Available Online at http://www.recentscientific.com

ISSN: 0976-3031

International Journal of Recent Scientific Research
Vol. 6, Issue, 2, pp.2571-2586, February, 2015

International Journal of Recent Scientific Research

RESEARCH ARTICLE

PERFORMANCES AND POTENTIALITIES OF INTRODUCED VARIETIES AND LOCAL TYPES OF OLIVE TREES (*OLEA EUROPAEA L.*) GROWN IN THE OUAZZANE AREAS (NORTH OF MOROCCO)

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ARTICLE INFO

Article History:

Received 2nd, January, 2015
Received in revised form 10th, January, 2015
Accepted 4th, February, 2015
Published online 28th, February, 2015

Key words:

Olive tree (*Olea europaea L.*), genetic resources, flowering period, flowering rate, number of flowers and perfect flowers per inflorescence, ovary abortion, self-compatibility, cross-pollination, pollinators, parthenocarpy.

ABSTRACT

The aim of this study was to evaluate the floral biology characteristics of the present olive genetic resources. For the period of flowering, varieties Bouchouk Rkike and Bakhboukh Beldi, are the earliest. Gordal, Ascolana Tenera, Ascolana Dura, Cucco, Manzanille, and types of oleasters BM4, BMK, appears later. Varieties Bouchouika, Bouchouk Laghlide, types Picholine Marocaine G9, G10, S1, S2, M1, M6, Dahbia, Picholine du Languedoc, Picual, types of oleasters BMR, BMM, BM3, BM2, showed seasonal flowering. The flowering rate ranged from 50% to 71% depending on the variety, local types and years. The local types (BM2, BMM, BM4, Bakhboukh Beldi) recorded the highest number of flowers per inflorescence (18.99 to 24.67). Others cultivars and local types, have given the lowest values of this studied character (11.34 to 17.82). The number of perfect flowers per inflorescences ranged from 4,85 to 12,99. Picholine du Languedoc, BMR, BM3, BMK, BMM, Bouchouika, Bouchouk Rkike, Manzanille and BM2 have shown the highest values (10.09 to 12.99). Gordal, BM4, Dahbia, Ascolana Dura, Picual, Bouchouk Laghlide, Cucco, M1, G9, G10, M6, S2, Ascolana Tenera, Bakhboukh Beldi, and S1 presented a values varying from 4.85 to 7.27. The percentage of pistil abortion appears very high (9.904% to 81.531%). The lowest ovary abortion rates recorded in years of low production (year off), was compensated by an increase in the number of hermaphrodite flowers per inflorescences. The highest ovarian abortion rates (59.632% to 86.252%), were observed in varieties Bouchouk Laghlide, Picual, Ascolana Dura, Gordal, BM4, Bakhboukh Beldi, Ascolana Tenera and types Picholine Marocaine S1 and S2. Types Picholine Marocaine M1, G10, M6, G9, BM2 and Cucco gave a mean ovary abortion (50.20% to 58.411%). While varieties Picholine du Languedoc, Manzanille, Bouchouika, Dahbia, Bouchouk Rkike, BMM, BMK, BM3 showed low ovarian abortion rates (9.904% to 41.866%). This parameter reached (24% to 72.5%) in Moroccan Picholine, (11.5% to 27%) in Picholine du Languedoc and (16.4% to 59.4%) in the Manzanille variety. As for varieties Dahbia, Ascolana Dura, Gordal and Cucco, they have presented ovary abortion rate of 12.81%; 69%; 34% and 66.3% respectively. The inflorescences situated at the base of the flowering shoots presented the highest ovary abortion rates(15.75% to 81.79%) compared to the inflorescences located at the apical parts(7.78% to 82.55%) and median part of the same shoots (8.21% to 82.55%).

The lowest ovary abortion rates were also observed in the flowers situated in the top of the inflorescences and the highest ovary abortion rate is obtained in the lateral flower of inflorescences. Statistical analysis (PCA) has permitted to identify three distinct groups:

-Group I (types of oleasters BM3, BMR, BMK, Picholine du Languedoc, Manzanille, Bouchouk Rkike, Bouchouika, Dahbia), with a high number of perfect flowers per inflorescences and a low ovarian abortion percentage.

-Group II: (types of oleasters BM2, BMM), with also a high number of flowers and perfect flowers per inflorescences and a low ovary abortion percentage.

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-Group III: (types of oleasters BM4, types Picholine Marocaine G9, G10, M1, M6, S1, S2, Bouchouk Laghlide, Picual, Cucco, Ascolana Dura, Ascolana Tenera, Gordal, Bakhboukh Beldi), characterized by a high percentage of ovarian abortion (over 50%) and a low number of flowers and perfect flowers per inflorescence.The number of perfect flowers per inflorescence and percentage of ovarian abortion are strongly and negatively correlated.

