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Morphological Diversity in Wild Populations of Mastic Tree, *Pistacia lentiscus* L. (Anacardiaceae) in Morocco

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ABSTRACT

Pistacia lentiscus is an evergreenperennial shrubnative to the Mediterranean Basin, used as fodder shrub for livestock and useful for rehabilitation of degraded landsand also as as medicinal plant. In Morocco, *P. lentiscus* L. spreads naturally in almost the whole of the country and has the ability to grow in several regions under different climates and other conditions. In this study, we used morphological traits to evaluate the variation among eleven Moroccan populations of *P. lentiscus* (five from High Atlas, five from Middle Atlas and one from the Souss, coastal, zone) using 24 morphological traits. The results showed large variability among and within populations for most traits. Principal components analysis showed four major groups from different regions. These results showed that the populations of M'rirt and Bin El Ouidane had the maximum length and width of leaf and largest number of leaflets, while the populations Tighassaline, Bin El Ouidane and Tifrdine demonstrated the largest length and width of fruit, and thickness of fruit wall). In contrast, the population of El Kebab showed the least desirable values for most of the characteristics measured.

Keywords: Atlas mountains, lentisk, Morocco, natural population, variability

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Introduction

Pistacia lentiscus L. (Anacardiaceae) named also Lentisk and mastic tree, is a wild and evergreen shrub producing bright red globose berries (Dhifi et al., 2013; Fazeli-Nasab &_Fooladvand, 2014)._The species is cultivated in areas across the world, such as Morocco, Italy, Turkey, Iran, and China (Tang et al., 2012; Kozhoridze et al., 2015; Sajadian & Hokmabadi, 2015). Mastic trees are native of the Mediterranean region and occur in different countries such as Morocco, Tunisia, Algeria, Italy, Iberia and Greece (FAO, 2015; Kozhoridze et al., 2015). This shrub is known by its medicinal roles since ancient Greeks and is used for this purpose in the Mediterranean region (Charef et al., 2008; Dhifi et al., 2013; Doghbage et al., 2016; El Haouari et al., 2018). It has been reported that almost of the parts of *Lentisk*, such as fruits, galls, resin and leaves are used in the traditional medicine (Charef et al., 2008; Dhifi et al., 2013). Its resin has analgesic, antibacterial, antifungal, antioxidant, stimulating, diuretic and spasmolytic characteristics (Dedoussis et al., 2004; Mahmoudi et al., 2010; Fazeli-Nasab & Fooladvand, 2014). Plants are characterized by the ability to resist drought and resprout after fire and cutting, which explains their resistance to soil erosion (Cristiano et al., 2016).

In Morocco *P. lentiscus* spreads naturally in the whole country and grows in different types of soils (Aafi et al., 2002; Fennane et al., 2007; Fazeli-Nasab & Fooladvand, 2014). It has the ability to resist in different climate and adapt to several conditions, because of its resilience and minor nutrient demands (Benmahioul et al., 2010; Fazeli-Nasab & Fooladvand, 2014; Koc et al., 2014; Bammou et al., 2015**)**. This species is used in several purposes especially medicinal goals and livestock feed (EL Haouari et al., 2018).

To the best of our knowledge, there is little information in Morocco related to wild *P. lentiscus* plants, or studies in relation to the diversity of local populations of this species. Therefore, it became imperative to evaluate the diversity in the Moroccan *Lentisk* germplasm.With this view, we focused on the morphological characterization of vegetative and fruit traits in wild populations collected in different regions. Given the importance of this species for the development of marginal areas, study would provide knowledge on its variability across populations.

Materials and Methods

Sampled Areas

This work was carried out in different geographic regions of *Lentisk* trees in Morocco. Eleven sites were chosen from three zones: zone I: Middle Atlas (five sites: 1, 3, 5, 8 and 10), zone II: High Atlas (five sites: 2, 4, 6, 9 and 11) and zone III: coastal region (one site: 7) (Fig. 1). Geographical characteristics and ecological data of samplings sites are presented in Table 1. The altitude of the studied area ranged between 1111-1451m in the Middle Atlas region, 805-1427 m in the High Atlas, and 298 m in the coastal region (Table 1).

Morphological measurements

For each site, five trees in fructification stage were randomly chosen and sampled. From each tree, 20 mature fruits and 20 fully sun exposed mature leaves (n = 11 x 5 x 20 = 110 in each) were carefully harvested in a randomized manner. Analysis of morphological variation was based on 14 characters of leaves and 10 characters of fruits (Table 2). These traits were chosen according to the guidelines provided by International Plant Genetic Resources Institute (IPGRI, 1998) in the descriptors for the genus *Pistacia*. Descriptions and classiûcation of qualitative morpho-pomological characters of according to IPGRI descriptors are presented in Table 3.

