9)	3280 m amsl	Lahaul and Spiti

Table 3.2 Location detail of wild apricot genotypes

Location	Code
Nichar- N	KN (1,2,3,4,5)
Katgaon- KT	KKT (1,2,3,4,5)
Chagaon- CG	KCG (1,2,3,4,5)
Kanai- KN	KKN (1,2,3,4,5)
Sangla- S	KS (1,2,3,4,5)
Pooh- P	KP (1,2,3,4,5)
Chango- CH	KCH (1,2,3,4,5)
Poh- P	SP (1,2,3,4,5)
Hurling- H	SH (1,2,3,4,5)

Sampling Methodology and Analytical Frame of Work:

Number of altitudinal zones : 3

Number of sites in each altitudinal zone : 3

Total number of sites : 9

Number of trees per site : 5

Number of replications : 3

Design employed : RBD (Factorial) in field.

CRD in laboratory.

3.3 EXPERIMENTAL METHODS

3.3.1 TREE MORPHOLOGY

3.3.1.1 Tree Height (m):

Tree height was measured from ground to the apex of leading shoot by Ravi Multimeter.

3.3.1.2 Diameter at Breast Height (cm):

Diameter was measured at breast-height *i.e.*, 1.37 m above ground level, with the help of a calliper at both the axis of the tree at right angles to each other and mean of both the values was taken into consideration for data analysis.

3.3.1.3 Crown Length (m):

Crown length was measured with the help of Ravi Multimeter.

3.3.1.4 Crown Width (m):

Crown width was measured with the help of a tape at two different axis at ground level.

3.3.1.5 Tree age:

The approximate age of tree was recorded after interaction with the farmers or concerned villager who acknowledged that particular tree since its plantation and expressed in years.

3.3.1.6 Total number of primary branches per tree:

Total number of primary branches on the tree was counted manually.

3.3.1.7 Number of fruits per branch:

Branches bearing fruits were selected randomly from the top, middle, and bottom portions of the tree. The average value was then calculated.

3.3.2 Leaf characteristics:

3.3.2.1 Leaf length (cm):

It was measured with the help of a scale in centimeters.

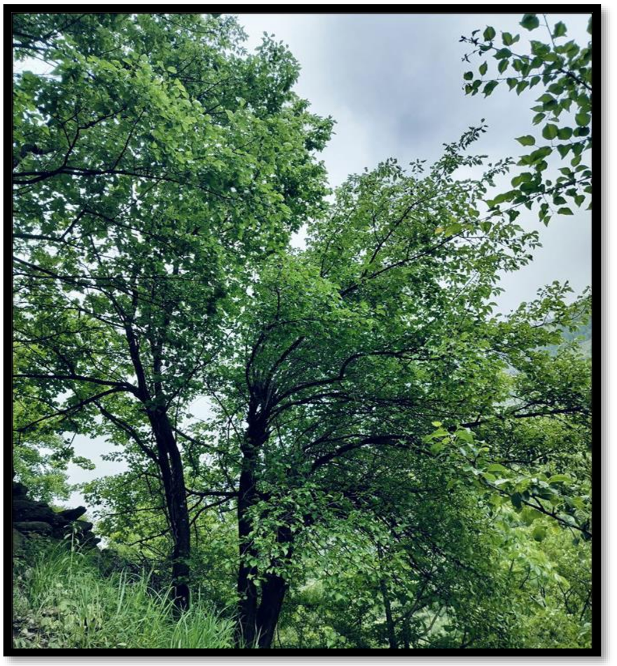
3.3.2.2 Leaf Width (cm):

Leaf width was measured using a scale in centimeters.

3.3.2.3 Leaf Area (cm^2):

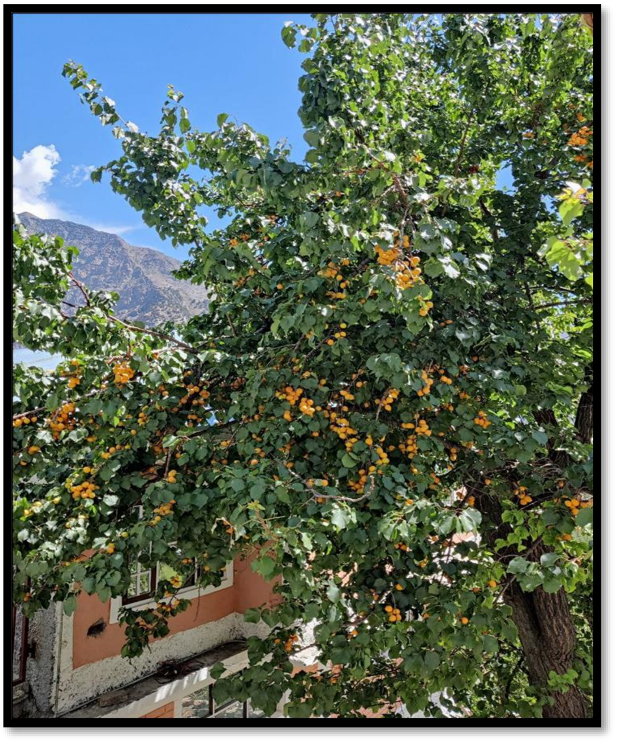
Average leaf area of ten leaves was measured in the laboratory by using leaf area meter.

SH1



KKT4

KCH1



KP1

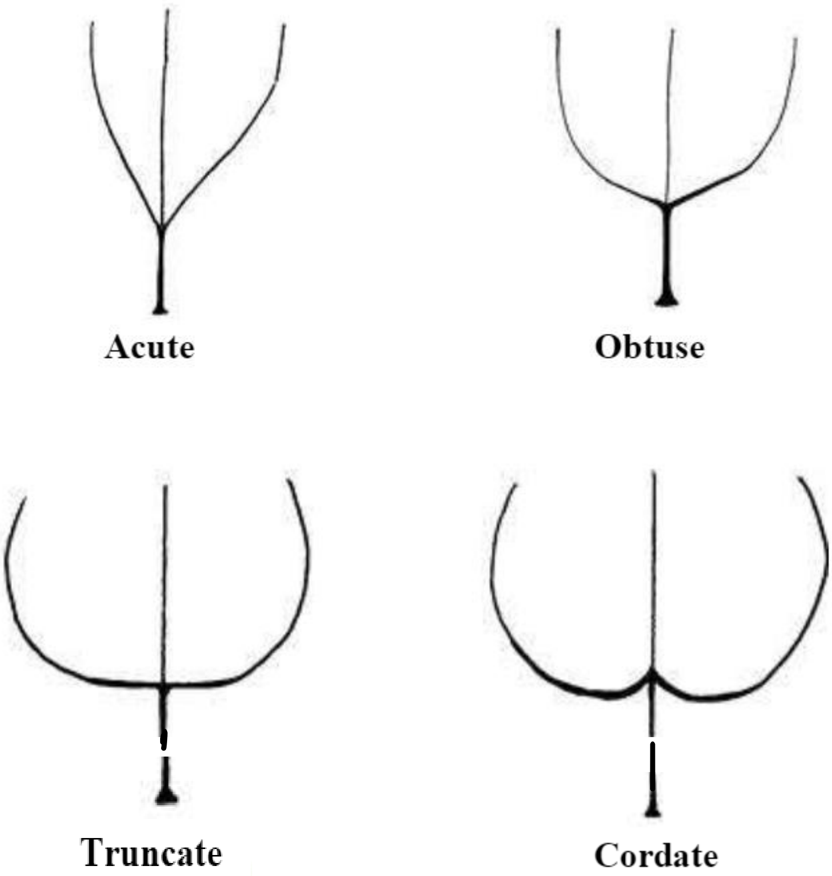
Plate 1. Overview of some genotypes having good morphometric traits

3.3.2.4 Leaf colour:

The leaf colour of each genotype was determined by comparing with the colour charts of Royal Horticultural Society, London.

3.3.2.5 Leaf shape:

Leaf shape was observed visually following Standard Cyclopaedia of Horticulture (Bailey 1963; UPOV 2007).



3.3.2.6 Petiole length (mm):

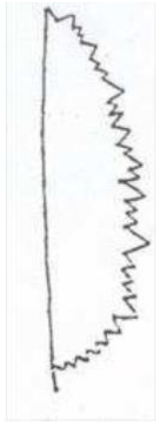
The length of ten petioles was measured using scale and average value was taken into consideration.

3.3.2.7 Leaf margin:

Leaf margin was examined for the presence or absence of the serration in each genotype.

Crenate

Bicrenate



Bidentate

Serrate

Biserrate

3.3.3 Floral characteristics:

3.3.3.1 Time and season of flowering:

The number of days from the date of first flower opening to the date of opening of last flower was recorded in each genotype.

3.3.3.2 Size of flower (mm):

The size of flower was measured with the help of digital Vernier Callipers.

3.3.3.3 Colour of flower:

The colour of flower was observed visually.

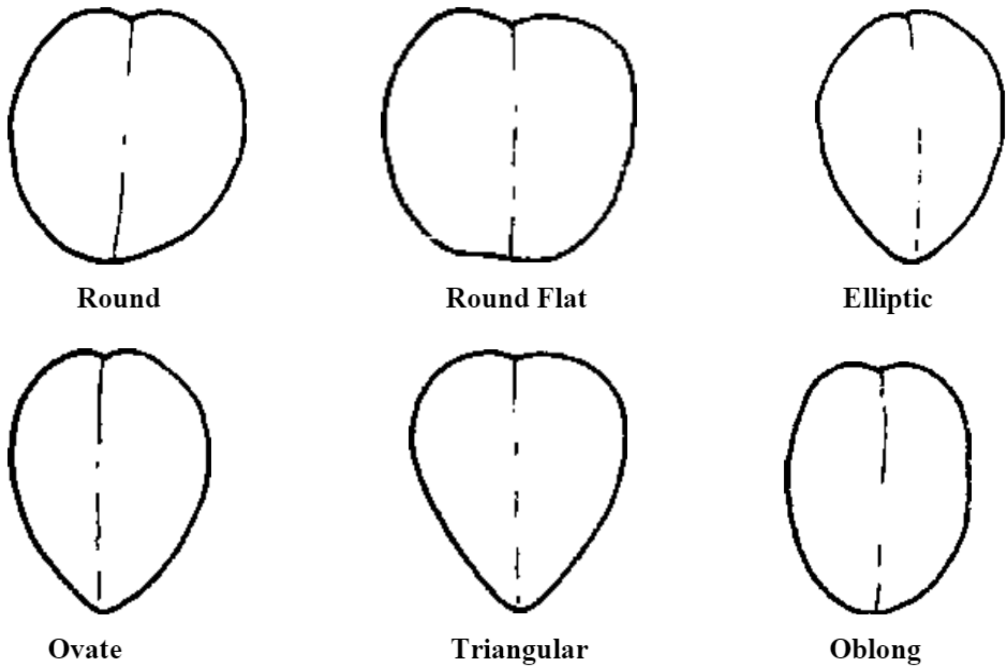
3.3.4 Fruit Characteristics:

3.3.4.1 Fruit size (mm) and fresh weight (g):

The length and diameter of fruit was measured by digital Vernier Callipers. The average fruit size was expressed in mm. The weight of fruits was measured by using Electronic Balance.

3.3.4.2 Fruit shape:

Fruit shape was described as round, round flat, elliptic, ovate, triangular and oblong as per International Board for Plant Genetic Resource (IBPGR 1984) descriptors.



3.3.4.3 Color of fruit:

Color of fruit was determined by comparing it with the colour charts of The Royal Horticultural Society, London.

3.3.4.4 Stone weight (g):

Stone weight was determined by weighing it on Electronic Balance.

3.3.4.5 Pulp weight (g):

The pulp was removed with the help of knife and then weight was determined on Electronic Balance.

3.3.4.6 Pulp Stone ratio:

In order to determine pulp: stone ratio, the pulp weight of a fruit was divided by corresponding stone weight.

3.3.4.7 Volume and specific gravity: Fruit volume was calculated using the water displacement method. Fruits were submerged in a graduated cylinder filled with water up to a predetermined volume. The starting and final volumes were noted, and the volume of the fruit was computed by deducting the original volume from the final volume. The following formula was used to calculate the fruit's specific gravity:

$$\textbf{Specific gravity} = \frac{Weight\ of\ fruit}{Vol.of\ that\ fruit}$$

3.3.5 Seed Morphology:

3.3.5.1 Kernel length (mm):

Kernel length was measured by using Digital Vernier Calliper and mean was expressed in millimetres (mm).

3.3.5.2 Kernel breadth (mm):

Kernel breadth was measured by using Digital Vernier Calliper and mean was expressed in millimetres (mm).

3.3.5.3 100 seed (stone) weight (g):

Seed after being extracted manually from fruit was weighed on 100 seed bases.

3.3.5.4 100 kernel weight (g):

Kernel after being extracted manually from seed was weighed on Electronic Balance and the mean was expressed in grams (g).

3.3.5.5 Kernel taste:

It was observed by tasting the kernels.

3.3.6 Oil content and quality parameters:

3.3.6.1 Physical characteristics of oil:

3.3.6.1.1 Oil content %:

The extraction of oil was carried out by following the method of Anonymous (1965). For which the kernels were first crushed by using pestle and mortar. Then oil was extracted from this powdered sample (known weight) by using Soxhlet apparatus with petroleum ether (60-80^{0}C) as solvent. This process took 7-8 hours. The solvent (Petroleum ether) was then evaporated by keeping the oil in hot air oven. The oil yield was expressed in terms of percentage of powdered sample.

$$\text{Oil content (\%)} = \frac{\text{Weight of oil extracted from the sample}}{\text{Weight of sample}} \times 100$$

3.3.6.1.2 Specific gravity:

Specific gravity is a measure of the density of a substance to the density of water at constant room temperature. The specific gravity of oil was measured by making use of specific gravity bottles according to standard methods (Ranganna, 1997) and was calculated as:

$$\text{Specific gravity} = \frac{\text{Weight of oil with bottle} - \text{Weight of bottle}}{\text{Weight of water with bottle} - \text{Weight of bottle}} \times 100$$

3.3.6.1.3 Refractive index:

Refractive index, also known as index of refraction, is a measure of the bending of a ray of light when it passes from one medium to another. As deviation from the set values were a sign of adulteration therefore, it was one of the main objective test techniques used to assess the quality of the oil. The refractiv index of oil sample was determined by using Abbe's Refractometer by placing 2-3 drops on the prism. A temperature of 30^0C was maintained throughout the experiment (AOAC, 1995).

3.3.6.2 Chemical characteristics of oil:

3.3.6.2.1 Acid Value:

Acid value is defined as the weight of KOH (mg) required to neutralize the organic acids present in 1 g of fat and is a measure of the free fatty acids present in the fat or oil. The acid value of seed oil was estimated by titrating a known weight of sample (10g) containing 50 ml neutral solvent (25 ml ether + 25 ml 95% alcohol + 1% phenolphthalein) against 0.1N KOH solution using phenolphthalein as indicator with continuous shaking until pink colour persisted. The acid value was be calculated by using the formula:

$$\text{Acid value (mg KOH/g)} = \frac{\text{Titre} \times \text{Normality of KOH}}{\text{Weight of Sample (g)}} \times 56.1$$

3.3.6.2.2 Saponification Value:

Saponification is used to determine the total acid content, both free and combined of fats. Therefore, it is a measure of fatty acid quantity. It was determined by measuring the alkali required to saponify the combined acids and neutralize the free acid. To estimate saponification value of oil, the oil sample (5.0 g) was first mixed with alcoholic potassium hydroxide and the mixture was refluxed for 30 minutes to completely saponify the sample and then titrated against

0.5 N HCl using phenolphthalein as indicator. It was titrated until the pink colour disappeared. Blank titration was also carried out along with the sample.

$$\textbf{Saponification value} = \frac{\textbf{28.05} \times \textbf{(Blank titre – Sample titre)}}{\textbf{Weight of Sample (g)}}$$

3.3.6.2.3 Unsaponifiable Matter:

In order to estimate the amount of unsaponifiable matter present in oil, 2.5 gm of oil was mixed with 25 ml of 10% ethanol and 0.5M of KOH. The sample was boiled for 30 minutes while being attached to a condenser. A clear and transparent solution indicated a complete saponification. After this the solution was transferred into a separating funnel. 25ml of distilled water and n-hexane were poured into the separating funnel twice. It was shaken vigorously and kept for 20 minutes. Two separated layers were seen. The lower layer was drained and collected in a beaker.

20 ml distilled water was again measured and poured in second separating funnel (SF-2) along with the upper layer of n-hexane from SF-1. A second extraction and third extraction were done by using the already collected lower layer (yellowish in colour) and the same procedure was followed.

After performing the above steps, 8-9 washings were done. Washings were done using 20 ml distilled water, 20ml of 0.5M KOH and 20 ml of 10% ethanol. Two -three drops of phenolphthalein indicators were used to check whether the KOH is removed completely or not. If the colour turned pink further washings were done to completely remove the KOH.

When the colour of the washing finally did not change then it was transferred from SF-2 along with the emulsions into a beaker which is marked as “Collected ether extract”. It was then placed into hot air oven for 90 minutes at 90-degree Celsius.

After the stipulated time, the extracts were poured into separating funnel. It was then shaken vigorously and kept still for 20 minutes. Again, the lower layer was drained and discarded. The upper layer which contained n-hexane was collected and dried at 90- degree Celsius for 60 minutes until the extracts remained upto 5 ml.

A clean and dry flask was weighed and hexane extract was added into it along with the washings (beaker washed with n-hexane). The extract was dried at 90-degree for 30 minutes to evaporate the hexane completely. Unsaponified oil extract can be seen at the bottom of the flask. Then, 3 ml of acetone was added to it while continuously swirling it. The flask was oven dried for 30 minutes at 90- degree Celsius. After cooling down the weight of the residue was noted down.

50 ml of ethanol after being heated for 5 minutes was used for titration. Phenolphthalein indicator was also added into it. 0.1 N NaOH was added to it drop-wise to neutralize the ethanol until a faint pink colour appeared. Then the neutralized ethanol was added to the flask containing the residue. It was then heated and again the indicator was added to it. Lastly, it was titrated against 0.1 N NaOH. A faint pink colour indicated the end point of titration (AOAC 933.08). The unsaponifiable matter was determined by using the following formula:

$$\textbf{Unsaponifiable Matter} = \frac{100 \times (A-B)}{\text{Weight of sample}}$$

Where, A = Residue weight (Flask with residue weight- Flask weight)

B = Weight of fatty acids in extracts (0.282 x V x N)

V = Final burette reading - Initial reading

N = Normality of NaOH

3.3 STATISTICAL ANALYSIS

For the gathering, assessing, and interpreting of data, statistical analysis is a crucial tool. RBD factorial and CRD were used in the field and the lab, respectively, for the statistical analysis of the data.

A. Critical Difference (CD):

In order to compare the mean of various entries, the critical difference will be calculated by the formula:

$$\mathbf{CD = SE \times t_{0.05\ \text{error degree of freedom}}}$$

$$\mathbf{SE = \sqrt{2MSE/r}}$$

Where, SE = Standard error

t = Tabulated value of t at 5 per cent level of significance

r = Number of replications

MSE Mean sum of error

B. Correlation Coefficient:

The formula for calculating Karl Pearson's Correlation Coefficient is:

$$\mathbf{r\,(XY)} = \frac{\mathbf{\mathit{Cov}.XY}}{\sqrt{\mathbf{V(X)\times V(Y)}}}$$

Where,

r (XY)	=	Correlation between X and Y
Cov.XY	=	Covariance between Xand Y
V (X)	=	Variance of X character
V (Y)	=	Variance of Y character

C. Variance:

Vp = Vg + MSE

Where, Vp = Phenotypic variance

Vg = Genotypic variance

MSE = Mean sum of error (Environmental variance).

