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Original Research

Morphological and Biochemical Performance of Exotic Apricot Germplasm under Agro-Climatic Conditions of Mansehra

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ABSTRACT

This study evaluates the growth, yield, and biochemical quality of exotic and local apricot (*Prunus armeniaca* L.) genotypes under the agro-climatic conditions of Mansehra, Pakistan. Despite favourable climatic factors, the region's apricot productivity remains suboptimal, necessitating the introduction of high-yielding germplasm. Field trials at the National Tea and High Value Crops Research Institute (NTHRI) compared exotic varieties (Moorpark, Castle Bright, Hunter) with local cultivars (Doghli, Trivet) using a Randomized Complete Block Design. Morphological parameters, including days to 50% fruit setting, fruit maturity, fruit count, yield, fruit weight, and seed weight, were measured alongside biochemical traits (total soluble solids, sugar content, acidity). Results revealed that exotic genotypes outperformed locals significantly: Moorpark and Hunter achieved 50% fruit setting 4-8 days faster, while Castle Bright matured earliest (63 days vs. locals' 120+ days). Exotic Hunter produced the highest fruit count (968.73 fruits plant^{-1}) and yield (Moorpark: 38.43 kg tree^{-1}), surpassing locals by 40-50%. Biochemically, Castle Bright exhibited superior sweetness (47.83 °Brix, 10.48% sugar), whereas acidity remained uniform across all varieties (0.91-1.04%). These findings underscore the adaptability of exotic germplasm to Mansehra's climate, offering enhanced productivity, marketable fruit quality, and resilience. The study advocates for integrating exotic cultivars into local breeding programs to bridge yield gaps, improve farmer livelihoods, and meet consumer demands for nutrient-rich apricots in temperate Himalayan regions.

Keywords: *Prunus armeniaca, exotic, morphological parameters, biochemical parameters, cultivars, nutrient rich.*

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INTRODUCTION

Apricot (*Prunus armeniaca* L.) is a popular stone fruit that is grown all over the world and is prized for its distinct flavour, delicious texture, high nutritional content, and substantial financial worth. The Latin term arbour praecox, meaning "early-ripening tree," is where the word "apricot" originates, and it accurately characteries the species' distinctive early fruiting behaviour (Corrado et al., 2021). Originating in mountainous areas of Central Asia, specifically the Tien-Shan range, apricots have been grown for thousands of years and have spread over diverse geographic regions, including temperate to subtropical regions of Asia, Europe and parts of the Americas (Sheikh et al., 2021). This earliest domesticated fruit is a member of the Prunoideae subfamily and the Rosaceae family, with a genome size of around 590 million base pairs. It is a diploid species (2n = 16 chromosomes) that is genetically situated between stone fruits like cherries and peaches (Zargar et al., 2022). *P. armeniaca's* wide genetic diversity supports its ability to adapt to a variety of soil types and climatic conditions, allowing for extensive cultivation.

Diversity of cultivars and broad agro-ecological adaptability of apricots make it 3rd most extensively grown stone fruit across the world after peaches and plums (Groppi et al., 2021). The Mediterranean region and Central Asia are the main apricot-producing regions. These regions have an ideal climate for growing apricots, with warmer, drier summers and mild winters. Together, nations like Pakistan, Uzbekistan, Iran and Turkey control the majority of the world's apricot production, including dried apricots, which are highly valuable commercially (Huang, 2023). Pakistan is a leading producer of apricots, particularly in its northern regions, which are rich in apricot biodiversity. Khyber Pakhtunkhwa, Gilgit-Baltistan, and Balochistan are home to the majority of the nation's more than 180 different apricot genotypes (Jan et al., 2022).

Fruit size, colour, flavour and maturation time vary greatly among these genotypes, which reflect both the influence of regional agro-climatic conditions and inherent genetic variation.

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These climatic conditions include cool temperatures, enough chilling hours during winter, moderate precipitation and long photoperiod during the growing season. Despite these beneficial conditions, Mansehra's apricot productivity is below the national average, indicating a lack of use of exotic or high-yielding apricot germplasm that might be more adapted to the agro-climatic conditions of the area (Khan and Idrees, 2021). In Mansehra and other similar areas, evaluating and introducing exotic apricot germplasm are essential tactics for improving fruit quality, yield and overall crop flexibility. Systematic evaluation of these germplasm collections has been done through morphological parameters, physiological, and yield performance in local conditions. Superior genotypes with improved resistance against biotic and abiotic stresses like drought, insect pests, frost and fluctuating soil fertility are considered.

