INTRODUCTION

Olive (Olea europaea L.) belongs to a dicotyledonous family Oleaceae. It is an ancient tree which has been found in Egyptian tombs from 2000 years BC. Olive tree of Vouves is considered as the oldest olive tree in the world and it is estimated to be over 3000 years old (Maravelakis et al., 2012). Olive tree is grown in all regions of the world except arctic. However, 98% of the world olive cultivation is carried out in Mediterranean region, and it contributes a major share in olive oil production (Hashmi et al., 2015). More than 2000 olive cultivars are present in Mediterranean basin and these cultivars are characteristically distinguished through tree and fruit morphology (Bartolini et al., 1998; Ganino et al., 2006).

Botanically, olive is an evergreen tree of subtropical nature. It can attain the height of up to 10 m or more. Leaves are shortly stalked, oblong or lanceolate in their shape. White creamy flowers are produced in leaf axils. Fruit is drupe, ovoid in shape, and blackish-violet in color when ripe (Shu, 1996). It is a monoecious plant and pollination occurs through wind. Genetically, it possesses a diploid set of chromosomes as $2n = 46$ (Kumar et al., 2011). Olive tree thrives well in climates having hot summers with low humidity and cold winters. Winter chilling of at least 2 months is required.
## Table 1: Statistical descriptive parameters for morphological traits used to study olive cultivars