D. Coefficient of Variability:

Coefficient of variability was worked out by the formula given by Burton and De Vane (1953).

$$\mathbf{PCV\ (\%)} = \frac{\sqrt{Vp}}{x} \times 100$$ Vp = Phenotypic Variance

$$\mathbf{GCV\ (\%)} = \frac{\sqrt{Vg}}{x} \times 100$$ Vg = Genotypic Variance

Where, PCV = Phenotypic Coefficient of Variability

GCV = Genotypic Coefficient of Variability

$\overline{X}$ = Population mean of the charact

Chapter-4

RESULTS AND DISCUSSION

The present study entitled **"Seed source variation in tree morphology and oil quality of *Prunus armeniaca* L."** was undertaken during the years 2021-2023 with the purpose of assessing the level of variation within the natural populations of concerned species. The variations were found for different morphometric characteristics *i.e.*, flower, leaf, fruit, seed etc. and physico-chemical properties of oil among forty-five genotypes in nine sites and three elevation ranges. Basic details of selected 45 genotypes are presented in Appendix 1. The findings obtained on several aspects are described under the following headings:

4.1 Variation in tree morphology

4.2 Variation in fruit, seed and oil quality attributes

4.3 Correlation studies

4.4 Statistical analysis

4.1 VARIATION IN TREE MORPHOLOGY

4.1.1 Age (Years)

The information in Table 1 showed that among forty-five genotypes that were surveyed and studied maximum age was recorded for KKN4 while KS1 had the minimum age. Mean age was reported to be 33.76 years and their coefficient of variation was 25.32 per cent.

The data presented in Table 2 clearly revealed that among the three altitudinal ranges maximum value for age was recorded in altitudinal zone A1 (36.13) which was statistically at par with A2 (34.40) and A3 (30.73). There is no significant difference between them. Maximum value for the site within altitudinal zone was noted for S2 (42.4) and minimum for S8 (27). The sites S7 (37.6), S3 (37), S6 (35.2), S5 (34) and S4 (34) were found to be statistically at par with S2. Sites in altitudinal zone 1 were found to have significant differences among them.

4.1.2 Tree height (m)

It is evident from the data presented in Table 1 that maximum plant height (14.5 m) was recorded in KKN4 followed by (14 m) in KKT2 while minimum plant height was recorded in

KN2 (5 m), KN4 (5 m), KKN3 (5 m), KKN5 (5 m) and KS1 (5 m) followed by KN3 (5.5 m), KKN1 (5.5 m), KS2(5.5 m) and KP4 (5.5 m). Average tree height was reported to be 7.69 m and their coefficient of variation was 30.29 per cent.

Observations from Table 2 showed that among three altitudinal zones maximum value for tree height (m) was accounted for A3 (8.10 m) which was found to be statistically at par with A1 (8.07 m) and A2 (6.90 m). Tree height was recorded maximum in S2 (11.2 m) and minimum in S1 (6 m) and S8 (9 m) was observed to be statistically at par with S2. Sites in altitudinal zone 1 were found to have significant differences among them.

4.1.3 Diameter (cm)

Maximum diameter was recorded in the genotype KKN4 (28.18 cm) followed by KS5 (19.74 cm) whereas, minimum values were recorded for KKT3 (7.3 cm) followed by KS1 (7.4 cm). Mean diameter was found to be 12.62 cm and their coefficient of variation was 28 per cent (Table 1).

The findings made from the data in Table 2 showed that between three altitudinal zones maximum value for diameter was noted for A3 (12.90 cm) which was found to be statistically at par with A1 (12.19 cm) and A2 (6.90 cm). Variation was also observed among the sites, with maximum diameter recorded for S4 (14.39 cm) whereas, minimum for S3 (11.04 cm). S1 (13.49 cm), S2 (12.05 cm), S5 (12.53 cm), S6 (11.40 cm), S7 (11.84 cm) and S8 (12.80 cm) were found to be statistically at par with S4.

4.1.4 Crown length (m)

The observations of data presented in Table 1 elucidated that maximum crown length was noted for KKN4 (13 m) followed by KKT5 (11 m) and KKT1 (11 m) while, minimum crown length was observed in KN3 (4 m), KKN5 (4 m), KS1 (4 m), KS2 (4 m) and KP4 (4 m) followed by KN2 (4.5 m), KN4 (4.5 m), KN5 (4.5 m), KCG3 (4.5 m), KKN1 (4.5 m), KKN3 (4.5 m), KS3 (4.5 m) and KCH5 (4.5 m).The overall mean for crown length was recorded as 6.43 m and value for their coefficient of variation was 32.58 per cent.

The perusal of data presented in Table 2 revealed that maximum value for crown length was recorded for A3 (6.77 m) which was statistically at par with A1 (6.70 m) and A2 (5.83 m). There was no significant difference among these zones. Significant variation was observed among sites, with maximum crown length recorded in S2 (9.3 m) and minimum in S1 (4.9 m). S2 was found to be statistically at par with S9 (7.6 m). Sites in altitudinal zone 1 were found to have significant differences among them.

4.1.5 Crown width (m)

The findings made from the data in Table 1 showed that the maximum crown width was found in KKN4 and KN1(8 m) followed by KCG1 and KCG4 (7.5 m) whereas, minimum value was observed for genotype SP1 (2.5 m) followed by KKT3 and KS1 (3 m) with an average crown width of 5.08 m. Their coefficient of variation was recorded to be 26.88 per cent.

Inquisition of the data presented in Table 2 revealed that maximum crown width was noted for altitudinal zone A1 (5.40 m) which was statistically at par with A2 (5.30 m) and A3 (4.53 m). No significant difference was seen among the zones. Whereas, among the sites maximum and minimum value for crown width was accounted for S3 (6.7 m) and S8 (3.9 m), respectively. S4 (5.7 m), S5 (5.4 m) and S1 (5.2 m) were found to be statistically at par with S3. Only the sites in altitudinal zone 1 were found to have significant differences among them.

4.1.6 Total number of primary branches per tree

Among the genotypes maximum number of primary branches were recorded in KKN4 (21) followed by KCG3 and KCH1 (20). The minimum values were recorded for KKN2, KS2, KCH3 and SP3 (9). Average primary branches were 14.20 and their coefficient of variation was noted as 24.97 per cent (Table 1).

Observations from Table 2 showed that maximum number of primary branches were recorded in altitudinal zone A2 (14.53) which was statistically at par with A1 (14.13) and A3 (13.93). There was no significant difference among these zones. Maximum number of primary branches were found in S4 (16) and minimum in S8 (12.2). S3 (15.2), S7 (15.2), S6 (14.6), S2 (14.4), S9 (14.4), S5 (13), S1(12.8) were statistically at par which implies that there was no significant difference among these sites.

4.1.7 Number of fruits per branch

Maximum number of fruits per branch was recorded for KKN4 (52) followed by KKT4 (45) while the minimum values were accounted for KCG and KCH3 (19) followed by KS1 and SP1 (20). Average number of fruits per branch were recorded to be 31.73 and their coefficient of variation was observed as 24.14 per cent (Table 1).

The perusal of data presented in Table 2 revealed that maximum value for number of fruits per branch was noted for altitudinal zone A2 (33.00) which was statistically at par with A1 (31.73) and A3 (30.47). The zones did not significantly differ from one another. However, among the sites maximum value was recorded for S9 (37.6) and minimum for S7 (25). The difference between the sites for this parameter was found to be non-significant.

Table 1. Variations in morphological characters among different genotypes of *Prunus armeniaca* L.

Sr. No.	Genotype	Age (Years)	Tree Height (m)	Diameter (cm)	Crown Length (m)	Crown Width (m)	No. of Primary Branches	No. of Fruits Per Branch
1	KN1	30	8.50	16.87	7.0	8.0	12	35
2	KN2	25	5.00	12.40	4.5	4.0	10	25
3	KN3	32	5.50	12.89	4.0	6.0	17	40
4	KN4	28	5.00	14.17	4.5	4.0	15	28
5	KN5	30	6.00	11.14	4.5	4.0	10	22
6	KKT1	35	12.00	9.50	11.0	5.5	13	29
7	KKT2	55	14.00	17.26	10.5	3.5	17	40
8	KKT3	28	7.00	7.30	6.0	3.0	14	28
9	KKT4	45	10.00	11.76	8.0	3.5	10	45
10	KKT5	49	13.00	14.41	11.0	6.0	18	28
11	KCG1	48	7.00	15.40	6.0	7.5	19	35
12	KCG2	27	6.50	8.91	6.0	6.0	10	30
13	KCG3	35	6.00	10.19	4.5	7.0	20	40
14	KCG4	37	8.50	9.55	7.0	7.5	11	19
15	KCG5	38	7.00	11.14	6.0	5.5	16	32
16	KKN1	25	5.50	10.82	4.5	4.0	19	28
17	KKN2	27	7.50	13.21	7.0	6.5	9	25
18	KKN3	30	5.00	9.07	4.5	5.5	16	35

19	KKN4	60	14.50	28.18	13.0	8.0	21	52
20	KKN5	28	5.00	10.66	4.0	4.5	15	31
21	KS1	23	5.00	7.40	4.0	3.0	11	20
22	KS2	30	5.50	10.05	4.0	6.0	9	25
23	KS3	34	6.00	10.50	4.5	5.5	19	23
24	KS4	38	6.50	14.96	6.0	5.5	15	35
25	KS5	45	8.50	19.74	7.5	7.0	11	38
26	KP1	35	7.50	10.19	6.0	5.0	14	40
27	KP2	37	7.00	11.78	5.5	4.0	15	38
28	KP3	40	8.00	14.33	7.0	5.5	14	44
29	KP4	25	5.50	9.23	4.0	4.5	17	32
30	KP5	39	6.50	11.46	6.0	5.0	13	29
31	KCH1	45	9.00	14.64	7.5	5.0	20	22
32	KCH2	40	8.50	12.73	8.0	5.5	18	29
33	KCH3	35	7.00	9.55	6.0	4.0	9	19
34	KCH4	38	8.00	10.19	6.5	6.0	10	25
35	KCH5	30	6.00	12.10	4.5	3.5	19	30
36	SP1	25	7.00	12.73	5.5	2.5	14	20
37	SP2	30	8.00	13.37	6.5	4.0	10	26
38	SP3	28	6.50	11.14	5.0	3.5	9	31
39	SP4	25	7.50	14.33	5.5	4.5	11	33
40	SP5	27	9.00	12.42	8.5	5.0	17	34
41	SH1	30	11.00	15.92	8.5	6.5	15	29
42	SH2	30	10.00	13.05	9.0	4.5	13	42
43	SH3	24	7.00	12.10	6.0	4.0	12	37
44	SH4	26	9.00	14.33	8.0	4.5	17	39
45	SH5	28	8.00	14.96	6.5	5.0	15	41
Mean		33.76	7.69	12.62	6.43	5.08	14.20	31.73
CV (%)		25.32	30.29	28.00	32.58	26.88	24.97	24.14

Table 2. Variation in morphological characters among populations of *Prunus armeniaca* L. at altitudinal gradient

Altitudinal Zone (m amsl)	SITES (S)	Age (Years)	Tree Height (m)	Diameter (cm)	Crown Length (m)	Crown Width (m)	No. of Primary Branches	No. of Fruits per Branch
A1 (2000-2500)	**S1**	29.0	6.0	13.49	4.9	5.2	12.8	30.0
	S2	42.4	11.2	12.05	9.3	4.3	14.4	34.0
	S3	37.0	7.0	11.04	5.9	6.7	15.2	31.2
	Mean	36.13	8.07	12.19	6.70	5.40	14.13	31.73
A2 (2500-3000)	**S4**	34.0	7.5	14.39	6.6	5.7	16	34.2
	S5	34.0	6.3	12.53	5.2	5.4	13	28.2
	S6	35.2	6.9	11.40	5.7	4.8	14.6	36.6
	Mean	34.40	6.90	12.77	5.83	5.30	14.53	33.00
A3 (3000-3500)	**S7**	37.6	7.7	11.84	6.5	4.8	15.2	25.0
	S8	27.0	7.6	12.80	6.2	3.9	12.2	28.8
	S9	27.6	9.0	14.07	7.6	4.9	14.4	37.6
	Mean	30.73	8.10	12.90	6.77	4.53	13.93	30.47
CV (%)		23.89	25.15	29.48	28.23	25.58	26.21	23.17
CD (0.05) ALTITUDE		6.00	1.44	2.77	1.35	0.97	2.77	5.47
SITES WITHIN ALTITUDE		10.39	2.49	4.79	2.34	1.67	4.79	9.47

4.1.8 Leaf length (cm)

Maximum leaf length was recorded for the genotype KS1 (9.92 cm) followed by KN1 (9.09 cm) while minimum leaf length was observed in SH5 (6.13 cm) followed by KS5 (6.17 cm) and SP5 (6.17cm). The overall mean was noted as 7.54 cm and value for their coefficient of variation was 12.42 per cent (Table 3).

Observations from Table 6 showed that significant variation was found among the three altitudinal zones. Maximum leaf length was noted for altitudinal zone A1 (7.84 cm) which was statistically at par with A2 (7.77 cm). A3 differed significantly from A1 and A2. Maximum value for leaf length was found in S3 (8.32 cm) and minimum in S9 (6.62 cm). S6 (8.29 cm), S1 (7.83 cm), S7 (7.77 cm), S5 (7.58 cm) and S4 (7.44 cm) were found to be statistically at par with S3. Significant difference can be seen among sites.

4.1.9 Leaf Width (cm)

Among the genotypes maximum leaf width was accounted for KN1 (8.93 cm) followed by KS1 (8.65 cm) and minimum value was noted for SP4 (3.99 cm) followed by KCH3 (4.97

cm) with average leaf width of 7.69 cm. Their coefficient of variation was recorded to be 16.47 per cent (Table 3).

Inquisition of the data presented in Table 6 revealed that maximum leaf width was recorded for altitudinal zone A1 (6.52 cm) which was statistically at par with A2 (6.26 cm). A3 differed significantly from A1 and A2. Among the sites maximum and minimum leaf width was recorded for S1 (7.15 cm) and S8 (5.13 cm), respectively. S3 (6.72 cm), S6 (6.40 cm) and S5 (6.28 cm) were found to be statistically at par with S1. Sites in altitudinal zone 1 were found to have significant differences among them.

4.1.10 Leaf area (cm^2)

Maximum leaf area was recorded for the genotype KN1 (84.43 cm^2) followed by KN4 (80.67 cm^2) whereas, minimum was recorded for SP2 (23.42 cm^2) followed by SH1 (33.65 cm^2). Average leaf area was noted to be 58.65 cm^2 with 17.68 per cent coefficient of variation (Table 3).

Observations from Table 6 revealed that maximum value for leaf area was recorded in altitudinal zone A1 (64.77 cm^2) which was at par with A2 (60.69 cm^2). The zones vary significantly from one another, with A3 being different from A2 and A1. S1 (73.65 cm^2) showed maximum value for leaf length among sites while S9 (41.74 cm^2) showed minimum value. Significant variations among sites in altitudinal zones A1 and A3 were recorded.

4.1.11 Petiole length (cm)

The findings made from the data in Table 3 showed that the maximum petiole length was found in KCG4 (3.92 cm) followed by KN2 (3.88 cm) whereas, minimum values was observed for genotype KKT4 (2.19 cm) followed by KKN5 (2.22 cm) with an average petiole length of 3.02 cm. Their coefficient of variation was recorded to be 16.40 per cent.

The perusal of data presented in Table 6 revealed that maximum value for petiole length was observed in altitudinal zone A1(3.22 cm) which was statistically at par with A3 (2.97 cm). Significant differences exist between the zones, with A2 being distinct from A1 and A3. However, among the sites maximum value was recorded for S1 (3.59 cm) and minimum for S2 (2.76 cm). S3 (3.33 cm) and S9 (3.17) were statistically at par with S1. Sites in altitudinal zone 1 were found to have significant differences among them.

Table 3. Variation in leaf characteristics among different genotypes of *Prunus armeniaca* L.

Sr. No.	Genotype	Leaf length (cm)	Leaf width (cm)	Leaf area (cm^2)	Petiole length (cm)	Leaf shape	Leaf margin	Leaf Colour
1	KN1	9.09	8.93	84.43	3.55	Obtuse	Serrate	Green group 138 A
2	KN2	7.33	6.82	65.83	3.88	Obtuse	Serrate	Green group 138 B
3	KN3	6.47	6.53	66.38	3.87	Truncate	Serrate	Green group 137 C
4	KN4	8.82	7.52	80.67	3.72	Obtuse	Serrate	Green group 137 D
5	KN5	7.42	5.93	70.93	2.91	Obtuse	Biserrate	Green group 137 B
6	KKT1	8.45	6.80	60.29	2.88	Obtuse	Biserrate	Green Group 137 C
7	KKT2	7.13	4.74	61.89	2.34	Cordate	Biserrate	Green group 137 D
8	KKT3	6.86	5.69	58.75	3.11	Obtuse	Serrate	Green group 137 B
9	KKT4	7.16	5.90	59.62	2.19	Cordate	Serrate	Green group 138 A
10	KKT5	7.26	5.31	60.45	3.28	Cordate	Biserrate	Green group 137 C
11	KCG1	8.82	6.92	64.97	3.64	Obtuse	Serrate	Green group N137 A
12	KCG2	8.90	6.43	56.28	2.95	Obtuse	Serrate	Green group N137 B
13	KCG3	7.65	6.32	59.78	3.09	Obtuse	Biserrate	Green group 137 A
14	KCG4	7.87	6.94	63.43	3.92	Truncate	Serrate	Green group 137 A
15	KCG5	8.38	7.01	57.89	3.03	Obtuse	Biserrate	Green group 137 B
16	KKN1	8.39	6.90	60.54	3.31	Obtuse	Crenate	Green group N137 A
17	KKN2	7.10	5.76	56.98	2.77	Obtuse	Serrate	Green group N137 B
18	KKN3	6.81	5.84	61.67	2.43	Obtuse	Serrate	Green group 137 A
19	KKN4	7.61	5.34	59.96	3.14	Cordate	Serrate	Green group 137 D
20	KKN5	7.31	6.65	60.43	2.22	Cordate	Crenate	Green group N137 C
21	KS1	9.92	8.65	57.29	2.92	Obtuse	Serrate	Green group N137 D
22	KS2	7.49	5.18	59.97	2.98	Obtuse	Serrate	Green group N137 A

23	KS3	6.45	5.84	67.65	3.07	Cordate	Serrate	Green group 138 A
24	KS4	7.85	6.93	61.05	2.38	Obtuse	Biserrate	Green group 138 B
25	KS5	6.17	4.79	63.86	2.65	Obtuse	Crenate	Green group 138 A
26	KP1	7.41	6.87	59.96	3.48	Cordate	Biserrate	Green group 137 B
27	KP2	8.54	6.56	55.98	2.74	Obtuse	Biserrate	Green group 137 C
28	KP3	8.65	5.97	57.48	2.84	Obtuse	Serrate	Green group 137 D
29	KP4	8.92	6.04	61.98	3.46	Obtuse	Crenate	Green group 138 B
30	KP5	7.95	6.58	65.56	2.68	Obtuse	Serrate	Green group N137 B
31	KCH1	8.82	6.92	64.57	3.64	Cordate	Biserrate	Green group N137 A
32	KCH2	7.43	5.45	58.65	2.39	Cordate	Serrate	Green group 138 A
33	KCH3	6.94	4.97	65.86	2.99	Obtuse	Serrate	Green group 137 B
34	KCH4	7.68	5.75	54.65	3.14	Obtuse	Biserrate	Green group 137 D
35	KCH5	7.96	6.74	61.86	2.29	Cordate	Biserrate	Green group N137 D
36	SP1	6.57	5.64	54.75	3.65	Cordate	Serrate	Green group N137 C
37	SP2	6.81	5.29	23.42	2.54	Obtuse	Crenate	Green group 137 D
38	SP3	7.48	5.95	48.39	3.21	Obtuse	Serrate	Green group 143 C
39	SP4	6.22	3.99	56.28	2.47	Obtuse	Biserrate	Green group 137 A
40	SP5	6.17	4.80	60.29	2.34	Obtuse	Serrate	Green group 137 B
41	SH1	6.87	5.19	33.65	3.64	Truncate	Crenate	Green group 137 D
42	SH2	6.24	5.93	47.96	2.84	Obtuse	Serrate	Green group 137 B
43	SH3	7.41	4.76	43.78	3.67	Obtuse	Crenate	Green group 137 D
44	SH4	6.43	4.95	39.87	2.62	Cordate	Serrate	Green group 137 A
45	SH5	6.13	5.01	43.45	3.06	Obtuse	Biserrate	Green group 143 C
Mean		**7.54**	**6.07**	**58.65**	**3.02**			
CV (%)		**2.75**	**2.72**	**2.58**	**2.77**			
CD $_{(0.05)}$		**0.34**	**0.27**	**2.46**	**0.14**			

4.1.12 Leaf shape

Leaf shape in the genotypes studied was observed to be Obtuse in 30 genotypes; Cordate in 12 genotypes and truncate in 3 genotypes (Table 4).