Additionally, expanding the genetic base of apricot cultivars available for breeding programs, these initiatives help create cultivars with better agronomic traits and consumer demand characteristics such as fruit size, sweetness and nutritional value (Stanley et al., 2016). Hence, introducing exotic germplasm can be important to maintaining apricot production and bolstering local growers' livelihoods on a sustainable basis. The nutritional and therapeutic qualities of apricots further increase their importance. Consuming apricots, which are high in vitamins A, C and several B-complex vitamins, as well as bioactive compounds such as carotenoids, antioxidants and phenolics, is linked to several health advantages, like anti-inflammatory and anti-cancerous properties (Abbas et al., 2016). Because of these qualities, producers are more motivated to adopt improved cultivars that can meet both yield and consumer demand.

The purpose of the current study is to close the recent knowledge gap regarding exotic apricot germplasm performance in the unique agroclimatic conditions of Mansehra district. Through assessments covering phenological phases, vegetative development, fruit development, and yield indicators, this research aims to pinpoint the most promising exotic apricot genotypes for regional commercial production. Breeders, horticulturists, and legislators interested in increasing apricot production, enhancing fruit quality, and eventually raising the socioeconomic standing of apricot growers in Mansehra and the surrounding areas are anticipated to find great value in the findings.

MATERIALS AND METHODS

Research area

The study was carried out in March 2023 at the National Tea and High Value Crops Research Institute (NTHRI), Shinkiari, Mansehra, Pakistan (34° 27'31.87" N, 73° 16'6.82" E). The site's climatic and edaphic conditions are representative of the region's apricot-growing environment.

Plant material and experimental design

The experiment involved established apricot trees of both exotic and local varieties, each with a fruit-bearing history of approximately 10 years. Exotic varieties included Moorpark, Castle Bright, and Hunter, with nine plants selected per variety. Three plants, each of the local varieties Doghli and Trivet, were also included. The study utilized a Randomized Complete Block Design (RCBD). Data were collected from four cardinal directions on branches of each selected plant to ensure representative sampling.

Morphological parameters

Morphological parameters, including phenological stages (days to fruit setting and maturity), productivity metrics (fruit count, yield, and weight), and seed characteristics, were systematically recorded through field observations and standardized measurements.

Days to 50% fruit setting

Calculated as the number of days from the date of full bloom (when 80-90% of flowers are open) until 50% of the flowers have visibly set fruit (small fruit formation).

Days to fruit maturity

Measured as the number of days from the flowering stage (first open flower) to the stage when fruits reached physiological maturity (full size, colour change, and softness).

Number of fruits per plant

Total fruits counted on each tree.

Fruit weight (g)

Five fully mature fruits per genotype were randomly selected, weighed individually using a digital balance (precision ±0.01 g), and the average weight was calculated.

Seed weight (g)

Seeds extracted from five randomly selected fruits per genotype were pooled, dried, and weighed collectively using a digital balance. The average seed weight per fruit was calculated.

Biochemical parameters

Biochemical traits, including total soluble solids (°Brix), sugar content, and acidity, were analyzed using laboratory assays to assess fruit quality.

Sugar content (%)

Total sugar content was quantified using the Anthrone-Sulfuric Acid method. Fruit pulp homogenate was treated with anthrone reagent, and absorbance was measured spectrophotometrically at 620 nm.

Total soluble solids (°Brix)

Fresh fruit juice was extracted, and total soluble solids (TSS) were measured using a handheld refractometer (calibrated with distilled water). Readings were taken in triplicate and averaged.

Fruit acidity (%)

Titratable acidity was determined via titration with 0.1N NaOH using phenolphthalein as an indicator.