| No. | Character                                      | Abbreviation | Unit   | Min. | Max.  | Mean  | SD   | CV (%) |
|-----|-----------------------------------------------|--------------|--------|------|-------|-------|------|--------|
| 1   | Tree growth habit                              | TGH          | Code   | 1    | 5     | 2.77  | 1.53 | 55.05  |
| 2   | Tree growth vigor                              | TGV          | Code   | 1    | 5     | 3.91  | 1.11 | 28.31  |
| 3   | Tree height                                    | TH           | Code   | 1    | 5     | 3.36  | 1.39 | 41.22  |
| 4   | Trunk diameter                                 | TD           | Code   | 1    | 5     | 3.27  | 1.40 | 42.81  |
| 5   | Trunk color                                    | TC           | Code   | 1    | 5     | 2.34  | 1.42 | 60.60  |
| 6   | Canopy density                                 | CADe         | Code   | 1    | 5     | 4.12  | 1.08 | 26.09  |
| 7   | Branching                                      | B            | Code   | 1    | 5     | 3.81  | 1.11 | 29.16  |
| 8   | Branch density                                 | BDe          | Code   | 3    | 5     | 4.14  | 0.99 | 23.99  |
| 9   | Branch flexibility                             | BF           | Code   | 1    | 5     | 4.19  | 1.16 | 27.57  |
| 10  | Skin color of perennial branch                 | SCPB         | Code   | 1    | 7     | 5.02  | 2.10 | 41.77  |
| 11  | Skin color of current branch                   | SCCuB        | Code   | 1    | 5     | 2.92  | 0.77 | 26.27  |
| 12  | Leaf density                                   | LDe          | Code   | 3    | 5     | 4.44  | 0.90 | 20.27  |
| 13  | Leaf length                                    | LLe          | mm     | 27.07| 78.54 | 51.41 | 10.80| 21.01  |
| 14  | Leaf width                                     | LWi          | mm     | 5.42 | 23.06 | 10.59 | 2.82 | 26.67  |
| 15  | Petiole length                                 | PeLe         | mm     | 1.79 | 9.56  | 4.90  | 1.29 | 26.28  |
| 16  | Petiole diameter                               | PeD          | mm     | 0.50 | 1.53  | 0.92  | 0.14 | 15.28  |
| 17  | Leaf upper surface color                       | LUSuC        | Code   | 1    | 5     | 3.32  | 1.18 | 35.66  |
| 18  | Transparency of leaf upper color               | TrLUC        | Code   | 1    | 5     | 4.17  | 1.20 | 28.75  |
| 19  | Leaf lower surface color                       | LLoSuC       | Code   | 1    | 3     | 1.51  | 0.87 | 57.88  |
| 20  | Leaf shape                                     | LSh          | Code   | 1    | 7     | 4.87  | 1.32 | 27.04  |
| 21  | Leaf apex shape                                | LASH         | Code   | 1    | 5     | 3.86  | 1.36 | 35.16  |
| 22  | Leaf base shape                                | LBsSh        | Code   | 1    | 3     | 1.55  | 0.90 | 57.81  |
| 23  | Ripening date                                  | RiDa         | Date   | Late-Aug | Early-Oct | 5.51 | 2.49 | 45.26  |
| 24  | Fruit density                                  | FrDe         | Code   | 1    | 5     | 3.25  | 1.48 | 45.51  |
| 25  | Mean of fruit number in inflorescence          | MFNo         | Number | 1    | 10    | 3.32  | 2.29 | 68.92  |
| 26  | Fruit stalk length                             | FrStLe       | mm     | 1.04 | 10.93 | 3.93  | 1.82 | 46.31  |
| 27  | Fruit stalk diameter                            | FrStD        | mm     | 0.54 | 2.07  | 0.98  | 0.23 | 23.78  |
| 28  | Fruit shape                                    | FrSh         | Code   | 1    | 5     | 3.39  | 1.45 | 42.89  |
| 29  | Fruit Symmetry                                 | FrSy         | Code   | 1    | 5     | 2.88  | 1.60 | 55.42  |
| 30  | Fruit apex shape                               | FrAsh        | Code   | 1    | 3     | 1.86  | 0.99 | 53.39  |
| 31  | Fruit base shape                               | FrBsSh       | Code   | 1    | 3     | 1.77  | 0.98 | 55.14  |
| 32  | Fruit nipple shape                             | FrNiSh       | Code   | 1    | 5     | 2.37  | 1.50 | 63.33  |
| 33  | Fruit length                                   | FrLe         | mm     | 13.04| 33.72 | 22.52 | 4.09 | 18.16  |
| 34  | Fruit diameter                                 | FrWi         | mm     | 10.24| 23.71 | 15.77 | 3.25 | 20.58  |
| 35  | Fruit color                                    | FrC          | Code   | 1    | 15    | 7.44  | 4.93 | 66.24  |
| 36  | Lenticel on fruit skin                         | LenFrSk      | Code   | 1    | 5     | 3.91  | 1.61 | 41.10  |
| 37  | Fruit weight                                   | FrWt         | g      | 0.97 | 9.61  | 3.44  | 1.81 | 52.44  |
| 38  | Fruit flesh firmness                           | FrFiFi       | Code   | 1    | 5     | 3.86  | 1.33 | 34.56  |
| 39  | Fruit flesh thickness                          | FrFTTh       | mm     | 1.63 | 7.65  | 4.03  | 1.14 | 28.36  |
| 40  | Stone shape                                    | StSh         | Code   | 1    | 7     | 4.03  | 1.73 | 42.88  |
| 41  | Stone Symmetry                                 | StSy         | Code   | 1    | 5     | 2.65  | 1.45 | 54.60  |
| 42  | Stone apex shape                               | StAsH        | Code   | 1    | 3     | 1.40  | 0.80 | 57.00  |
| 43  | Stone base shape                               | StBSSh       | Code   | 1    | 5     | 3.27  | 1.51 | 46.27  |
| 44  | Stone length                                   | StLe         | mm     | 9.13 | 25.71 | 16.35 | 3.18 | 19.47  |
| 45  | Stone diameter                                 | StD          | mm     | 4.82 | 12.73 | 8.22  | 1.59 | 19.40  |
| 46  | Stone color                                    | StC          | Code   | 1    | 5     | 3.26  | 1.34 | 41.20  |
| 47  | Stone surface                                  | StSu         | Code   | 1    | 5     | 2.99  | 1.45 | 48.46  |
| 48  | Groove number on stone                         | GNoSt        | Code   | 1    | 5     | 2.30  | 1.05 | 45.83  |
| 49  | Stone weight                                   | StWe         | g      | 0.20 | 1.79  | 0.70  | 0.34 | 47.74  |
| 50  | Flesh ratio to stone                           | FiSt         | Ratio  | 1.02 | 7.68  | 3.91  | 1.22 | 31.16  |
| Character                          | Frequency (no. of cultivars) | 1   | 3   | 5   | 7   | 9   | 11  | 13  | 15  |
|-----------------------------------|-----------------------------|-----|-----|-----|-----|-----|-----|-----|-----|
| Tree growth habit                 | Drooping (86)               |     |     |     |     |     |     |     |     |
|                                   | Spreading (99)              |     |     |     |     |     |     |     |     |
|                                   | Erect (58)                  |     |     |     |     |     |     |     |     |
| Tree growth vigor                 | Low (7)                     |     |     |     |     |     |     |     |     |
|                                   | Moderate (119)              |     |     |     |     |     |     |     |     |
|                                   | High (117)                  |     |     |     |     |     |     |     |     |
| Tree height                       | Low (40)                    |     |     |     |     |     |     |     |     |
|                                   | Moderate (119)              |     |     |     |     |     |     |     |     |
|                                   | High (84)                   |     |     |     |     |     |     |     |     |
| Trunk diameter                    | Low (45)                    |     |     |     |     |     |     |     |     |
|                                   | Moderate (120)              |     |     |     |     |     |     |     |     |
|                                   | High (78)                   |     |     |     |     |     |     |     |     |
| Trunk color                       | Brown–green (114)           |     |     |     |     |     |     |     |     |
|                                   | Brown (95)                  |     |     |     |     |     |     |     |     |
|                                   | Dark brown (34)             |     |     |     |     |     |     |     |     |
| Canopy density                    | Low (5)                     |     |     |     |     |     |     |     |     |
|                                   | Moderate (97)               |     |     |     |     |     |     |     |     |
|                                   | High (141)                  |     |     |     |     |     |     |     |     |
| Branching                         | Low (8)                     |     |     |     |     |     |     |     |     |
|                                   | Moderate (128)              |     |     |     |     |     |     |     |     |
|                                   | High (107)                  |     |     |     |     |     |     |     |     |
| Branch density                    | -                           |     |     |     |     |     |     |     |     |
|                                   | Moderate (106)              |     |     |     |     |     |     |     |     |
|                                   | High (138)                  |     |     |     |     |     |     |     |     |
| Branch flexibility                | Low (11)                    |     |     |     |     |     |     |     |     |
|                                   | Moderate (77)               |     |     |     |     |     |     |     |     |
|                                   | High (155)                  |     |     |     |     |     |     |     |     |
| Skin color of perennial branch    | Light green (20)            |     |     |     |     |     |     |     |     |
|                                   | Brown–green (72)            |     |     |     |     |     |     |     |     |
|                                   | Light brown (37)            |     |     |     |     |     |     |     |     |
|                                   | Brown (114)                 |     |     |     |     |     |     |     |     |
| Skin color of current branch      | White–green (23)            |     |     |     |     |     |     |     |     |
|                                   | Light green (207)           |     |     |     |     |     |     |     |     |
|                                   | Green (13)                  |     |     |     |     |     |     |     |     |
| Leaf density                      | -                           |     |     |     |     |     |     |     |     |
|                                   | Moderate (68)               |     |     |     |     |     |     |     |     |
|                                   | High (175)                  |     |     |     |     |     |     |     |     |
| Leaf upper surface color          | Light green (26)            |     |     |     |     |     |     |     |     |
|                                   | Green (152)                 |     |     |     |     |     |     |     |     |
|                                   | dark green (65)             |     |     |     |     |     |     |     |     |
| Transparency of leaf upper color  | Transparent (14)            |     |     |     |     |     |     |     |     |
|                                   | Relatively transparent (73)  |     |     |     |     |     |     |     |     |
|                                   | Matt (156)                  |     |     |     |     |     |     |     |     |
| Leaf lower surface color          | Silver–green (181)         |     |     |     |     |     |     |     |     |
|                                   | Silver (62)                 |     |     |     |     |     |     |     |     |
| Leaf shape                        | Obovate (5)                 |     |     |     |     |     |     |     |     |
|                                   | Elliptic (46)               |     |     |     |     |     |     |     |     |
|                                   | Elliptic–Lanceolate (152)   |     |     |     |     |     |     |     |     |
|                                   | Lanceolate (40)             |     |     |     |     |     |     |     |     |
| Leaf apex shape                   | Munronate (26)              |     |     |     |     |     |     |     |     |
|                                   | Cuspidate (87)              |     |     |     |     |     |     |     |     |
|                                   | Acuminat (130)              |     |     |     |     |     |     |     |     |
| Leaf base shape                   | Cuneate (176)               |     |     |     |     |     |     |     |     |
|                                   | Acute (67)                  |     |     |     |     |     |     |     |     |
| Ripening date                     | Late-August (30)            |     |     |     |     |     |     |     |     |
|                                   | Early-September (40)        |     |     |     |     |     |     |     |     |
|                                   | Mid-September (46)          |     |     |     |     |     |     |     |     |
|                                   | Late-September (92)         |     |     |     |     |     |     |     |     |
|                                   | Early–October (35)          |     |     |     |     |     |     |     |     |
| Fruit density                     | Low (53)                    |     |     |     |     |     |     |     |     |
|                                   | Moderate (107)              |     |     |     |     |     |     |     |     |
|                                   | High (83)                   |     |     |     |     |     |     |     |     |
| Fruit shape                       | Spherical (45)              |     |     |     |     |     |     |     |     |
|                                   | Ovoid (106)                 |     |     |     |     |     |     |     |     |
|                                   | Elongated (92)              |     |     |     |     |     |     |     |     |
| Fruit Symmetry                    | Symmetric (85)              |     |     |     |     |     |     |     |     |
|                                   | Slightly asymmetric (88)    |     |     |     |     |     |     |     |     |
|                                   | Asymmetric (70)             |     |     |     |     |     |     |     |     |
| Fruit apex shape                  | Pointed (138)               |     |     |     |     |     |     |     |     |
|                                   | Rounded (105)               |     |     |     |     |     |     |     |     |
| Fruit base shape                  | Truncate (149)              |     |     |     |     |     |     |     |     |
|                                   | Rounded (94)                |     |     |     |     |     |     |     |     |
| Fruit nipple shape                | Absent (118)                |     |     |     |     |     |     |     |     |
|                                   | Tenuous (83)                |     |     |     |     |     |     |     |     |
|                                   | Obvious (42)                |     |     |     |     |     |     |     |     |
| Fruit color                       | Light green (42)            |     |     |     |     |     |     |     |     |
|                                   | Green (50)                  |     |     |     |     |     |     |     |     |
|                                   | Green–purple (12)           |     |     |     |     |     |     |     |     |
|                                   | Purple–green (28)           |     |     |     |     |     |     |     |     |
|                                   | Purple–green (30)           |     |     |     |     |     |     |     |     |
|                                   | Purple (3)                  |     |     |     |     |     |     |     |     |
|                                   | Dark purple (57)            |     |     |     |     |     |     |     |     |
|                                   | Black (21)                  |     |     |     |     |     |     |     |     |
for flower bud initiation. However, it cannot withstand freezing temperature, which ultimately leads to death of the plant. It can tolerate drought very well and can be successfully grown in areas with annual rainfall of 900–1000 mm. It can withstand moderate soil conditions, but water logging conditions are injurious for plant health (Munir, 2009).