Then, if one of these parameters increases, the other decreases and inversely, and which explains the location opposite groups 1 and 3 reconstituted of studied varieties and local types (figure 4). Varieties Bouchouk Laghlide, Bouchouk Rkike, Bakhboukh Beldi, Bouchouika, types of oleasters (BM2, BM3, BMK, BM4, BMM, BMR), Moroccan Picholine M1, M6, G9, G10, Dahbia, Picual, are qualified as strongly self-compatibles, while Moroccan Picholine S1 and S2 are qualified as a partially self-incompatibles and requires an effective and compatible pollinators. Bakhboukh Beldi is a bad pollinator cultivar for Moroccan Picholine S1 and S2, while Bouchouk Rkike and Bouchouk Laghlide are potential pollinators for Moroccan Picholine M1 and M6. Local variety Bouchouika is an excellent and potential pollinator cultivar and more efficient and compatible with Picholine Marocaine G9 and G10. The types Moroccan Picholine are qualified as good pollinators for the varieties Picual and Dahbia.Cross-pollination proved to be more effective in the types Moroccan Picholine whose degree of self compatibility is medium or low (M1, S1, S2, partially self-incompatible) when pollinated with pollen proceeding of indigenous varieties, and less effective when indigenous varieties (self-compatibles) were reciprocally pollinated by pollen produced by types of Moroccan Picholine. These local varieties 'givers' of pollen (Bouchouk Rkike, Bouchouk Laghlide, Bouchouika) and studied types Moroccan Picholine 'receivers' of pollen (M1, M6, G9, G10) are qualified as intercompatibles.

Local varieties and types of oleasters, even if they are self-compatibles, they has produced parthenocarpic fruits in their growing areas and this during studies of most envisaged years (Bouchouk Rkike: 4.26%; Bakhboukh Beldi 10.21%), types of oleasters, BM4, BMM, BMK (4.05%; 4.05%; 10.21% respectively) and types of Moroccan Picholine, M1,G10 and M6 (6.13%; 8.33%;11.11%).

INTRODUCTION

The mediterranean basin protects rich autochthonous genetic resources, considered a very distinctive and original refuge of biological diversity. It also includes a variety of local varieties or terroirs and traditional and original cultivars that represent a source of new desirable characteristics for the present genetic diversity and to assess the improvement of the production of cultivated plants such as olive: resistance to drought, pests, diseases, salinity, adaptability to edaphic aridity, local and harsh environments, and abiotic and biotic stresses. (Besnard, 2009; Boulouha, 2006 and 2010; Breton, 2005; Ouazzani, 2007 and 2008).

In Morocco, the olive trees has a great socio-economical importance indeed it occupies an area of 1000000 ha, the number of trees planted is about 100 million, covers 65% of the national trees area (Ouazzani and Adil, 2013; Ouazzani, 2014). The oil obtained by cold pressing of the fruit has excellent nutritional and dietary characteristics and medical virtues, proven beneficial in the mediterranean diet for human health (Mercedes, 2004). Moroccan olive patrimony (indigenous varieties) contain very rich and diverse genetic resources, including a large number of cultivars widely extended for its economic value and are not yet been exploited, because their productivity and quality potentials remains still largely unknown and ignored. However, there are urgent threats over this heritage and its biodiversity (modernization, migration to cities, and social evolutions) (Boulouha, 2006 and 2010; Ouazzani, 2007 and 2008).

The inventorization, collection and characterization of olive genetic resources are able to play a key role to improve the national olive growing to meet the new economic demands required by a free competitive market, (quality, labeling, local products, AOC, AOP, DOP, IGP) and to deep cultural significance as a symbol of traditional society and ties to the land. The identification and selection of highest oil yielding varieties of olive trees proved to be as a first step in the study of the varieties behaviour in a determinate region. They are usually based on descriptors of agronomical performance (Ouazzani and Adil, 2013; Ouazzani, 2014).

In fact, the characters of floral biology (Villemur *et al*., 1978; Carles, 1983; Villemur *et al*., 1984 and 1989; Lavée, 1997), tolerance and/or susceptibility to biotic and abiotic stresses (diseases, pests, regional climate conditions) (Cavusoglu and Oktar, 1994) depends on the variety genetic constitution (Lavée, 1997). Flowering is one of the critical phases in the chronology of the annual cycle that determines the production. For a given variety, the number of flowers per inflorescence, fertility and the ability to be pollinated by dominant or non self-pollination are a varietal characteristic that may affect the fruiting rate (Bradley and Griggs, 1963; Lavée, 1997; Lavée *et al*., 1997 and 2002). The most olive varieties are self-incompatibles and does not produce a commercial yield when self-pollinated (after self-pollination) (Morettini *et al*., 1942;

Chaux, 1958; Lavee *et al*., 2002), while in others regions or countries, they are considered self-compatibles (De Almeida, 1940; Lavee *et al*., 2002).