4.1.13 Leaf margin:

Among the genotypes studied leaf margin was observed to serrate in 24 genotypes; biserrate in 14 genotypes and crenate in 7 genotypes (Table 4).

4.1.14 Leaf colour:

Colour of leaves was recorded to be Green group 137 (A, B, C, D) in 24 genotypes; Green group N137 (A, B, C, D) in 11 genotypes; Green group 138 (A, B) in 8 genotypes and Green group 143 C in 2 genotypes (Table 5).

Table 4. Leaf characters (non -metric) of *Prunus armeniaca* L. genotypes

Character	Leaf Shape			Leaf Margin		
Extent of variation	**Cordate**	**Obtuse**	**Truncate**	**Biserrate**	**Crenate**	**Serrate**
Frequency (No. of genotypes)	12	30	3	14	7	24
Percentage (%)	27	67	6	31	16	53

Table 5. Leaf colour variation in the genotypes of *Prunus armeniaca* L.

Character	Leaf Colour			
Extent of variation	**Green group 137 (A, B, C, D)**	**Green group 138 (A, B)**	**Green group N137 (A, B, C, D)**	**Green group 143 C**
Frequency (No. of genotypes)	24	8	11	2
Percentage (%)	53	18	24	5

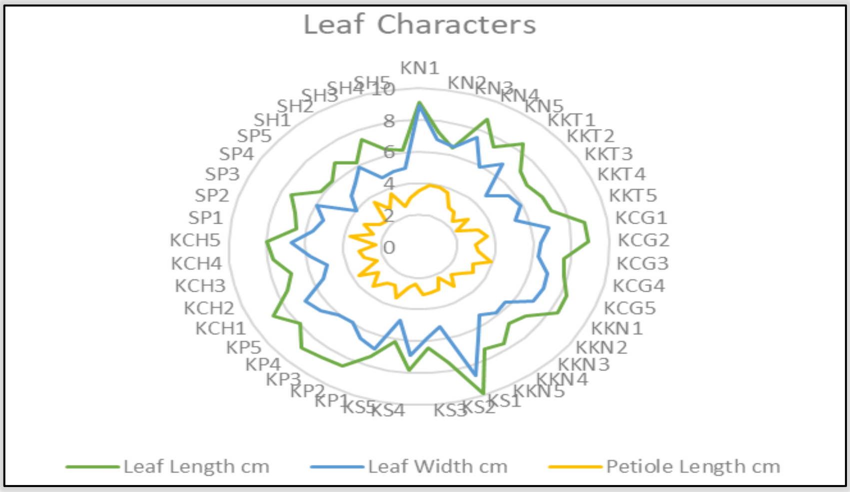


Fig 2. Extent of variation in leaf characters of wild apricot genotypes

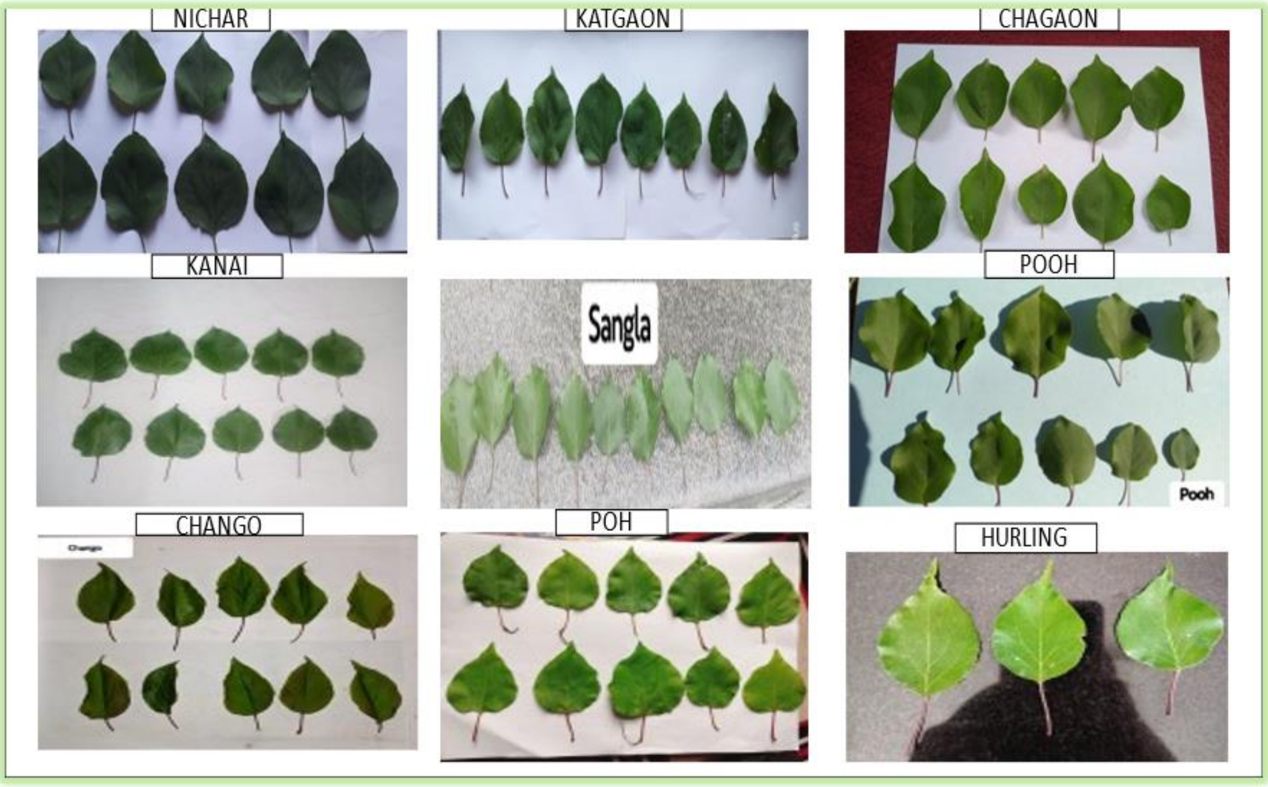


Plate 2. Leaf samples of *Prunus armeniaca* L.

Plate 3. Flowers of *Prunus armeniaca* L.

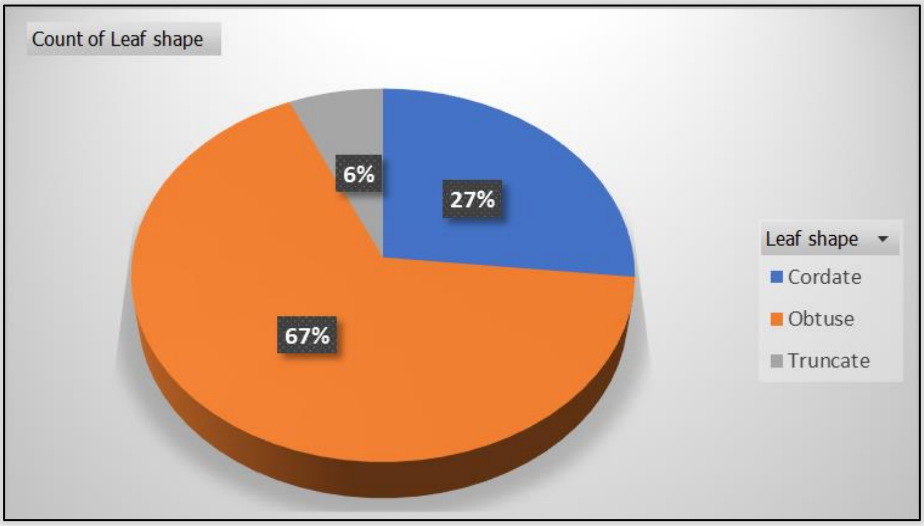


Fig 3. Extent of variation in leaf shape of wild apricot genotypes

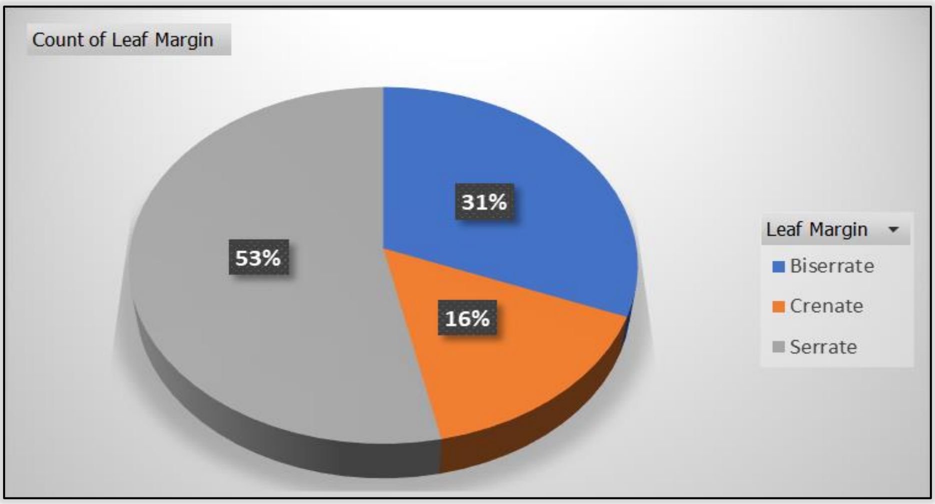


Fig 4. Extent of variation in leaf margin of wild apricot genotypes

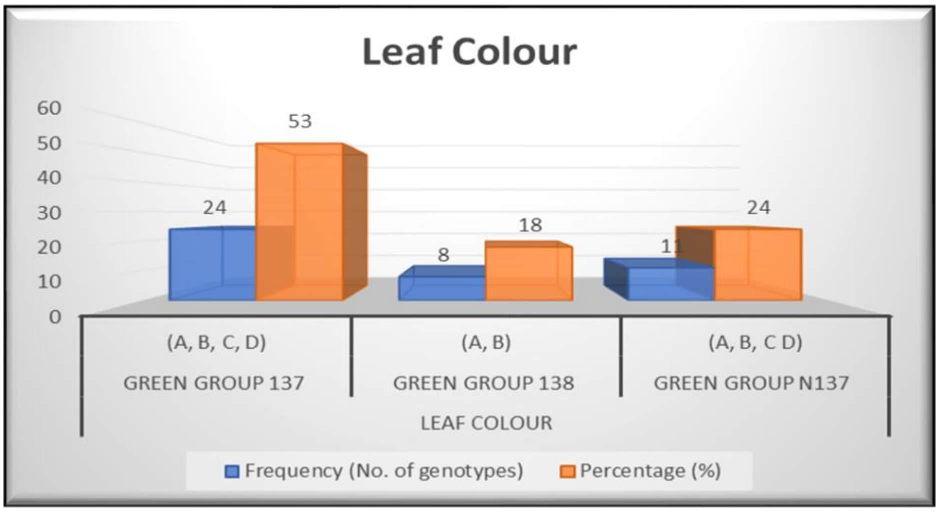


Fig 5. Extent of variation in leaf colour of wild apricot genotypes

Table 6. Variation in leaf characteristics among populations of *Prunus armeniaca* L. at altitudinal gradient

Altitudinal Zone (m amsl)	SITES (S)	Leaf length (cm)	Leaf width (cm)	Leaf area (cm^2)	Petiole length (cm)
A1 (2000-2500)	S1	7.83	7.15	73.65	3.59
	S2	7.37	5.69	60.20	2.76
	S3	8.32	6.72	60.47	3.33
	Mean	7.84	6.52	64.77	3.22
A2 (2500-3000)	S4	7.44	6.10	59.92	2.77
	S5	7.58	6.28	61.96	2.80
	S6	8.29	6.40	60.19	3.04
	Mean	7.77	6.26	60.69	2.87
A3 (3000-3500)	S7	7.77	5.97	61.12	2.89
	S8	6.65	5.13	48.63	2.84
	S9	6.62	5.17	41.74	3.17
	Mean	7.01	5.42	50.50	2.97
CV (%)		9.55	11.82	10.86	12.83
CD (0.05) ALTITUDE		0.54	0.53	4.74	0.29
SITES WITHIN ALTITUDE		0.93	0.92	8.20	0.50

4.1.15 Time and season of flowering

S1 having genotypes KN1, KN2, KN3, KN4 and KN5, the initiation of flowering was observed from the last week of February and time of full bloom was recorded on the first week of March (Table 7).

S2, which has the genotypes KKT1, KKT2, KKT3, KKT4 and KKT5, started to bloom in the first week of March and reached full bloom in the second week of March (Table 7).

In S3, having genotypes KCG1, KCG2, KCG3, KCG4 and KCG5 the time of opening of flower was first noticed in the first week of March whereas the second week of March marked the moment of full bloom (Table 7).

In S4, having genotypes KKN1, KKN2, KKN3, KKN4 and KKN5 the time of flower opening was initially noted in the second week of March, whereas the third week of March represented the period of full bloom (Table 7).

The timing of flower opening in S5, which has genotypes KS1, KS2, KS3, KS4 and KS5, was first seen in the second week of March, while the third week of March indicated the period of full bloom (Table 7).

In S6, which has the genotypes KP1, KP2, KP3, KP4 and KP5, the time of flower opening was observed in the second week of March, whereas the third week of March indicated the period of full bloom (Table 7).

The time of flower opening was noted in the third week of March in S7, which has the genotypes KCH1, KCH2, KCH3, KCH4 and KCH5. The fourth week of March was observed as the period of full bloom (Table 7).

S8 having genotypes SP1, SP2, SP3, SP4 and SP5, the initiation of flowering was observed from the first week of April and time of full bloom was recorded on the second week of April (Table 7).

S9, which has the genotypes SH1, SH2, SH3, SH4 and SH5, started to bloom in the first week of April and reached full bloom in the second week of April (Table 7).

4.1.16 Size of flower (mm)

The findings made from the Table 7 showed that maximum flower length was shown by KKN3 (29.69 mm) followed by KKN1 (29.65 mm), minimum values for flower length was shown by SP5 (17.29 mm) followed by KKT5 (20.72 mm). Overall mean for flower length was recorded as 24.35 mm. The coefficient of variation was 10.23 per cent.

Observations from Table 9 showed that maximum value for flower length was noted in altitudinal zone A2 (25.20 mm) which was statistically at par with A1(23.79 mm) and A3 (24.07 mm). The zones did not significantly differ from one another. Among sites, maximum value was noted for S4 (28.02 mm) and minimum for S2 (23.01 mm). A notable difference can be seen among the sites in altitudinal zone A2.

The findings made from the data in Table 7 showed that the maximum flower breadth was found in KKN3 (27.41mm) followed by KKN1 and SP4 (26.56 mm) whereas, minimum value was observed for genotype KP4 (14.89 mm) followed by SP5 (15.01mm) with an average flower breadth of 21.48 mm. Their coefficient of variation was recorded to be 13.61 per cent.

Inquisition of the data presented in Table 9 revealed that maximum flower breadth was noted for altitudinal zone

A2 (22.17 mm) which was statistically at par with A1 (21.16 mm) and A3 (21.10 mm). No significant difference was seen among the zones. Whereas, among the sites maximum and minimum value for flower breadth was accounted for S4 (25.53 mm) and S6 (20.00 mm), respectively. S1 (23.23 mm) was found to be statistically at par with S4. Only the sites in altitudinal zone 2 were found to have significant differences among them.

Table 7. Variation in floral characteristics among different genotypes of *Prunus armeniaca* L.