The cross-pollinating nature of olive and its secular history contributed to determine a wide germplasm biodiversity with a large number of more than 1200 cultivars present in the main olive oil producing countries (Bartolini et al., 2005). This genetic diversity could be an important resource for the development of modern olive culture toward typical olive oil and fresh productions. This richness in terms of available biodiversity, however, often has determined some drawbacks in the management and identification of the plant material to distinguish between cultivars, and this has been further complicated by the frequency of homonyms and synonyms (Hegazi et al., 2012).

Morphological and agronomic characters have been widely used for descriptive purposes (Khadivi & Arab, 2021; Khadivi et al., 2021; Mirmahdi & Khadivi, 2021) and are commonly used to distinguish olive cultivars (Arias-Calderon et al., 2014; Barranco et al., 2000; Rotondi et al., 2003, 2011; Trentacoste & Puertas, 2011). Biometric indexes should always be accompanied by a detailed morphological description of the organs (inflorescence, leaf, fruit, and stone) of olive varieties following the UPOV method (Barranco et al., 2000). Many researchers observed that different cultivars are morphologically variable based on geographical locations and under various plant growth management practices (Grati et al., 2002; Youssefi et al., 2011).

The present research aimed to investigate the phenotypic characterizations of olive cultivars from Gilvan area in Zanjan province/Iran.

## 2 MATERIALS AND METHODS

### 2.1 Plant material

Morphological and pomological diversity of 24 olive cultivars (5–15 replications for each cultivar, 243 trees in total) was evaluated at a collection in Gilvan area in Zanjan province/Iran. Gilvan area is located at 36º44′20″N latitude, 48º53′42″E longitude, and 1080 m height above sea level. The cultivars were between 10 and 12 years old and were healthy and in full fruiting stage. The orchard management operations, including nutrition, irrigation, and pest and disease control, were performed regularly and uniformly for the cultivars.

### 2.2 The characters evaluated

Fifty morphological and pomological traits were used to evaluate phenotypic diversity (Table 1). A total of 50 adult leaves and 50 mature fruits per cultivar were randomly selected and harvested.
traits related to dimensions of leaf, fruit, and stone were measured using a digital caliper. A digital scale with an accuracy of 0.01 g was used to measure the weight of fruit and stone. The qualitative traits (Table 2) were visually examined and coded according to the olive descriptor (UPOV, Barranco et al., 2000).

2.3 | Statistical analysis

Analysis of variance (ANOVA) was performed to evaluate the variation among cultivars based on the traits measured using SAS software (SAS Institute, 1990). Principal component analysis (PCA) was used to investigate the relationship between cultivars and determine the main traits useful in cultivars segregation using SPSS software. Hierarchical cluster analysis (HCA) was performed using Ward’s method and Euclidean coefficient using PAST software (Hammer et al., 2001). The first and second principal components (PC1/PC2) were used to create a scatter plot with PAST software. Also, independent traits affecting the fruit weight as a dependent trait were determined through multiple regression analysis (MRA) using the “linear stepwise” method with SPSS software.
RESULTS AND DISCUSSION

There were significant differences among the cultivars studied based on the characters recorded. Mean of fruit number in inflorescence exhibited the highest CV (68.92%) and followed by fruit color (66.24%), fruit nipple shape (63.33%), and trunk color (60.60%), while the lowest CVs were related to petiole diameter (15.28%), fruit length (18.16%), stone diameter (19.40%), and stone length (19.47%). Overall, the CV was more than 20.00% in 46 of 50 characters measured. Lazovic and Adakalic (2020) studied an olive germplasm from Montenegro and reported that the CV for all the measured characters was lower than 20.00%.

Tree growth habit was drooping in 86, spreading in 99, and erect in 58 cultivars. Tree growth vigor, tree height, trunk diameter, and branching were predominantly moderate and then high. Leaf density was moderate in 68 and high in 175 characters measured. Lazovic and Adakalic (2020) studied an olive germplasm from Montenegro and reported that the CV for all the measured characters was lower than 20.00%.