This self-incompatibility referred to the total or partial disability (male sterility) of pollen to fecundate the fertile ovule and produce seed and fruit when deposed in a viable flower of one variety or two different varieties (Villemur, 1978 and 1989; Carles, 1983; Cuevas *et al*., 2001; Lavée *et al*., 2002). Most of the widespread olive varieties are partially or fully self-incompatibles and need cross-pollinators for successful fertilization and fruit-set (Lavée and Datt, 1978; Trigui *et al*., 1995; Lavee, 1997; Cuevas *et al*., 2001; Lavée *et al*., 2002). The positive response to cross-pollination varied from variety to another and inter-incompatibility cases can be occurred, as example, between Mission and Manzanilla de Sevilla (Griggs *et al*., 1975) and between Picual and Lechin Granada (Cuevas *et al*., 2001).

It's urgently required to complete and reorganize the best knowledge of the high diversity of genetic resources of the olive tree about aspects reliable to the floral biology and the agronomical traits. In the rich regional Moroccan olive heritage, a very interesting genetic pool has been identified and resulted in the faithful identification of a number of old local genotypes which causes a huge problem in the germoplasm collections management and traceability and authenticity of olive oils produced. The evaluation of major bio-agronomical characteristics of this Moroccan material enabled to construct a full database for the reference collection of genotypes, its domestication and its diffusion to olive farmers for future renovation of the national olive orchards and olive oil sector.
The aim of this study was to evaluate the floral biology characteristics of the present olive genetic resources of introduced varieties and local types of olive trees (*Olea europaea* L.) grown in the Ouazzane areas (North of Morocco).

MATERIALS AND METHODS

Plant material

To study their behaviour in their original geographical site, we used 4 local varieties (Bouchouk Laghlide, Bouchouk Rkike, Bouchouika, Bakhboukh Beldi), 6 types of oleaster (BM2, BM3, BMK, BMM, BMR, BM4), 6 types of Morrocan Picholine (M1, M6, G9, G10, S1,S2), traditional Moroccan variety Dahbia and 7 exotic olive cultivars, the most widespread species in Ouazzane areas (Picual,Gordal, Cucco Manzanille, Picholine du Languedoc, Ascolana Tenera, Ascolana Dura).

Study of floral characteristics

Floral phenology and time of flowering

The identification of following phenological phases of flowering F, F1 and G (Colbrant and Fabre, 1974),were checked every week from first flowers opening until petal fall and allowed to note the duration of each phenological stage (F: 10% of flowers opened, F1: 50% of flowers bloomed, G: 50% of flowers dropped their petals) and to determine the time of flowering and to verify that the concordance of flowering period account of them and to identify an effective and potential pollinators for varieties partially self-incompatible (self-fertile) (COI, 1997; Lavee *et al*, 2002).

Flowering index

It's quantifying the potential development of the inflorescence at full bloom (anthesis) of each considered varieties and local types ((number of inflorescences / number total of buds) x100) (COI, 1997).

Morphological characteristics of inflorescences

The floral shoots were chosen randomly at mean height at the south facing side of the heavily flowering trees, the length of the inflorescences was measured and the total number of flowers and the number of perfect flowers in each inflorescence were counted on a sample of 200 panicles at the white stage collected from the floral shoots middle part of the labeled tree (COI, 1997).

Ovary or pistil abortion

The ovary abortion was determined by numbering abnormal or imperfect flowers (male, staminate flowers), flowers physiologically staminate (the pistil exists but is rudimentary or aborted), considering three location or position respectively of the inflorescences on floral shoots and the flowers on the axis of inflorescences individually (tip, middle, base) to study their influences on the ovarian abortion rate.

Self-compatibility degree

In order to determinate the degree of self-compatibility in high or low yielding years, the proportion of self-fertilization(fertility) was evaluated in monovarietal olive orchard (comparing measurements fruit set among self-and free-pollination)(Villemur, 1978 and 1989; Carles,1983; Androulakis *et al*., 1990 and 2001; Moutier *et al*., 2001).
In self-pollination, 10 floral shoots were bagged a few days before opening flowers using pollination paper (white flowers stage). Thus, Isolated flowers opened later, they cannot receive foreign pollen, and only their self-pollen landed on their stigma at full bloom (Villemur *et al*., 1989). The bags were tacked out at browning and petal falls (fruitfully or fruit set). In free-pollination, 10 others flowering shoots were marked, and leaved to be freely wind-pollinated. The number of developed fruits is determined from 50 to 60 days after full bloom and set fruiting rate is calculated (number of fruits developed/ total number of flowers counted).