Genotype	Flowering Time		Size of Flower		Colour of Flower
	Time of opening of flower	Time of full bloom	Length (mm)	Breadth (mm)	
KN1	Last week of February	First week of March	26.25	23.83	Whitish flower
KN2	Last week of February	First week of March	25.45	22.82	Pinkish flower
KN3	Last week of February	First week of March	25.03	23.05	Whitish flower
KN4	Last week of February	First week of March	24.74	24.32	Pinkish flower
KN5	Last week of February	First week of March	24.60	22.14	Whitish flower
KKT1	First week of March	Second week of March	27.44	24.80	Whitish flower
KKT2	First week of March	Second week of March	23.18	20.26	Pinkish flower
KKT3	First week of March	Second week of March	21.25	18.17	Whitish flower
KKT4	First week of March	Second week of March	22.48	19.32	Pinkish flower
KKT5	First week of March	Second week of March	20.72	17.75	Whitish flower
KCG1	First week of March	Second week of March	21.79	18.49	Pinkish flower
KCG2	First week of March	Second week of March	23.26	19.95	Whitish flower
KCG3	First week of March	Second week of March	24.80	22.08	Pinkish flower
KCG4	First week of March	Second week of March	22.84	20.36	Pinkish flower
KCG5	First week of March	Second week of March	22.97	20.11	Pinkish flower
KKN1	Second week of March	Third week of March	29.65	26.46	Whitish flower
KKN2	Second week of March	Third week of March	27.87	25.00	Pinkish flower
KKN3	Second week of March	Third week of March	29.69	27.41	Whitish flower
KKN4	Second week of March	Third week of March	26.75	24.95	Pinkish flower
KKN5	Second week of March	Third week of March	26.12	23.84	Whitish flower
KS1	Second week of March	Third week of March	25.28	22.2	Whitish flower
KS2	Second week of March	Third week of March	26.02	23.36	Whitish flower

KS3	Second week of March	Third week of March	21.45	18.78	Whitish flower
KS4	Second week of March	Third week of March	22.71	19.97	Whitish flower
KS5	Second week of March	Third week of March	22.49	20.54	Whitish flower
KP1	Second week of March	Third week of March	26.36	21.63	Whitish flower
KP2	Second week of March	Third week of March	22.87	19.48	Whitish flower
KP3	Second week of March	Third week of March	24.97	21.86	Whitish flower
KP4	Second week of March	Third week of March	21.65	14.89	Pinkish flower
KP5	Second week of March	Third week of March	24.07	22.14	Whitish flower
KCH1	Third week of March	Fourth week of March	23.45	17.27	Whitish flower
KCH2	Third week of March	Fourth week of March	23.50	17.25	Pinkish flower
KCH3	Third week of March	Fourth week of March	22.70	20.39	Whitish flower
KCH4	Third week of March	Fourth week of March	27.67	24.57	Whitish flower
KCH5	Third week of March	Fourth week of March	25.95	21.07	Pinkish flower
SP1	First week of April	Second week of April	27.11	24.77	Whitish flower
SP2	First week of April	Second week of April	25.69	24.90	Whitish flower
SP3	First week of April	Second week of April	22.40	19.88	Whitish flower
SP4	First week of April	Second week of April	28.23	26.46	Whitish flower
SP5	First week of April	Second week of April	17.29	15.01	Whitish flower
SH1	First week of April	Second week of April	23.04	22.19	Whitish flower
SH2	First week of April	Second week of April	23.44	21.93	Pinkish flower
SH3	First week of April	Second week of April	25.67	19.11	Whitish flower
SH4	First week of April	Second week of April	23.20	22.12	Whitish flower
SH5	First week of April	Second week of April	21.74	19.65	Whitish flower
Mean			**24.35**	**21.48**	
CV (%)			**2.49**	**2.62**	
CD (0.05)			**0.98**	**0.91**	

4.1.17 Colour of flower

Colour of flower was observed to be whitish in 31 genotypes and pinkish in 14 genotypes (Table 8)

Table 8. Flower characters (non-metric) of *Prunus armeniaca* L. genotypes

Character	Colour of Flower	
Extent of variation	**Pinkish Flower**	**Whitish Flower**
Frequency (No. of genotypes)	14	31
Percentage (%)	31	69

Table 9. Variation in floral characteristics among populations of *Prunus armeniaca* L. at altitudinal gradient

Altitudinal Zone (m amsl)	SITES (S)	Length (mm)	Breadth (mm)
A1 (2000-2500)	**S1**	25.21	23.23
	S2	23.01	20.06
	S3	23.13	20.20
	Mean	23.79	21.16
A2 (2500-3000)	**S4**	28.02	25.53
	S5	23.59	20.97
	S6	23.98	20.00
	Mean	25.20	22.17
A3 (3000-3500)	**S7**	24.65	20.11
	S8	24.14	22.20
	S9	23.42	21.00
	Mean	24.07	21.10
CV (%)		8.69	11.95
CD (0.05) ALTITUDE		1.57	1.91
SITES WITHIN ALTITUDE		2.73	3.31

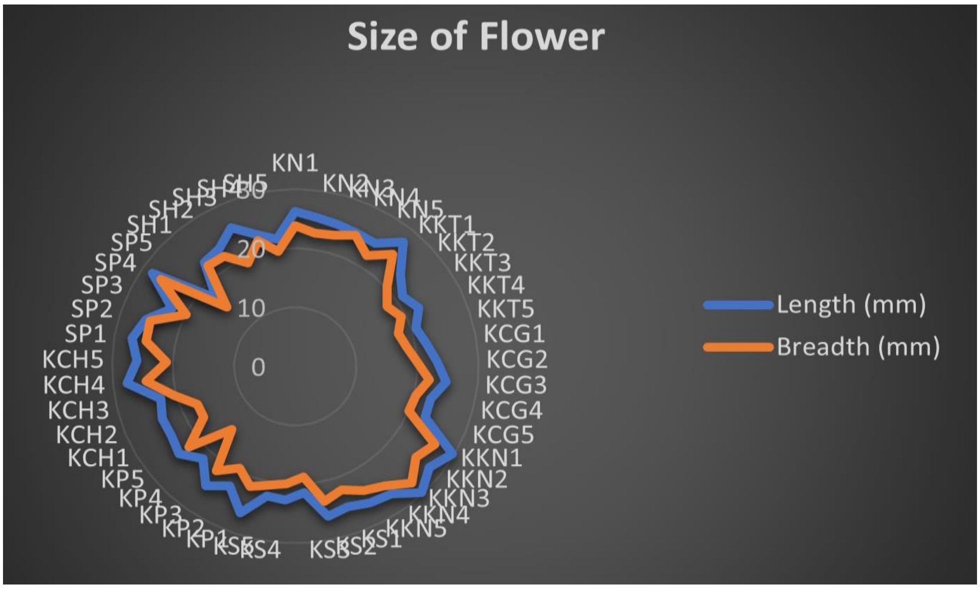


Fig 6. Extent of variation in the size of flowers of Prunus armeniaca L. genotypes

KN5

KCG4

KKN4

KS1

Plate 4. Genotypes of *Prunus armeniaca* L. in full bloom

The examination of data on variation in morphological features of wild apricots across several genotypes, in various sites, and at different altitudinal ranges indicates that significant variations are observed among genotypes and sites, but for altitudinal zones, the data is not varying significantly. Genotype KKN4 excels in all the morphometric traits, *i.e*., tree height, diameter, crown length, crown width, number of primary branches, and number of fruits per branch. Only genotype KN1 shared the maximum value for crown width with genotype KKN4. Site S2 (Katgaon) has maximum values for the traits, *i.e.,* age, tree height, and crown length. Crown width is recorded at its maximum for site S3 (Chagaon). Site S4 (Kanai) is noted to have the maximum value for the number of primary branches, whereas the maximum number of fruits per branch is recorded at site S9 (Hurling). A1 was accounted to have highest values for age and crown width, A2 excelled other zones in maximum number of primary branches and number of fruits per branch while, A3 was noted to have maximum values for tree height, diameter and crown length.

For leaf characters, *i.e*., leaf width and leaf area, genotype KN1 accounted for maximum values, whereas leaf length was observed highest in genotype KS1. For petiole length, KCG4 showed the highest values. Maximum genotypes were reported to have an obtuse leaf shape, serrate margin and leaf colour as in Green group 137 (A, B, C, and D). Among the sites, significant variations in leaf characters were observed in S1 (Nichar), outperforming others in parameters such as leaf width, leaf area, and petiole length. The maximum leaf length was observed in S3 (Chagaon). Altitudinal zone A1 was reported to have maximum values for all the leaf traits. A decrease in values of morphometric characters like leaf length, leaf width, leaf area, and petiole length can be seen with an increase in altitude. Significant differences can be seen among the zones.

For floral characters, genotype KKN3 was recorded as having the largest flowers. Lower elevations were having an earlier start to blossom, and with ideal climatic conditions, full bloom requires, on average, one week to complete. S4 (Kanai) was noted for its maximum flower size. With no discernible variation across the zones, A2 accounted for the highest values among the altitudinal zones.

These results are consistent with those of several researchers. Townsend (1977), reported that height, diameter, and other factors significantly vary depending on the local climate. Oyerinde *et al*. (2018) investigated variation in *Parkia biglobosa* morphometric features (tree height, diameter at breast height, and crown diameter) in three states of Nigeria.

The findings showed that the attributes significantly vary across the chosen states. It was determined that variations in the edapho-climatic parameters of the States were the primary source of this variance. According to Arya *et al*. (1992), environmental and genetic variables may both have a role in the degree of variation seen in morphological features.

Previous research on wild apricots reveals similar types of variability in tree height (Wani and Mughal, 2017) and the other considerable differences can be attributed to the age and edaphic conditions. Similar kind of variations in foliage characters is in confirmation with the previous studies of (Kamrani and Bouzari, 2013; Krichen *et al*., 2014; Zargar *et al*.,202). Similar results pertaining to floral characters is reported by various workers (Sharma, 1991; Avilekh, 2019) in the past. The different cooling hours needed by the chosen genotypes to overcome bud dormancy may be the cause of the diversity in blooming times. According to Blasse and Hofmann (1993), the beginning of apricot blooming is reliant on the rise in temperature following dormancy.

4.2 VARIATION IN FRUIT, SEED AND OIL QUALITY ATTRIBUTES

4.2.1 Fruit length (mm)

The results derived from Table 11 revealed that KCG2 (38.79 mm) was having maximum values for fruit length followed by KKN4 (35.96 mm). KKN5 (27.25 mm) demonstrated the minimal values for fruit length followed by KKT1 (26.92 mm). The average fruit length was measured to be 30.55 mm. The coefficient of variation was 7.81 per cent.

Examining the data in Table 13 showed that the altitudinal zone A1 (31.05 mm) had the largest fruit length, which was statistically comparable to A2 (30.38 mm) and A3 (30.22 mm). Between the zones, there was no discernible change. While S3 (32.52 mm) and S5 (28.94 mm), respectively, had the highest and lowest values for fruit length across the locations. S3 is statistically at par with S2 (30.30 mm), S3 (32.52 mm), S4 (31.19 mm), S6 (31.00mm), S7 (30.04 mm), S8 (29.92 mm) and S9 (30.70 mm). There were no observable differences between the sites.

4.2.2 Fruit breadth (mm)

Maximum fruit breadth was found in KKN4 (34.60 mm) followed by KCG3 (33.68 mm) whereas, minimum value was observed for genotype KKT1 (26.54 mm) followed by KKN5 (26.95 mm) with an average fruit breadth of 29.66 mm. Their coefficient of variation was recorded to be 6.55 per cent (Table 11).

The perusal of data presented in Table 13 revealed that maximum value for fruit breadth was observed in altitudinal zone A1 (29.92 mm) which was statistically at par with A2 (29.79 mm) and A3 (29.27 mm). There were no notable distinctions across the zones. However, among the sites maximum value was recorded for S3 (30.50 mm) and minimum for S5 (28.62 mm). S1 (29.70 mm), S4 (30.32) and S6 (30.44 mm) were statistically at par with S3. There were no observable differences between the sites.

4.2.3 Fruit weight (g)

The data on fruit weight have been presented in Table 11. It is evident from the data that maximum fruit weight was noted in genotype KKT4 (37.08 g) followed by KCG4 (33.00 g) and minimum value was accounted for genotype SH2 (10.41 g), KP5 (11.34 g) came next. Overall mean was 22.73 g with 28.27 per cent coefficient of variation.

Inquisition of the data presented in Table 13 showed that maximum fruit weight was noted for altitudinal zone A1 (29.15 g). Significant difference was seen among the zones. Whereas, among the sites maximum and minimum value for fruit weight was accounted for S3 (30.94 g) and S6 (14.93 g), respectively. S3 was found to be statistically at par with S2 (30.51 g). A notable difference can be seen among the sites.

4.2.4 Pulp weight (g)

The observation of data presented in Table 11 elucidated that among the genotypes maximum pulp weight was recorded for genotype KKT4 (35.23 g) followed by KCG2 (31.28 g) and minimum pulp weight for SH2 (8.41 g) followed by KP4 and KP5 (9.34 g). Average pulp weight and coefficient of variation was observed to be 20.57 g and 30.70 per cent, respectively.

The findings made from the data in Table 13 showed that between three altitudinal zones maximum value for pulp weight was noted in A1 (26.88 g) and minimum in A3 (15.90 g). Significant difference was seen among the three zones. Significant variation was also observed among the sites, with maximum pulp weight recorded for S3 (28.42 g) whereas, minimum for S6 (12.80 g). S2 (28.33 g) was found to be statistically at par with S3.

4.2.5 Stone weight (g)

The data pertaining to Table 11 depicted that genotype having maximum value for stone weight was KCG5 (3.10g) followed by KS1 (3.00 g), whereas minimum value was demonstrated by KKN3 (0.82 g) whereas, SH1 (1.00 g) came next. The average stone weight was 2.16 g. Their coefficient of variation was 28.15 per cent.

The conclusions drawn from Table 13 imply that A1 displayed the largest stone weight (2.27 g) which was also statistically at par with A2 (2.12 g) and A3 (2.08 g). Hence, there was no significant difference observed between the zones. The site S3 (2.52 g) had the highest stone weight value, whereas S4 (2.01 g) had the lowest. S1 (2.10 g), S2 (2.18 g), S4 (2.01 g), S5(2.23 g), S6(2.13 g) S7(2.13 g), S8 (2.04 g) and S9 (2.09 g) were statistically at par with S3. Between the sites, there was also no discernible change.

4.2.6 Pulp: Stone

The pooled values given in Table 11 indicates that KKN3 (26.94) was having maximum pulp stone ratio followed by KCH3 (19.90) and KP4 was observed for the minimum value (4.09), while SH2 (4.21) came next. Overall mean was noted to be 10.43. Their coefficient of variation was 45.28 %.

The perusal of data presented in Table 13 revealed that maximum value for pulp stone ratio was observed in altitudinal zone A1(12.37) which was statistically at par with A2 (10.18). Significant difference exists between the zones, with A1 being distinct from A3. However, among the sites maximum value was recorded for S2 (13.34) and minimum for S6 (6.77). All the sites except S9 and S6 were statistically at par with S2. There were no observable differences between the sites.

4.2.7 Volume

The findings made from the data in Table 11 showed that the maximum volume was found in genotypes KN5 and KKT4 (38 ml) followed by KKT3, KKT5 and KCG4 (30 ml) whereas, minimum value was observed for genotype SH2 (7 ml) followed by KP5 (8 ml) with an average volume of 19.27 ml. Their coefficient of variation was recorded to be 35.38 per cent.

Inquisition of the data presented in Table 13 revealed that maximum volume was noted for altitudinal zone A1 (24.87 ml) and minimum for A3 (14.73 ml). Significant difference was seen among the zones. Whereas, among the sites maximum and minimum value for volume was accounted for S2 (27.60 ml) and S9 (12.00 ml), respectively. S2 was found to be statistically at par with S1 (23.60 ml), S3 (23.40 ml) and S5 (22.20 ml). Sites within altitudinal zone A2 were observed to have significant differences among them.

4.2.8 Specific gravity

Maximum value for specific gravity was recorded for the genotype KCG2 (1.71) followed by KP1 (1.61) whereas, minimum values were recorded for KN5 (0.81) followed by KS4 and KP3 (0.91). Mean value was found to be 1.22 and their coefficient of variation was 16.12 per cent (Table 11).

The findings made from the data in Table 13 showed that between three altitudinal zones maximum value for specific gravity was noted for A3 (1.25) which was found to be statistically at par with A1 (1.22) and A2 (1.19). No significant difference was observed between the zones. Among the sites maximum value recorded was for S9 (1.37) whereas, minimum for S5 (1.11). S1(1.16), S2(1.15), S3 (1.34), S4(1.25), S6(1.22), S7(1.22) and S8 (1.17) were found to be statistically at par with S9. The difference between the sites for this parameter was found to be non-significant.

4.2.9 Fruit shape

Among the genotypes investigated fruit shape was observed round flat in 17 genotypes, round in 14, oblong in 7, ovate in 4 and elliptic in 3 genotypes (Table 10).

Table 10. Fruit characters (non-metric) of *Prunus armeniaca* L. genotypes

Character	**Fruit Shape**				
Extent of variation	**Elliptic**	**Oblong**	**Ovate**	**Round Flat**	**Round**
Frequency (No. of genotypes)	3	7	4	17	14
Percentage (%)	7	15	9	38	31

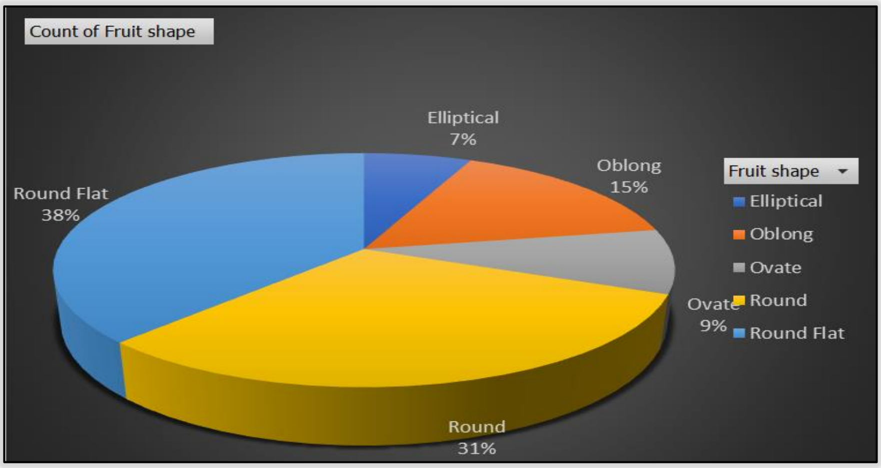


Fig 7. Extent of variation in fruit shape of *Prunus armeniaca* L. genotypes

Table 11. Variation in fruit characteristics among different genotypes of *Prunus armeniaca* L.

Sr. No.	Genotypes	Fruit Length (mm)	Fruit Breadth (mm)	Fruit Weight (g)	Pulp Weight (g)	Stone Weight (g)	Pulp: Stone	Vol. (ml)	Specific gravity	Fruit Shape	Fruit Color
1	KN1	30.52	29.05	25.41	23.91	1.50	15.94	22.00	1.15	Round	YO- 23A
2	KN2	29.37	29.06	24.32	22.32	2.00	11.16	18.00	1.35	Round Flat	YO- 21A
3	KN3	31.60	31.10	20.19	18.00	2.19	8.22	20.00	1.01	Ovate	YO-23B
4	KN4	28.66	28.15	29.12	26.62	2.50	10.65	20.00	1.46	Round	YO- 20C
5	KN5	31.50	31.16	30.89	28.60	2.29	12.49	38.00	0.81	Oblong	YO- 22A
6	KKT1	26.92	26.54	26.76	24.17	2.59	9.33	20.00	1.34	Round Flat	YO- 23B
7	KKT2	28.88	28.00	29.24	27.09	2.15	12.60	20.00	1.46	Round	YO- 22B
8	KKT3	30.35	29.88	28.00	26.12	1.88	13.89	30.00	0.93	Oblong	O- 24B
9	KKT4	32.95	33.21	37.08	35.23	1.85	19.04	38.00	0.98	Round Flat	O-24A
10	KKT5	32.38	30.11	31.47	29.02	2.45	11.84	30.00	1.05	Round Flat	O- 24A
11	KCG1	30.36	29.15	27.43	25.10	2.33	10.77	22.00	1.25	Ovate	YO- 22A
12	KCG2	38.79	33.55	34.15	31.28	2.87	10.90	20.00	1.71	Round	YO-21B
13	KCG3	35.57	33.68	32.21	30.65	1.56	19.65	23.00	1.40	Round Flat	O- 24A
14	KCG4	28.51	26.98	33.00	30.25	2.75	11.00	30.00	1.10	Round	YO- 23A
15	KCG5	29.37	29.16	27.92	24.82	3.10	8.01	22.00	1.27	Round Flat	YO-22A
16	KKN1	32.12	31.47	26.30	24.00	2.30	10.43	22.00	1.20	Round Flat	YO-23C
17	KKN2	31.39	29.39	24.32	22.41	1.91	11.73	20.00	1.22	Round Flat	O- 24B
18	KKN3	29.24	29.21	22.91	22.09	0.82	26.94	18.00	1.27	Round	YO-16A
19	KKN4	35.96	34.60	23.65	21.02	2.63	7.99	17.00	1.39	Round	YO- 17B
20	KKN5	27.25	26.95	21.45	19.05	2.40	7.94	18.00	1.19	Ovate	O- 25A
21	KS1	28.69	28.17	22.75	19.75	3.00	6.58	20.00	1.14	Oblong	YO- 21A
22	KS2	27.37	27.07	29.77	27.39	2.38	11.51	26.00	1.15	Round Flat	YO-23C
23	KS3	28.69	28.68	22.56	20.72	1.84	11.26	19.00	1.19	Round	O- 22A
24	KS4	30.59	29.97	20.00	18.77	1.23	15.26	22.00	0.91	Oblong	YO- 23A
25	KS5	29.35	29.21	27.57	24.86	2.71	9.17	24.00	1.15	Round Flat	O- 24B