Tree growth habit was drooping in 86, spreading in 99, and erect in 58 cultivars. Tree growth vigor, tree height, trunk diameter, and branching were predominantly moderate and then high. Leaf density was moderate in 68 and high in 175 cultivars (Table 2). Leaf shape showed high variation, including obovate (5 cultivars), elliptic (46), elliptic–lanceolate (152), and lanceolate (40). Leaf length ranged from 27.07 to 78.54 mm, leaf width varied from 5.42 to 23.06 mm, the range of petiole length was from 1.79 to 9.56 mm, and petiole diameter varied from 0.50 to 1.53 mm (Table 1). Leaf length and width are important varietal characters and are used for cultivar identification. They are genetic characters which may differ from cultivar to cultivar under similar soil and environmental conditions (Singh et al., 1999).

Ripening date ranged from late-August to early-October. Fruit density was low (53 cultivars), moderate (107), and high (83). The range of fruit number in an inflorescence was 1–10. Fruit length ranged from 13.04 to 33.72 mm, fruit diameter varied from 10.24 to 23.71 mm, fruit weighted from 0.97 to 9.61 g, and the range of fruit flesh thickness was 1.63–7.65 mm (Table 1). Fruit showed three shapes, including spherical (45), ovoid (106), and elongated (92) (Table 2). There was high variability in terms of fruit color, including light green (42 cultivars), green (50), green–purple (12), purple–green (28), purple–green (30), purple (3), dark purple (57), and black (21). Fruit flesh firmness was predominantly high (129 cultivars). The average of stone length, stone diameter, and stone weight was 16.35 mm, 8.22 mm, and 0.70 g, respectively. Fruit- and stone-related traits are considered very efficient morphological characters in distinguishing among the cultivated olives (Lazovic et al., 2018; Peres et al., 2011; Rotondi et al., 2011). The pictures of leaves and fruits of the studied olives are shown in Figure 1.

Here, fruit weight was considered as a dependent variable and then the direct and indirect effects of each independent variable on this key trait were calculated using MRA (Table 3). The MRA showed that fruit weight was found to be associated with 18 characters. Fruit weight showed the highest positive standardized beta coefficient ($\beta$) value with stone weight ($\beta = 0.61$, $p < .000$). Thus, this key variable is one of the main traits accounting for fruit weight and should be considered in breeding programs.
| Character                              | Component | 1  | 2  | 3  | 4  | 5  | 6  | 7  | 8  | 9  | 10 | 11 | 12 | 13 | 14 |
|----------------------------------------|-----------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| Tree growth habit                      |           | 0.19 | -0.02 | 0.48 | -0.22 | -0.16 | 0.09 | -0.37 | -0.15 | -0.18 | -0.13 | -0.20 | -0.02 | 0.21 | 0.37 |
| Tree growth vigor                      |           | 0.24 | -0.03 | 0.63** | 0.09 | 0.07 | -0.14 | 0.01 | 0.14 | -0.01 | -0.21 | 0.36 | -0.10 | 0.05 | -0.01 |
| Tree height                            |           | -0.10 | -0.18 | 0.87** | 0.08 | 0.07 | 0.05 | 0.00 | 0.14 | -0.05 | -0.02 | -0.05 | 0.02 | 0.09 | 0.09 |
| Trunk diameter                         |           | 0.07 | -0.05 | 0.77** | 0.05 | -0.02 | 0.15 | 0.08 | 0.19 | 0.11 | 0.14 | 0.05 | -0.03 | -0.18 | -0.18 |
| Trunk color                            |           | 0.35 | -0.24 | 0.42 | 0.01 | -0.35 | 0.01 | -0.23 | -0.16 | 0.05 | 0.16 | -0.20 | -0.16 | -0.41 | 0.14 |
| Canopy density                         |           | 0.06 | 0.08 | 0.13 | 0.83** | -0.03 | 0.05 | -0.12 | 0.04 | -0.05 | -0.07 | -0.06 | -0.10 | 0.00 | 0.07 |
| Branching                              |           | -0.12 | 0.20 | 0.03 | 0.44 | -0.16 | -0.20 | 0.25 | -0.19 | -0.09 | -0.16 | 0.04 | 0.03 | 0.14 | -0.51 |
| Branch density                         |           | 0.03 | 0.08 | -0.04 | 0.85** | -0.03 | -0.01 | 0.19 | 0.04 | 0.06 | 0.04 | 0.08 | -0.03 | 0.13 | -0.13 |
| Branch flexibility                     |           | 0.11 | 0.03 | 0.05 | 0.24 | 0.40 | 0.00 | 0.44 | 0.22 | -0.07 | -0.33 | -0.26 | -0.14 | 0.20 | -0.11 |
| Skin color of perennial branch         |           | 0.07 | -0.12 | -0.02 | 0.16 | 0.30 | 0.31 | 0.07 | 0.44 | -0.12 | -0.05 | 0.63** | 0.03 | 0.10 | -0.07 |
| Skin color of current branch           |           | -0.10 | -0.18 | 0.00 | -0.15 | 0.05 | -0.10 | 0.05 | 0.01 | -0.04 | 0.07 | 0.07 | -0.01 | -0.88** | 0.06 |
| Leaf density                           |           | -0.21 | 0.11 | 0.22 | 0.35 | 0.08 | -0.09 | 0.44 | -0.26 | 0.03 | -0.26 | 0.21 | 0.08 | -0.14 | 0.28 |
| Leaf length                            |           | 0.28 | 0.08 | -0.04 | -0.20 | 0.01 | 0.67** | 0.09 | -0.03 | -0.01 | -0.29 | 0.11 | 0.03 | 0.26 | 0.09 |
| Leaf width                             |           | 0.06 | 0.01 | 0.25 | -0.07 | -0.20 | 0.46 | 0.09 | 0.65** | -0.02 | -0.28 | 0.14 | -0.03 | 0.08 | 0.05 |
| Petiole length                         |           | 0.11 | 0.12 | 0.07 | -0.07 | 0.06 | 0.68** | 0.13 | 0.09 | 0.04 | -0.19 | 0.13 | 0.16 | 0.02 | 0.27 |
| Petiole diameter                       |           | 0.06 | -0.07 | 0.05 | 0.18 | -0.02 | 0.76** | 0.04 | -0.02 | -0.04 | 0.18 | -0.06 | 0.00 | -0.05 | -0.17 |
| Leaf upper surface color               |           | -0.15 | 0.03 | 0.42 | -0.05 | -0.12 | 0.27 | -0.02 | 0.09 | -0.32 | 0.28 | 0.31 | 0.04 | -0.10 | -0.01 |
| Transparency of leaf upper color       |           | 0.22 | -0.12 | 0.07 | -0.09 | 0.11 | -0.13 | -0.04 | -0.17 | 0.12 | 0.75** | -0.01 | -0.20 | -0.08 | 0.08 |
| Leaf lower surface color               |           | -0.18 | 0.50 | 0.06 | -0.03 | -0.41 | -0.18 | -0.31 | -0.26 | 0.19 | 0.08 | -0.13 | -0.07 | 0.33 | -0.08 |
| Leaf shape                             |           | 0.10 | 0.08 | -0.23 | -0.09 | 0.20 | 0.12 | -0.04 | -0.83** | 0.05 | 0.08 | -0.02 | 0.06 | 0.10 | 0.04 |
| Leaf apex shape                        |           | 0.03 | 0.12 | -0.02 | -0.27 | 0.69** | -0.11 | -0.03 | -0.17 | 0.14 | -0.07 | 0.08 | 0.09 | -0.06 | -0.12 |
| Leaf base shape                        |           | 0.01 | -0.03 | -0.02 | -0.18 | -0.74** | -0.05 | 0.03 | 0.03 | 0.14 | -0.25 | 0.10 | -0.05 | 0.06 | 0.02 |
| Ripening date                          |           | -0.51 | 0.05 | 0.24 | -0.06 | 0.27 | -0.08 | -0.22 | -0.01 | 0.13 | -0.04 | 0.10 | 0.40 | 0.02 | -0.17 |
| Fruit density                          |           | 0.09 | -0.30 | 0.21 | 0.39 | 0.10 | -0.09 | -0.20 | 0.11 | -0.09 | 0.42 | 0.12 | 0.21 | 0.00 | 0.05 |
| Mean of fruit number in inflorescence  |           | -0.50 | 0.16 | 0.06 | 0.32 | 0.12 | 0.03 | 0.06 | -0.06 | -0.43 | 0.08 | -0.26 | 0.34 | 0.11 | -0.16 |