Statistical analysis

The data obtained were subjected to statistical analysis including the analysis of variance (ANOVA) and correlation analysis which is based on the Pearson correlation coefficient ($\alpha = 0.01$) performed by SAS Microsoft windows 8.0 (SAS, 1999); principal components analysis (PCA) was done using the software XLSTAT.

Results

Morphological variability

The overall mean values for all characters measured and their standard deviations are presented in Table 4. Analysis of variance (ANOVA) shows a significant effect of populations for fruit traits except for the fruit shape, indicating that all populations are marked by high levels of heterogeneity in fruit traits. The longest fruits were found in the populations Tighssaline,

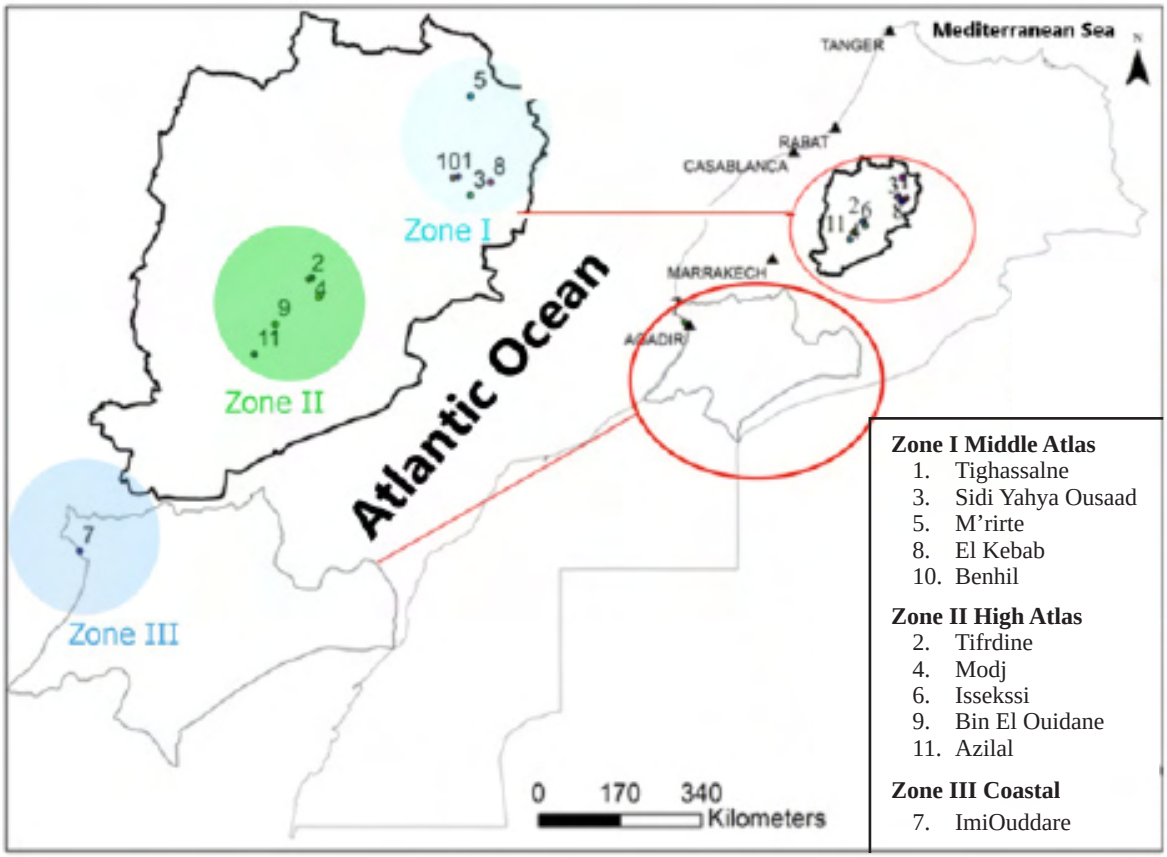

Figure 1. The sampling zones

Table 1. Geographic and meteorological conditions of eco-regions of Lentisk populations used in this study.