26	KP1	31.43	31.08	16.14	13.89	2.25	6.17	10.00	1.61	Round	YO- 20C
27	KP2	30.20	29.26	17.94	15.22	2.72	5.60	21.00	0.85	Round Flat	YO- 22A
28	KP3	30.39	29.98	16.34	15.20	1.14	13.33	18.00	0.91	Round	O- 25B
29	KP4	30.33	30.08	12.89	10.36	2.53	4.09	10.00	1.29	Oblong	YO- 23A
30	KP5	32.63	31.78	11.34	9.34	2.00	4.67	8.00	1.42	Round Flat	YO-22A
31	KCH1	29.72	29.03	18.44	15.48	2.96	5.23	14.00	1.32	Oblong	YO-23C
32	KCH2	28.57	28.04	17.00	14.42	2.58	5.59	16.00	1.06	Round Flat	YO- 21 B
33	KCH3	31.89	31.77	20.90	19.90	1.00	19.90	17.00	1.23	Oblong	O- 25C
34	KCH4	29.96	29.63	14.18	12.16	2.02	6.02	11.00	1.29	Elliptic	YO- 16A
35	KCH5	30.07	29.61	15.83	13.76	2.07	6.65	13.00	1.22	Round Flat	YO- 17B
36	SP1	31.13	28.07	20.78	18.97	1.81	10.48	16.00	1.30	Round	O- 24A
37	SP2	30.01	29.15	21.54	18.57	2.97	6.25	20.00	1.08	Round	O- 24B
38	SP3	28.26	27.34	17.43	16.35	1.08	15.14	15.00	1.16	Elliptic	YO- 22A
39	SP4	29.08	28.03	19.31	17.79	1.52	11.70	14.00	1.38	Elliptic	YO-23C
40	SP5	31.11	30.78	23.17	20.37	2.80	7.28	25.00	0.93	Round Flat	O- 24B
41	SH1	29.42	27.50	11.96	10.96	1.00	10.96	9.00	1.33	Round	YO-20A
42	SH2	27.62	27.43	10.41	8.41	2.00	4.21	7.00	1.49	Ovate	YO-20C
43	SH3	31.81	31.54	18.91	16.36	2.55	6.42	14.00	1.35	Round	O- 24A
44	SH4	29.35	28.63	19.88	16.83	3.05	5.52	15.00	1.33	Round Flat	YO- 24A
45	SH5	35.28	32.53	20.01	18.17	1.84	9.88	15.00	1.33	Round Flat	YO- 24B
Mean		**30.55**	**29.66**	**22.73**	**20.57**	**2.16**	**10.43**	**19.27**	**1.22**		
CV (%)		**2.53**	**2.34**	**2.93**	**2.72**	**2.48**	**3.00**	**2.62**	**2.90**		
CD $_{(0.05)}$		**1.25**	**1.13**	**1.08**	**0.91**	**0.09**	**0.51**	**0.82**	**0.06**		

*YO = Yellow Orange
*O = Orange

4.2.10 Fruit colour

Although most wild apricot trees produced fruits that ranged in colour from yellow to orange, there were some notable variations when the fruits were subjectively assessed using colour charts. Fruit colour of the genotypes studied were observed to be Yellow Orange Group (23 A, B, C) and Orange Group (24 A, B) in 10 genotypes, Yellow Orange Group (22 A, B) in 7 genotypes, Yellow Orange Group (20 A, C) and Yellow Orange Group (21 A, B) in 4 genotypes, Orange Group (25 A, B, C) in 3 genotypes, Yellow Orange Group (16 A), Yellow Orange Group (17 B) and Yellow Orange Group (24 A, B) in 2 genotypes each and Orange Group (22 A) in one genotype (Table 12).

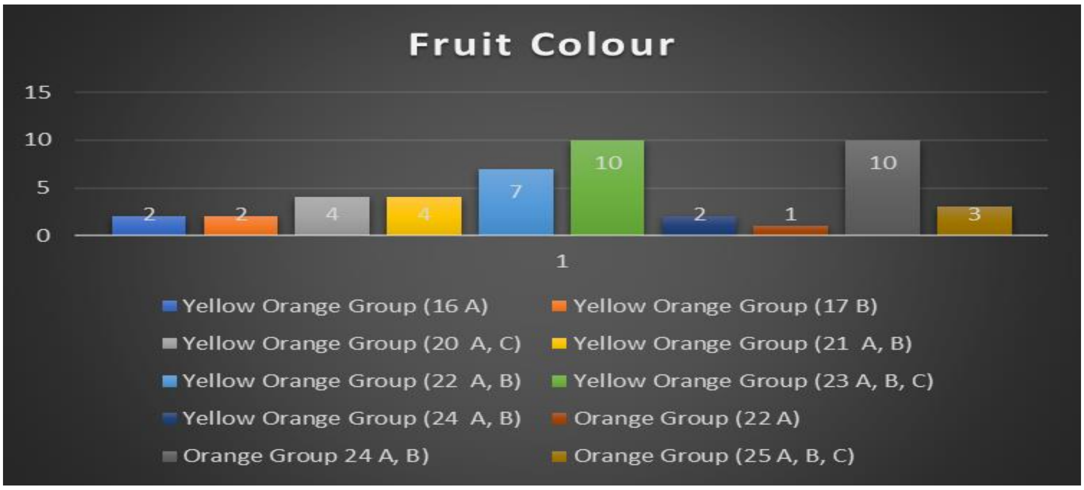


Fig 8. Extent of variation in the fruit colour of *Prunus armeniaca* L. genotypes

Table 12. Fruit colour variation in the genotypes of *Prunus armeniaca* L.

Character	**Fruit Colour**									
Extent of variation	**Yellow Orange Group (16 A)**	**Yellow Orange Group (17 B)**	**Yellow Orange Group (20 A, C)**	**Yellow Orange Group (21 A, B)**	**Yellow Orange Group (22 A, B)**	**Yellow Orange Group (23 A, B, C)**	**Yellow Orange Group (24 A, B)**	**Orange Group (22 A)**	**Orange Group (24 A, B)**	**Orange Group (25 A, B, C)**
Frequency (No. of genotypes)	2	2	4	4	7	10	2	1	10	3
Percentage (%)	4	4	9	9	17	22	4	2	22	7

Measurement of fruit size

Fruits of *Prunus armeniaca* L.

Fruit colour determination

Plate 5. Fruit characteristics

Table 13. Variation in fruit characteristics among populations of *Prunus armeniaca* L. at altitudinal gradient

Altitudinal Zone (m amsl)	SITES (S)	Fruit Length (mm)	Fruit Breadth (mm)	Fruit Weight (g)	Pulp Weight (g)	Stone Weight (g)	Pulp: Stone	Volume (ml)	Specific gravity
A1 (2000-2500)	**S1**	30.33	29.70	25.99	23.89	2.10	11.69	23.60	1.16
	S2	30.30	29.55	30.51	28.33	2.18	13.34	27.60	1.15
	S3	32.52	30.50	30.94	28.42	2.52	12.07	23.40	1.34
	Mean	31.05	29.92	29.15	26.88	2.27	12.37	24.87	1.22
A2 (2500-3000)	**S4**	31.19	30.32	23.73	21.71	2.01	13.01	19.00	1.25
	S5	28.94	28.62	24.53	22.30	2.23	10.76	22.20	1.11
	S6	31.00	30.44	14.93	12.80	2.13	6.77	13.40	1.22
	Mean	30.38	29.79	21.06	18.94	2.12	10.18	18.20	1.19
A3 (3000-3500)	**S7**	30.04	29.62	17.27	15.14	2.13	8.68	14.20	1.22
	S8	29.92	28.67	20.45	18.41	2.04	10.17	18.00	1.17
	S9	30.70	29.53	16.23	14.15	2.09	7.39	12.00	1.37
	Mean	30.22	29.27	17.98	15.90	2.08	8.75	14.73	1.25
CV (%)		8.28	6.81	15.45	16.74	27.15	38.30	26.23	16.22
CD (0.05) ALTITUDE		1.88	1.50	2.61	2.56	0.44	2.97	3.76	0.15
SITES WITHIN ALTITUDE		3.26	2.60	4.53	4.44	0.75	5.15	6.51	0.26

An appraisal of data on variation in fruit, seed and oil quality attributes of *Prunus armeniaca* L. indicated that there are significant differences in the parameters undertaken for fruit and seed characteristics assessment whereas, non-significant variations are noted for the metrics used to assess oil quality. The data for fruit varies considerably among the genotypes, among the sites, and within the altitudinal zones. Maximum fruit length and breadth are recorded for the genotypes KCG2 and KKN4, respectively. For fruit weight and pulp weight, KKT4 was found to have the highest values. While among the sites, S3 was recorded to have the highest values for fruit length, fruit breadth, fruit weight, and pulp weight. Maximum genotypes had a round, flat shape, and the fruit colours Yellow Orange Group (23 A, B, and C) and Orange Group (24 A, B) each had 10 genotypes. Overall, the altitudinal zone A1 was found to have the highest values for all the fruit traits.

These observations were in accordance with those of (Dwivedi *et al*. 2003; Asma and Ozturk 2005; Jannatizadeh *et al*. 2008; Onal 2014; Kumar *et al*. 2015) who have previously studied the physical properties of apricots and have noted a significant difference in the fruits of wild apricot genotypes.

4.2.11 100 Seed (stone) weight (g)

The data on fruit weight have been presented in Table 14. It is evident from the data that maximum 100 seed weight was noted in genotype KN1 (141 g) followed by SP1 (139 g) and minimum value was accounted for genotypes KKT5 and KS1 (81 g), KKT4 (82 g) came next. Overall mean was 102.20 g with 17.15 per cent coefficient of variation.

Inquisition of the data presented in Table 16 showed that maximum seed weight was noted for altitudinal zone A3 (114.40 g) and minimum in A2 (91.00 g). Significant difference was seen among the zones. Whereas, among the sites maximum and minimum value for fruit weight was accounted for S8 (126.4 g) and S2 (83.4 g), respectively. S8 was found to be statistically at par with S1 (119 g) and S9 (124.2). A notable difference can be seen among the sites of all the three zones.

4.2.12 100 Kernel weight (g)

The observation of data presented in Table 10 elucidated that among the genotypes maximum kernel weight was recorded for genotype KCH4 (42.02 g) followed by KP1 (40.83 g) and minimum kernel weight was observed for SH4 (21.37 g) followed by SH3 (21.89 g). The observed values for the average kernel weight and coefficient of variation were 30.93 g and 20.82 %, respectively.

According to the conclusions drawn from the data in Table 16, the largest kernel weight was recorded in Altitudinal Zone A1 (32.37 g), and the lowest value was recorded in Altitudinal Zone A3 (29.18 g). There were noticeable differences across the three zones. Significant differences were seen between the locations, with S7 recording the highest kernel weight (40.45 g) and S9 the lowest (22.52 g). S7 was found to be statistically at par with S6 (39.76 g). The sites of the three zones all differ noticeably from one another.

4.2.13 Seed length (mm)

The findings made from the Table 14 showed that maximum seed length was shown by KP4 (18.00 mm) followed by KCH5 (15.16 mm), minimum values for seed length was shown by KKN2 (11.33 mm) followed by KS1 (11.57 mm). Overall mean for seed length was recorded as 13.10 mm. The coefficient of variation was 9.99 per cent.

Observations from Table 16 showed that maximum value for seed length was noted in altitudinal zone A2 (13.33 mm) which was statistically at par with A3 (13.25 mm). Significant difference can be seen among the zones. Among sites, maximum value was noted for S6 (15.40 mm) and minimum for S5 (12.17 mm). S6 was noted to be statistically at par with S7 (14.88 mm). A notable difference can be seen among the sites in the altitudinal gradients.

4.2.14 Seed breadth (mm)

The findings made from the data in Table 14 showed that the maximum seed breadth was found in KCG3 (10.12 mm) followed by KCH4 (9.75 mm) whereas, minimum value was observed for genotype KKN2 (8.03 mm) followed by KKT4 (8.11mm) with an average seed breadth of 9.06 mm. Their coefficient of variation was recorded to be 5.23 per cent.

Inquisition of the data presented in Table 16 revealed that maximum seed breadth was noted for altitudinal zone A3 (9.18 mm) which was statistically at par with A1 (9.00 mm) and A2 (9.00 mm). No significant difference was seen among the zones. Whereas, among the sites maximum and minimum value for seed breadth was accounted for S6, S7 (9.57 mm) and S2 (8.50 mm), respectively. Only S3 (9.41 mm) was found to be statistically at par with S6 and S7. Significant differences can be seen among the sites in all the zones.

Table 14. Variation in seed morphology among different genotypes of *Prunus armeniaca* L.

Sr. No.	Genotype	100 Seed (stone) Weight (g)	100 Kernel Weight (g)	Kernel Length (mm)	Kernel Breadth (mm)	Kernel Taste
1	KN1	141	39.92	13.17	9.62	Bitter
2	KN2	113	32.98	13.02	8.30	Bitter
3	KN3	110	35.38	12.66	9.05	Bitter
4	KN4	118	39.34	12.14	9.18	Sweet
5	KN5	113	35.83	12.40	9.29	Bitter
6	KKT1	87	29.76	12.23	8.73	Bitter
7	KKT2	83	26.70	12.17	8.21	Sweet
8	KKT3	84	30.02	12.26	8.55	Bitter
9	KKT4	82	28.70	11.73	8.11	Bitter
10	KKT5	81	29.14	12.49	8.90	Bitter
11	KCG1	106	31.35	12.35	9.11	Sweet
12	KCG2	86	31.49	12.70	8.96	Bitter
13	KCG3	103	30.00	14.46	10.12	Sweet
14	KCG4	116	33.92	12.99	9.14	Sweet
15	KCG5	95	31.05	13.86	9.73	Bitter
16	KKN1	87	28.95	12.88	8.89	Bitter
17	KKN2	92	28.59	11.33	8.03	Bitter
18	KKN3	93	28.40	12.84	8.92	Bitter
19	KKN4	90	27.77	12.87	8.90	Sweet
20	KKN5	87	26.96	12.13	8.59	Bitter

21	KS1	81	25.29	11.57	8.55	Bitter
22	KS2	84	25.27	12.06	8.41	Bitter
23	KS3	88	26.59	12.76	9.29	Bitter
24	KS4	85	25.90	12.19	8.78	Sweet
25	KS5	83	26.15	12.29	8.83	Sweet
26	KP1	100	40.83	14.82	9.57	Bitter
27	KP2	97	39.86	14.56	9.51	Bitter
28	KP3	103	40.25	15.00	9.59	Bitter
29	KP4	98	40.00	18.00	9.68	Sweet
30	KP5	97	37.84	14.64	9.52	Bitter
31	KCH1	94	39.84	14.66	9.35	Bitter
32	KCH2	88	40.74	14.92	9.63	Sweet
33	KCH3	88	39.05	14.63	9.37	Bitter
34	KCH4	104	42.02	15.03	9.75	Bitter
35	KCH5	89	40.60	15.16	9.73	Sweet
36	SP1	139	25.04	12.68	9.26	Bitter
37	SP2	130	24.93	12.12	9.12	Bitter
38	SP3	108	23.96	12.07	8.90	Bitter
39	SP4	130	25.09	12.52	9.07	Bitter
40	SP5	125	23.86	13.27	8.77	Bitter
41	SH1	116	22.00	12.28	8.91	Bitter
42	SH2	126	24.01	12.65	9.11	Sweet
43	SH3	130	21.89	12.56	9.06	Bitter
44	SH4	126	21.37	12.16	8.86	Bitter
45	SH5	123	23.32	12.10	8.77	Bitter
Mean		**102.20**	**30.93**	**13.10**	**9.06**	
CV (%)		**2.19**	**2.49**	**2.62**	**2.68**	
CD $_{(0.05)}$		**3.64**	**1.25**	**0.56**	**0.39**	

4.2.15 Kernel taste

In the majority of genotypes examined, the taste of the kernel was bitter. Only 12 genotypes were found to have a sweet taste, whereas 33 genotypes had a bitter taste. In district Kinnaur, sweet kernels are used to make garlands, and bitter ones are used to extract oil.

Table 15. Kernel taste variation among the genotypes of *Prunus armeniaca* L.

Character	**Kernel Taste**	
Extent of variation	**Sweet**	**Bitter**
Frequency (No. of genotypes)	12	33
Percentage (%)	27	73

Plate 6. Seeds (stones) collected from the study sites

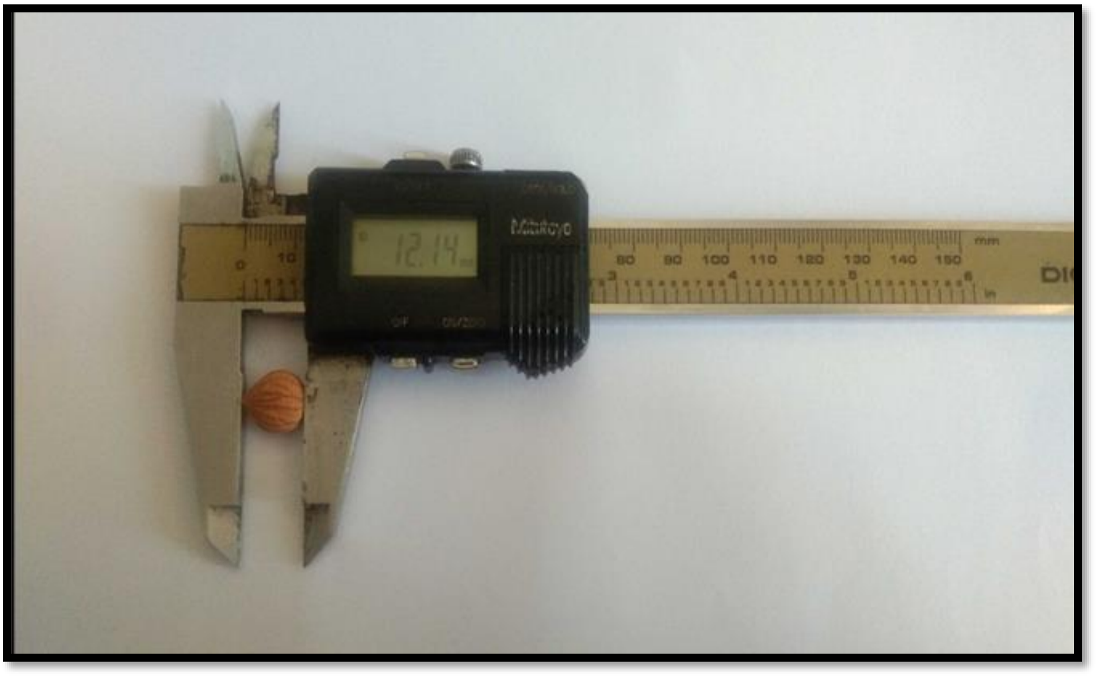


Plate 7. Measurement of Kernel length

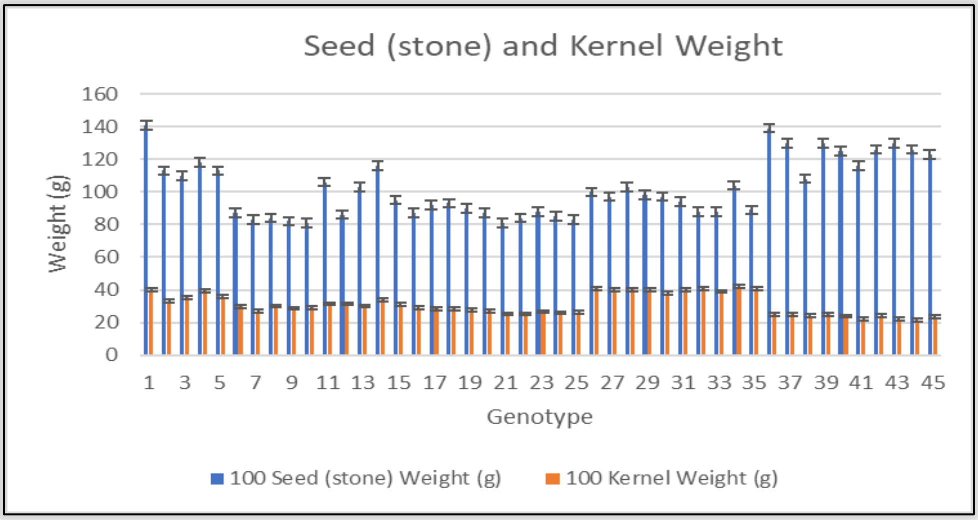


Fig 9. Difference between 100 seed (stone) weight and 100 kernel weight among genotypes of *Prunus armeniaca* L.