(Continues)
| Character                  | Component      | 1   | 2   | 3   | 4   | 5   | 6   | 7   | 8   | 9   | 10  | 11  | 12  | 13  | 14  |
|---------------------------|----------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Fruit stalk length       | 0.03           | -0.07 | 0.39 | -0.08 | -0.10 | -0.19 | 0.28 | -0.15 | 0.16 | 0.00 | 0.03 | 0.31 | 0.07 | 0.03 |
| Fruit stalk diameter     | 0.20           | -0.21 | 0.07 | 0.15 | -0.50 | -0.05 | -0.17 | 0.16 | -0.03 | -0.02 | -0.34 | 0.13 | -0.15 | -0.11 |
| Fruit shape              | -0.15          | 0.83** | 0.00 | 0.10 | 0.16 | 0.01 | 0.04 | -0.02 | -0.09 | -0.04 | -0.08 | -0.09 | 0.11 | 0.22 |
| Fruit symmetry           | -0.24          | 0.41 | -0.18 | -0.13 | 0.21 | 0.17 | 0.25 | 0.30 | -0.06 | 0.10 | -0.08 | 0.20 | -0.06 | 0.08 |
| Fruit apex shape         | 0.02           | -0.85** | 0.12 | -0.06 | 0.02 | -0.10 | 0.09 | 0.10 | -0.04 | 0.01 | -0.09 | -0.06 | 0.11 | 0.19 |
| Fruit base shape         | 0.00           | -0.77** | 0.13 | 0.06 | 0.10 | 0.12 | 0.10 | -0.13 | 0.13 | -0.12 | -0.18 | 0.10 | -0.15 | 0.22 |
| Fruit nipple shape       | -0.06          | 0.79** | -0.13 | 0.01 | 0.07 | 0.04 | 0.01 | -0.11 | -0.09 | -0.14 | 0.04 | 0.28 | 0.01 | -0.13 |
| Fruit length             | 0.85**         | 0.40 | 0.07 | 0.06 | 0.07 | 0.06 | 0.06 | -0.01 | 0.14 | 0.01 | -0.07 | -0.04 | 0.08 | 0.14 |
| Fruit diameter           | 0.93**         | -0.16 | 0.04 | 0.00 | -0.06 | 0.04 | -0.02 | -0.03 | 0.23 | 0.08 | -0.02 | -0.03 | 0.02 | 0.02 |
| Fruit color              | 0.44           | 0.08 | -0.09 | -0.03 | -0.43 | -0.13 | 0.25 | 0.07 | 0.21 | 0.21 | -0.04 | -0.49 | -0.09 | 0.10 |
| Lenticle on fruit skin   | -0.19          | 0.06 | 0.01 | -0.07 | 0.01 | -0.13 | -0.83 | -0.11 | -0.01 | 0.06 | 0.03 | -0.03 | 0.12 | 0.05 |
| Fruit weight             | 0.94**         | -0.08 | 0.02 | 0.04 | 0.01 | 0.07 | 0.01 | -0.06 | 0.16 | 0.04 | -0.06 | -0.03 | 0.05 | 0.05 |
| Fruit flesh firmness     | -0.15          | 0.06 | -0.07 | -0.10 | 0.02 | 0.14 | 0.02 | -0.01 | -0.19 | -0.06 | 0.05 | 0.78** | -0.02 | 0.01 |
| Fruit flesh thickness    | 0.79**         | -0.10 | 0.07 | -0.01 | -0.02 | 0.03 | -0.04 | -0.04 | 0.46 | 0.12 | -0.07 | -0.06 | 0.06 | 0.09 |
| Stone shape              | -0.19          | 0.83** | 0.02 | 0.10 | 0.14 | -0.04 | 0.04 | 0.03 | 0.10 | -0.13 | -0.24 | -0.05 | 0.12 | 0.14 |
| Stone symmetry           | -0.15          | 0.43 | 0.12 | 0.05 | 0.10 | 0.02 | 0.29 | 0.47 | 0.04 | 0.27 | -0.05 | 0.06 | 0.23 | 0.17 |
| Stone apex shape         | -0.18          | -0.54 | 0.08 | -0.04 | 0.11 | -0.10 | 0.05 | -0.09 | -0.38 | 0.30 | 0.16 | 0.04 | -0.03 | 0.30 |
| Stone base shape         | -0.35          | -0.11 | 0.27 | 0.01 | -0.06 | 0.04 | 0.00 | -0.07 | -0.13 | 0.06 | 0.64** | 0.15 | -0.17 | 0.04 |
| Stone length             | 0.70**         | 0.57 | 0.04 | 0.07 | 0.14 | 0.06 | 0.05 | 0.04 | 0.08 | -0.06 | -0.15 | -0.07 | 0.03 | 0.13 |
| Stone diameter           | 0.90**         | -0.26 | 0.03 | -0.04 | -0.09 | 0.08 | 0.04 | 0.02 | -0.12 | 0.04 | 0.06 | -0.02 | -0.10 | -0.06 |
| Stone color              | -0.28          | 0.07 | 0.04 | -0.02 | 0.15 | 0.00 | -0.03 | 0.01 | -0.12 | -0.07 | -0.03 | 0.04 | 0.05 | -0.60** |
| Stone surface            | 0.57           | -0.32 | 0.03 | -0.12 | -0.03 | 0.16 | -0.11 | 0.00 | 0.04 | -0.08 | -0.15 | -0.23 | -0.06 | 0.24 |
| Groove number on stone   | 0.03           | 0.06 | -0.06 | 0.14 | 0.02 | -0.20 | -0.50 | -0.05 | 0.35 | -0.05 | -0.13 | 0.11 | -0.18 | -0.01 |
| Stone weight             | 0.93**         | -0.08 | 0.00 | 0.07 | 0.03 | 0.03 | 0.06 | -0.02 | -0.24 | -0.02 | 0.03 | 0.02 | 0.05 | -0.03 |
| Flesh ratio to stone     | 0.26           | -0.01 | 0.05 | -0.04 | -0.05 | 0.02 | -0.05 | -0.08 | 0.80** | 0.13 | -0.11 | -0.22 | 0.07 | 0.14 |
| Total                    | 7.36           | 5.37 | 3.00 | 2.49 | 2.48 | 2.31 | 2.24 | 2.18 | 1.96 | 1.79 | 1.76 | 1.74 | 1.63 | 1.58 |
| % of variance            | 14.72          | 10.74 | 6.00 | 4.99 | 4.95 | 4.61 | 4.48 | 4.36 | 3.92 | 3.58 | 3.53 | 3.49 | 3.26 | 3.17 |
| Cumulative %             | 14.72          | 25.46 | 31.46 | 36.44 | 41.39 | 46.01 | 50.49 | 54.85 | 58.77 | 62.35 | 65.88 | 69.37 | 72.63 | 75.80 |