Station name	Station Number	Zone	Altitude	Latitude (m)	Longitude North	Rainfall west	Annual average mm/year	temperature
Tighssaline	1	Middle Atlas	**Zone I**	1344 m	32°76	5°63	635 mm	16.1 °C
Sidi yahyaOussad	3	Middle Atlas		1451m	32°68	5°54	620 mm	13.3 °C
M'rirt	5	Middle Atlas		1111m	33°19	5°54	717 mm	14.7 °C
EL kebab	8	Middle Atlas		1401 m	32°71	5°57	616 mm	14.1 °C
Benkhlil	10	Middle Atlas		1245 m	32°76	5°65	635 mm	16.1 °C
Tifrdine	2	High Atlas	**Zone II**	805 m	32°32	6°32	493 mm	18.3 °C
Modj	4	High Atlas		1200 m	32°30	6°30	594 mm	14.7 °C
Isseksi	6	High Atlas		1427 m	32°22	6°27	594 mm	14.7 °C
Bin El Ouidane	9	High Atlas		866 m	32°10	6°46	490 mm	17.6 °C
Azilal	11	High Atlas		1354 m	32°01	6°56	563 mm	15.7 °C
Imi Ouddare	7	Littoral	**Zone III**	298m	30°59	9°74	290.6 mm	18.3 °C

Table 2. Vegetative traits and pomological traits used for Moroccan Lentisk populations study.

	Abreviation	Characters
Pomological traits	FL (mm)	Fruit Length (mm)
	FW (mm)	Fruit Width (mm)
	ET (mm)	Envelope Thickness (mm)
	KW (g)	Kernel Width (g)
	FWg (g)	Fruit Weight (g)
	KK (mm)	Kernel Length (mm)
	FC	Fruit Color
	LWF	Length/Width of the Fruit
	LWK	Length/Width of the Kernel
	FS	Fruit Shape
Vegetative traits	LL (cm)	Leaf Length (cm)
	LW (cm)	Leaf Width (cm)
	NL	Number of Leaflets
	TLL (mm)	Terminal Leaflet Length
	TLW (mm)	Terminal Leaflet Width
	STL	Shape Terminal Leaflet
	TLM	Terminal leaflet margin
	APTL	Absence or Presence of the Terminal Leaflet
	SZTL (mm)	Size Terminal Leaflet
	TLS	Terminal Leaflet Base Shape
	LWL	Ratio (L/W) of leaf
	TLSA	Terminal Leaflet Apex Shape
	LWTL	Ratio (L/W) of Terminal Leaflet
	LC	Leaf Color

Bin El Ouidane and Tifrdine (5.28 mm, 5.26 mm and 5.24 mm, respectively); the smallest fruits were detected in El Kebab and Isseksi populations (4.57 mm, and 4.60 mm, respectively). The widest fruit were observed in Imi Ouddare, Bin El Ouidane, Tifrdine and Azilal populations (5.73 mm, 5.59 mm, 5.22 mm and 5.16 mm, respectively), while the lowest values were recorded for El Kebab and Sidi Yahya Oussad populations (4.29 mm and 4.32 mm, respectively). The highest weight of 10 fruits was found in populations Imi Ouddare, Bin El Ouidane and Tighssaline (0.84 g, 0.81 g and 0.77 g, respectively) and lowest weight was observed in Isseksi, Sidi Yahya Oussad, Moudj and El Kebab populations (0.47-0.50 g).

Regarding leaves, six traits show significant differences between populations: length and width of the leaf, absence or presence of the terminal leaflet, size of terminal leaflet, shape of the base of the terminal leaflet and ratio (length / width) of the leaf. The populations M'rirt, Bin El Ouidane and Tifridine had the longest leasve (7.80, 7.27 and 6.95 cm, respectively) and the widest leaf (4.95, 4.91 and 5.16 cm, respectively). The shape of the base of the terminal

Table 3. Description and classiûcation of the qualitative morpho-pomological characters of *Pistachia lentiscus* according to IPGRI descriptor.

Characteristic	1	2	3	4	5
Shape of the terminal leaflet	Broad lanceolate	Elliptic	Ovate	Round ovate	Roundish
Shape of the apex of the terminal leaflet	Acuminate	Mucronate	Mucronulate	Obtuse	Retuse
Shape of the fruit	Roundish	Ovoid	Elongated	Narrowly cordate	Cordate
Fruit color	Clear red	Red	Dark red	Black	
Terminal leaflet base	Attenuate	Obtuse	Truncate	Oblique	
Terminal leaflet margin	Wavy	Flat			
Color of the leaf	Light green	Green	Dark green		
Absence or presence of the terminal leaflet	Absent	Present			

Table 4. The average values of the morphological characteristics measured in the Moroccan populations of the *Pistacia lentiscus*.

