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ASSESSMENT OF MORPHOLOGICAL AND YIELD TRAITS OF PROMISING OLIVE (*OLEA EUROPAEA* L.) VARIETIES FOR CULTIVATION IN THE HIGHLAND AGRO-ECOLOGICAL ZONE OF BALOCHISTAN

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Abstract

Olive cultivation has gained popularity in Pakistan in past decade due to its value for table use and oil extraction whereas, Balochistan is considered suitable for the olive cultivation. The study was carried out at Balochistan Agriculture Research and Development Centre (BARDC), aimed to assess four olive variety i.e., Arbosana, Leccino, Arbiquina, Pendolino, for potential yield and adaptability of the olive production under climatic condition of Quetta. key morphological and yields traits observed included, trunk girth, plant height, canopy spread, fruit girth, fruit length, fruit weight per plant and oil percentage. It was notable that, Pendolino displayed excellent canopy spread and plant height 3.115 and 3.3 m respectively, moreover var. Leccino and var. Pendolino showed excellent fruit development, as shown by length (both 2 cm), and girth (1.6 and 1.5 cm) alongwith highest weight of fruit per plant, 5 and 7 kg while minimum fruit weight per plant was found in Arbiquina (2.75 kg), respectively. Oil content was found to be maximum in Leccino 15 % and minimum in Arbosana 12.4%. Variety Leccino along with Pendolino were found to be best performing varieties in terms of morphological and yields traits under Agro-Ecological zone of Quetta.The research is beneficial to olive growers and researchers about determining appropriate cultivar to be used in that area. In the same way, the outcome was a benchmark on future varietal improvement and olive cultivation in Balochistan.

Key words: Olive; Varieties; Growth; Adaptability; Oil recovery; Agro-climatic conditions

Introduction

The olive tree (*Olea europaea* L.), belonging to the family Oleaceae which includes about 30 genera and 600 species, is one of the oldest cultivated tree species in the world, with domestication dating back approximately 6,000-7,000 years. It is an evergreen species known for its longevity, often living up to 500 years (Ali & Ashraf, 2015). Olive is grown in all Mediterranean countries as well as in Australia, New Zealand, South America, North America, South Africa and Pakistan (Rizwan *et al*., 2019). Syria, Turkey, Libya, Morocco and Egypt also produce olive, but yield is less due to lack of adoption of modern olive production techniques (Masri *et al*., 2025). While Spain is known for its healthiest of all Vegetable oils which have high antioxidant and polyphenols, is the top producer of olive in the world (Seray, 2018; Torres *et al*., 2017). Olives are cultivated world-wide for virgin oil and table olives which have high economic value and are known for their highly enriched monounsaturated fatty acid content and rich minor components like polyphenols and phytosterols, which make them unique among oil plants (Ussia *et al*., 2025).

In 2023/2024, the olive oil and table olive imports increased by 0.6% and 9.7% respectively. Seven countries represent around 80% of the imports of olive oils and virgin olive oils around the world, the United States with 35%, the European Union with 17%, Brazil with 8%, Japan with 6%, Canada with 5%, China with 4% and Australia with 3% showcasing its high economic value (Anon., 2024). Since 1980s, different national and international donors and development agencies made efforts for the commercial cultivation of olives in Pakistan by importing exotic olive germplasm from different European, African, Middle East countries and provided to research and development organizations. Multiple projects were initiated at federal and provincial levels in the country where billions of rupees have been spent for the promotion of olive cultivation (Anon., 2025). The high price and demand of olive oil and other value-added products like Olive pickles, jam, squash and murabah enforcing the farmer to cultivate olive. Currently, more than 5.00 million olive plants had been planted over an area of 40450 hectares in Balochistan, Khyber Pakhtunkhwa (KPK), Punjab, Azad Jammu Kashmir (AJK) and Gilgit Balistan (GB) (Jan *et al*., 2024). At present, Pakistan produces about 861 tons of table olives annually, which are consumed domestically. With a vision to enhance self-sufficiency, Pakistan has set a target of producing 4,600 tons of olive oil by 2030 to reduce its reliance on imports (Anon., 2025).