** **Eigenvalues ≥0.60 are significant at the p ≤.01 level.**
The PCA was used to understand the relationships among the cultivars. The first 14 PCs explained 75.80% of the total variance (Table 4). The PCA has been used in the evaluation of olive germplasm (Bandelj et al., 2002; Cantini et al., 1999; Hannachi et al., 2008; Hosseini-Mazinani et al., 2004; Lazovic & Adakalic, 2020; Lazovic et al., 2018; Strikic et al., 2009; Trentacoste & Puertas, 2011; Uylaser et al., 2008; Zaher et al., 2011). The first three PCs explained 31.46% of the total variance observed. The characters, including fruit length, fruit diameter, fruit weight, fruit flesh thickness, stone length, stone diameter, and stone weight, were positively correlated with PC1, explaining 14.72% of the total variance. Fruit size morphology is the product of complex genetic and environmental character (Strikic et al., 2009). Five characters, including fruit shape, fruit apex shape, fruit base shape, fruit nipple shape, and stone shape, were placed into the PC2, representing 10.74% of the total variance. The PC3 explained 6.00% of the total variance and showed positive correlations with tree growth vigor, tree height, and trunk diameter. Results obtained agreed with previous PCA of morphological characters in olive cultivars grown in different olive areas (Cantini et al., 1999; Lavee & Wonder, 2004; Lazovic et al., 2018; Ozkaya et al., 2006; Taamalli et al., 2006; Trentacoste et al., 2010; Zaher et al., 2011).

In addition, the scatter plot created based on the PC1 and PC2, accounted for 25.46% of the total variance (Figure 2), showed that the cultivars with close proximity were more similar in terms of effective traits in PC1 and PC2 and were placed in the same group. The scatter plot showed that residuals of the majority of cultivars bounce randomly around 0.00 line forming the horizontal band. This suggests that the variances in the error terms are equal and the relationship among the cultivars is linear. However, few outliers were observed among the cultivars evaluated, which might be due to their extreme values for particular traits.

Besides, the HCA performed based on the mean of replications with Euclidean distance and Ward method (Figure 3) grouped the cultivars into two major clusters. The first cluster (I) was divided into three subclusters. Subcluster I-A consisted of six cultivars. Subcluster I-B included 12 cultivars, while subcluster I-C included 2 cultivars. The second cluster (II) included four cultivars. Furthermore, according to an analysis based on replications of cultivars (Figure 4), the studied cultivars were placed into four groups. The mean values of most important fruit traits for the studied olives are shown in Table 5.

The present study confirms previous studies in other countries on the importance of measuring morphological and pomological traits (Cantini et al., 1999; Lavee & Wonder, 2004; Lazovic et al., 2018; Ozkaya et al., 2006; Taamalli et al., 2006; Trentacoste et al., 2010; Zaher et al., 2011), which successfully classified cultivated olives. Furthermore, the evaluation of agronomic traits may
be difficult since it may take as long as 10 years to reach reproductive maturity (Suarez, et al., 2011). Hannachi et al. (2008) found that there was a genetic basis in olive cultivars related to fruit size and probable fruit use.

4 | CONCLUSION

The identification of olive cultivars and their area of origin are very important to expand cultivation of those commercial varieties with superior products that are best adapted to specific local environmental conditions. Differences in many of the morphological traits were observed across the cultivars. These sets of data were used to identify unique and desirable cultivars morphologically. Stable phenotypic traits were used to discriminate between use of fruit as well as cultivar origins (local or introduced). This research demonstrates that local olive cultivars have unique characteristics that differentiate them from imported cultivars. Thus, local cultivars provide novel genetic resources that should be conserved.
ACKNOWLEDGMENTS

None.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

Ali Khadivi: Formal analysis (lead); Methodology (lead); Supervision (lead); Writing – review & editing (lead). Farhad Mirheidari: Investigation (equal). Younes Moradi: Investigation (equal). Simin Paryan: Investigation (equal).

