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The Bioagronomic Characteristics of a Local Olive Cultivar Gerboui

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Abstract: The objective of this study was to identify a local olive cultivar Gerboui based on biometric characteristics. All the experiments were conducted in selected olive grove situated in northern part of Tunisia (Testour and Thibar) where the most widespread variety is Chetoui following by Gerboui which is a local variety. The experimental approach was based on using 32 parameters as recommended by COI for characterization and the bioagronomic observations concerned the morphological characteristics of the trees, leaves, fruit and inflorescence and the flowering period. The olive fruits were examined for their morphology and oil composition (oil content, oil quality and maturity index) and for endocarp characteristics. The field comparison, carried out in 2003, 2004 and 2005 and in the 2 regions, showed a good vegetative and reproductive behaviour of this cultivar, good productivity with high oil content and quality (fatty acids based on IOOC standards). Flowers occurred on inflorescences that measured about 3 cm in length. On average 23 flowers were observed by inflorescence but 42% were aborted which is acceptable for obtaining a commercially profitable crop in olive trees. Inflorescence length, number of flowers per inflorescence and pistil failure percentage resulted higher in Testour than in Thibar. The parameters of pollen capacity studied indicate that the pollen of Gerboui olive cultivar show a rapid germinative capacity and a good growth of the pollen tube, which is suitable as pollinizer. Olive oil of cultivar Gerboui is considered to be highly nutritional oil due in part to the high level of monounsaturated oleic acid and lower palmitic and linoleic acid content. The fruit samples had oil yields greater than 18% (25%) calculated at 50% moisture, oleic acid levels greater than 55% (60.5%), palmitic acid between 7.5 and 20% (13.4%) and linolenic acid levels less than 1% (0.55%). The self fertility behaviour of this olive cultivar shown it is self-compatible, with satisfactory fruit set when flowers were self pollinated. The fruit set in self pollinated flowers was 3.12% resulting in higher fruit set in free pollinated flowers 4.21%. It has shown compatibility to local climatic conditions and was well adapted to the cultural and environmental conditions of the site. This description analyses numerous characters of local cultivars which can solve some cases of varietal homonymy and synonymy, resolving the confusion in cultivar identity. This can also assist olive producers in making informed varietal choices from the comparative physiological information on the performance of local olive cultivars in Tunisia.

Key words: Fatty acid composition, local cultivar, olive tree, self compatibility

Introduction

Tunisia has a long tradition of producing olive oil and nowadays, three main olive production regions are distinguished: the northern, the central and the southern parts. Olive production remains

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highly concentrated in these regions where it generates regional employment and is an important source of income in rural areas, thereby reducing migration to urban areas. It also provides ecological benefits by contributing to soil retention and reducing erosion.

In the northern part of Tunisia there are more than 180.000 ha cultivated to olive groves, which represent 34% of olive cultivation in Tunisia with 19 millions of trees. The oil production represents 16% of national production. The most widespread variety in the north is Chetoui following by Gerboui which is a local variety. The latest has been traditionally cultivated and present some interesting characteristics because of its adaptation (development and production) to the conditions of these regions.

Tunisia is characterized by contrasts, both in geographical conditions and in agricultural practices, between the Mediterranean area of the coast and the sahara. However, in all these various agricultural systems, people conserved their local varieties which are considered as an heritage. Olive tree is one such species. The farmers have selected some olive varieties adapted to the conditions, but this genetic diversity is threatened by modernization of production practices and by changes in agricultural and economical policies. So there is an urgent need to study and to inventory these traditional varieties before their lost.

Gerboui was first described by Tournieroux (1929) but little morphological information is available (Mehri *et al.*, 1997; Mehri and Hellali, 1995) and the precise locality remains unknown. It is characterized by its small geographic dispersion and It has additional variety name according to the regions: Regregui in Kef, Bidh El Hammam in Neber (Tournieroux, 1929). The traditional growing areas of this variety is the northwest part of Tunisia consisting of a continuous trip from Teboursouk to Thala and from Dorsale mountains to Algerian boundary (Mehri *et al.*, 1997). So a good description of this cultivar is needed, leading to identify and to detect the main agronomical characteristics which may improve qualitative and quantitative yields. Several agronomic and commercial characteristics of olive cultivars were analysed in different regions of Mediterranean area (Tous *et al.*, 1990, 2000; Bellini *et al.*, 2000). Identification by isozymes analyses (Trujillo *et al.*, 1995) and by bimolecular markers (Fabbri *et al.*, 1995; Besnard and Berville, 2000) has also been developed.

This study aim to examine a local olive tree Gerboui by carrying out an experimental study in a uniform growing environment in northern Tunisia and to describe the frequency of the principal bio-agronomic characters in 2003, 2004 and 2005. This description analyses numerous characters of this local cultivar and can solve some cases of varietal homonymy and synonymy.

Materials and Methods

Plant Material and Sampling

All the experiments were conducted in 2003, 2004 and 2005 on a local orchard located in two different areas of the north Testour and Thibar. Each of the fields contained mainly Chetoui followed by Gerboui cultivars but also others local cultivars: Hamray, Meski, Bouchouka and Beldi. Both of fields are planted at 4×6 m and received irrigation (from June to September) besides the customary cultural practices.

Sample Collection

The agronomic characteristics have been evaluated on the observations of 5 trees (20-30 years old) over a period of 2-3 years. At least ten shoots per treatment were tagged on each of the five trees. Branches about 20 cm long were chosen for all experiments of this study. All experiments with Gerboui were repeated 3 times in different orchards and during three years. Twenty-five samples of fruits, leaves and inflorescences were collected from the center of the trees and on the four cardinal aspects. Inflorescence size, length, and number of flowers as well as the percent of staminate flowers were determined annually on at least 100 inflorescences.