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Olive trees grow best in temperate and subtropical regions of the world where the summers are warm and dry while winters are cool and wet like the Mediterranean region where it is grown abundantly. Olive trees are highly drought-tolerant but require adequate irrigation during critical growth stages, particularly during flowering and fruit development (Brito *et al.*, 2019). Olive grows in temperature between 10°C and 30°C and require a period of low temperatures (0–7°C) for flowering bud differentiation while temperature below -7 harm the fruits (Tombesi & Tombesi, 2007) and in mineral deficient soils with a pH range of 6.5 to 8.0 but for good yield in calcareous silt soil (Awan *et al*., 2020).

Balochistan, is most suitable for olive cultivation in Pakistan. However, varieties of *Olea europaea* L. do not perform well in all agroclimatic zones and each climatic zone must choose suitable varieties for adaptability and profitability. There is not much research on varietal performance in climatic zones of Balochistan (Palwasha *et al*., 2022; Sumrah *et al.*, 2021). Therefore, this research was conducted to find best variety under Agro-Ecological zone of Quetta, Balochistan. Four varieties were selected in olive orchard at Balochistan Agriculture Research and Development Centre (BARDC), namely Arbosana, Leccino, arbequina and Pendolino with randomly selected 4 olive trees of each variety and data were collected for morphological features including trunk girth, plant height, canopy spread, and yield parameters i.e., fruit length, girth, yield, and oil percentage.

Methods and Materials

Location: The study about assessment of 4 olive varieties was conducted at Balochistan Agriculture Research and Development Centre (BARDC) in 2024 and 2025. Quetta lies at 30.18 latitudes and 66.99 longitudes with an elevation of 1680m and mean annual rainfall about 210 mm with winter minimum temperatures commonly fall between -8°C and -2°C and maximum of 30°C to 36°C in summer (Durrani *et al*., 2021). Soil samples were collected at 3 different depths, i.e., 0-15 cm, 15-30 cm and 30-45 cm and were analyzed to measure pH, electrical conductivity (EC), total dissolved solids (TDS), calcium carbonate (CaCO3), organic matter (OM) and nitrogen (N) by combo meter. PH was found to be in a fairly narrow spectrum with the upper two layers having pH of 7.76, whereas the bottom most layer showing a pH value of 7.81 where the soil was slightly alkaline and EC was measured 180 µS/cm at 1st layer, 183 µS/cm at middle layer and 117 µS/cm at bottom layer. Similarly, TDS was 59 mg/L at 0 to 15 cm and 58mg/L was observed at 15 to 45 cm. The proportion of CaCO3 was low and observed 0.2; 0.2; 0.1% in the first 3 layers respectively. The OM level was even a little higher in the 15-30 cm layer (0.44%) than the values of 0.42% and 0.41% in the upper and lower layers. Increase in N content was also observed with depth and lowest (0.04%) at 0-15 cm and 0.1% in the deeper layers.

Experimental design and plant materials: Experiment was laid out in randomized complete block design (RCBD) with 4 treatment and 4 replication each. Morphological and yield parameter data were collected from four olive trees of each variety i.e., Arbosana, Leccino, Arbequina, and Pendolino, which were of same age and maintained by some horticultural practices like pruning, irrigation, fertilizer, and ploughing.

Morphological parameters

Trunk girth: Plant girth was measured by using measurement tape approximately 30 cm above ground level by warping the tape around the steam and total circumference of trunk was measured in centimeter (cm) for accurate result as DBH measurement was not applicable due to small plant size.

Height of the plant and canopy spread: Plant height was measured in meters (m) by using a measurement tape with a calibrated stick to acquire the correct height of plants. Direct measurement of trees up to 2 meters was done with the use of a tape and in the case of taller trees, a vertical stick labelled with the height in intervals was used to record the measurement. Measuring tape was also used to find the average spread of canopy of each olive tree. The widest axis of the canopy was measured first and a second measurement was recorded in a direction, appropriate perpendicular to the first, then average canopy spread was determined by summing up of both diameters and dividing with two (Jimenez *et al.*, 2017; Iqbal *et al.*, 2019).