FIGURE 4  Biplot for the studied olive cultivars based on the morphological characters

TABLE 5  The mean value of most important fruit-related traits of the olive cultivars studied

| Cultivar   | Fruit length (mm) | Fruit diameter (mm) | Fruit weight (g) | Fruit flesh thickness (mm) | Stone length (mm) | Stone diameter (mm) | Stone weight (g) |
|------------|-------------------|---------------------|------------------|---------------------------|------------------|---------------------|------------------|
| Kavi       | 22.99             | 16.67               | 3.90             | 4.27                      | 16.74            | 8.89                | 0.85             |
| Khasiri    | 23.80             | 18.99               | 5.21             | 4.45                      | 15.90            | 10.70               | 1.18             |
| Dosalayi   | 23.05             | 17.82               | 4.36             | 4.56                      | 15.32            | 9.62                | 0.90             |
| Zard       | 24.23             | 19.58               | 5.29             | 5.37                      | 17.46            | 9.79                | 0.97             |
| Shange5    | 24.65             | 16.33               | 3.53             | 4.38                      | 18.27            | 8.41                | 0.67             |
| Motahar    | 23.92             | 18.97               | 4.90             | 4.86                      | 15.95            | 9.87                | 0.85             |
| Karidolia  | 25.96             | 16.62               | 3.74             | 3.80                      | 19.48            | 9.09                | 0.98             |
| Korfolia   | 23.25             | 16.81               | 3.39             | 4.49                      | 16.43            | 8.52                | 0.64             |
| Dan        | 20.17             | 10.84               | 1.34             | 2.20                      | 16.23            | 6.57                | 0.43             |
| Mission    | 20.44             | 14.95               | 2.97             | 3.77                      | 15.27            | 8.50                | 0.72             |
| Conservolia| 22.07             | 16.67               | 3.71             | 4.25                      | 14.28            | 8.96                | 0.72             |
| Gaillet    | 17.23             | 10.95               | 1.55             | 2.18                      | 12.40            | 6.59                | 0.73             |
| Fooji      | 28.01             | 21.04               | 6.62             | 5.70                      | 19.81            | 9.85                | 1.12             |
| Arbequina  | 15.34             | 11.80               | 1.37             | 2.59                      | 11.90            | 6.79                | 0.35             |
| Mastoides  | 21.44             | 12.98               | 1.86             | 3.54                      | 15.73            | 6.03                | 0.36             |
| Belidi     | 24.36             | 14.10               | 2.88             | 3.73                      | 19.39            | 6.58                | 0.51             |
| Kalamata   | 26.05             | 14.24               | 3.07             | 3.72                      | 20.40            | 7.26                | 0.63             |
| Kroniki    | 19.80             | 11.91               | 1.53             | 2.84                      | 14.95            | 6.08                | 0.35             |
| Damad      | 25.58             | 17.36               | 4.34             | 4.67                      | 18.99            | 8.68                | 0.92             |
| Loko       | 15.34             | 12.14               | 1.39             | 2.58                      | 11.28            | 7.19                | 0.39             |
| Aboosatal  | 28.10             | 19.47               | 6.25             | 5.85                      | 20.78            | 8.84                | 0.87             |
| Mosabi     | 19.39             | 14.59               | 2.42             | 3.65                      | 13.64            | 7.61                | 0.49             |
| Dofnia     | 25.08             | 18.42               | 4.83             | 4.66                      | 17.29            | 9.27                | 0.98             |
| Voliotiki  | 21.07             | 16.58               | 3.27             | 4.88                      | 14.25            | 8.04                | 0.53             |
ETHICS STATEMENT
Research involving Human Participants and/or Animals: None.

INFORMED CONSENT
None.

DATA AVAILABILITY STATEMENT
The data that support the findings of this study are available from the corresponding author upon reasonable request.

ORCID
Ali Khadivi  https://orcid.org/0000-0001-6354-445X

REFERENCES
Arias-Calderon, R., Rouiss, H., Rodriguez-Jurado, D., De la Rosa, R., & Leon, L. (2014). Variability and heritability of fruit characters in olive progenies from open-pollination. *Scientia Horticulturae*, 169, 94–98. https://doi.org/10.1016/j.scienta.2014.02.011

Bandelj, D., Jakše, J., & Javornik, B. (2002). DNA fingerprinting of olive varieties by microsatellite markers. *Food Technology and Biotechnology*, 40(3), 185–190.

Barranco, D., Cimato, A., Fiorino, P., Rallo, L., Touzani, A., Castañeda, C., Serafini, F., & Trujillo, I. (2000). *World catalogue of olive varieties* (p. 360). Consejo Oleicola Internacional.

Bartolini, G., Prevost, G., Messeri, C., & Carignani, G. (Eds.) (1998). *Perspectives in cultivar development (memories of Professor Bruno Zevi)*. FAO Rome.

Bartolini, G., Prevost, G., Messeri, C., & Carignani, G. (2005). Olive germplasm: *Cultivars and world-wide collections*. Available via DIALOG http://www.appsf3.fao.org/view/olive/oliv.jsp

Cantini, C., Cimato, A., & Graziano, S. (1999). Morphological evaluation of olive germplasm present in Tuscany region. *Euphytica*, 109, 173–181.

Cantini, C., Bartolini, G., & Fabbri, A. (2006). The classification of olive germplasm – a review. *The Journal of Horticultural Science and Biotechnology*, 81(3), 319–334. https://doi.org/10.1080/14620316.2006.11512069

Grati, K. N., Ouazzani, N., & Trigui, A. (2002). Characterizing isozymes of some Tunisian olive (*Olea europaea L.*) cultivars. *Acta Horticulturae*, 586, 137–140. https://doi.org/10.17660/ActaHortic.2002.586.21

Hammer, Ø., Harper, D. A. T., & Ryan, P. D. (2001). *PAST: Paleontological statistics software package for education and data analysis*. *Palaeontologia Electronica*, 4(1), 9. http://palaeo-electronica.org/2001_1/past/issue1_01.htm

Hannachi, H., Breton, C., Msallem, M., El Hadj, S. B., El Gazzah, M., & Berville, A. (2008). Differences between native and introduced olive cultivars as revealed by morphology of drupes, oil composition and SSR polymorphisms: A case study in Tunisia. *Scientia Horticulturae*, 116, 280–290. https://doi.org/10.1016/j.scienta.2008.01.004

Hashmi, M. A., Khan, A., Hanif, M., Farooq, U., & Perveen, S. (2015). Traditional uses, phytochemistry, and pharmacology of *Olea europaea* (olive). *Evidence-Based Complementary and Alternative Medicine*, 2015, 1–29.

Hegazi, E. S., Hegazi, A. A., Tawfik, A. A., & Sayed, H. A. (2012). Molecular characterization of local and imported olive cultivars grown in Egypt using ISSR technique. *Journal of Horticultural Science & Ornamental Plants*, 4(2), 148–154.