	M'rirt	Bin El Ouidane	Tifrdine	Tighssaline	Sidi yahya Oussad	Benkhlil	Isseksi	El kebab	Moudj	Imi Ouddare	Azilal	Mean	CV	F	P value
FL (mm)	5.04±0.03c	5.26±0.04de	5.24±0.07cde	5.28±0.04e	5.11±0.06cd	5.14±0.06cde	4.60±0.02ab	4.57±0.07a	4.69±0.01ab	5.01±0.03c	4.73±0.03b	4.97±0.08	11.56	2.10	0.0043**
FW(mm)	5.00±0.04d	5.59±0.06f	5.22±0.05e	5.00±0.05d	4.32±0.05a	4.56±0.06b	4.83±0.04c	4.29±0.04a	4.62±0.06b	5.73±0.03g	5.16±0.04e	4.94±0.14	13.31	1.68	0.0361*
ET (mm)	0.53±0 .01e	0.72±0.03f	0.66±0.04c	0.60±0.02e	0.42±0.02c	0.20±0.01a	0.39±0.01b	0.22±0.01b	0.52±0.01d	0.72±0.01d	0.72±0.02f	0.52±0.06	49.64	204.30	0.0001***
KW(g)	4.67±0.06a	5.23±0.05a	4.87±0.05a	4.70±0.05a	4.01±0.04a	4.04±0.08a	4.49±0.04a	3.66±0.08a	4.30±0.09a	5.23±0.02a	4.70±0.04a	4.54±0.15	15.52	254.39	0.0001***
FWg(g)	0.66±0.02d	0.81±0.02d	0.65±0.00c	0.77±0.02d	0.48±0.01ab	0.63±0.01b	0.47±0.01a	0.50±0.00ab	0.49±0.01ab	0.84±0.01d	0.61±0.01b	0.63±0.04	30.15	5.63	0.0001***
KK (mm)	4.32±0.03e	4.35±0.03f	4.41±0.06g	4.38±0.04f	4.45±0.05h	4.44±0.05h	3.90±0.02a	3.91±0.05a	4.05±0.02c	4.15±0.02d	3.92±0.03b	4.21±0.07	11.62	28.30	0.0001***
FC	1.85±0.03c	2.33±0.11f	1.57±0.16a	2.53±0.06gh	2.19±0.09de	2.21±0.06e	2.12±0.08c	2.12±0.07d	2.40±0.08g	1.72±0.05b	3.09±0.11h	2.19±0.13	40.98	29.57	0.0001***
LWF	1.02±0.04d	0.95±0.01ab	1.01±0.01c	1.06±0.01d	1.19±0.01e	1.15±0.02e	0.96±0.01b	1.07±0.01e	1.01±0.06d	0.87±0.00a	0.92±0.01ab	1.02±0.03	14.23	2.04	0.0060***
LWK	0.94±0.01c	0.84±0.01a	0.91±0.01b	0.94±0.01c	1.11±0.01d	1.15±0.03d	0.87±0.01a	1.12±0.03d	0.94±0.01c	0.79±0.00a	0.84±0.01a	0.95±0.04	20.67	5.08	0.0001***
FS	1.14±0.03abc	1.09±0.03bcd	1.07±0.05e	1.22±0.04abc	1.78±0.05b	1.78±0.09d	1.03±0.02a	1.59±0.05bc	1.25±0.01bcd	1.00±0.00e	1.01±0.01bc	1.27±0.09	39.23	0.8	0.9258 n.s.
LL (cm)	7.80±0.12e	7.27±0.13d	6.95±0.12d	6.95±0.19d	5.88±0.11ab	6.03±0.13bc	6.44±0.13c	5.46±0.14a	6.52±0.13c	5.91±0.13bc	6.57±0.14c	6.53±0.21	23.98	2.43	0.0006***
LW (cm)	4.95±0.07f	4.91±0.09ef	5.16±0.12f	4.84±0.14ef	4.40±0.07cd	4.01±0.08ab	4.32±0.07bcd	3.74±0.11a	4.57±0.10de	4.14±0.09bc	4.41±0.09cd	4.50±0.13	23.18	2.11	0.0039**