Yield parameters

Fruit length and girth (fruit size): To calculate the average fruit girth and length, 15 fully mature fruits from each olive unit (16 plants) were taken and measurements for fruit girth was taken from the widest part, while length from the tip to base by using vernier caliper in centimeter. The Average fruit length and girth was calculated by summing all 15 measurements of each plant and dividing by the number of samples.

Fruit yield and oil % age: To determine fruit weight and oil% age, fully matured and ripened fruits were harvested from all under studies olive trees and after cleaning and washing each olive plant fruits were weighed by using digital weighing machine in kg. After harvesting within 24 hours olive oil was extracted by using commercial extraction unit with capacity of 600kg/hour (Model Pieralisi, Italy) and while oil percentage was measured with the formula:

$$\text{Oil percentage} = \frac{\text{Extracted oil (liters)}}{\text{Fruit yield (kg)}} \times 100$$

Statistical analysis

ANOVA for the morphological and yield traits of olive varieties was analysed in Statistix-10. The LSD was then calculated by $p>0.05$ (Steel *et al*., 1997) (Tables 1 and 2).

Trunk girth: The maximum plant girth of 39.75 cm was recorded for olive variety Leccino while minimum was observed 33.25 cm for Arbosana (Table 3). Besides from the small differences in steam girth the statistically analysis result was non-significant ($p>0.05$) between of under studies olive varieties, despite significant variations in plant height and canopy spread. This non-significant variation between

the olive varieties likely reflects same age, cultural practices (pruning, fertilizer, irrigation), minimal genetic makeup differences and same environmental conditions where the growth of stem girth rate tends to develop at a steady rate, contribute to overall plant strength and stability (Naqvi *et al*., 2015; Akram *et al*., 2019). The olive trees which had bigger steam girth were more resistant to winds and produced more fruits. The results are in conformity with the findings of other researchers (Scalisi *et al*., 2024; Ikinci & Ali, 2014; Sumrah *et al*., 2021).

Table 1. ANOVA for different studied vegetative traits.

Source	DF	SS	MS	F	P
Trunk girth	3	95.188	31.7292	2.01	0.1831
Plant height	3	3.47087	1.15696	17.61	0.0004
Canopy spread	3	2.67107	0.89036	7.74	0.0073

Table 2. ANOVA for different studied yield traits.

Source	DF	SS	MS	F	P
Fruit yield	3	46.6719	15.5573	12.86	0.0013
Fruit length	3	1.41187	0.47062	20.11	0.0003
Fruit diameter	3	0.45688	0.15229	11.36	0.0020
Oil % age	3	13.64	4.54667	2.305433	0.00001

Table 3. Mean performance of olive varieties for plant girth, plant height and canopy spread.

Variety	Trunk girth (cm)	Plant hight (m)	Canopy spread (m)
Arbosana	33.25 A	1.99 C	2.17 C
Leccino	39.75 A	2.57 B	2.74 B
Arbiquina	38 A	3.11 A	2.95 AB
Pendolino	38.25 A	3.11 A	3.3 A
LSD	**NS**	**1.61**	**1.49**

Table 4. Mean performance of olive varieties for yield, fruit length, fruit girth and oil percentage.

Variety	Fruit yield (kg)/ plant	Fruit length (cm)	Fruit girth (cm)	Oil percentage
Arbosana	4.63 B	1.73 B	1.37 B	12.4 D
Leccino	5.5 B	2.17 A	1.57 A	15 A
Arbiquina	2.75 C	1.4 C	1.2 C	13.7 C
Pendolino	7.5 A	2.03 AB	1.63 A	13.9 B
LSD	**2.89**	**0.543**	**0.338**	**2.24**