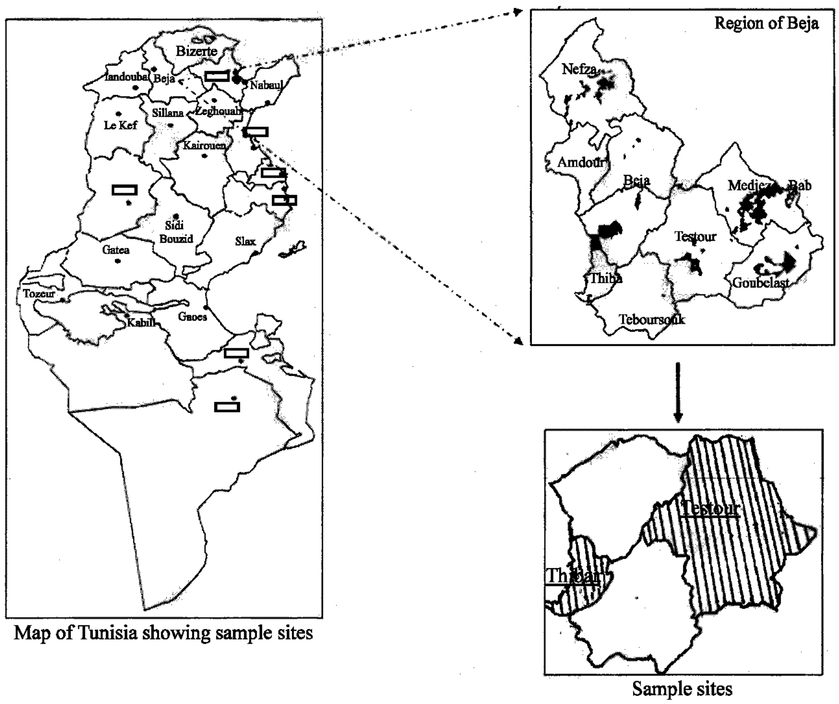


Fig. 1: Geographical location of sites of olive cultiver Gerboui in Tunisia

In order to study the suitability for oil production of the cultivar Gerboui, 200-300 olives, from different orchards have been collected during 15 December-15 January to provide additional data on fruit size, maturity index, oil content and fatty acid profile.

Geographical Parameters of the Study Area

The location of Testour and Thibar (belonging to the) throughout the northern region is represented in Fig. 1. The olive cultivation area was about 3,000 ha distributed over four Imadats: Thibar, Djebba, Nchima and Ain Dfali and was situated at about 30 km south of the gouvernorat of Béja (latitude 37° and altitude 128 m).

The climate is Mediterranean with mild springs and hot and dry summers coupled to traditional farming techniques employing a low level of fertilizers and herbicides. Annual rainfall is evenly distributed throughout the year although it is slightly higher in the winter. Temperatures vary between 5-6°C minimum in December to 42°C maximum in July-August. The soil texture is mostly clay, fertile with a typical colour black. The orchards are planted in brownish-black clay-loam soils, uniform to a 1m depth, which have a pH ranging from 6.5 to 8.5.

Agro-Morphological Characterization

The pomological protocol followed for the biometric characterization is based on the study of Barranco and Rallo (1984) on Spanish olive cultivars and Mehri and Hellali (1995) on Tunisian olive cultivars. Methods used for primary olive characterization belong to a list adopted by the Conseil Oleicole International (COI) which refers the analysis of 32 different characteristics including the tree, leaves, flowering and fruit. After fruit characterization, the endocarp was removed and subject to the characterization.

The following characters were studied:

Tree

Trunk circumference at 20 cm from the soil

Leaves

Length, width, weight, width: length ratio, area, apical angle and basal angle

Inflorescence

The indices level of flowering (number of flower buds, days to full bloom, total duration of flowering, the starting and ending date of flowering, the date of full bloom, number of flowers), pistillate flowers at full bloom (FB), fruit set percentages (fructification percentages 45 days after FB and at harvest) were also recorded.

Pollen

Pollen was collected from flowers having the same physiological stage (anthesis) from various inflorescences and shoot locations. Viability percentage and germination capacity (germination rate and tube growth) were determined. Freshly collected pollen for viability by staining with carmin acetic (Martoja and Martoja-Pierson, 1967). Germination of pollen was determined on solid medium with 0.7% agar, 20% sucrose, 100 ppm H_3BO_3 (Mehri *et al*., 2003) at pH = 5. Cultures were held at temperature regime of 25°C for 48 h. Counted pollen grains were at least 500 per petri dish. A pollen grain was considered germinated when the length of its pollen tube was equal to or exceeded its diameter (Stanley and Linkens, 1974). Pollen germination and tube growth were determined after 3, 6, 12, 24 and 48 h on 20 pollen grains chosen at random from various locations in the pollen sample. Germination rate was determined using five replicates of approximately 100 grains (Pinney and Polito, 1990).

For Fruit

The morphological parameters are length, width, weight, fruit and endocarp shape, width:length ratio, flesh:stone ratio and number of grooves. Oil content, oil quality and maturity index have been described. The index of the fruit maturity was determined according to a scale from 0 to 7 (Frias *et al*., 1991).

Oil yields were determined by Soxhlet extraction and oil composition (fatty acid content) was measured by gas chromatography (IOOC, 1999). Fatty acid profiles of the oil were determined by gas chromatographic analysis of the fatty acid as methylesters. 0.25 g of oil were derivatised by heating with 0.25 mL of freshly made potassium methoxide (2N) in anhydrous methanol in a capped tube for 60 min at 60°C. After cooling to room temperature, 4 mL of hexane and 5 mL of deionised water were added mixed by vortexing and centrifuged at 3800 rpm for 10 min. The hexane supernatant was transferred to a GC vial and the fatty acid methylesters measured on a Shimadzu GC-17A gas chromatograph fitted with a capillary column (15×0.25 mm ID) operating isothermally at 180°C. Nitrogen was the carrier gas and injector temperature of 220°C and flame ionization detector temperature of 250°C were used.