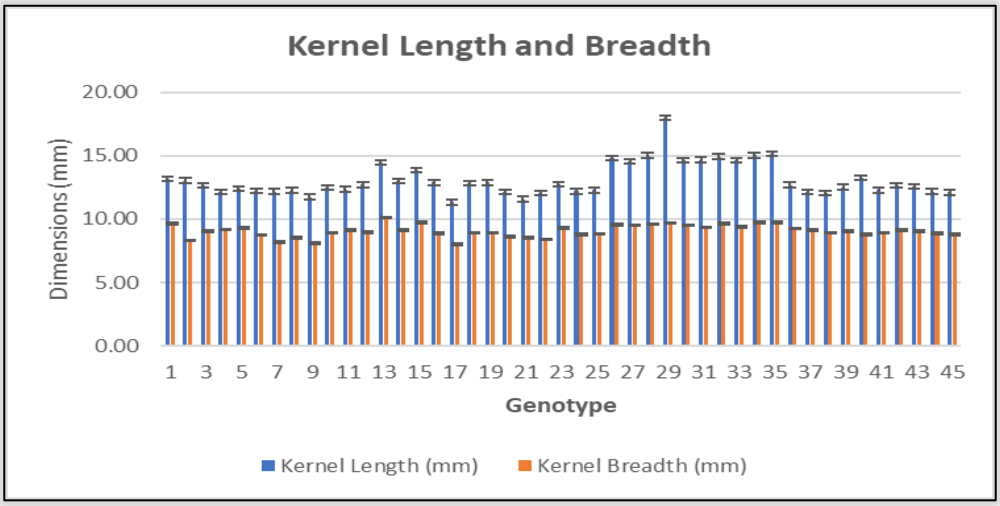


Fig 10. Extent of variation in size of kernels among the genotypes *of Prunus armeniaca* L.

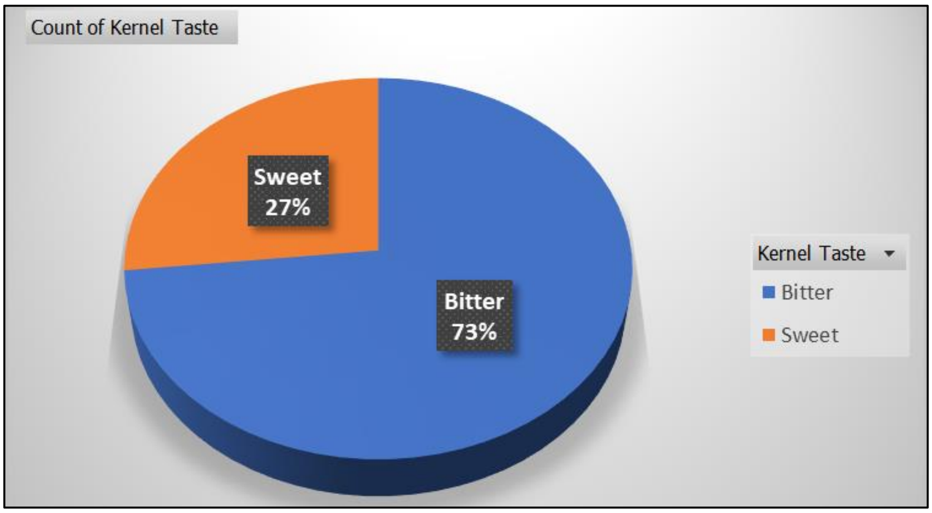


Fig 11. Extent of variation in the kernel taste of *Prunus armeniaca* L. genotypes

Table 16. Variation in seed morphology among populations of *Prunus armeniaca* L. at altitudinal gradient

Altitudinal Zone (m amsl)	SITES (S)	100 Seed (stone) Weight (g)	100 Kernel Weight (g)	Kernel Length (mm)	Kernel Breadth (mm)
A1 (2000-2500)	S1	119	36.69	12.68	9.09
	S2	83.4	28.86	12.18	8.50
	S3	101.2	31.56	13.27	9.41
	Mean	101.20	32.37	12.71	9.00
A2 (2500-3000)	S4	89.8	28.13	12.41	8.67
	S5	84.2	25.84	12.17	8.77
	S6	99	39.76	15.40	9.57
	Mean	91.00	31.24	13.33	9.00
A3 (3000-3500)	S7	92.6	40.45	14.88	9.57
	S8	126.4	24.58	12.53	9.02
	S9	124.2	22.52	12.35	8.94
	Mean	114.40	29.18	13.25	9.18
CV (%)		7.19	4.39	5.27	3.37
CD $_{(0.05)}$ ALTITUDE		5.47	1.01	0.51	0.23
SITES WITHIN ALTITUDE		9.47	1.75	0.89	0.39

According to the analysis of seed morphology data, there are considerable differences between genotypes, locations, and even within an altitudinal gradient. KN1 excelled in 100 seed (stone) weight, and KCH4 in 100 kernel weight. For kernel length and breadth, KP4 and KCG3 were recorded to have maximum values, respectively. Among sites, S8 excelled in 100 seed (stone) weight; S7 was found to be best for 100 kernel weight; whereas, for kernel length and kernel breadth, S6 was found to have the highest values. Altitudinal zone A3 depicted maximum values for 100 Seed (stone) weight and Kernel breadth; for 100 kernel weight, A1 recorded the maximum value, and the highest value for kernel length was noted in A2. Genotypes with a bitter kernel taste were 73%, whereas only 27% had sweet kernels.

These outcomes are in line with those of several scholars who have worked on the concerned species. The range of kernel characters in present study lie close to the range observed by (Alpaslan and Hayta 2006; Kumar *et al*. 2015 and Arora 2018).

4.2.16 Oil content (%)

Oil content percent in altitudinal zone A1 ranged between 43.2 and 46.5% with a mean value of 44.70%, while in altitudinal zone A2 it ranged between 44.7 and 46.2% with an overall mean of 45.50%, and in altitudinal zone A3 it was observed to be between 44.1 and 46.8% with

Plate 8. Extraction of oil using Soxhlet apparatus

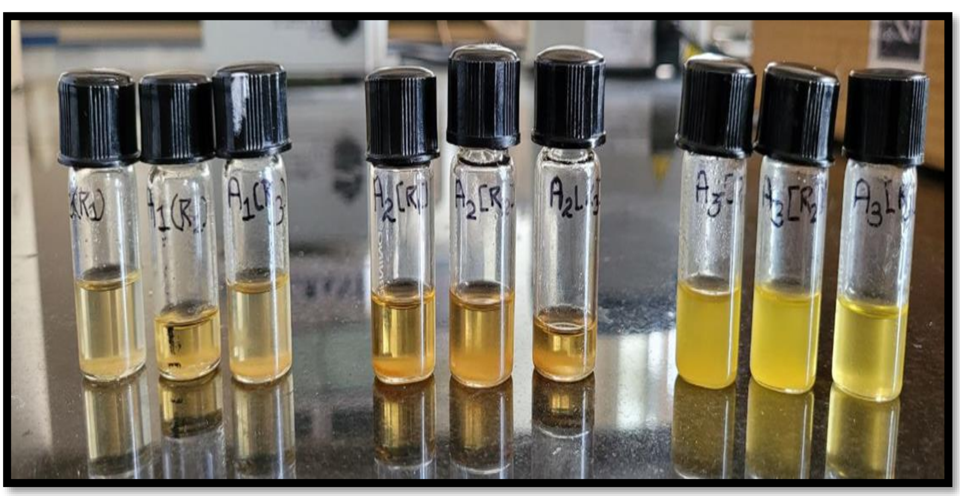


Plate 9. Oil samples of *Prunus armeniaca* L.

a mean value of 45.60%. Their coefficient of variation was 3.74%, 1.66% and 3.01%, respectively (Table 17).

Table 17. Altitudinal variation in oil content (%) of *Prunus armeniaca* L.

Altitudinal Zone (m amsl)	**A1 (2000-2500)**	**A2 (2500-3000)**	**A3 (3000-3500)**
Range	43.2-46.5	44.7-46.2	44.1-46.8
Mean	44.70	45.50	45.60
CV (%)	3.74	1.66	3.01
CD $_{(0.05)}$	NS		

4.2.17 Specific gravity

The specific gravity noted to be between 0.914 and 0.915 with a mean value of 0.914333 in altitudinal zone A1, 0.914 to 0.915 with an overall mean of 0.914667 in altitudinal zone A2, and 0.914 to 0.915 with a mean value of 0.914667 in altitudinal zone A3. Their respective coefficients of variation were 0.063144%, 0.063121% and 0.063121% (Table 18).

Table 18. Altitudinal variation in specific gravity of *Prunus armeniaca* L. oil

Altitudinal Zone (m amsl)	**A1 (2000-2500)**	**A2 (2500-3000)**	**A3 (3000-3500)**
Range	0.914-0.915	0.914-0.915	0.914-0.915
Mean	0.914333	0.914667	0.914667
CV (%)	0.063144	0.063121	0.063121
CD $_{(0.05)}$	NS		

4.2.18 Refractive index

The analysis of data pertaining to refractive index of *Prunus armeniaca* L. oil shown in Table 19 suggested that no significant variation was found among the altitudinal gradients. The values for A1 and A2 were respectively between 1.467 and 1.4725, 1.472 and 1.4729, while A3 was between 1.4671 and 1.4726. Mean value was approximately 1.47 for all the three zones. Their coefficient of variation was 0.208529%, 0.033499 and 0.212096%, respectively.

Table 19. Altitudinal variation in refractive index of *Prunus armeniaca* L. oil

Altitudinal Zone (m amsl)	A1 (2000-2500)	A2 (2500-3000)	A3 (3000-3500)
Range	1.467-1.4725	1.472-1.4729	1.4671-1.4726
Mean	1.470533	1.472567	1.4707
CV (%)	0.208529	0.033499	0.212096
CD (0.05)	NS		

4.2.19 Acid value

An appraisal of Table 20 indicated a non-significant variation in acid value among the three altitudinal zones. In A1, acid values ranged between 2.26 and 2.78 with a mean value of 2.44 and a coefficient of variation of 11.95%, whereas in A2, acid values ranged between 2.25 and 2.75 with an overall mean value of 2.52 and a coefficient of variation of 10.02%. In A3, the acid value varied between 2.28 and 2.72, with 2.54 as a mean value and a 9.14% coefficient of variation.

Table 20. Altitudinal variation in acid value of *Prunus armeniaca* L. oil

Altitudinal Zone (m amsl)	A1 (2000-2500)	A2 (2500-3000)	A3 (3000-3500)
Range (mg KOH/g)	2.26-2.78	2.25-2.75	2.28-2.72
Mean	2.44	2.52	2.54
CV (%)	11.95	10.02	9.14
CD (0.05)	NS		

4.2.20 Saponification value

Saponification value in altitudinal zone A1 ranged between 189.2 and 190.8 with a mean value of 189.90, while in altitudinal zone A2 it ranged between 189.4 and 191.5 with an overall mean of 190.33, and in altitudinal zone A3 it was observed to be between 190.4 and 191.3 with a mean value of 190.80. Their coefficient of variation was 0.43%, 0.56% and 0.24%, respectively (Table 21).

Table 21. Altitudinal variation in saponification value of *Prunus armeniaca* L. oil

Altitudinal Zone (m amsl)	A1 (2000-2SSSS500)	A2 (2500-3000)	A3 (3000-3500)
Range (mg KOH/g)	189.2-190.8	189.4-191.5	190.4-191.3
Mean	189.90	190.33	190.80
CV (%)	0.43	0.56	0.24
CD (0.05)	NS		

4.2.21 Unsaponifiable matter

The perusal of data presented in Table 22 revealed that in altitudinal gradient A1, values for unsaponifiable matter ranged between 0.6 and 0.75 with a mean value of 0.67 and a coefficient of variation of 11.46%, whereas in A2, unsaponifiable matter ranged between 0.73 and 0.8 with an overall mean value of 0.77 and a coefficient of variation of 4.90%. In A3, the unsaponifiable matter varied between 0.78 and 0.81, with 0.80 as a mean value and a 1.92% coefficient of variation.

Table 22. Altitudinal variation in unsaponifiable matter of *Prunus armeniaca* L. oil

Altitudinal Zone (m amsl)	A1 (2000-2500)	A2 (2500-3000)	A3 (3000-3500)
Range (%)	0.6-0.75	0.73-0.8	0.78-0.81
Mean	0.67	0.77	0.80
CV (%)	11.46	4.90	1.92
CD (0.05)	NS		

The observations of data on oil content and quality attributes of *Prunus armeniaca* L. worked under laboratory condition suggests that no significant variation was observed among the three zones for various physical and chemical characteristics studied. The genetic make-up of plants, local environmental conditions may be the causes of differences in the stone and kernel characteristics as well as oil content (Sharma and Sharma, 2001). Jessinta *et al*. (2014) suggested that geographical variation plants affect the chemical and physical attributes of the oil. The current findings on oil content % were found to be in agreement with the results of (Gupta and Sharma 2009; Gayas *et al*. 2016; Arora 2018; Stryjecka *et al*. 2019). Indian cultivars of apricot are thought to have 44% oil, according to the study by Joshi *et al*. (1986).

The result for specific gravity, refractive index, acid value, saponification value and unsaponifiable matter are in agreement with the results of (Gupta 2006; Singh *et al*. 2010; Gupta *et al*. 2012; Gayas *et al*. 2016; Stryjecka *et al.* 2019). Ruan and Huang (2006) discovered that there was no statistically significant difference in the saponification value among the various seed sources of *Sapindus mukorossi* (Reetha). Sharma (2015) in his study revealed that all the oil quality parameters *i.e*., Relative viscosity, Specific gravity, Refractive index, Saponification value did not vary significantly among the seed sources. Sophia (2004) investigated the variation in seed sources in *Juglans regia* for oil quality parameters and discovered non-significant variation in the specific gravity and saponification value of oil sample extracted from walnut collected from various seed sources.

4.3 CORRELATION STUDIES

4.3.1 Estimation of Karl Pearson's correlation coefficient among different morphological traits.

Data presented in Table 23 depicted that out of 45 correlation coefficients worked out for 10 different morphological traits, 7 were found significantly correlated at 0.01 level whereas, 9 (out of which 7 were positively correlated and 2 were negatively corelated) were found significantly correlated at 0.05 level.

Positive and highly significant correlations were obtained among diameter and tree height (0.598), diameter and crown length (0.596), diameter and crown width (0.418), diameter and number of fruits per branch (0.524), tree height and crown length (0.970), leaf length and leaf width (0.754), leaf width and leaf area (0.491) at 1% level of significance.

Positive and highly significant correlations were also obtained among diameter and number of primary branches (0.310), tree height and number of fruits per branch (0.369), crown length and crown width (0.312), crown length and number of fruits per branch (0.368), number if primary branches and number of fruits per branch (0.321), leaf length and leaf area (0.364), leaf width and petiole length (0.312) at 5% level of significance.

Table 23. Karl Pearson's Correlation Coefficient among Morphological traits

	Diameter	Tree Height	Crown Length	Crown Width	No. of Primary Branches	No. of Fruits per Branch	Leaf Length	Leaf Width	Leaf Area	Petiole Length
1	1									
2	0.598**	1								
3	0.596**	0.970**	1							
4	0.418**	0.267NS	0.312*	1						
5	0.310*	0.198NS	0.188NS	0.177NS	1					
6	0.524**	0.369*	0.368*	0.232NS	0.321*	1				
7	-0.164NS	-0.186NS	-0.161NS	0.090NS	0.068NS	-0.164NS	1			
8	-0.231NS	-0.348*	-0.309*	0.095NS	0.054NS	-0.185NS	0.754**	1		
9	-0.006NS	-0.201NS	-0.176NS	0.201NS	0.126NS	-0.114NS	0.364*	0.491**	1	
10	0.007NS	-0.114NS	-0.141NS	0.216NS	0.040NS	-0.233NS	0.245NS	0.312*	0.172NS	1
Where; 1-Diameter, 2-Tree height, 3- Crown length, 4- Crown width, 5- No. of primary branches, 6-No. of fruits per branch, 7-Leaf length, 8-Leaf width, 9-Leaf area, 10- Petiole length.										

*Correlation is significant at the 0.05 level, ** Correlation is significant at the 0.01 level, NS = non-significant

Analysis of data presented in Table 24 revealed that out of 21 correlation coefficients worked out for 7 different traits, 5 were found to be significantly correlated at 0.01 level and only one was significantly correlated at 0.05 level. Positive and highly significant correlations were obtained among fruit length and fruit breadth (0.916), kernel weight and kernel length (0.720), kernel weight and kernel breadth (0.593), kernel length and kernel breadth (0.748) at 1% level of significance.

Table 24. Karl Pearson's Correlation Coefficient among different Fruit and Kernel traits

Parameters	Fruit Weight	Fruit Length	Fruit Breadth	Seed Weight	Kernel Weight	Kernel Length	Kernel Breadth
Fruit Weight	1						
Fruit Length	0.251^{NS}	1					
Fruit Breadth	0.195^{NS}	0.916^{**}	1				
Seed Weight	-0.261^{NS}	-0.036^{NS}	-0.125^{NS}	1			
Kernel Weight	-0.142^{NS}	0.041^{NS}	0.127^{NS}	-0.157^{NS}	1		
Kernel Length	-0.457^{**}	0.086^{NS}	0.192^{NS}	-0.074^{NS}	0.720^{**}	1	
Kernel Breadth	-0.363^{*}	0.114^{NS}	0.146^{NS}	0.224^{NS}	0.593^{**}	0.748^{**}	1

*Correlation is significant at the 0.05 level, ** Correlation is significant at the 0.01 level, ^{NS} = non-significant

Present results were in confirmation with th findings of Lune and Tewari (2008) examined eight morphological characteristics in 49 native and foreign poplar clones and found a positive and substantial association between the plant and diameter. Kumaran *et al*. (2010) conducted correlation research on fifteen *Simarouba glauca* seed sources and discovered a highly significant and positive association between height and diameter.

Thakur (2012) in his study on *Ulmus villosa*, discovered a highly significant and positive genotypic correlation, whereas a significant and positive phenotypic correlation also existed between the parameters of height and diameter. Conclusion of the study was that the existence of such a correlation could be used for indirect selection, allowing for the measurement of one trait to provide a reliable estimate of the correlated trait.

Devi (2016) found that there are significant and positive relationships between tree height and crown length, tree height and crown width, crown length and crown width in her research on variability studies in *Quercus leucotricophora* (Ban oak) groups in Himachal Pradesh. Klepacki (2017) investigated the connections between height and crown traits of birch species and found that significant and positive correlation existed between height of the tree and crown length and width.