RESULTS

Morphological parameters

Effects of agro-climatic conditions on days to 50% fruit setting in different varieties of *Prunus armeniaca*

Figure 1 shows how long it takes for 50% of flowers to turn into fruits after full bloom. When compared to local varieties, Doghli (15.0 days) and Trivet (18.33 days), exotic varieties Moorpark (11.0 days) and Hunter (10.69 days) showed noticeably faster fruit setting. Because of genetic features that favour early flowering and adequate pollination, exotic genotypes are more suited to Mansehra's climate, as indicated by the LSD value (1.375), Table 1**,** which validates statistical significance. Faster fruit setting increases exotics' resistance to pests and late frosts.

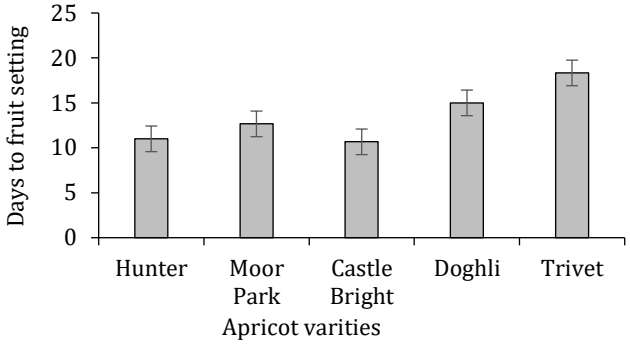


Figure 1: Exotic apricot varieties (Moorpark, Hunter) achieved 50% fruit setting 4-8 days faster than local cultivars (Doghli, Trivet).

Effects of agro-climatic conditions on days to fruit maturity in different varieties of *Prunus armeniaca*

Figure 2 shows the time between flowering and when the fruit is ready for harvest. Exotic Castle Bright matured first (63.0 days), taking almost half as long as locals Doghli (121.67 days) and Trivet (120.0 days). Moorpark (81.0 days) and Hunter (94.33 days) also reached adulthood earlier than the locals. Significant differences are highlighted by the LSD (7.223), which implies that exotic varieties are more appropriate for areas with erratic weather or shorter growing seasons. Profitability is increased by early maturity, which lowers labour costs and market risks.

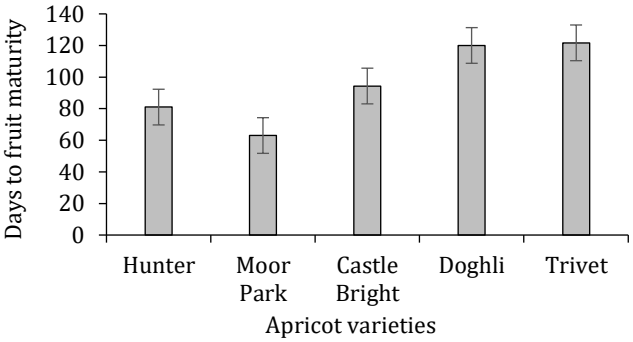


Figure 2: Exotic Castle Bright reached fruit maturity in 63 days, nearly half the time required by local Doghli (122 days) and Trivet.

Effects of agro-climatic conditions on the number of fruits per plant in different varieties of *Prunus armeniaca*

Figure 3 shows that productivity is indicated by the total number of fruits produced by each tree. With 968.73 fruits plant^{-1}, Exotic Hunter performed better than any other variety. Moorpark (736.80 fruits plant^{-1}) and Castle Bright (286.03 fruits plant^{-1}) came next. Trivet (654.05 fruits plant^{-1}) and local Doghli (719.45 fruits plant^{-1}) trailed behind. The superior fruit-bearing capacity of exotic germplasm is indicated by the statistical separation shown by the LSD (91.536). Higher fruit numbers correlate with increased yield potential, though factors like fruit size and weight also influence final output.

Effects of agro-climatic conditions on the yield of tree^{-1} in different varieties of *Prunus armeniaca*

Figure 4 shows that exotic Moorpark (38.43 kg tree^{-1}) and Castle Bright (36.96 kg tree^{-1}) delivered the highest yields, dwarfing local Doghli (23.20 kg tree^{-1}) and Trivet (26.61 kg tree^{-1}). The LSD (5.635) confirms significant differences. Exotics' higher yields stem from efficient fruit set, faster maturation, and larger fruit size, directly benefiting farmers' incomes and commercial viability.