Result and Discussion

Plant height and canopy spread: Significant variations were recorded in plant height and canopy spread of olive varieties, as in Arbiquina and Pendolino showed maximum plant height of 3.11 m while minimum height was observed in Arbosana (Table 3). In case of canopy spread where Pendolino and Arbequina had the biggest canopies 3.3 and 2.95 m followed by Leccino 2.74 m and while Arbosana having the smallest canopy (Table 3). These findings proved that Pendolino and Arbequina were more vigorous in their vegetative sense, one of the factors in adeptness and productivity at a variety level. The genotypic variation in height is mainly explained due to the nature of genetic constitution and the reaction of every variety to its own environment (Hammami *et al*., 2011; Mnasri *et al*., 2017; Bartoli *et al*., 2020). These results are comparable to the earlier findings that varietal variation, climate condition and culture activities have a major impact on olive tree height (Sumrah *et al*., 2021). Broader canopy width and increased plant height promote interception of light as well as photosynthetic capacity and their improvement promotes vegetative growth and yield capacity. This correlation of architecture, plant and vigor are in line with the findings of Bally & Ibell, 2013 who reported that canopy structure is closely correlated with overall plant vigor with growth performance. It is also an observed fact that the dimensions of canopies, including those of spread and height change with varied circumstances, but the trunk girth or shoot tend to be relatively less affected, which implies that radial growth thereby responds poorly to architectural modification (Das & Jana, 2012). Besides that, both canopy spread and height responses are more flexible than the changes dependent on trunk diameter, meaning that in many cases, observed changes in spread and height are not directly linked to a change in trunk girth (Chaploutskyi *et al*., 2023).

Fruit girth and length (fruit size): Fruit length and girth (fruit size) are an important quality factor, which determine the processing suitability as well as market compliances of olives. Pendolino exhibited maximum fruit length and girth of 2 and 1.63 cm followed by leccino 2.17 and 1.57 cm while minimum was observed in Arbequina (Table 4). Such variation in length and girth of fruit are directly attributed to the genetic makeup of a variety, climatic conditions and as well as cultural practices can influence fruit size (Iniesta *et al.*, 2009; Khadivi *et al*., 2022), the results of our study are in conformity with result of Al-Ruqaie *et al*., (2016) who reported longer length 25 mm in Picual and Arbosana than in Arbequina and Koroneiki.

Fruit yield: Fruit weight is an important attribute which estimate the adaptability of an olive plant under any agroclimatic condition and yield potential of olive variety. In the current study, Pendolino showed maximum yield 7.5 kg followed by Leccino 5.5 kg and the minimum 2.75 kg was observed in Arbiquina (Table 4). Our results were in conformity with that of Palwasha *et al*., (2022) who found significant variations in fruit yield of 5 olive varieties under agroclimatic condition of Loralai, Balochistan. Similarly, Ali *et al*., (2024) concluded in their study that genetic varietal makeup and environmental conditions had strong impact on yield of olive cultivar and selection of variety is an important factor for the high productivity of olive in Pakistan.

Oil % age: The oil content is a key trait which determines market value and processing efficiency of olives and therefore a vital quality parameter to the growers. In our study variation in oil content was found among studied varieties, with the highest percentage being in leccino 15 % along with Pendolino 13.9 % and the lowest of 12.4 % in (Table 4). The earlier literature showed that the variability in the oil content of different varieties could be largely attributed to the genetic makeup but other factors, such as soil type, temperature and climatic conditions also play a very important role. While temperature is proved to be a major factor which effect oil content. The concentration of oil in the fruit also displays positive correlation with the size of fruit but driven by both external and internal factors (Oteros *et al*., 2014; Palwasha *et al.*, 2022; Hammami *et al*., 2011; Sumrah *et al.*, 2021). This leads to the conclusion that the cultivars exhibit variations when it comes to oil yield potential, and therefore it is crucial to choose varieties

depending on the local agroclimatic conditions.

Conclusion and Recommendation

All studied olive varieties respond differently regarding vegetative and yield parameters under agroclimatic condition of Quetta. The varieties like leccino, Pendolino and Arbequina showed good response regarding vegetive and yield traits led us to conclude that *Olea europaea* L. cultivars performed differently under any specific growing condition. That's why it is important to select suitable variety for high yield. Olive varieties, Pendolino and leccino are found to be good choice of olives cultivars regarding high yield and growth potential and making them a good choice for the farmers of Quetta and adjoining areas, for commercial cultivation.

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