Vegetative Growth

Ten bearing shoots were sampled to record the following data concerning vegetative growth: shoot length, number of nodes of the previous year's and leaves.

Fertility Behaviour

The self fertility behaviour and free pollination requirements of Gerboui were investigated during 2003, 2004 and 2005, only in the region of Thibar. Five trees were used and before flower opening, five branches bearing about 150 inflorescences were tagged and isolated using paper bags. Five branches served as controls. Before enclosing, the number of inflorescences was recorded. When flowers start to open the enclosed branches were hand-shaken to insure pollination. After petal fall, paper bags were removed and the fruit counted. This counting was repeated at monthly intervals from June to September and the number of fruits per number of flowers and perfect flowers for the enclosed self pollinated and the free pollination ones was determined. To evaluate the self fertility, an R1 index was calculated as the ratio between the number of fruits in self and free pollination.

Statistical Analysis

All the experimental results are reported as means of the values recorded in three growing seasons 2003, 2004 and 2005. The values reported in this study were statistically elaborated to compare means, using Student's test. This test was performed for each character to identify significant differences. The same letters are used to indicate values which do not differ for $p<0.01$.

Results and Discussion

Tree and Vegetative Growth

Gerboui cultivar growing in Thibar and Testour, is characterized by moderate vigour, semi-compact and upright habit. The majority of the trees of cultivar Gerboui were medium-to large in size, which is a parameter that is indicative of their vigour, there was a prevalence of trunk circumference values between 39.46 and 59.07 cm with an average of 47.9 cm. The trunk cross-sectional areas varied from 201 to 346.5 cm^2 with an average of 248 cm^2. The differences in tree vigour between site can be due to soil conditions, a minor degree to weather conditions and to age. Del Rio *et al*. (2000) indicate that for selecting or classifying cultivars for vigour, the olive trees must be at least six years old.

Shoot elongation reached an average of 18.66±2.71 in Thibar and 15.23±1.41 cm in Testour. The number of leaves and nodes developed during vegetative growth varied from 36±2.6 leaves and 18±1.4 nodes in Thibar to 26±3.3 leaves and 13.71±0.7 nodes. Shoot growth was characterized by two important stages of development (Fig. 2). The first which was longer and more intense, began in March and ended in early July and partially coincided with flowering and fruit set. The second, shorter period began in September and latest for about one month.

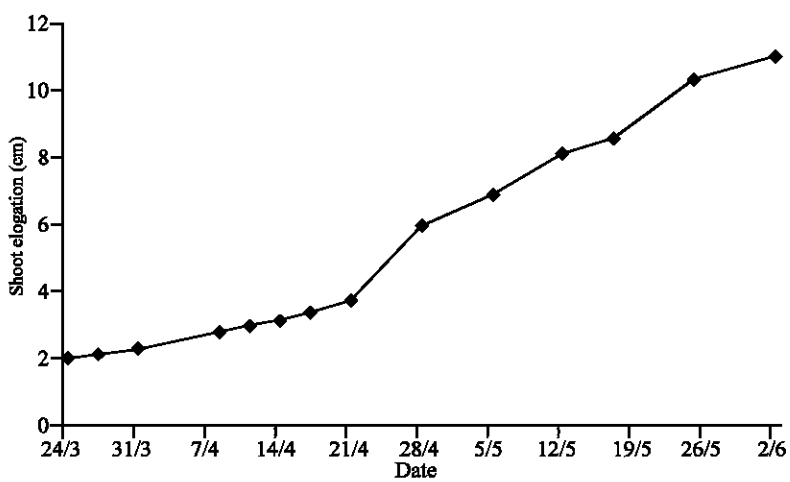


Fig. 2: Shoot growth of the local olive cultivar Gerboui

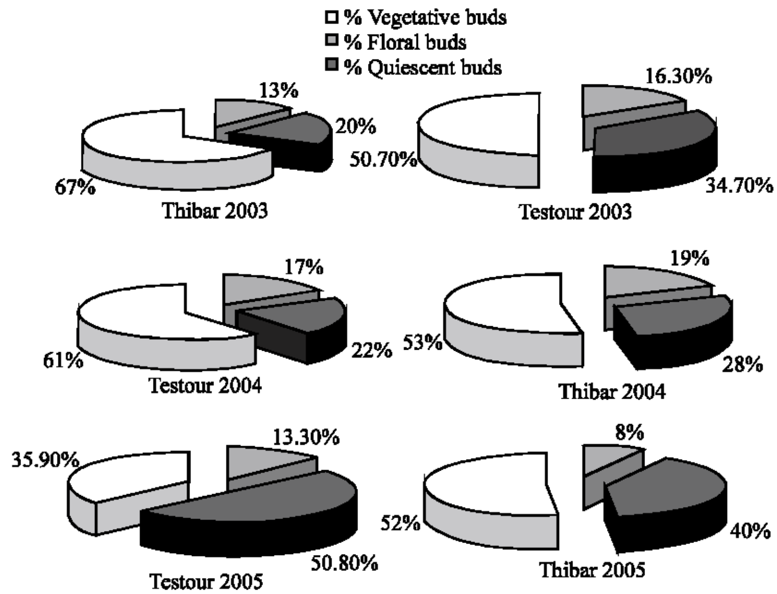


Fig. 3: Mean percentage of vegetative, floral and quiescent buds of local olive cultivar Gerboui cultivated in the regions of Testour and Thibar

Table 1: Blooming period of Gerboui cultivar in Testour and Thibar regions

	Field site					
	Thibar			Testour		
Parameters	2003	2004	2005	2003	2004	2005
Total duration of flowering	30/4 to 21/5	4/5 to 28/5	10/5 to 2/6	26/4 to 21/5	1/5 to 24/5	5/5 to 28/5
	21 days	24 days	23 days	25 days	23 days	23 days
Date of full bloom	14 May	20 May	24 May	12 May	18 May	21 May
Days to full bloom	14 days	16 days	14 days	16 days	17 days	16 days

Flowering

Figure 3 presents the mean percentage of vegetative, floral and quiescent buds of Gerboui as related to site and year. In Thibar, about 13.3% of lateral bud developed shoots which developed 18 nodes and in Testour, 15.5% of lateral bud developed shoots with 13.7 nodes in Thibar. In February, the mean percentage of flower buds on the shoot varied among the year and the site. In thibar, 20, 28 and 40% respectively in 2003, 2004 and 2005. In Testour, we noted 34, 22 and 50.8% respectively. Flowering dates of Gerboui cultivar were observed in Testour and in Thibar and the average flowering dates during 3 years (from 2003 to 2005) are shown in Table 1.