Effects of agro-climatic conditions on seed weight in different varieties of *Prunus armeniaca*

Figure 5 shows that seed weight reflects genetic vigour and potential for propagation. Exotic Castle Bright (3.58 g) and

Table 1: Mean data for days to 50% fruit setting, days to fruit maturity, number of fruits per plant, seed weight and yield per tree (kg).

Variety	Days to 50% fruit setting	Days to fruit maturity	Number of fruits per plant	Seed weight (g)	Yield per tree (kg)
Moorpark	11.00 D	81.00 C	736.80 A	3.490 AB	38.430 A
Castle Bright	12.67 C	63.00 D	286.03 A	3.583 AB	36.960 AB
Hunter	10.69 D	94.33 B	968.73 A	3.243 BC	35.483 AB
Doghli	15.00 B	121.67 A	719.45 AB	3.127 C	23.200 BC
Trivet	18.33 A	120.00 A	654.05 B	2.957 C	26.610 C
LSD	1.3750	7.2230	91.536	0.2925	5.6352

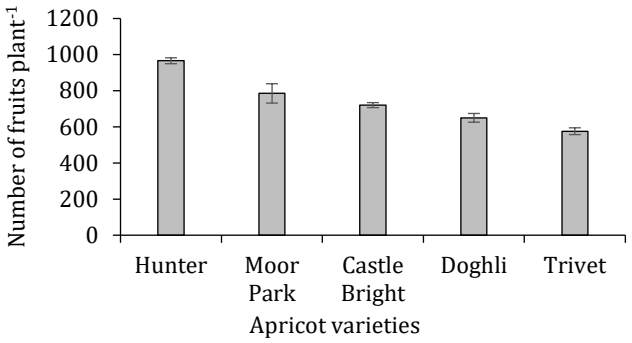


Figure 3: Exotic Hunter produced the highest fruit count (968.73 fruits plant^{-1}), significantly exceeding local Trivet.

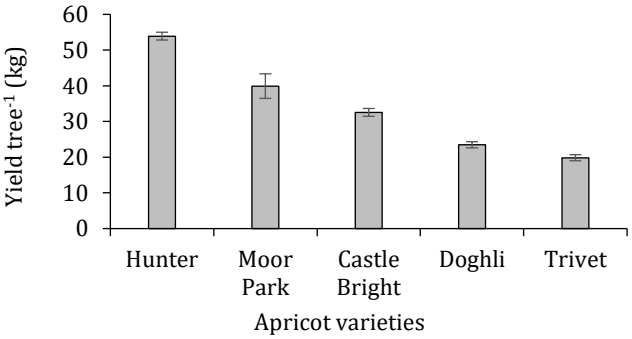


Figure 4: Moorpark (38.43 kg tree^{-1}) and Castle Bright (36.96 kg tree^{-1}) yielded 40-50% more than local Doghli.

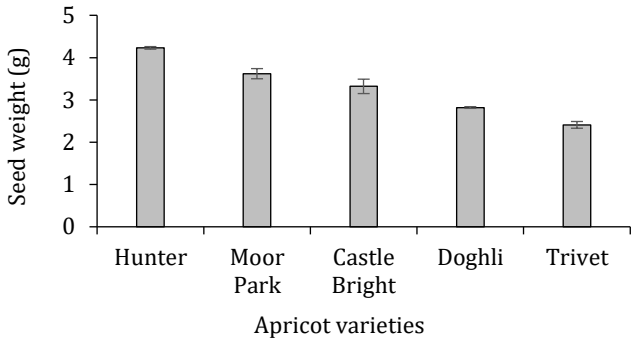


Figure 5: Exotic varieties exhibited heavier seeds (Castle Bright: 3.58 g) compared to local Trivet (2.96 g), reflecting genetic vigour.