RESULTS AND DISCUSSION

Flowering time

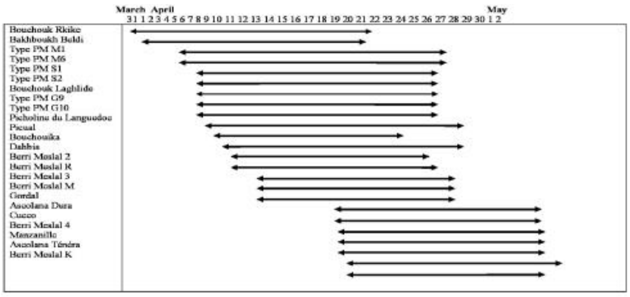
On floral shoot, the most of flowers in the inflorescence is differentiated at the same time (Lavee, 1997). The first perfect flowers, located in terminal position tend to bloom (to open) before the staminate flowers, located on the lateral, but not all the inflorescences complete the opening of flowers simultaneously. Thus the flowering in olive is heterogeneous, very gradual and spread out over time and through a successive phase (Bini, 1986). So, if the date of early flowering (F) and date of end bloom (G) are precisely distinguished, the full bloom (F1) can't be easily determinated.The figure 1 shows the dates of beginning and synchrony duration of three phenological stages (F), (F1), (G) for each studied varieties and local types. It's showed that the duration of flowering period varied according to cultivars, the environnemental factors and location. The average duration of flowering was 14 days, Thus we distinguish between three categories of varieties:

Early flowering varieties (earliest): Bouchouk Rkike, Bakhboukh Beldi.

Seasonal blooming varieties: Bouchouika, Bouchouk Laghlide, Picholine Marocaine Types G9, G10, S1, S2, M1, M6, Dahbia, Picholine du Languedoc, Picual, Types oleasters BMR, BMM, BM3, BM2.

Late flowering varieties (latest): Gordal, Ascolana tenera, Ascolana Dura, Cucco, Manzanille, Types oleasters BM4, BMK.

The difference in terms of the opening flowers beginning (early flowering) between each of the three categories of varieties is estimated at 7 days. The difference in the flowering period in types Picholine Marocaine and Picual and Ascolana Tenera in the three regions prospected was identifed. Thus, the flowers of types Moroccan Picholine M1, M6, grown in the Masmouda (subhumid bioclimatic conditions) open one day before the type Picholine G9, G10 of Mjaara, and Moroccan Picholine S1and S2 of Sidi Bousber per one day.



-Figure 1: Time of flowering of studied different varieties and local types of olive tree in Ouazzane region.

For the flowering of varieties Picual grown in Mjaara and Ascolana Tenera planted in Sidi Bousber (semi-arid bioclimatic conditions), they began 2 to3 days before the flowering of the same varieties grown in Ouazzane (subhumid bioclimatic conditions). This reflects the influence of soil and climatic conditions related to different local production areas.

The long period of normal external cooling in winter (very cold winter) (average minimum temperature in January: 6,07°C, February:7,14°C;March: 9,29°C;April: 10,64°C) delay the first flowers opening from 10 to 20 days, while a slight gradual elevation of spring temperatures (hot spring) (average maximum temperature in January: 15, 24°C; February: 17,12°C; March:19,89°C; April: 21,71°C) promote extremely rapidity the flowers opening (blowing) and a shorter flowering period compared to the normal of 3 to 10 days, depending on the genotype of considered varieties and local types (Walali,1977; Loussert, 1993).

So, earliest varieties began flowering16 days before the latest varieties. It's seen that the flowering period of varieties Gordal, Ascolana Dura, Cucco, Manzanille, and Ascolana Tenera, coincided with those of local varieties Bouchouk Rkike, Bakhboukh Beldi for a period of 3 to 4 days. It's difficult to have cross-pollination with local varieties and these five foreign varieties.

The varieties Picholine du Languedoc, types Moroccan Picholine, Bouchouk Rkike and Bakhboukh Beldi, have presented the longer blooming period compared with others studied autochthonous varieties and local types, respectively 19; 18 to 20 and 20 days. The dates of full bloom of these varieties coincide with the majority of others studied varieties and local types the most years of observation.