With respect to flowering period, the results obtained in the first year of the survey (an on year) reveal that the date of the full bloom varied according to year and site. It took place between 14 and 24 May in Thibar and between 12 and 21 May in Testour. Less variability was recorded in the total duration of blooming. In Thibar and in 2003, the total duration of flowering was 21 days between 30 April and 21 May. The following years (2004 and 2005), the flowering period was later in which anthesis began between 4 and 28 May in 2004 and between 10 May and 2 June in 2005. The same phenomenon was enregistred in Testour. Synchronous flowering was not observed in either of the years of this study. This could be due to climatic conditions as suggested by Lavee *et al*. (2002) and requires further investigations using cross pollination with the other olive cultivars existing in the same orchards (Meski, Hamray…).

Table 2: Average inflorescence length, number of flowers per inflorescence and percentage of staminate flowers of the local olive cultivar Gerboui

Locality		Inflorescence length (mm) 2003	2004	2005	No. of flowers per inflorescence 2003	2004	2005	Staminate flowers (%) 2003	2004	2005	Perfect flowers (%)
Thibar	Value	30±2.3	27±5.1	32±1.8	22±2.3	21±5.03	20±1.8	39.3±3.7	41.1±1.7	43.9±1.09	58.60
	Mean		29.6±3.01			21±3.06			41.4±2.16		
Testour	Value	32±0.6	33.1±1.5	29.8±1.07	24±3.5	25±5.6	21±4.1	38.4±6.3	37.4±5.8	47.4±4.7	52.60
	Mean		31.3±1.6			25±4.4			47.4±5.6		

±Standard error

Table 3: Number of flowers and staminate flowers as related to the position of inflorescence on the shoots of the local olive cultivar Gerboui (on year in 2005)

Position of inflorescence on the shoot	Thibar Basal	Medium	Apical	Testour Basal	Medium	Apical
Mean No. of flowers/inflorescence	15.7	21.3	26	18.3	30.1	26.6
Mean		21±3.06			25±4.4	
Mean No. of staminate flowers/inflorescence	6.3	10.13	11.51	7.11	16.3	13.2
% staminate flowers	40	47.60	44.30	38.90	53.60	49.70
Mean		43.9±1.09			47.4±4.7	
% perfect flowers		56.1			52.60	

±Standard error

A general description of the inflorescence size and flower-type composition of cv. Gerboui was determined, for each experimental year from 2003 to 2005, recording their length, number of flowers and percent of staminate flowers (Table 2). The standard error within each year and between years was small and thus uniformity of the inflorescence characteristics high. However, the differences between sites were 29.6±3.01 cm in Thibar and 31.3±1.6 cm. Previous studies showed the climatic influence of cultivation area on the phenological behaviour of the olive cultivars (Ait Radi *et al*., 1990; Martin *et al*., 1994).

Flowers occurred on inflorescences that measured about 3 cm in length. The number of flowers per inflorescence was variable between the years and among the site with higher mean in Testour (25±4.4 flowers) than in Thibar (21±3.06 flowers). Comparison to other Tunisian local cultivars, Mehri *et al*. (2003) found 29 flowers for Zarrazi, 23 for Besbessi and 17 for Meski. The Gerboui inflorescence had a medium length (between 25-35 mm) with medium number of flowers (between 18-25 flowers).

The percentage of staminate flowers varied in Thibar from 39.3% in 2003 to 43.9 in 2005 and in Testour from 37.4 to 47.4% in 2005. The pistil abortion rate observed in the olive cultivar Gerboui was about 41.4% in Thibar and 47.4% in Testour which is acceptable for obtaining a commercially profitable crop in olive trees. Inflorescence length, number of flowers per inflorescence and pistil failure percentage resulted higher in Testour than in Thibar. Year-to-year variation in number of flowers per inflorescence and percent pistil abortion were related to climatic conditions; daily temperature and monthly rainfall (Caruso *et al*., 1995; Lavee *et al*., 2002).

The intensity of flowers and perfect flowers according to the site and to the inflorescence position on the shoot is shown in Table 3. All shoots were divided into three parts: basal, medium and apical in order to assess the effect of the position on the shoots. Both in Thibar and Testour, the basal third of the shoot produced less flowers (15.7 in Thibar and 18.3 in Testour) and less staminate flowers (6.3 in Thibar and 7.11 in Testour) than the medium and the apical parts. This may lead to the suggestion that the flower bud initiation should be different among the buds on the same tree and that there was a relationship between flower process and bud position on the shoot. As indicated by

Table 4: *In vitro* pollen viability, germination and tube growth of olive cultivar 'Gerboui'

	Thibar			Testour		
Parameters	2003	2004	2005	2003	2004	2005
Viability (%)	92.8±3.1	93.3±3.06	88.3±2.6	86.8±1.9	87.7±2.06	83.5±3.8
Mean		91.4±2.92			86±2.58	
Germination (%)	55±1.8	69.2±0.9	43.18±0.67	51.9±1.2	51.2±0.5	42.09±0.78
Mean		55.8±1.12			48.38±0.82	
Tube length (μm)	520±8.2	529±5.4	515±7.3	479±4.8	501±4.03	488±5.1
Mean		521.3±6.96			489.3±4.64	

±Standard error

Table 5: Initial and final fruit set of olive cultivar Gerboui planted in Thibar and Testour