NL	8.71±0.33a	8.20±0.15b	8.10±0.14b	8.17±0.15b	7.74±0.17a	7.87±0.19b	7.75±0.16b	7.79±0.18b	7.74±0.16b	8.10±0.16b	8.29±0.18b	8.04±0.09	22.20	2.11	0.3115 n.s.
TLL	2.24±0.05d	2.18±0.05c	2.37±0.07e	2.36±0.06e	2.18±0.05bc	2.01±0.06ab	1.97±0.05ab	1.81±0.05a	2.22±0.07c	2.15±0.06ab	2.26±0.06e	2.16±0.05	28.20	1.39	0.1228 n.s.
TLW	0.80±0.06d	0.77±0.03de	0.70±0.03b	0.72±0.02bd	0.75±0.03de	0.63±0.03ab	0.72±0.02de	0.66±0.02abc	0.65±0.02ab	0.52±0.02a	0.67±0.02bc	0.69±0.02	53.93	0.72	0.6933 n.s.
STL	2.20±0.04a	3.22±0.10b	3.09±0.10b	3.08±0.11b	3.00±0.11b	3.12±0.10b	3.32±0.10b	2.24±0.13b	3.27±0.10b	2.60±0.09b	2.75±0.10b	2.90±0.12	37.00	0.82	0.6792 n.s.
TLM	1.21±0.03b	1.55±0.05d	1.41±0.05d	1.35±0.05d	1.21±0.04c	1.29±0.05cd	1.29±0.05cd	1.08±0.03a	1.51±0.05d	1.00±0.00a	1.31±0.05d	1.29±0.05	35.14	1.08	0.3710 n.s.
APTL	1.18±0.03a	1.31±0.05a	1.22±0.04a	1.36±0.05a	1.25±0.04a	1.26±0.04a	1.24±0.04a	1.39±0.05a	1.22±0.04a	1.20±0.04a	1.32±0.05a	1.27±0.02	34.83	1.75	0.0245*
SZTL	1.80±0.03a	1.58±0.05a	1.64±0.05a	1.67±0.06a	1.80±0.05a	1.64±0.05a	1.80±0.05a	1.71±0.05a	1.86±0.05a	1.85±0.04a	1.94±0.04a	1.75±0.03	27.55	28.23	0.0001***
TLS	1.09±0.04a	2.96±0.14c	3.14±0.13c	2.69±0.15cde	1.60±0.10b	2.08±0.13b	2.60±0.14cd	2.25±0.15bc	2.27±0.12cd	2.55±0.15cd	2.84±0.14ce	2.37±0.18	59.82	2.15	0.0031***
LWL	3.37±0.09bc	3.19±0.14d	3.18±0.15a	3.38±0.011cd	3.40±0.15a	3.08±0.14e	4.00±0.08e	3.43±0.10e	3.55±0.12bc	2.95±0.14ab	2.81±0.13e	3.30±0.10	38.58	28.23	0.0001***
TLSA	3.46±0.07a	3.05±0.08a	3.59±0.09a	3.35±0.05a	3.06±0.07a	3.50±0.11a	2.77±0.06a	2.83±0.06a	3.50±0.06a	4.26±0.07a	3.44±0.06a	3.35±0.13	24.61	0.60	0.9085 n.s.
LWTL	1.59±0.02e	1.50±0.02d	1.38±0.02a	1.46±0.02cd	1.36±0.03a	1.52±0.03e	1.50±0.02e	1.50±0.03e	1.45±0.02bc	1.44±0.02ab	1.51±0.03e	1.48±0.02	18.60	1.44	0.0996 n.s.
LC	2.42±0.05bc	2.43±0.06bcd	2.85±0.04e	2.53±0.06cd	2.31±0.08b	2.57±0.05d	2.09±0.07a	2.39±0.06bc	2.43±0.07bcd	2.80±0.04e	2.37±0.06bc	2.47±0.06	25.35	0.69	0.8335 n.s.