Considering as a minimum of flowering period coincidence 7 days, evaluated as sufficient duration for optimal cross-pollination between studied varieties and local types in the olive groves, there are different possibilities of varietal associations and grouping of varieties susceptible to be inter-pollinated (inter-feconded) between them, except for the possible phenomenon of pollen incompatibility that may occur between certain studied varieties and local types. Thus, for improvement of the productivity of types Moroccan Picholine,

low self-compatibles (partially self-incompatibles) (Chahbar, 1977; Loussert, 1978; Walali *et al*., 1984; Boulouha, 1986), the varieties Bouchouk Rkike, Bakhboukh Beldi, Bouchouk Laghlide, Bouchouika, Dahbia, Picholine du Languedoc and Picual, having a concordance duration of flowering opportunity above 13 days, are recommended as pollinators for varietal associations with types Moroccan Picholine in created orchard groves. In effect, the types Moroccan Picholine M1 and M6 have a flowering period that exceeds the types S1, S2, G9 and G10 of one day, while flowering varieties duration of Picual MJ and Ascolana tenera SB exceeds that of varieties Picual or and Ascolana Tenera of at least more than 2 or 3 days.

Flowering index

The flowering rate per shoot, evaluate the aptitude of buds of cultivars and local types to undergo induction, floral initiation, flowers differentiation and fruiting potential of inflorescence. This character quantify or determines the productivity of the olive tree varieties. The results obtained for this character are shown in figure 2. They varied from 50% to 71% and shows a significant differences between studied varieties and local types(The coefficient of interannual variation varied from 2.78% to 7.85%).It's noted that the flowering rate is very high in years of high production determined (year on).The varieties Moroccan Picholine, Dahbia, Picholine Languedoc, Manzanille, presented in respective order a flowering rates ranging from 52% to 83.4%; from 56.45% to 84.9% and from 54% to 81.7% (Moundi, 1974; Filali, 1978; ElMekkaoui, 1984; Boulouha, 1986; Ait Haddou, 1992; Ghrissi, 2001). For the variety Dole di Rossano, the flowering rate is very high (71.21%) but the proportion of aborted flowers reached 50% (Lombardo and Cilibert, 1987).

For the olive tree, the number of axillary buds evolved in inflorescences is nearly related to the canopy exposure time of the tree accumulating low winter temperatures (Hartmann, 1953; Nurhayat, 1987; Hartmann and Prolingis, 1957; Poli, 1986; Bini, 1986). In effect, the canopy of trees exposed to a cold winter for a long period (4 to 9 weeks), produced much more inflorescences per shoot than plants referring to olive groves and the total number of inflorescences developed per tree increased with the duration of cold accumulated in the exposed plants (Deng *et al*., 1988; Lavee *et al*., 2002). Hartmann and Whisler (1975) obtained optimum flowering in all seasons of the years in young olive trees elevated in pots after artificial cold treatment for 70 to 80 days under temperature between 2°C and 15°C, constant at 12, 5°C, while temperatures above 15°C inhibited the development of flower buds. Manzanillo variety formed the high flowering rate at temperatures between 2°C and 15°C, while the Ascolano variety reached the optimum of flowering rate at 12.5°C (Hartmann and Whisler, 1975) as minimum threshold of temperature for heat accumulation (low winter temperatures) to satisfied the cold requirements of the olive tree (chilling) (Alcala and Barranco , 1992).

Similarly in Greece, some varieties gave the maximum number of inflorescence for temperatures between 10°C and 14°C (Megariki, Koroneiki, Kolovs and Patron)(Prolingis, 1972;Walali, 1977). According to these authors, the characteristic of behaviour of each cultivar with regard to flowering, demonstrated the influence of genetic stock and abrupt temperature variation on the activity of vegetative growth and fruiting tree and on the cycle of the olive species. Indeed, the impact of intrinsic factors (physiological status of the tree, alternate bearing) and those extrinsic (minimum and extreme temperatures, rainfall) and others endogenous factors trophic and hormonal complex (auxin, abscisic acid, cytokinins, gibberellins) come to act and appeared to have a considerable effect on flower initiation, the flower differentiation, leading to the inflorescences development (floribondity), varied from one cultivar to another (Badr and Hartmann, 1971; Poli, 1986; Nurhayat,1987; Walali, 1977; Loussert, 1993; Walali, 2001). The critical period of normal pistil development is situated one month before full bloom (Uriu, 1959).

In the olive tree leaf, a metabolites biosynthesis site and cold perception organ, governing the normal induction process and flower differentiation (Hackett and Hartman, 1964; Msallem and Hellali, 1988). Thus, the process of flower induction began when cell division is accompanied by a cold treatment that means when the tissues are sufficiently penetrated with cold, thus the canopy is exposed to the low temperatures (cold spell) (2°C-15°C).