		Fruit set based on number of flowers			Fruit set based on number of perfect flowers		
Site		2003	2004	2005	2003	2004	2005
Thibar	Initial fruit set (%)	4.83±0.7	4.3±0.91	3.51±0.43	12.2±1.07	10.4±0.89	7.36±0.51
	Mean		4.21±0.68			9.98±0.82	
	Final fruit set (%)	2.66±0.77	2.54±0.82	1.98±0.37	3.2±0.64	4.4±1.01	2.97±0.68
	Mean		2.39±0.65			3.52±0.77	
Testour	Initial fruit set (%)	5.3±1.2	4.96±1.16	5.02±1.63	11.5±2.01	10.9±2.58	8.11±1.03
	Mean		5.10±1.33			10.17±1.87	
	Final fruit set (%)	3.66±0.55	3.07±1.09	3.72±0.91	4.23±1.33	3.9±1.19	3.75±1.02
	Mean		3.47±0.85			3.99±1.18	

Mehri *et al*. (2003) on other olive cultivars, this rate differed among the position of inflorescence on the shoot and the highest rate was localized in the middle inflorescence portion for Meski cultivar. This was explained by competition of assimilates among flowers and differences among years in flower quality may be attributed to physical and environmental effects. Similar findings were find by Cimato *et al*. (1990) on Frantoio cultivar. Flowering resulted to be the major factor in determining fruit set and crop in olive and Ramirez-Santa Pau *et al*. (2000) noted high flowering rates were associated to low levels of fruit set and small fruit size in Manzanillo de Sevilla.

In Vitro Pollen Viability and Germination

The data in Table 4, show that Gerboui had pollen grains with a very high degree of viability, more than 83.5% with an average of 86% in Testour and 91.4% in Thibar. No statistical differences were found in mean of pollen viability between the years. The mean germination percentage was 55.8 and 48.3% in Testour and in Thibar, respectively. Pollen exhibited fast pollen tube growth, with a mean length of 500, 521.3 and 489 μm in Thibar and Testour, respectively. Pollen germination showed considerable variation over the three years. The lowest results were recorded in the years coinciding with fruit set failure by free pollination. The results show that pollen of Gerboui gave significantly the highest pollen viability and germination percentage compared to another Tunisian olive cultivar Meski (Mehri *et al*., 2003). *In vitro* pollen viability and germination results show that patterns of pollen germination and tube growth were different among the site and between years. There was a consistent difference in the performance of the pollen among the year showing the highest percent germination in 2004 at Testour and at Thibar and the lowest in 2005, coinciding with fruit set failure by free pollination. Similar findings were recorded by Bartolini and Guerriero (1995) on olive cultivars. According to the positive correlation between fresh pollen viability and germinability, the tested pollen had the potential, when compatible to ensure good ovule fertilization of Gerboui cultivar and of Meski olive cultivar which is self-incompatible (Mehri *et al*., 2003). This cultivar growing in the Northern area shows a rapid germinative capacity of the pollen and a good growth of the pollen tube.

Fruit Set

Fruit set was recorded six weeks after full bloom (initial fruit set) and at harvest (final fruit set). It showed differences between sites, those from Testour were little higher than Thibar. These may be

Table 6: Fruit set of 'Gerboui' under free and self pollination in Thibar region

	Self pollination			Free pollination		
Parameters	2003	2004	2005	2003	2004	2005
Fruit set/total No. of flowers (%)	3.08±0.76	3.14±1.02	2.14±0.93	4.83±0.7	4.3±0.91	3.51±0.43
Mean		3.12±0.9			4.21±0.68	
Fruit set/ perfect flowers (%)	9.7±2.03	7.64±1.76	4.49±1.1	12.2±1.07	10.4±0.89	7.36±0.51
Mean		7.27±1.63			9.98±0.82	
R1 index		65.80			71.30	

related with higher tree vigour, tree age and better conditions (rainfall) in Testour. In Thibar, the mean initial and final fruit set based on the number of flowers were 4.21 and 2.39%, respectively. In Testour, these rates were higher 5.18 and 3.47%, respectively (Table 5). Based on the number of perfect flowers, the percent of initial fruit set is about 9.98% in Thibar and 10.17% in Testour. It depends from year to year in accordance with the level of reproductive bud differentiation and the inflorescence load per shoot (Lavee *et al*., 1996). The size of olive crops depends on viable pistillate flower buds, their subsequent development through anthesis, pollination and fertilization as fruit. The differences between initial and final fruits set observed in the present work have also been reported for some other olive cultivars (Rallo and Fernandez-Escobar, 1985), indicating the existence of post-fertilization factors essential for fruit-setting. Certain abnormalities in embryo and endosperm development have been observed by Cuevas and Rallo (1990) which could reduce the final value of fruit-set in olive trees.

Results concerning the evaluation of self fertility showed that the percent fruit set obtained by self pollination was statistically different as compared to the values obtained with free pollination. The three-year average self pollinated fruit set was found over 1%. The self fertility behaviour of Gerboui was studied in Thibar region during three years from 2003 to 2005. The average fruit set was 3.12% per total number of flowers and 7.27% per number of perfect flowers in self pollination conditions (Table 6).

In free pollination assays, the mean fruit set per total number of flowers (4.2%) or per number of perfect flowers (9.98%) was higher. Differences in fruit set were also found for Gerboui according to the years, it can be due to a varying of self fertility and cross pollination requirements. On the basis of the results, the Gerboui cultivar is self compatible in Thibar environment. Free pollination trials carried out gave higher fruit set. The increase of fruit set by free pollination indicate that cross pollination may improve yield. Presence of other olive cultivars in the study field can accelerate and increase the rate of fertilization and consequently a higher number of fertilized ovaries would start to grow earlier as suggested by Cuevas *et al.* (2001) and by Lavee and Datt (1978) for Manzanillo.