Fruit characters taken into consideration *i.e.*, fruit length and fruit breadth also showed positive and highly significant correlation and this was in accordance with the findings of Mratinic *et al*. (2011). Additionally, a significant and positive link between apricot stone, kernel weight and other kernel characteristics was noted by Singh and Chaudhary (1993).

The correlation coefficients have not been worked out for the oil quality and attributes as they exhibited non-significant variations among the altitudinal zones.

4.4 STATISTICAL ANALYSIS

Effective tree improvement programmes depend on the type and degree of genetic variety that already exists as well as how well characteristics are transmitted. The observed variation in traits across all genotypes is caused by the interaction between genotype and environment, with environmental changes being unavoidable. Therefore, genotypic and phenotypic coefficients of variation were calculated in the current study to assess the degree of genotypic and phenotypic variability. The analysis of the data for all the investigated features revealed that the phenotypic coefficient of variation was larger than the corresponding genotypic coefficient of variation (Table 25).

The estimates of phenotypic variance were highest for fruit weight (68.35) followed by pulp: stone (13.42), whereas it was recorded to be minimum for petiole length (0.23) followed by kernel breadth (0.31). Genotypic variance was recorded at its maximum for fruit weight (56.04), while flower breadth (3.68) came next. Minimum value was accounted for petiole length (0.08) followed by kernel breadth (0.22).

Phenotypic coefficient of variability was recorded maximum for pulp: stone (38.34) followed by fruit weight (37.13) whereas minimum value was recorded for kernel breadth (6.19) followed by flower length (10.84). Genotypic coefficient of variability was noted highest for fruit weight (33.62) followed by tree height (22.20). Kernel breadth (5.19) and flower length (6.49) were the lowest values, respectively.

Table 25. Variability Parameters for Morphological Traits of *Prunus armeniaca* L.

Morphometric Traits	Variance		Coefficient of Variability (%)	
	Phenotypic	Genotypic	Phenotypic	Genotypic
Tree Height	6.6	2.91	33.54	22.20
Crown Length	5.19	1.89	35.41	21.38
Crown Width	2.23	0.54	29.42	14.54
Flower Length	6.46	6.09	10.43	10.13
Flower Breadth	8.76	8.44	13.78	13.52
Leaf Length	0.91	0.86	12.62	12.31
Leaf Width	1.02	0.99	16.62	16.39
Petiole Length	0.25	0.24	16.56	16.32
Fruit Weight	41.60	41.16	28.38	28.22
Pulp: Ratio	22.37	22.28	45.35	45.25
Kernel Length	1.79	1.67	10.22	2.88
Kernel Breadth	0.26	0.20	4.67	4.99

High and moderate phenotypic coefficients of variation show that there is significant diversity and that there is plenty of room for their development through selection. Therefore, these characters may benefit from further enhancement. In contrast, a low phenotypic coefficient of variation suggested that these features were very stable throughout the range of genotypes examined and had limited room for improvement.

These results support the findings of Devi (2016) in *Quercus leucotricophora*, Kairon (2017) in *Hippophae rhamnoides* L., Chauhan (2018) in *Prunus armeniaca* L., and Aukta (2022) in *Quercus floribunda* Lindl., who, for all morphological features taken into account for the study, reported greater values for phenotypic coefficients of variability (PCV) than the corresponding genotypic coefficients of variability (GCV).

Chapter -5

SUMMARY AND CONCLUSIONS

The present study entitled **“Seed source variation in tree morphology and oil quality of *Prunus armeniaca* L.”** aimed to assess the variation in genotypes of wild apricot for different morphological traits and oil quality attributes along the altitudinal gradient. It was undertaken under natural conditions as well as in laboratory of Department of Tree Improvement and Genetic Resources, College of Forestry, Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan (H.P.) during the years 2021-2023. During the survey phenotypically superior trees were selected and marked properly for the measurements and collection of data related to flower, foliage, fruit and seeds. Further, physical and chemical properties of oil were also studied. The pooled data was then used to study the variations, correlations and statistical analysis. The salient findings of the results obtained and outlined below:

- The various morphological traits which were measured under the natural forest conditions include tree height, diameter at breast height, crown length, crown width, tree age, total number of branches per tree, number of fruits per branch, leaf length, leaf width, leaf colour, leaf shape, leaf margin, petiole length, time and season of flowering, size of flower, colour of flower, fruit size and fresh weight, fruit shape, colour of fruit, stone weight, pulp weight, pulp stone ratio, volume and specific gravity, 100 seed (stone) weight, kernel length, kernel width, kernel taste whereas leaf area, 100 kernel weight and various physical and chemical characteristics of oil studied under laboratory conditions were oil content %, specific gravity, refractive index, acid value, saponification value, and unsaponifiable matter.

- Given the age differences between the selected wild apricot genotypes, there was a significant amount of variation in the tree morphological traits. Genotype KKN4 excelled in all the morphometric traits recorded. Site S2, S3, S4 and S9 were recorded to have maximum values for traits *i.e.*, age, tree height, and crown length; Crown width; number of primary branches; number of fruits per branch, respectively. Among the three ranges A1 was reported to have the greatest values for age and crown width, A2 outperformed other zones in terms of the maximum number of primary branches and the number of fruits per branch, and A3 was noted to have the highest values for tree height, diameter, and crown length.

- Most genotypes had an obtuse leaf shape and serrated leaf margin. Colour of leaves varied from Green group 137 (A, B, C, and D) to Green group 143 C. In terms of leaf characteristics, such as leaf width and leaf area, genotype KN1 had the greatest values, but genotype KS1 had the longest leaves. The KCG4 genotype had the highest values for petiole length.

- The genotype KKN3 was noted to have the maximum flower size. Lower elevations started to bloom earlier, and under ideal climatic circumstances, full bloom takes an average of one week to complete.

- The data collected for fruit varies greatly across genotypes, between sites, and within altitudinal zones. For the genotypes KCG2 and KKN4, respectively, maximum fruit length and width were noted. KKT4 was identified to have the greatest values for fruit weight and pulp weight. Maximum genotypes had a round, flat shape, and the fruit colours varied between Yellow Orange Group (23 A, B, and C) and Orange Group (24 A, B) to Orange Group 22 A.

- Among genotypes, KCH4 excelled in 100 kernel weight, whereas KN1 excelled in 100 seed (stone) weight. The maximum values for kernel length and width were found to be KP4 and KCG3, respectively. Maximum genotypes were having bitter kernels while rest had sweet kernels.

- Site-wise analysis of pooled data showed that S1(Nichar) was accounted for as having maximum values for leaf width, leaf area, petiole length and stone weight (for stone weight value was at par with S5). S2 (Katgaon) was recorded to have the highest pulp-stone ratio and volume of fruit traits. S3 (Chagaon) was noted to have the maximum values for leaf length, fruit length, fruit breadth, fruit eight, pulp weight, and specific gravity. S4 (Kanai) had the largest flower size. S6 (Pooh) was identified to have the greatest values for kernel length and kernel breadth. S7 (Chango) had maximum 100 kernel weight and was on par with S6 for kernel breadth. 100 seed (stone) was observed maximum at S8 (Poh).

- An altitudinal zone-wise review of the data elucidated that A1(2000-2500 m) was found best for traits like leaf length, leaf width, leaf area, petiole length, fruit length, fruit breadth, fruit weight, pulp weight, stone weight, pulp: stone, volume and 100 kernel weight whereas A2 (2500–3000 m) had maximum values for flower size (flower length and flower breadth) and Kernel length. A3 (3000–3500 m) exhibited higher values for Specific gravity of fruits, 100 seed (stone) weight, and kernel breadth.

- The physical and chemical characteristics of oil were examined along the altitudinal ranges, and a non-significant variation was found. The highest mean values for oil content percentage, Specific gravity, and Refractive index were recorded in Altitudinal zones A3; A2 and A3; A2 respectively. Altitudinal zone A3 was observed to have maximum values for all the chemical characteristics of oil, *i.e.*, Acid value, Saponification value, and unsaponifiable matter.
- Karl Pearson's correlation studies for morphometric traits revealed positive and highly significant correlations among diameter and tree height, diameter and crown length, diameter and crown width, diameter and number of fruits per branch, tree height and crown length, leaf length and leaf width, and leaf width and leaf area. While among different fruit and kernel traits, positive and highly significant correlations were obtained for fruit length and fruit breadth, kernel weight and kernel length, kernel weight and kernel breadth, and kernel length and kernel breadth.
- Statistical analysis revealed higher values for phenotypic variance than genotypic variance and phenotypic coefficient of variability (PCV) than genotypic coefficient of variability (GCV).

CONCLUSIONS

The following conclusions can be drawn on the basis of present findings:

- Significant differences were found across the various populations, indicating a high degree of diversity in the genotypes of wild apricot, which demonstrates its appropriateness for future tree breeding initiatives.
- In terms of the morphological traits of trees, altitudinal zone A3 (3000-3500 m) displayed the maximum mean values indicating the potential for success when choosing from this area.
- A decrease in values of morphometric characters like leaf length, leaf width, leaf area and petiole length can be seen with increase in altitude.

- Data analysis of fruit traits has shown that there is a trend towards a decrease in fruit size and weight with an increase in altitude. Therefore, the genotypes from lower altitudinal zones may be bred to produce progeny that will have good fruit characteristics, which will be advantageous to the farmers who consider commercializing this.
- No significant variation in the physical and chemical properties of oil was recorded for the three zones, which suggests that for these properties of *Prunus armeniaca* L. oil, any of these studied zones can be used as a source of choice.
- High saponification value and low acid value of oil point to the possibility of its potential application in the cosmetics business.
- Further, the potential of deoiled cake to be used as cow feed may create new opportunities in this industry and raise a farmer's or grower's total revenue.

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APPENDIX-I

Basic information of wild apricot genotypes

Sr. No.	Genotype	Site	Latitude	Longitude	Altitude (m amsl)
1.	KN1	Nichar	N 31^{o}33.119’	E 077^{0}55.620’	2100
2.	KN2				
3.	KN3				
4.	KN4				
5.	KN5				
6.	KKT1	Katgaon	N 31^{0}35.537’	E 078^{0}02.125’	2086
7.	KKT2				
8.	KKT3				
9.	KKT4				
10.	KKT5				
11.	KCG1	Chagaon	N 31^{0}31.951’	E 078^{0}05.326’	2265
12.	KCG2				
13.	KCG3				
14.	KCG4				
15.	KCG5				
16.	KKN1	Kanai	N 31^{0}29.922’	E 078^{0}09.840’	2674
17.	KKN2				
18.	KKN3				
19.	KKN4				
20.	KKN5				
21.	KS1	Sangla	N 31^{0}25.545’	E 078^{0}15.851’	2621
22.	KS2				
23.	KS3				
24.	KS4				
25.	KS5				
26.	KP1	Pooh	N 31^{0}32.316’	E 078^{0}16.057’	2662
27.	KP2				
28.	KP3				
29.	KP4				
30.	KP5				
31.	KCH1	Chango	N 31^{0}97.58’	E 078^{0}59.052’	3058
32.	KCH2				
33.	KCH3				
34.	KCH4				
35.	KCH5				
36.	SP1	Poh	N 32^{0}07.083’	E 078^{0}19.186’	3280
37.	SP2				
38.	SP3				
39.	SP4				
40.	SP4				
41.	SH1	Hurling	N 32^{0}03.787’	E 078^{0}33.048’	3120
42.	SH2				
43.	SH3				
44.	SH4				
45.	SH5				

APPENDIX-II

1. ANOVA for variations in tree morphology

1.1 Age:

Source of Variation	Degree of Freedom	Sum of Squares	Mean Sum of Squares	F- Calculated	F- Table	Conclusion
Replication	4	91.20	22.80	0.35	2.67	NS
Treatment	8	1041.91	130.24	2.00	2.24	NS
Altitude	2	228.04	114.02	1.75	3.29	NS
Sites Within Altitude 1	2	454.53	227.27	3.49	3.29	SIG
Sites Within Altitude 2	2	4.80	2.40	0.04	3.29	NS
Sites Within Altitude 3	2	354.53	177.27	2.73	3.29	NS
Error	32	2081.20	65.04			
Total	44					

1.2 Tree height:

Source of Variation	Degree of Freedom	Sum of Squares	Mean Sum of Squares	F - Calculated	F- Table	Conclusion
Replication	4	19.14	4.79	1.28	2.67	NS
Treatment	8	99.84	12.48	3.34	2.24	SIG
Altitude	2	14.01	7.01	1.87	3.29	NS
Sites Within Altitude 1	2	76.13	38.07	10.18	3.29	SIG
Sites Within Altitude 2	2	3.60	1.80	0.48	3.29	NS
Sites Within Altitude 3	2	6.10	3.05	0.82	3.29	NS
Error	32	119.66	3.74			
Total	44					

1.3 Diameter:

Source of Variation	Degree of Freedom	Sum of Squares	Mean Sum of Squares	F- Calculated	F- Table	Conclusion
Replication	4	51.69	12.92	0.93	2.67	NS
Treatment	8	54.84	6.86	0.50	2.24	NS
Altitude	2	4.30	2.15	0.16	3.29	NS
Sites Within Altitude 1	2	15.24	7.62	0.55	3.29	NS
Sites Within Altitude 2	2	22.79	11.39	0.82	3.29	NS
Sites Within Altitude 3	2	12.52	6.26	0.45	3.29	NS
Error	32	442.97	13.84			
Total	44					

1.4 Crown length:

Source of Variation	Degree of Freedom	Sum of Squares	Mean Sum of Squares	F- Calculated	F- Table	Conclusion
Replication	4	15.97	3.99	1.21	2.67	NS
Treatment	8	71.80	8.97	2.72	2.24	SIG
Altitude	2	8.13	4.07	1.23	3.29	NS
Sites Within Altitude 1	2	53.20	26.60	8.07	3.29	SIG
Sites Within Altitude 2	2	5.03	2.52	0.76	3.29	NS
Sites Within Altitude 3	2	5.43	2.72	0.82	3.29	NS
Error	32	105.53	3.30			
Total	44					

1.5 Crown width:

Source of Variation	Degree of Freedom	Sum of Squares	Mean Sum of Squares	F- Calculated	F- Table	Conclusion
Replication	4	1.42	0.36	0.21	2.67	NS
Treatment	8	26.58	3.32	1.97	2.24	NS
Altitude	2	6.74	3.37	2.00	3.29	NS
Sites Within Altitude 1	2	14.70	7.35	4.36	3.29	SIG
Sites Within Altitude 2	2	2.10	1.05	0.62	3.29	NS
Sites Within Altitude 3	2	3.03	1.52	0.90	3.29	NS
Error	32	53.98	1.69			
Total	44					

1.6 Total number of primary branches per tree:

Source of Variation	Degree of Freedom	Sum of Squares	Mean Sum of Squares	F- Calculated	F- Table	Conclusion
Replication	4	45.64	11.41	0.82	2.67	NS
Treatment	8	64.40	8.05	0.58	2.24	NS
Altitude	2	2.80	1.40	0.10	3.29	NS
Sites Within Altitude 1	2	14.93	7.47	0.54	3.29	NS
Sites Within Altitude 2	2	22.53	11.27	0.81	3.29	NS
Sites Within Altitude 3	2	24.13	12.07	0.87	3.29	NS
Error	32	443.16	13.85			
Total	44					

1.7 Number of fruits per branch:

Source of Variation	Degree of Freedom	Sum of Squares	Mean Sum of Squares	F- Calculated	F- Table	Conclusion
Replication	4	45.64	11.41	0.82	2.67	NS
Treatment	8	64.40	8.05	0.58	2.24	NS
Altitude	2	2.80	1.40	0.10	3.29	NS
Sites Within Altitude 1	2	14.93	7.47	0.54	3.29	NS
Sites Within Altitude 2	2	22.53	11.27	0.81	3.29	NS
Sites Within Altitude 3	2	24.13	12.07	0.87	3.29	NS
Error	32	443.16	13.85			
Total	44					

1.8 a Leaf length (ANOVA for genotypes):

Source of Variation	Degree of Freedom	Sum of Squares	Mean Sum of Squares	F- Calculated	F- Table	Conclusion
Replication	2	0.03	0.02	0.35	3.10	NS
Treatment	44	115.73	2.63	60.99	1.51	SIG
Error	88	3.79	0.04			
Total	134	119.55				

1.8 b Leaf length (ANOVA for altitude and sites within altitude):

Source of Variation	Degree of Freedom	Sum of Squares	Mean Sum of Squares	F- Calculated	F- Table	Conclusion
Replication	4	6.98	1.74	3.36	2.67	SIG
Treatment	8	15.00	1.88	3.62	2.24	SIG
Altitude	2	6.36	3.18	6.13	3.29	SIG
Sites Within Altitude 1	2	2.27	1.13	2.19	3.29	NS
Sites Within Altitude 2	2	2.09	1.05	2.02	3.29	NS
Sites Within Altitude 3	2	4.28	2.14	4.13	3.29	SIG
Error	32	16.59	0.52			
Total	44					

1.9 a Leaf width (ANOVA for genotypes):

Source of Variation	Degree of Freedom	Sum of Squares	Mean Sum of Squares	F- Calculated	F- Table	Conclusion
Replication	2	0.07	0.04	1.29	3.10	NS
Treatment	44	131.77	2.99	109.80	1.51	SIG
Error	88	2.40	0.03			
Total	134	134.24				

1.9 b Leaf width (ANOVA for altitude and sites within altitude):

Source of Variation	Degree of Freedom	Sum of Squares	Mean Sum of Squares	F- Calculated	F- Table	Conclusion
Replication	4	9.52	2.38	4.63	2.67	SIG
Treatment	8	17.94	2.24	4.36	2.24	SIG
Altitude	2	9.86	4.93	9.58	3.29	SIG
Sites Within Altitude 1	2	5.63	2.81	5.47	3.29	SIG
Sites Within Altitude 2	2	0.24	0.12	0.23	3.29	NS
Sites Within Altitude 3	2	2.22	1.11	2.15	3.29	NS
Error	32	16.47	0.51			
Total	44					

1.10 a Leaf area (ANOVA for genotypes):

Source of Variation	Degree of Freedom	Sum of Squares	Mean Sum of Squares	F- Calculated	F- Table	Conclusion
Replication	2	0.58	0.29	0.13	3.10	NS
Treatment	44	14200.61	322.74	140.76	1.51	SIG
Error	88	201.77	2.29			
Total	134	14402.96				

1.10 b Leaf area (ANOVA for altitude and sites within altitude):

Source of Variation	Degree of Freedom	Sum of Squares	Mean Sum of Squares	F-Calculated	F- Table	Conclusion
Replication	4	245.80	61.45	1.52	2.67	NS
Treatment	8	3190.35	398.79	9.84	2.24	SIG
Altitude	2	1622.25	811.12	20.01	3.29	SIG
Sites Within Altitude 1	2	590.97	295.48	7.29	3.29	SIG
Sites Within Altitude 2	2	12.35	6.18	0.15	3.29	NS
Sites Within Altitude 3	2	964.78	482.39	11.90	3.29	SIG
Error	32	1297.38	40.54			
Total	44					

1.11 a Petiole length (ANOVA for genotypes):

Source of Variation	Degree of Freedom	Sum of Squares	Mean Sum of Squares	F- Calculated	F- Table	Conclusion
Replication	2	0.00	0.00	0.04	3.10	NS
Treatment	44	32.39	0.74	105.04	1.51	SIG
Error	88	0.62	0.01			
Total	134	33.01				