Then, too cold temperatures (≤10°C), provoked the stimulus of vernalization required (chilling requirement) to promote flowering in spring, whereas enough hot temperatures, induced the division activity and reactions of cellular metabolism (Wellensiek, 1964; Walali, 1977; Loussert, 1993).It's added that the number of inflorescences developed under a deficit of water along the period of flower differentiation (mid-february, mid-march) is less than that obtained in the control (Hartman and Panetsos 1962; Spiegel-Roy, 1965) and reconstituted nutrient reserves in years of low production (year off) and stocked in leaves similary, delaying harvest date inhibit flower initiation (Cimato and Fiorino, 1986) and has an important role in flower bud differentiation the following year (Nurhayat, 1987; Lombardo *et al*., 1990). In the Manzanille variety, fruit removal done before to endocarp sclerification (July), promoted fruit set the following year (Fernandez- Escobar *et al*., 1992). Oppositely, defoliation and shade had no effect on the flower induction and flower differentiation in the same variety (Cimato and Fiorino, 1986).

In the oil variety Chetoui, total defoliation of shoots, done early (November, December), inhibited the inflorescence development and stimulated vegetative growth and fall of buds. It's suggested that the flower induction in the olive tree began since November and continued until mid-December under the climatic conditions of the Tunis region (Msallem and Hellali, 1988) and much earlier (October, mid-December) in north and south regions of Italy (Mediterranean climate, with cool winter and warm dry summer) (Crescimanno, 1970; Fiorino, 1979, in Msallem and Hellali, 1988) and with the beginning of kernel or pit hardening at the variety Manzanille in south Spain (Fernandez-Escobar *et al*., 1992).

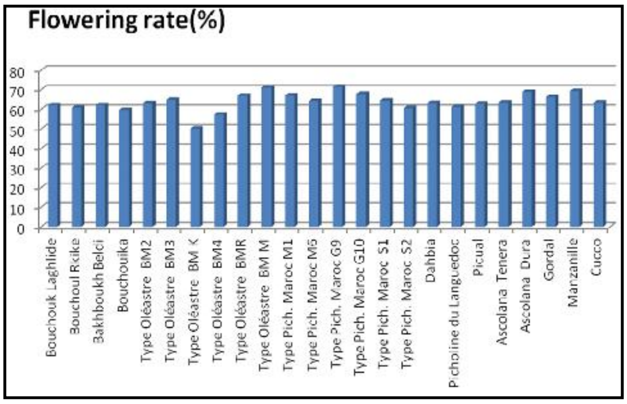


Figure 1 Flowering index of studied foreign and local varieties and local types of olive.

In the trees of the cultivar Carolea, early harvest and application of fertilizers in autumn (August, September), increased the percentage of flower buds differentiation (Lombardo and Bricoli-Bati, 1988).

Number of flowers per inflorescence

The number of flowers per inflorescence, recorded along several consecutive years of experimentation ranged for considered varieties and local types from11.34% to 24.69%. Statistical analysis revealed highly significant differences between studied varieties and local types for this character, while interannual variations are not significant and the coefficients of interannual variation obtained for each variety (from 2.03% to 10.68 %) weren't different from that obtained for all studied varieties and local types (10.05%).

The type oleaster BM2 has a relatively compact and dense panicle (17.73 to 28.98 flowers per inflorescence) and the variety Dahbia and type Moroccan Picholine M1, showed the lowest values (respectively 11.034 and 13.87 flowers per inflorescence). Examined varieties and local types were divided (Test Dunkan) into several groups depending on the number of flowers on their inflorescences.

- The type oleaster BM2 has the highest value (24.67 flowers per inflorescence) compared to most studied varieties and local types.
- BMM, presented a value of about 22.89 flowers per inflorescence.
- BM4, presented a value of approximately 21.57 flowers per inflorescence.
- BB and Ascolana Tenera, with respective values of 18.55 and 19.37 flowers per inflorescence.
- BM3, Gordal, Bouchouk Rkike, with values respectively, 17.89; 17.82 and 17.36.
- Manzanille, Cucco, BMR, Picholine of Languedoc, Ascolana Dura, Bouchouika, with values ranged from 16.15 to 16.79 flowers per inflorescence. The Manzanille varieties Picholine Languedoc has given 19 and 23 flowers per inflorescence (Ghrissi, 2001).

- Types Picholine Marocaine M6, G10, S2, G9, S1 and BMK, with values ranging from 14.14 to 14.84 flowers per inflorescence.
- Picholine Marocaine M1 and variety Dahbia, with values between 11.34 and 13.87 flowers per inflorescence. At Picholine Marocaine and Dahbia varieties, the number of flowers per inflorescence varied between 11 and 19.15 (Moundi, 1974; Chahbar, 1977; Filali, 1978; ElMekkaoui, 1984; Boulouha, 1986; Ghrissi, 2001).