leaflet was also variable and the longest were recorded to populations Tifridine and Bin El Ouidane (3.14 and 2.96). The highest values of the leaf traits were found in two High Atlas sites (Bin El Ouidane and Tifrdine) and one site in middle Atlas (M'rirt). However, the population El Kebab from Middle Atlas shows the lowest values of majority of the measured leaves parameters. In general, M'rirt population was found to have the longest leaf (7.80 cm) and the highest number of leaflets (8.71), whereas population from El Kebab was found to have the lowest leaf length (5.46 cm) and the lowest number of leaflets (7.79).

Correlations between morphological traits

The correlation between each pair of traits was calculated and several correlations were observed between the various morphological traits (Table 5).With regard to the pomological traits, high positive correlation was observed between fruit width and fruit weight (r = 0.59), envelope thickness and fruit color, and fruit shape (r = 0.78 and 0.79, respectively). Further, fruit shape is correlated positively with fruit color (r = 0.71). On the other hand, the kernel length and width are negatively correlated to fruit envelope thickness (r= -0.66 and -0.90, respectively).

High positive correlations was observed between the kernel and shape of terminal leaflet (r= 0.92). Furthermore, leaf length is correlated with terminal leaflet shape (r=0.64) and leaf color is correlated with terminal leaflet shape of the basis (r = 0.71). However, a negative correlation was determined between the size of the terminal leaflet and its length (r= -0.82). It was found that some leaf characteristics were in signification correlation with fruit characteristics. This is the case of the envelope thickness that is correlated positively with margin of the leaflet (r = 0.94) and kernel width with size terminal leaflet (r = 0.92). However, a negative correlation was found between the leaves shape and envelope thickness of the fruit, the fruit shape and the color fruit (- 0.87, - 0.74 and - 0.70, respectively). Also the length of the leaf is negatively correlated to the thickness of the envelope of the fruit (r= -0.62).

Principal components analysis (PCA)

The results from the PCA indicate that 52.35 % of the total variation among accessions was explained by the two first components. The first component PC2 explained 35.32 % of the variability observed. It is

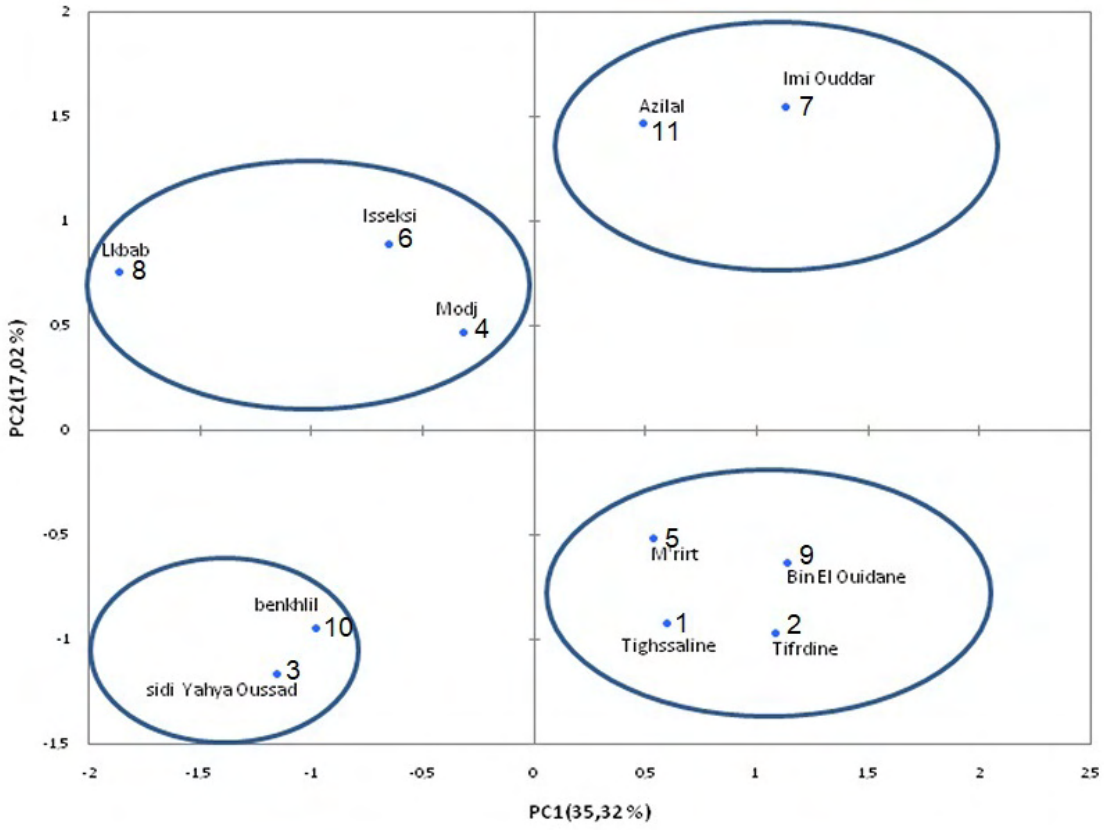

Figure 2. Plot on the first two Principal Components of 11 of Pistacia lentiscus populations on the basis of leaves and fruits morphological characters

Table 5. Pearson coefficient correlations between the morpho-pomological characteristics measured in the eleven populations studied.