1.11 b Petiole length (ANOVA for altitude and sites within altitude):

Source of Variation	Degree of Freedom	Sum of Squares	Mean Sum of Squares	F- Calculated	F- Table	Conclusion
Replication	4	2.68	0.67	4.46	2.67	SIG
Treatment	8	3.30	0.41	2.75	2.24	SIG
Altitude	2	1.00	0.50	3.33	3.29	SIG
Sites Within Altitude 1	2	1.78	0.89	5.94	3.29	SIG
Sites Within Altitude 2	2	0.22	0.11	0.72	3.29	NS
Sites Within Altitude 3	2	0.31	0.15	1.02	3.29	NS
Error	32	4.81	0.15			
Total	44					

1.12 a Flower length (ANOVA for genotypes):

Source of Variation	Degree of Freedom	Sum of Squares	Mean Sum of Squares	F- Calculated	F- Table	Conclusion
Replication	2	0.25	0.12	0.34	3.10	NS
Treatment	44	819.85	18.63	50.76	1.51	SIG
Error	88	32.30	0.37			
Total	134	852.40				

1.12 b Flower length (ANOVA for altitude and sites within altitude)

Source of Variation	Degree of Freedom	Sum of Squares	Mean Sum of Squares	F- Calculated	F- Table	Conclusion
Replication	4	34.15	8.54	1.91	2.67	NS
Treatment	8	95.85	11.98	2.68	2.24	SIG
Altitude	2	16.67	8.34	1.86	3.29	NS
Sites Within Altitude 1	2	15.31	7.66	1.71	3.29	NS
Sites Within Altitude 2	2	60.00	30.00	6.70	3.29	SIG
Sites Within Altitude 3	2	3.86	1.93	0.43	3.29	NS
Error	32	143.29	4.48			
Total	44					

1.13 a Flower breadth (ANOVA for genotypes):

Source of Variation	Degree of Freedom	Sum of Squares	Mean Sum of Squares	F- Calculated	F- Table	Conclusion
Replication	2.00	0.21	0.10	0.33	3.10	NS
Treatment	44.00	1127.85	25.63	80.65	1.51	SIG
Error	88.00	27.97	0.32			
Total	134.00	1156.03				

1.13 b Flower breadth (ANOVA for altitude and sites within altitude):

Source of Variation	Degree of Freedom	Sum of Squares	Mean Sum of Squares	F- Calculated	F- Table	Conclusion
Replication	4	23.82	5.96	0.90	2.67	NS
Treatment	8	141.15	17.64	2.68	2.24	SIG
Altitude	2	10.70	5.35	0.81	3.29	NS
Sites Within Altitude 1	2	32.14	16.07	2.44	3.29	NS
Sites Within Altitude 2	2	87.26	43.63	6.62	3.29	SIG
Sites Within Altitude 3	2	11.04	5.52	0.84	3.29	NS
Error	32	210.98	6.59			
Total	44					

ANOVA for variations in fruit, seed and oil quality attributes

2.1 a Fruit length (ANOVA for genotypes):

Source of Variation	Degree of Freedom	Sum of Squares	Mean Sum of Squares	F- Calculated	F- Table	Conclusion
Replication	2	0.02	0.01	0.02	3.10	NS
Treatment	44	750.54	17.06	28.61	1.51	SIG
Error	88	52.47	0.60			
Total	134	803.03				

2.1 b Fruit length (ANOVA for altitude and sites within altitude):

Source of Variation	Degree of Freedom	Sum of Squares	Mean Sum of Squares	F- Calculated	F- Table	Conclusion
Replication	4	5.93	1.48	0.23	2.67	NS
Treatment	8	39.41	4.93	0.77	2.24	NS
Altitude	2	5.83	2.92	0.46	3.29	NS
Sites Within Altitude 1	2	16.24	8.12	1.27	3.29	NS
Sites Within Altitude 2	2	15.59	7.80	1.22	3.29	NS
Sites Within Altitude 3	2	1.75	0.87	0.14	3.29	NS
Error	32	204.84	6.40			
Total	44					

2.2 a Fruit breadth (ANOVA for genotypes):

Source of Variation	Degree of Freedom	Sum of Squares	Mean Sum of Squares	F- Calculated	F- Table	Conclusion
Replication	2	3.07	1.53	3.18	3.10	SIG
Treatment	44	498.39	11.33	23.50	1.51	SIG
Error	88	42.41	0.48			
Total	134	543.86				

2.2 b Fruit breadth (ANOVA for altitude and sites within altitude):

Source of Variation	Degree of Freedom	Sum of Squares	Mean Sum of Squares	F- Calculated	F- Table	Conclusion
Replication	4	16.28	4.07	1.00	2.67	NS
Treatment	8	19.22	2.40	0.59	2.24	NS
Altitude	2	3.53	1.76	0.43	3.29	NS
Sites Within Altitude 1	2	2.63	1.32	0.32	3.29	NS
Sites Within Altitude 2	2	10.36	5.18	1.27	3.29	NS
Sites Within Altitude 3	2	2.70	1.35	0.33	3.29	NS
Error	32	130.63	4.08			
Total	44					

2.3 a Fruit weight (ANOVA for genotypes):

Source of Variation	Degree of Freedom	Sum of Squares	Mean Sum of Squares	F- Calculated	F- Table	Conclusion
Replication	2	1.63	0.82	1.84	3.10	NS
Treatment	44	5452.43	123.92	279.41	1.51	SIG
Error	88	39.03	0.44			
Total	134	5493.09				

2..3 b Fruit weight (ANOVA for altitude and sites within altitude):

Source of Variation	Degree of Freedom	Sum of Squares	Mean Sum of Squares	F- Calculated	F- Table	Conclusion
Replication	4	18.17	4.54	0.37	2.67	NS
Treatment	8	1404.33	175.54	14.22	2.24	SIG
Altitude	2	997.17	498.59	40.39	3.29	SIG
Sites Within Altitude 1	2	75.36	37.68	3.05	3.29	NS
Sites Within Altitude 2	2	283.63	141.81	11.49	3.29	SIG
Sites Within Altitude 3	2	48.17	24.08	1.95	3.29	NS
Error	32	394.98	12.34			
Total	44					

2.4 a Pulp weight (ANOVA for genotypes):

Source of Variation	Degree of Freedom	Sum of Squares	Mean Sum of Squares	F- Calculated	F- Table	Conclusion
Replication	2	1.60	0.80	2.55	3.10	NS
Treatment	44	5266.40	119.69	382.48	1.51	SIG
Error	88	27.54	0.31			
Total	134	5295.54				

2.4 b Pulp weight (ANOVA for altitude and sites within altitude):

Source of Variation	Degree of Freedom	Sum of Squares	Mean Sum of Squares	F- Calculated	F- Table	Conclusion
Replication	4	11.84	2.96	0.25	2.67	NS
Treatment	8	1364.06	170.51	14.37	2.24	SIG
Altitude	2	964.07	482.04	40.64	3.29	SIG
Sites Within Altitude 1	2	67.01	33.51	2.82	3.29	NS
Sites Within Altitude 2	2	283.23	141.62	11.94	3.29	SIG
Sites Within Altitude 3	2	49.74	24.87	2.10	3.29	NS
Error	32	379.57	11.86			
Total	44					

2.5 a Stone weight (ANOVA for genotypes):

Source of Variation	Degree of Freedom	Sum of Squares	Mean Sum of Squares	F- Calculated	F- Table	Conclusion
Replication	2	0.00	0.00	0.60	3.10	NS
Treatment	44	48.72	1.11	386.81	1.51	SIG
Error	88	0.25	0.00			
Total	134	48.97				

2.5 b Stone weight (ANOVA for altitude and sites within altitude):

Source of Variation	Degree of Freedom	Sum of Squares	Mean Sum of Squares	F- Calculated	F- Table	Conclusion
Replication	4	4.33	1.08	3.15	2.67	SIG
Treatment	8	0.93	0.12	0.34	2.24	NS
Altitude	2	0.28	0.14	0.41	3.29	NS
Sites Within Altitude 1	2	0.51	0.25	0.74	3.29	NS
Sites Within Altitude 2	2	0.12	0.06	0.18	3.29	NS
Sites Within Altitude 3	2	0.02	0.01	0.03	3.29	NS
Error	32	10.98	0.34			
Total	44					

2.6 a Pulp: Stone (ANOVA for genotypes):

Source of Variation	Degree of Freedom	Sum of Squares	Mean Sum of Squares	F- Calculated	F- Table	Conclusion
Replication	2	0.14	0.07	0.73	3.10	NS
Treatment	44	2944.68	66.92	685.14	1.51	SIG
Error	88	8.60	0.10			
Total	134	2953.42				

2.6 b Pulp: Stone (ANOVA for altitude and sites within altitude):

Source of Variation	Degree of Freedom	Sum of Squares	Mean Sum of Squares	F- Calculated	F- Table	Conclusion
Replication	4	244.54	61.13	3.83	2.67	SIG
Treatment	8	226.11	28.26	1.77	2.24	NS
Altitude	2	99.65	49.83	3.12	3.29	NS
Sites Within Altitude 1	2	7.50	3.75	0.23	3.29	NS
Sites Within Altitude 2	2	99.66	49.83	3.12	3.29	NS
Sites Within Altitude 3	2	19.29	9.65	0.60	3.29	NS
Error	32	510.91	15.97			
Total	44					

2.7 a Volume (ANOVA for genotypes):

Source of Variation	Degree of Freedom	Sum of Squares	Mean Sum of Squares	F- Calculated	F- Table	Conclusion
Replication	2	1.24	0.62	2.42	3.10	NS
Treatment	44	6134.40	139.42	546.19	1.51	SIG
Error	88	22.46	0.26			
Total	134	6158.10				

2.7 b Volume (ANOVA for altitude and sites within altitude):

Source of Variation	Degree of Freedom	Sum of Squares	Mean Sum of Squares	F- Calculated	F- Table	Conclusion
Replication	4	85.02	21.26	0.83	2.67	NS
Treatment	8	1142.40	142.80	5.59	2.24	SIG
Altitude	2	795.73	397.87	15.58	3.29	SIG
Sites Within Altitude 1	2	56.13	28.07	1.10	3.29	NS
Sites Within Altitude 2	2	198.40	99.20	3.88	3.29	SIG
Sites Within Altitude 3	2	92.13	46.07	1.80	3.29	NS
Error	32	817.38	25.54			
Total	44					

2.8 a Specific gravity (ANOVA for genotypes):

Source of Variation	Degree of Freedom	Sum of Squares	Mean Sum of Squares	F- Calculated	F- Table	Conclusion
Replication	2	0.00	0.00	1.92	3.10	NS
Treatment	44	5.11	0.12	92.89	1.51	SIG
Error	88	0.11	0.00			
Total	134	5.22				

2.8 b Specific gravity (ANOVA for altitude and sites within altitude):

Source of Variation	Degree of Freedom	Sum of Squares	Mean Sum of Squares	F- Calculated	F- Table	Conclusion
Replication	4	0.14	0.03	0.88	2.67	NS
Treatment	8	0.31	0.04	0.99	2.24	NS
Altitude	2	0.03	0.01	0.35	3.29	NS
Sites Within Altitude 1	2	0.12	0.06	1.55	3.29	NS
Sites Within Altitude 2	2	0.06	0.03	0.76	3.29	NS
Sites Within Altitude 3	2	0.10	0.05	1.31	3.29	NS
Error	32	1.25	0.04			
Total	44					

2.9 a 100 Seed (stone) weight (ANOVA for genotypes):

Source of Variation	Degree of Freedom	Sum of Squares	Mean Sum of Squares	F- Calculated	F- Table	Conclusion
Replication	2.00	4.23	2.11	0.42	3.10	NS
Treatment	44.00	40533.60	921.22	183.45	1.51	SIG
Error	88.00	441.91	5.02			
Total	134.00	40979.74				

2.9 b 100 Seed (stone) weight (ANOVA for altitude and sites within altitude):

Source of Variation	Degree of Freedom	Sum of Squares	Mean Sum of Squares	F- Calculated	F- Table	Conclusion
Replication	4	348.98	87.24	1.61	2.67	NS
Treatment	8	11432.40	1429.05	26.44	2.24	SIG
Altitude	2	4129.20	2064.60	38.19	3.29	SIG
Sites Within Altitude 1	2	3168.40	1584.20	29.31	3.29	SIG
Sites Within Altitude 2	2	558.40	279.20	5.16	3.29	SIG
Sites Within Altitude 3	2	3576.40	1788.20	33.08	3.29	SIG
Error	32	1729.82	54.06			
Total	44					

2.10 a 100 Kernel weight (ANOVA for genotypes):

Source of Variation	Degree of Freedom	Sum of Squares	Mean Sum of Squares	F- Calculated	F- Table	Conclusion
Replication	2.00	0.03	0.02	0.03	3.10	NS
Treatment	44.00	5475.66	124.45	209.02	1.51	SIG
Error	88.00	52.39	0.60			
Total	134.00	5528.09				

2.10 b 100 Kernel weight (ANOVA for altitude and sites within altitude):

Source of Variation	Degree of Freedom	Sum of Squares	Mean Sum of Squares	F- Calculated	F- Table	Conclusion
Replication	4	9.97	2.49	1.35	2.67	NS
Treatment	8	1756.17	219.52	118.91	2.24	SIG
Altitude	2	78.53	39.27	21.27	3.29	SIG
Sites Within Altitude 1	2	158.04	79.02	42.80	3.29	SIG
Sites Within Altitude 2	2	556.65	278.32	150.76	3.29	SIG
Sites Within Altitude 3	2	962.96	481.48	260.81	3.29	SIG
Error	32	59.07	1.85			
Total	44					

2.11 a Kernel length (ANOVA for genotypes):

Source of Variation	Degree of Freedom	Sum of Squares	Mean Sum of Squares	F- Calculated	F- Table	Conclusion
Replication	2.00	0.70	0.35	2.99	3.10	NS
Treatment	44.00	226.11	5.14	43.74	1.51	SIG
Error	88.00	10.34	0.12			
Total	134.00	237.15088				

2.11 b Kernel length (ANOVA for altitude and sites within altitude):

Source of Variation	Degree of Freedom	Sum of Squares	Mean Sum of Squares	F-Calculated	F- Table	Conclusion
Replication	4	1.35	0.34	0.71	2.67	NS
Treatment	8	58.78	7.35	15.44	2.24	SIG
Altitude	2	3.44	1.72	3.62	3.29	SIG
Sites Within Altitude 1	2	3.01	1.51	3.16	3.29	NS
Sites Within Altitude 2	2	32.42	16.21	34.06	3.29	SIG
Sites Within Altitude 3	2	19.91	9.96	20.92	3.29	SIG
Error	32	15.23	0.48			
Total	44					

2.12 b Kernel breadth (ANOVA for genotypes):

Source of Variation	Degree of Freedom	Sum of Squares	Mean Sum of Squares	F- Calculated	F- Table	Conclusion
Replication	2.00	0.08	0.04	0.66	3.10	NS
Treatment	44.00	29.59	0.67	11.40	1.51	SIG
Error	88.00	5.19	0.06			
Total	134.00	34.86				

2.12 b Kernel breadth (ANOVA for altitude and sites within altitude):

Source of Variation	Degree of Freedom	Sum of Squares	Mean Sum of Squares	F- Calculated	F- Table	Conclusion
Replication	4	0.82	0.20	2.20	2.67	NS
Treatment	8	6.06	0.76	8.12	2.24	SIG
Altitude	2	0.31	0.15	1.65	3.29	NS
Sites Within Altitude 1	2	2.14	1.07	11.46	3.29	SIG
Sites Within Altitude 2	2	2.46	1.23	13.21	3.29	SIG
Sites Within Altitude 3	2	1.15	0.57	6.16	3.29	SIG
Error	32	2.98	0.09			
Total	44					

2.13 Oil content (%):

Source of Variation	Degree of freedom	Sum of Squares	Mean sum of Squares	F-Calculated
Replication	2	0.024		
Altitude	2	1.461	0.731	0.418
Error	4	10.499	2.625	
Total	8	11.961		

2.14 Specific gravity:

Source of Variation	Degree of freedom	Sum of Squares	Mean sum of Squares	F-Calculated
Replication	2	0		
Altitude	2	0	0	0.316
Error	4	0	0	
Total	8	0		

2.15 Refractive index:

Source of Variation	Degree of freedom	Sum of Squares	Mean sum of Squares	F-Calculated
Replication	2	0		
Altitude	2	0	0	0.368
Error	4	0	0	
Total	8	0		

2.16 Acid value:

Source of Variation	Degree of freedom	Sum of Squares	Mean sum of Squares	F-Calculated
Replication	2	0		
Altitude	2	0.016	0.008	0.121
Error	4	0.406	0.101	
Total	8	0.422		

2.17 Saponification value:

Source of Variation	Degree of freedom	Sum of Squares	Mean sum of Squares	F-Calculated
Replication	2	0		
Altitude	2	1.192	0.596	0.888
Error	4	4.029	1.007	
Total	8	5.222		

2.18 Unsaponifiable matter:

Source of Variation	Degree of freedom	Sum of Squares	Mean sum of Squares	F-Calculated
Replication	2			
Altitude	2	0.029	0.014	5.76
Error	4	0.015	0.003	
Total	8	0.044		

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Admission Number	:	**F-2021-33-M**
Major Advisor	:	**Dr. H.P. Sankhyan**
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ABSTRACT

The present study entitled **"Seed source variation in tree morphology and oil quality of *Prunus armeniaca* L."** aimed to assess the variation in genotypes of wild apricot for different morphological traits and oil quality attributes along the altitudinal gradient. A total of 45 healthy and phenotypically superior genotypes of wild apricot were selected from nine sites in Kinnaur District and Spiti Valley of Himachal Pradesh during the years 2021-2023. The findings of the study revealed that significant variations were observed for morphological traits, fruit characters and oil parameters among genotypes, sites and altitudinal zones. Site-wise analysis of pooled data showed that S1(Nichar) was accounted for as having maximum values for leaf width, leaf area, petiole length and stone weight (for stone weight value was at par with S5). S2 (Katgaon) was recorded to have the highest pulp-stone ratio and volume of fruit traits. S3 (Chagaon) was noted to have the maximum values for leaf length, fruit length, fruit breadth, fruit eight, pulp weight, and specific gravity. S4 (Kanai) had the largest flower size. S6 (Pooh) was identified to have the greatest values for kernel length and kernel breadth. S7 (Chango) had maximum100 kernel weight and was on par with S6 for kernel breadth. 100 seed (stone) was observed maximum at S8 (Poh). Among the three zones A1(2000-2500 m) was found best for traits like leaf length, leaf width, leaf area, petiole length, fruit length, fruit breadth, fruit weight, pulp weight, stone weight, pulp: stone, volume and 100 kernel weight whereas A2 (2500–3000 m) had maximum values for flower size (flower length and flower breadth) and Kernel length. A3 (3000–3500 m) exhibited higher values for Specific gravity of fruits, 100 seed (stone) weight, and kernel breadth. The highest mean values for oil content percentage, Specific gravity, and Refractive index were recorded in Altitudinal zones A3 (45.60%), A2 and A3 (0.914667) and A2 (1.4726) respectively. Altitudinal zone A3 was observed to have maximum values for all the chemical characteristics of oil, i.e., Acid value (2.54), Saponification value (190.80), and unsaponifiable matter (0.80%). Further, these superior genotypes could be used to raise progenies with desired attributes and deoiled cakes for cow feed, potentially creating new opportunities in the industry and increasing a farmer's or grower's total revenue.

Signature of Major Advisor **Signature of the Student**

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