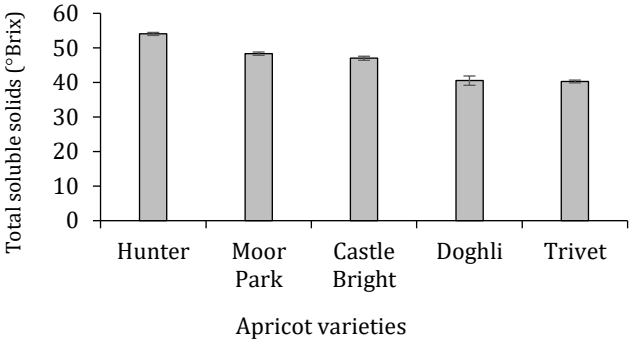


Figure 6: Superior sweetness in exotic Castle Bright (47.83 °Brix) and Moorpark (46.64 °Brix) vs. local Trivet.

Moorpark (3.49 g) had heavier seeds compared to local Trivet (2.96 g) and Doghli (3.13 g). Hunter (3.24 g) overlapped slightly with locals but was statistically distinct (LSD = 0.2925). Heavier seeds may indicate better germination rates or seedling strength, useful for breeding programs.

Biochemical parameters

Effects of agro-climatic conditions on total soluble solids (°Brix) in different varieties of *Prunus armeniaca*

Figure 6 shows that TSS measures fruit sweetness and quality. Exotic Castle Bright (47.83 °Brix) and Moorpark (46.64 °Brix) scored highest, while local Trivet (42.10 °Brix) ranked lowest. The LSD (4.3681) validates these differences (Table 2). Higher TSS in exotics enhances market appeal for fresh consumption or processing (e.g., jams, dried apricots), aligning with consumer preferences for sweeter fruits.

Effects of agro-climatic conditions on sugar content in different varieties of *Prunus armeniaca*

Figure 7 shows that exotic Castle Bright (10.48%) and Hunter (10.32%) had the highest sugar levels, contrasting sharply with local Trivet (8.72%). The LSD (1.545) confirms statistical significance. Elevated sugar content improves palatability and competitive edge in markets, making exotic varieties preferable for both fresh and processed products.

Effects of agro-climatic conditions on acidity in different varieties of *Prunus armeniaca*

Figure 8 shows that acidity influences tartness and shelf stability. All varieties showed minimal differences (0.91-1.04%), with LSD = 0.1412 indicating no statistical significance. Uniform acidity suggests this trait is less influenced by genotype under Mansehra's conditions. Balanced acidity is crucial for flavour complexity and preservation, and consistency across varieties simplifies processing requirements.

DISCUSSION

Significant differences between apricot genotypes in important developmental and fruit quality traits under local conditions were revealed by the study conducted at NTHRI, Shinkiari. Due

Table 2: Mean data for total soluble solids, sugar content and acidity.

Variety	Total soluble solids (°Brix)	Sugar content (%)	Acidity
Moorpark	46.640 A	10.167 AB	0.9100 A
Castle Bright	47.830 A	10.480 A	0.9800 A
Hunter	46.910 A	10.323 A	1.0433 A
Doghli	44.700 AB	9.823 AB	0.9800 A
Trivet	42.097 B	8.720 B	1.0300 A
LSD	4.3681	1.5450	0.1412

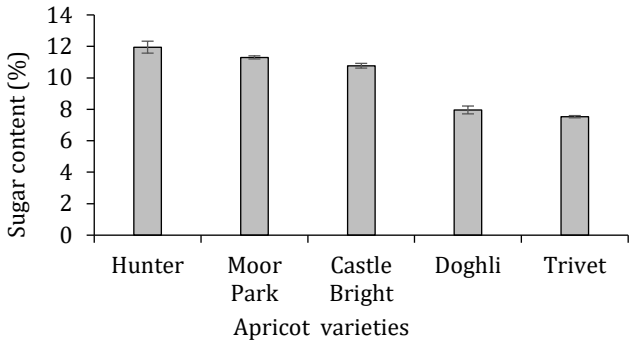


Figure 7: Exotic Castle Bright (10.48%) and Hunter (10.32%) had 18-20% higher sugar content than local Trivet.