The R1 index was superior to 30% and vary from season to season suggesting that the stigma-pollen relationship can be highly dependent on the environmental conditions. The effect of environmental conditions on pollination was also reported by Griggs (1953) insisting in particular on temperature which can affect germination and growth of pollen tube.

About 30% of self pollinated fruits were parthenocarpic (Fig. 4A). The parthenocarpic fruitlets which are as shotberries with persistent petals showed abnormal size and contained unviable seeds. Abnormal ovule development and incomplete embryo sac formation were observed by Rapoport and Rallo (1990) in the Gordal Sevillana cultivar and by Sibbett *et al.* (1992) in Manzanillo cultivar. Rallo *et al.* (1981) established relationships between abnormal embryo sac development and fruitfulness in olive fruit. This has major implications for yield and quality and reinforce the importance of selecting a pollinator cultivar.

Fig. 4A: Parthenocarpic self pollinated fruits showing parthenocarpic fruitlets with persistent petals and abnormal size

Table 7: Average and standard deviation of the fruit and the endocarp data variables

	Fruit		Endocarp	
Variables	Average	Standard deviation	Average	Standard deviation
Length (mm)	17.9	1.6	13.40	1.20
Maximum diameter Dmax (mm)	15.9	1.1	8.60	0.70
Minimum diameter Dmin (mm)	13.2	1.4	7.80	0.60
Weight (g)	3.1	0.8	0.62	0.11

Table 8: Most discriminating category variables of the fruit and the endocarp data

Variables			
Olive symmetry	Symmetric 100%	Lightly asymmetric 35%	Asymmetric 2%
Olive nipple	Evident 10%	Less evident 35%	Absent 56%
Olive turn	From the base 46%	Uniform 54%	From the apex 0%
Endocarp symmetry A	Symmetric 63%	Lightly asymmetric 35%	Asymmetric 2%
Endocarp apex	Sharp pointed 14%	Rounding 86%	-
Endocarp n° Sulcus	Reduced 62%	Medium 38%	Elevated 0%
Endocarp D Sulcus	Uniform 2.50%	Grouped 97.50%	-

Description: Fruit, Leaves and Stone

The averages and respective standard deviations of five continuous variables for the olive and endocarp of Gerboui cultivar are given in Table 7 and 8 shows the percentages of seven most discriminating category variables of the fruit and the endocarp data according to the COI 1997 recommendations.

Mean mature fruit length of Gerboui cultivar was 17.9 mm, width 15.9 mm and fruit weight 3.1 g. The mean weight of stone is 0.6 g, Flesh/stone ratio was about 19.8. These informations are important because the higher the weight of the fruit and the lower the weight of the endocarp, the olive oil yield is higher. The leaves were long with mean leaf length > 70 mm (79.19 mm), the width was medium between 10 and 15 cm (11.88 mm). The shape is lanceolate (defined by the length:width ratio L/W >6.6).

The olives are spheric with a symmetrical section and a round apex without mucro (absence of olive nipple). The shape at the base is depressed with a deep stalk cavity. The shapes range round to oval (L/W= 1.1 ratio under 1.25). The size is medium and varied from small (up to 1.9 g) to medium (from 2 to 4 g) with mean fruit weight of 3.1 g. In respect to longitudinal axis, the position of apex and base is symmetrical. At green stage, the fruit has a green peel (epicarp) with few and small number of

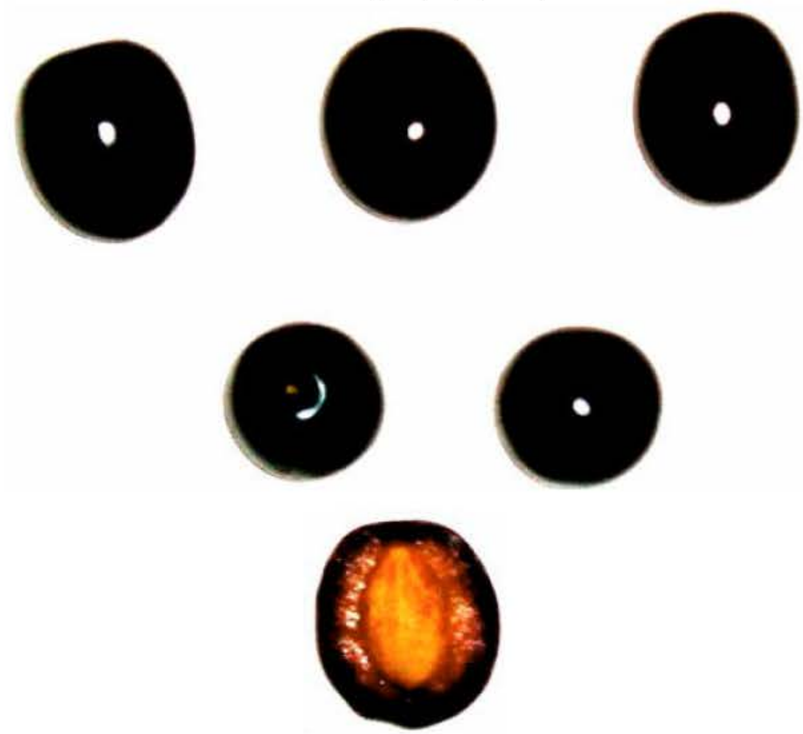
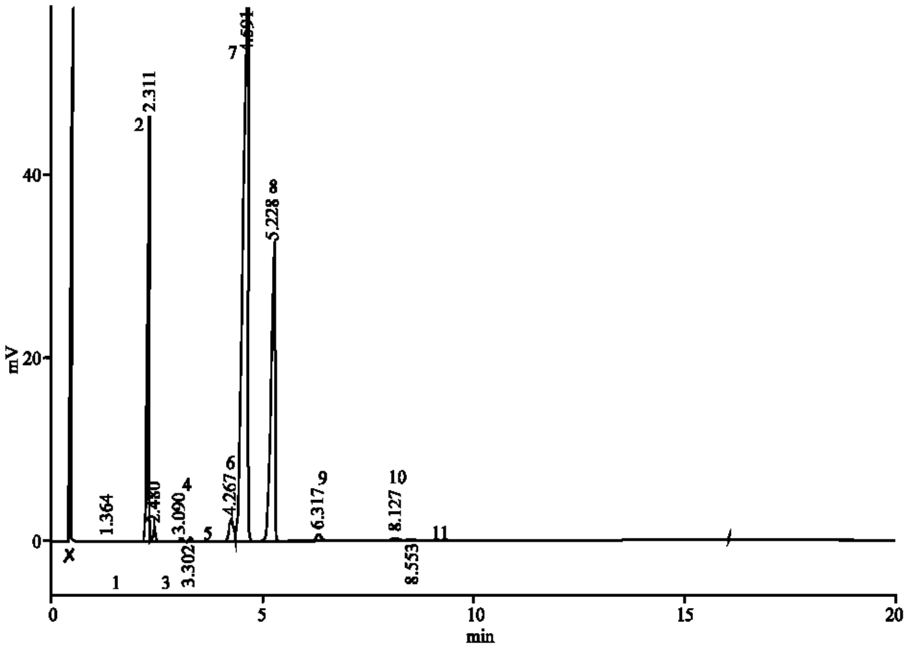