Hosseini-Mazinani, S. M., Mohammadreza Samaee, S., Sadeghi, H., & Caballero, J. M. (2004). Evaluation of olive germplasm in Iran on the basis of morphological traits: Assessment of ‘Zard’ and ‘Rowghani’ cultivars. *Acta Horticulturae*, 634, 145–151. https://doi.org/10.17660/ActaHortic.2004.634.17

Khadivi, A., & Arab, M. (2021). Identification of the superior genotypes of pomegranate (*Punica granatum L.*) using morphological and fruit characters. *Food Sciences and Nutrition*, 9, 4579–4589.

Khadivi, A., Mirheidari, F., Moradi, Y., & Paryan, S. (2021). Identification of superior jujube (*Ziziphus jujuba* Mill.) genotypes based on morphological and fruit characterizations. *Food Sciences and Nutrition*, 9, 3165–3176.

Kumar, S., Kahlon, T., & Chaudhary, S. (2011). A rapid screening for adulterants in olive oil using DNA barcodes. *Food Chemistry*, 127(3), 1335–1341. https://doi.org/10.1016/j.foodchem.2011.01.094

Lavee, S., & Wonder, M. (2004). The effect of yield, harvest time and fruit size on the oil content in irrigated olive trees (*Olea europaea*), cvs. Barnea and Manzanillo. *Scientia Horticulturae*, 99, 267–277. https://doi.org/10.1016/S0304-4238(03)00100-6

Lazovic, B., & Adakalic, M. (2020). Intra-varietal morphological diversity of montenegrin olive variety ‘Zutica’ based on multivariate analysis. *Erwerbs-Obstbau*, 62, 443–453. https://doi.org/10.1007/s10341-020-00517-7

Lazovic, B., Perovic, T., & Adakalic, M. (2018). Fruit and endocarp properties in relation to intra-varietal morphological diversity of Montenegrin olive variety ‘Zutica’. *Acta Scientarium Polonorum Hortorum Cultus*, 17, 71–81.

Maravelakis, E., Bilalis, N., Mantzorou, I., Konstantaras, A., & Antoniadis, A. (2012). 3D modelling of the oldest olive tree of the world. *International Journal of Computational Engineering Research*, 2(2), 340–347.

Mirmahdi, N.-S., & Khadivi, A. (2021). Identification of the promising Persian walnut (*Juglans regia* L.) genotypes among seedling-originated trees. *Food Sciences and Nutrition*, 9, 2217–2226.

Munir, R. (2009). Various propagation approaches in olive. B.Sc. (Hons.) Internship report Khyber Pakhtunkhwa Agriculture University, Peshawar, Pakistan. pp. 22–23.

Ozkaya, M. T., Cakir, E., Gokbayrak, Z., Erkan, H., & Taskin, N. (2006). Morphological and molecular characterization of Derik Halhali olive (*Olea europaea L.*) accessions grown in Derik–Mardin province of Turkey. *Scientia Horticulturae*, 108, 205–209. https://doi.org/10.1016/j.scienta.2006.01.016

Peres, A. M., Baptista, P., Malheiro, R., Dias, L. G., Bento, A., & Pereira, J. A. (2011). Chemometric classification of several olive cultivars from Trás- os Montes region (northeast of Portugal) using artificial neural networks. *Chemometrics and Intelligent Laboratory Systems*, 105, 65–73. https://doi.org/10.1016/j.chemolab.2010.11.001

Rotondi, A., Cultrera, N. G. M., Mariotti, R., & Baldoni, L. (2011). Genotyping and evaluation of local olive varieties of a climatically disfavoured region through molecular, morphological and oil quality parameters. *Scientia Horticulturae*, 130, 562–569. https://doi.org/10.1016/j.scienta.2011.08.005

Rotondi, A., Magli, M., Ricciolini, C., & Baldoni, L. (2003). Morphological and molecular analyses for the characterization of a group of Italian olive cultivars. *Euphytica*, 132, 129–137.

(1990) SAS® procedures version 6 (3rd ed.). SAS Institute.

Shu, M. X. L. (1996). *Olea* Flora China, 15, 295–298.

Singh, K., Chowdhary, B. M., Shankar, R., & Jain, B. P. (1999). Studies on the physiological changes in litchi fruits during growth and development under Ranchi condition. *Progressive Horticulture*, 31, 151–155.

Strikic, F., Bandelj Mavsar, D., Perica, S., Cmelik, Z., Satovic, Z., & Javornik, B. (2009). The main Croatian olive cultivar, ‘Oblica’, shows high morphological but low molecular diversity. *The Journal of Horticultural Science and Biotechnology*, 8(3), 345–349. https://doi.org/10.1016/j.jhsb.2009.11512529

Taamalli, W., Geuna, F., Banfi, R., Bassi, D., Daoud, D., & Zarrour, M. (2006). Agronomic and molecular analyses for the characterization of accessions in Tunisian olive germplasm collections. *Electronic Journal of Biotechnology*, 9(5), 467–481. https://doi.org/10.2225/vol9-issue5-fulltext-12
Trentacoste, E. R., & Puertas, C. M. (2011). Preliminary characterization and morpho-agronomic evaluation of the olive germplasm collection of the Mendoza province (Argentina). *Euphytica*, 177, 99–109. https://doi.org/10.1007/s10681-010-0270-4

Trentacoste, E. R., Puertas, C. M., & Sandras, V. O. (2010). Effect of fruit load on oil yield components and dynamics of fruit growth and oil accumulation in olive (*Olea europaea* L.). *European Journal of Agronomy*, 32, 249–254. https://doi.org/10.1016/j.eja.2010.01.002

Uylaser, V., Tamer, C. E., Incedayi, B., Vural, H., & Copur, O. U. (2008). The quantitative analysis of some quality criteria of Gemlik variety olives. *Journal of Food, Agriculture and Environment*, 6(3–4), 26–30.

Youssefi, O., Guido, F., Daoud, D., & Mokhtar, Z. (2011). Effect of cultivar on minor components in Tunisia olive fruits cultivated in microclimate. *Journal of Horticulture and Forestry*, 3(1), 13–20.

Zaher, H., Boulouha, B., Baaziz, M., Sikaoui, L., Gaboun, F., & Udupa, S. M. (2011). Morphological and genetic diversity in olive (*Olea europaea* subsp. *europaea* L.) clones and varieties. *Plant Omics*, 4(7), 370–376.

How to cite this article: Khadivi, A., Mirheidari, F., Moradi, Y., & Paryan, S. (2022). Identification of the promising olive (*Olea europaea* L.) cultivars based on morphological and pomological characters. *Food Science & Nutrition*, 10, 1299–1311. https://doi.org/10.1002/fsn3.2767