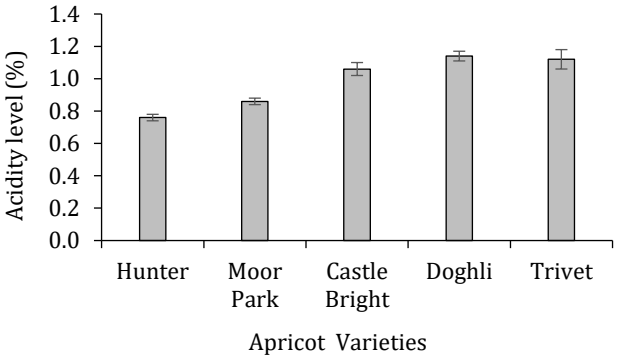


Figure 8: Uniform acidity levels (0.91-1.04%) across all varieties, indicating minimal genotypic variation.

to different genetic and physiological factors influencing maturation, Hunter reached 50% fruit setting the quickest (10.67 days) and Trivet the slowest (18.33 days) (Bolat and Ikinci, 2020). Doghli took the longest (121.67 days) to reach fruit maturity, indicating that late-maturing cultivars might benefit from specialised management to maximise fruit quality and market timing. Fruit maturity duration also revealed significant genotype effects (Velardo-Micharet et al., 2021).

The importance of genotype selection for productivity was highlighted by the notable variation in fruit yield per plant, with Trivet having the lowest yield (654 fruits) and Castle Bright and Moorpark producing the highest numbers (~782 and 781 fruits per plant, respectively) (Elmenofy et al., 2021). Moorpark consistently performed better in terms of fruit size, with weight (47.92 g), length (48.54 mm), and width (47.75 mm) likely due to advantageous genetic and environmental influences on fruit development (Naryal et al., 2020; Karatas et al., 2021). Trivet, on the other hand, showed smaller fruit dimensions, suggesting possible limitations that call for improved cultural practices or breeding.

The different seed characteristics also highlighted variability in reproductive traits. Trivet produced the lightest seeds (2.96 g), while Castle Bright produced the heaviest seeds (3.58 g), which may have contributed to increased seedling vigour (Yaman and Turan, 2021). Genotypic variations revealed by seed-to-pulp ratios impacted marketability and fruit composition. The genetic control over overall productivity and the necessity of focused improvement efforts are reflected in the yield per tree, which was highest in Moorpark (38.43 kg) and lowest in Doghli (23.20 kg) (Kareem et al., 2016).

The TSS and sugar content were two examples of quality characteristics that varied significantly. Potential breeding targets were indicated by the lowest values of Trivet and the highest sugar concentration (10.48%) and TSS (47.83 °Brix) of Castle Bright, which are traits linked to superior taste and consumer preference (Waseem et al., 2021).

However, there were no discernible differences in acidity levels, indicating that there is slight genetic variation for this characteristic.

In summary, the intricate interplay between genetic and environmental factors influencing fruit development is highlighted by the varied responses of apricot genotypes in growth, yield, and quality traits. Fruit quality and orchard productivity can be improved by choosing genotypes like Hunter, Moorpark, and Castle Bright because of their unique benefits. More investigation into the genetic processes governing these characteristics will aid in the creation of superior apricot cultivars suited to market demands and sustainability.

CONCLUSION

According to the current study, exotic apricot varieties (Moorpark, Castle Bright, and Hunter) perform significantly better than local genotypes in the agro-climatic conditions of Mansehra, resulting in higher yields, early fruit setting and improved biochemical attributes. Due to their early maturity, high sugar content and firm productivity, exotic genotypes are well-adapted for areas with erratic growing seasons. While local varieties displayed similar levels of acidity, they trailed behind in terms of fruit characteristics and yield. In addition to improving market competitiveness and addressing regional productivity issues, adopting exotic germplasm can promote sustainable apricot farming on a sustainable basis. Future initiatives should concentrate on distributing these genotypes among farmers and investigating their genetic potential in order to create high-value, climate-resilient cultivars that are suited to Pakistan's horticultural requirements.

DECLARATION OF COMPETING INTERESTS

The authors declare no conflict of interest.

AUTHOR CONTRIBUTION STATEMENT

Hassan Wajid, **Ijaz Hussain:** Equally contributed to executing research and preparing the manuscript.

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AVAILABILITY OF DATA AND MATERIAL

All data is published in this research article.

INFORMED CONSENT

Not applicable.

CONSENT FOR PUBLICATION

All the authors have submitted consent to publish this research article in the 'Journal of Horticulture Sciences and Technology'.

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