Fig. 4B: Fruits of local olive cultivar Gerboui showing the shape the flesh/stone ratio, the color and endocarp characteristics

lenticels but well visible. It's black when completely ripe. Coloration begins apically and laterally. The green skin will change gradually to become purple to black. At harvesting, the colour is black violet with gradual colour change. The skin is black and the flesh is a violet colour halfway or almost through to the stone (Fig. 4B), the localization of initial turning is uniform under all epidermis. The ripening time is from October to December. It presents a facility in flesh detaching from the stone. The stone is ovoid (L/W between 1.4 and 1.8) with a symmetric longitudinal section, elliptic cross section and round base. The suture line is not very evident and the surface is wrinkled. The endocarp apex is open, rounding with a little mucro, stone length was 13.4 mm and mean maximum diameter was 8.6 mm. The maximum width (position of maximum transversal diameter) is central and the surface is rugose with a medium number of groves. The endocarp distribution of fibrovascular sulcus is grouped in proximities of suture. The course of the grooving is longitudinal with medium depth.

Methods used for primary tree, leave, fruit and stone characterization belong to a list adopted by the COI (1997) but a high phenotypical and morphological variability was recorded within the orchards for these parameters evaluated (Table 8). For Sweeney (2003), it is not possible in the great majority of cases to distinguish between olive cultivars on the basis of the genotypic characteristics of vegetative growth or fruit. This is due to a natural homogeneity of general appearance and the broad range of minor variability attributable to local climatic and edaphic conditions. The phenotypical variability is the result of interaction between selection over time, genetic potential and environmental conditions (Nieddu *et al.*, 1995) and also of the frequent use of homonyms and synonyms (Mehri *et al.*, 1997).



Chromatographic conditions: Capillary column (15 m × 0.25 mm)
Carrier gaz: nitrogen
Injector temperature 220°C
Flame ionization detector temperature 250°C

Legend X: solvent pic; 1-$C_{14:0}$/ 2-$_{16:0}$/ 3-$C_{16:1}$/ 4-$C_{17:0}$/ 5-$C_{17:1}$/ 6-$C_{18:0}$
7-$C_{18:1}$/ 8-$C_{18:2}$/ 9-$C_{18:3}$/ 10-$C_{20:0}$/ 11-$C_{20:1}$

Fig. 5: Chromatogram CPG of fatty acid determined as methylesters of Gerboul oil

Table 9: Oil composition and characteristics of olive cultivar Gerboui

Cultivar		% Composition					
Fatty acids	Oil content	Palmitic	Palmitoleic	Stearic	Oleic	Linoleic	Linolenic
		C16:0	C16:1	C18:0	C18:1	C18 :2	C18 :3
Accepted limits	-	7.5-20	0.3-3.5	0.5-5.0	55-83.0	3.5-21.0	≤1.0
Gerboui oil (%)	25	13.40	0.58	1.78	60.56	22.26	0.55

Oil Content, Oil Quality of Olive Cultivar Gerboui

The most common form in yield potential assessment is done by measuring oil content of the fruit and fatty acid profile (Pinelli *et al*., 2003; Fourati *et al*., 2003). Gerboui cultivar produces 25% of oil yield. Gaz chromatography was used for qualitative and quantitative determination in samples of oil of methylesters of palmitic (16:0), palmitoleic (16:1), stearic (18:0), oleic (18:1), linoleic (18:2) and linolenic (18:3) acids (Fig. 5). The relative standard error for each AG in mixture samples was less than 10%. The olive oil obtained from Gerboui (Table 9), has an acidic composition characterized by a relatively high proportion of oleic acid (60.5%), a little high proportion of linoleic acid (22%) and 0.22% of palmitoleic acid.

Palmitic acid, which is a saturated fatty acid and as such provides stability is present in olive oil of Gerboui at acceptable levels of 13.4% (between the accepted limits 7.5-20%). The ratio of saturated/unsaturated fatty acids is high with an average of 3.2%.

Oleic acid (C18:1) which is a monounsaturated fatty acid, is considered to be nutritionally beneficial and is quantitatively the most important fatty acid and therefore contributes to that stability. However linoleic and linolenic acids, despite their perceived nutritional benefits are both susceptible to oxidation as they are polyunsatured.

Linoleic acid (C18:2) contributes toward oil instability due to the unstable polyunsaturated fatty acid is about 22% little higher to IOOC standard (3.5-21%). Fourati *et al*. (2003) signaled for another Tunisian olive cultivar Chemlali a content in linoleic acid higher than the international Olive Oil norms. This compound contributes to the oil oxidation during storage.