	FL	FW	ET	KW	FWg	KK	FC	LWF	LWK	FS	LL	LW	NL	TLL	TLW	STL	TLM	APTL	SZTL	TLS	LWL	TLSA	LWTL	LC
FL	1																							
FW	0.40	1																						
ET	0.13	0.03	1																					
KW	0.16	0.10	-0.90	1																				
FWg	0.24	0.59	-0.17	0.20	1																			
KK	0.10	0.01	-0.66	0.67	0.31	1																		
FC	0.14	0.40	0.78	-0.78	0.12	-0.53	1																	
LWF	0.20	-0.57	0.05	0.16	-0.39	0.08	-0.49	1																
LWK	0.16	-0.44	0.31	-0.22	-0.40	-0.10	-0.01	0.46	1															
FS	0.03	0.03	0.79	-0.80	-0.05	-0.56	0.71	-0.20	0.13	1														
LL	0.16	0.18	-0.62	0.68	0.27	0.46	-0.44	-0.03	-0.28	-0.31	1													
LW	0.07	0.08	0.62	-0.57	-0.01	-0.38	0.54	-0.15	0.15	0.67	-0.32	1												
NL	-0.01	-0.02	0.02	-0.01	-0.001	-0.03	-0.03	0.01	-0.03	-0.02	-0.01	-0.01	1											
TLL	0.06	0.04	0.50	-0.46	-0.03	-0.34	0.41	-0.07	0.14	0.42	-0.26	0.34	-0.08	1										
TLW	0.13	0.24	0.09	-0.06	0.21	-0.04	0.16	-0.14	-0.11	0.09	0.02	-0.09	-0.01	0.52	1									
STL	0.13	0.15	-0.87	0.92	0.28	0.65	-0.70	0.09	-0.28	-0.74	0.64	-0.53	0.02	-0.60	0.005	1								
TLM	0.09	0.02	0.94	-0.89	-0.15	-0.63	0.76	-0.10	0.26	0.78	-0.61	0.59	0.001	0.34	-0.06	-0.82	1							
APTL	0.03	0.20	-0.01	0.05	0.19	0.01	0.09	-0.17	-0.11	0.01	0.09	0.05	-0.08	0.78	0.56	-0.14	-0.16	1						
SZTL	0.27	0.20	-0.22	0.04	0.04	0.19	-0.19	0.08	-0.06	-0.20	0.17	-0.16	0.07	-0.82	-0.31	0.46	-0.08	-0.85	1					
TLS	0.42	0.05	-0.37	0.27	0.04	0.33	-0.39	0.10	-0.06	-0.35	0.28	-0.26	0.001	-0.56	-0.21	0.51	-0.29	-0.29	0.31	1				
LWL	0.10	0.01	-0.08	0.11	0.11	0.06	-0.04	-0.004	-0.02	0.01	0.21	0.002	-0.06	0.53	0.46	-0.002	-0.22	0.52	-0.31	-0.61	1			
TLSA	-0.14	-0.01	0.14	-0.14	-0.04	-0.06	0.15	0.01	0.12	0.11	-0.11	0.06	0.06	-0.62	-0.72	-0.07	0.35	-0.75	0.57	0.22	-0.62	1		
LWTL	-0.47	0.02	0.47	0.47	0.11	-0.36	0.40	-0.10	0.11	0.50	-0.23	0.36	-0.07	0.89	0.43	-0.60	0.32	0.70	-0.77	-0.54	-0.54	-0.56	1	
LC	0.05	0.05	-0.06	0.05	-0.06	0.17	0.01	-0.05	-0.03	-0.03	0.03	-0.04	0.05	-0.57	-0.59	0.12	0.11	-0.66	0.63	-0.007	-0.25	0.71	-0.51	1

positively correlated with leaf length (LL), leaf width (LW), number of leaflets (NL), fruit width (FW), envelope thickness (ET), fruit weight (FW) and kernel width (KW) and negatively correlated with fruit shape (FS). The second component (PC2) accounted for 17.02% of the total variability, had positive loading for size terminal leaflet (SZTL) and ratio (length / width) of leaf (LWL) and negative loading for fruit length (FL) and kernel length (KL).

The PCA plots show that Moroccan *Lentisk* populations constitute four distinct groups (Fig. 2). The first cluster was constituted with four populations (M'rirt, Bin el Ouidane, Tighssaline and Tifrdine). These populations are characterized by longest fruits, longest leaves, and highest number of leaflets. The second group consisted of two populations (Benkhliland Sidi Yahya Oussad), which are characterized by smallest number of leaflets. The third group is formed by three populations (El Kebab, Modj and Isseksi) distinguished essentially by a smallest fruits, lowest leaf length and lowest number of leaflets. The fourth group includes two populations (Azilal and Imi Ouddar) characterized by highest values of kernel width and fruit shape.