According to Lavee (1997), the number of flowers per inflorescence is determined by the genotype, and therefore specific to each variety. It varies from year to year, depending on the physiological status of the tree and climatic conditions. In many Mediterranean varieties collected and in the edaphoclimatic conditions in Montpellier (South France) (Picholine, Saloninque, Bouteillan, Lucque, Tanche, Corniale), the number of flowers per inflorescence varied slightly from year to year (Villemur *et al.*, 1989). It's founded that the number of flowers per inflorescence varied greatly in 31 cultivars studied suitably irrigated, as well between inflorescences of the same shoots and between trees and years (Lavée *et al*., 2002). There was no significatif effect of canopy exposure on the number of flowers and staminate flowers per panicles (Shatat and Sawwan, 1986).

The treatment with annular incision (December, January, February), were effective to improve the level of carbohydrates in the buds of the shoots compared to other parts of the tree, and tend to stimulate flower initiation and to increase the number of flowers per inflorescence (Hartmann, 1950).

In Chetoui oil variety, total defoliation applied early (November, December), affected the number of flowers per inflorescence and has no effect on this parameter, when it's practiced partially (50% of leaf) or lately (February and March) (Msallem and Hellali, 1988).

Moreover, the number of flowers per inflorescence, obtained from trees that have undergone a temporary water stress in early march is lower than that of control trees (who does not undergo any water deficit) (Spiegel-Roy, 1965).

In a behavioral study of four olive cultivars planted in trials and outside their natural habitat (microclimate)(Conservolia, Picholine, Manzanilla, Nocellara Delb), it's concluded that number of flowers per inflorescence is depending on the genetic aptitude of the tested varieties (Marco *et al*., 1990). Other authors believed that the number of flowers per inflorescence is a stable and constant character for each determinate variety (Chaux, 1955; Moundi, 1974; Chahbar, 1977; Filali, 1978; Walali, 1984; Boulouha, 1986; Bini, 1986; Ghrissi, 2001; Lavee *et al*., 2002).

Number of perfect flowers per inflorescence

Perfect (pistillate, fertile) flowers are those whose floral parts or carpellary are normally developed (no malformation) and therefore are consequently enabled to receive in their receptive stigma self or allo pollen viable compatible and fecundating. At the floral clusters, their high number, which is related to the profusely ontogeny of the inflorescence (Villemur, 1981) provide best information about flowers fertility of each variety. In cultivar with high percentage of staminate flowers, the perfect flowers were in terminal positions and the staminate on the laterals. The number of perfect flowers per inflorescence varied from 4.85 to 12.99. Statistical analysis showed a highly significant difference between considered varieties and local types for this studied character (the coefficient of variation between varieties is 20.59%) and the following groups have been distinguished:

- Picholine of Languedoc, BMR, BM3, BMK, and BMM, with a number of perfect flowers per inflorescence ranging from 12.33 to 12.99.
- Bouchouika, Bouchouk Rkike, Manzanille and BM2, presented a number of perfect flowers per inflorescence oscillating between 10.09 and 11.34. Gordal, BM4, and Dahbia, with a number of perfect flowers per inflorescence ranging from 7.07 to 7.27.
- Ascolana Dura, Picual, Bouchouk Laghlide, Cucco, M1, G9, G10, and M6, presented a number of perfect flowers per inflorescence ranging from 6.11to 6.89.
- S2, Ascolana Tenera, Bakhboukh Beldi, and S1, presented a number of perfect flowers per inflorescence varying from 4.85 to 5.47.

For the same variety, highly significant differences were found between the considered years of observations, the coefficient of variation oscillated between 4.14% and 19.31%. It's noticed that the number of perfect flowers per inflorescence was higher during years of excessive production (year on). Varieties of Manzanille, Moroccan Picholine and Picholine Languedoc had given a number of perfect flowers per inflorescence respectively of 7.5; 15.5 and 20 (Ghrissi, 2001).

It appears that this character is influenced by physiological and nutritional status of the tree (leaves/buds ratio, exposure canopy, alternate bearing) and climatic conditions (soil moisture, temperature, rainfall) encountered in flowering period, during which is produced the initiation, differentiation, and complete flowers development during the considered years (period between bud break and early opening flowers).

The north exposure of the tree canopy usually produces a large number of perfect flowers per inflorescence (Uriu, 1959). The perfect flowers are most often founded in the apical part of the tree (Hartman and Panetsos, 1962). Panicles from apical and medium zone of the floral shoots contained more perfect flowers, than panicles from the basal zone of the same shoot (Shatat and Sawwan, 1986).