Linolenic acid (C18:3) which reached the level of 0.55%, needs to be below 1% because it is unstable and can increase of oxidation. Olive oil has to conform to international standards and local olive oil Gerboui is not outside of those requirements. This is commercially very important to farmers because IOOC standards set the level of linolenic acid at below 1% of the total fatty acids for the oil to be labeled as edible olive oil.

These findings indicate that olive oil of cultivar Gerboui is considered to be highly nutritional oil due in part to the high level of monounsaturated oleic acid and a lower palmitic and linoleic acid content. Shelf life and oil stability are closely related to the degree of saturation and polyunsaturation of oils. The traditional fatty acid profile of olive oil Gerboui produces a relatively stable product. The assessment of stability is an important component of olive oils which must remain at a high quality during storage and prior to consumption. These results are also valuable in determining acceptable times of harvest to ensure fatty acids as suggested by Rahmani *et al*. (1997) and Mailer *et al*. (2005).

Fatty acid profile is important in relation to nutritional quality, in determining oil stability and is of significant importance in selecting oil with good stability, particularly polyunsaturated fatty acids which contribute to stability. Leon *et al*. (2004) find significant correlations between several characters including olive oil yield components and fatty acid composition. The main factors that contribute to the quality of oil are the genetic (because the cultivar determines the characteristics of the fruit as the chemical composition of the oil), cultural (the crop time), pedologic and climate conditions (Pinhero and Da Silva, 2005).

Discussion

The aim of this study is the study of an olive cultivar from the northern Tunisian material based on morphological characteristics of the tree, leaves and fruits and on oil analysis. This study will define for the first time in Tunisia the biometric characteristics of a local olive tree. Gerboui cultivar showed a good performance in the north as a local olive cultivar; a good vegetative and reproductive behaviour, good oil yields and oil content (25%). Gerboui cultivar showed moderate vigour, semi-compact and upright habit with an equilibrated vegetative growth habit and a satisfying fruit-set. With respect to flowering period, the results obtained reveal that Gerboui flowers early and abundantly and has a lengthy flowering period. Data reported in this study show that the duration of bloom for 2 years was influenced by the weather conditions and ranged from 20 to 24 days in Thibar and 25 days in Testour. The self fertility behaviour is nearly self compatible. Due to its compatibility, good pollen behavior of Gerboui can be used as pollinizer for another local olive cultivar Meski which is self-incompatible.

Mean fruit weight is 3.1 g with a flesh/stone ratio > 19 (19.8) and a high oil content (25%). It was described as very suitable in those areas and has shown considerable adaptability to local microclimate conditions. This area site is where olive trees could be grown profitably because, according to their assessment, temperatures in Thibar and in Testour get cold enough in the winter to induce flowering and relatively mild, able to satisfy the vernalization requirement of olives. The summer temperatures are hot and provide the long ripening period necessary for maximum oil accumulation in the fruit. The shortage period of water during specific critical periods in the vegetative-productive cycle of the olive in these sites is perhaps the main limiting factor on obtaining good harvest. This variety was well adapted to the cultural and environmental conditions of Thibar and Testour and can respond to the latest cultural techniques and can be used in the conversion of traditional olive farming. In these regions, potential exists to improve yield and quality for domestic and export markets and to increase local production both for domestic and export markets.

The methodology used in this characterization is based on the recommendations of the COI (1997) which refer the analysis of 32 different characteristics including the tree, leaves, flowering, fruits and endocarp. According to pomological characters, high variability was recorded within the orchards for the parameters evaluated. But it will be necessary to characterize this genotype using modern genetic markers such as restriction length polymorphism to pinpoint the exact differences rather than working with many unknown factors which characterize conventional breeding techniques. Morphological markers have proved insufficient because establishing identification keys comprise a large number of parameters which are often difficult to measure and require time and space. The morphological markers are dependent on the environment and sometimes remain subjective (Hilali *et al*., 1995). Molecular markers have proved highly useful in the cultivar identification of the olive Fabbri *et al*., 1995; Besnard and Berville, 2000).

This cultivar with interested characters can be profitably exploited in an olive breeding program. It is characterized for its productivity, excellent oil quality, is grown in an area where olive has big interest. Traditional agricultural systems represent centuries of farmers accumulated experience of interaction with the environment. The considerable potential of traditional agricultural systems can be very important. There is an enormous potential for oil and table olive production in Tunisia but ensuring a correct varietal identity of a local cultivar is important because there is a great deal of confusion in olive variety identification. This study has been established to resolve the confusion in olive cultivar identity as well as to evaluate the performance of unknown commercial olive cultivar as Gerboui. At this stage, this study has revealed much about the performance of this cultivar. However, more data is required on total yields, on easiness for vegetative multiplication and grafting behaviour, on adaptation to mechanical harvesting and resistance to stress environmental factors to gain a full picture of the cultivar production potential.

This current study was limited to orchards in Thibar and Testour. An expanded study to take in groves in different environments is essential to determine the results of all the characteristics studied under different conditions and to evaluate the performance of this cultivar in different environments (collection) because little is known about performance of varieties outside their traditional growing regions. Studies of correlation between characters in Gerboui must be carried out in cultivars collections installed in different regions of Tunisia. This cultivar has been introduced into two Tunisian collections located in Chott-Meriem (central part of Tunisia) and in Tunis (northern part of Tunisia). They include cultivars of national and foreign origin allowing to compare cultivar adaptation and performance under specific regional conditions.

Only one local cultivar was included in this study. It is estimated that Tunisian olive tree consist of many interested local cultivars. Additional cultivars should be included in future research to provide the same information to the growers who demand technical information on management and environment factors that can be used to improve yield and quality. The results of these surveys provided encouraging information for developing this cultivar. The information derived from this work will be available to improve management of current plantings, for the development and management of future plantings and for the correction of planting errors by top working. The development of this cultivar adapted to the environment will increase opportunities for export and domestic consumption but in these regions olive growers have to restructure their olive orchards and to make improvements on the olive fruit harvest and extraction techniques.

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