Discussion

The results of the present study showed morphologi-cal and pomological variability of Moroccan natural populations of *P. lentiscus*. This was reflected insignificant differences between the populations tested. This result agreed with the study of Barazani et al. (2003) who reported a large variability of *P. lentiscus* species in the Mediterranean area.

Regarding the fruit, our results revealed variation in pomological charactersacross locations that might be associated with climatic factors. The longest fruits were found in populations Tighssaline, Bin El Ouidane and Tifrdine. These sites are characterized by a high temperature ranged between 16.1°C and 18.3°C. In contrast, the smallest fruits were found in populations El Kebab and Isseksi characterized by a high altitude (1401 m and 1427 m, respectively) and low temperature (14.1°C and 14.7°C).

About the leaf parameters, the longest leaves

were found in population M'rirt and the smallest was detected in populations El Kebab and Sidi Yahya Oussad. The latter two sites were characterized by a low annual temperature (El Kebab: 14.1°C and Sidi Yahya Oussad: 13.3°C) and high annual precipitation (El Kebab: 616 mm and Sidi Yahya Oussad 620 mm) comparing to M'rirt (temperature: 14.7°C and precipitation: 717 mm). Several studies reported that leaf length generally varies according to local conditions such as drought (Jonasson et al., 1997; Ait Said et al., 2011) and cold (Karimi et al., 2009). Karimi et al. (2009) reported that the small leaves have a tendency of being more abundant in populations of cold areas. Moreover, Ait Said et al. (2011) reported that the smallest leaves were seen in *Pistacia* populations grown in arid sites. In general, leaves are sensitive to environmental changes and their characteristics such as color in considered as a good indicator of the palatability of fodder shrubs (Chriyaa, 2009). In fact, leaf color is highly influenced by eco-physiological factors (Belhadj et al., 2007).

Our results showed that only 20% of the counted leaves per tree contained terminal leaflets. This result is in agreement with previous result reported by Barazani et al. (2003) who showed the absence of the terminal leaflets in the majority of the observed leaves.

Our results indicated correlations between the measured morphological and pomological traits. Leaf length was positively correlated with the length and the weight of the fruit and negatively correlated with the thickness of the envelope of the fruit. This finding is in accordance with the findings of Karimi et al. (2009) where a significant correlation between leaf characteristics and nut traits was observed. Obtained negative correlations could be explained by the compensation effect between the vegetative and fruit traits.Generally, our findings might suggest that the populations of M'rirt and Bin El Ouidane are superior with regard to vegetative production (length of the leaves, width of the leaves and number of leaflets) while the populations Tighassaline, Bin El Ouidane and Tifrdine are superior with regard to fruit (length of the fruits, width of the fruits, thickness of the envelope). In contrast, the population of El Kebab showed the least desirable values for most of the characteristics measured. Moreover, several populations from different areas were more similar to each other and were in the same group, such as Azilal from Middle Atlas and Imi Ouddar from the coast, M'rirt and Tighssaline from Middle Atlas and Tifrdin and Bin El Ouidane from High Atlas. This finding might suggest that the variations obtained are independent of the geographic origin and the altitude of the mountain. This is in agreement with other results obtained in Moroccan plant species such as *Pinus halepensis* (Boulli et al. 2001) and *Pinus pinaster* (Wahid et al., 2009).

This work is the first study on the morphological characters of wild populations of*Pistacia lentiscus* in Morocco. The results showed variability among the Moroccan populations of this species in the measured traits. Significant variation was found in fruit characters with longest fruits found in populations Tighssaline, Bin El Ouidane and Tifrdine and the highest weight of fruits was observed in populations Imi Ouddare, Bin El Ouidane and Tighssaline. In terms of leaf characters, the populations of *P. lentiscus* from M'rirt was found to have the longest leaf and the highest number of leaflets, whereas population from El Kebab was found to have the shortest leaf and almost the lowest number of leaflets.

Furthermore, populations from High Atlas (especially Bin El Ouidane and Tifrdine) were found to have a constant leaf length and highest values of most measured morphological traits and significantly different compared to populations from the Middle Atlas (El Kebab) which showed the lowest values of most traits. So, re-vegetation of degraded land can be carried out by planting from the High Atlas populations.

This study contributes to a better knowledge of this species in Morocco, allowing the selection of the most efficient populations. In order to have a good overview of *P. lentiscus* diversity, this study needs to be complemented by biochemical and molecular analyses.

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