According to Morettini (1952) and Spiegel Roy (1965), the percentage of hermaphrodite flowers is mainly a varietal characteristic. The oil fruits varieties have a higher percentage of pistiled flowers than the table fruits varieties (Ascolano, 12%) (Oppenheimer, 1946; Spiegel Roy, 1965).

In the olive tree, the number of perfect flowers varies considerably not only with the cultivar and climatic conditions, but also in the same cultivar throughout the years and the level of the previous year fruiting (Esna-Ashari and Gholami, 1989; Lavée, 1985; Lavee *et al*., 2002).

About Moroccan Picholine variety, shoots giving a high flowering (floribondity) have shown a low set fruiting. Flowers produced readjusted the number of fruits developed per tree (Boulouha, 1986). For the Manzanille variety, the fall of perfect flowers and developed fruit reached the maximum 13 to 15 days after full bloom and became progressive, considering the fruit competition to get nutrients (Rapoport and Rallo, 1991). Villemur *et al.* (1989) has observed differences in the percentage of hermaphrodite flowers relative to the total number of flowers in olive varieties planted in Mediterranean collection of Bel Air in Montpellier (Southern France).

Hartmann (1951) found a decrease in the percentage of pistiled flowers after a year of heavy set fruiting (year on) in varieties Manzanille (66.28% against 33.7% the following year) and Sevillano (58.9% against 8.1% the following year).
Cuevas and Rallo (1990) and Cuevas *et al.* (1994) reported that the trees of Manzanille variety compensated the low levels of set fruiting in the low production year (year off) by an increase in the number of perfect flowers, a high fruitful and high content of nitrogen exert a beneficial effect on the stimulation of flowering (cited in Walali, 1977).

It's unknown if the number of flowers per inflorescence is precisely related to the number of perfect flowers or potential yield (Lavee *et al*., 1999; Rallo and Escobar, 1985). These results have shown that the number of flowers per inflorescence was positively correlated with the number of perfect flowers per inflorescence (R2=0.46). Leaf areas have a first importance for the complete flowers development nearly related to the carbohydrate levels of trees and their tendency to bloom.

In the Souri variety, loss of leafage, prejudiced with the severe attack of *Spilocea oleaginum*, reduced the percentage of complete flowers at 35.6%, this percentage reached 72.9% while trees are slightly damaged and 85.2% in treated trees against diseases the following year (Spiegel Roy, 1965; Hartmann and Panetsos, 1961). At the same variety Souri, low content of carbohydrate reserves in the tree, causes noticeable decrease in the percentage of complete flowers (Lavee *et al*., 2002).

For the Sevillano variety, the incision of branches, improved the phytohormone content and carbohydrate levels in buds, and increased the percentage of complete flowers (57.27% against to 46% in the non incised trees).

At the variety Mission conducted in California, elimination of removed buds induced a high leaves/buds rate when performed early before full bloom (mid-April), ensued high percentage of perfect flowers per inflorescence and in contrast the defoliation giving a low leaves/buds rate, and established after the critical period of mid April, provoked a great decrease and rapid declivity in the percentage of perfect flowers (Uriu, 1959).

For the Souri variety, an early deficiency of water, applied even during a relatively short period and at different stages of flower buds differentiation, affected the number of flowers and number of perfect flowers per inflorescence (Hartmann and Panetsos, 1961; Spiegel Roy, 1965). Then while a deficit of water occurred during the period of flower differentiation and of floral organs development (mid-February, mid-April), has a fatal effect on the percentage of complete flowers (0.6%) (Hartmann and Panetsos, 1961).

The correction in the early season of the soil deficiency of water, growled the percentage of perfect flowers per inflorescence, while the delayed irrigation until mid-April, has inflicted no increase of this measured parameter (Hartmann and Hoffman, 1953; Uriu, 1959). Also, high temperatures prevailing during the differentiation of flower buds (January, mid-February), has a greater influence on the percentage of hermaphrodite flowers per inflorescence and regenerated its decrease (Spiegel Roy, 1965).

Pistil failure or abortion

At the olive an androhermaphroditic species (Poli, 1986), female sterility, is a very frequent biological phenomena ensued from an arrest of pistil development or abortion or atrophy of the ovary collapse (Lavee, 1997). This is one of the parameters which determine the olive trees yields. The percentage of aborted flowers (staminate flowers with only male organs complete and functional; flowers with an invisible ovary, or with a style or stigma atrophied), is relatively constant for each variety and constitutes a varietal characteristic ,it informs about the quality of the bloom and the degree of fertility of flowers and therefore the production of the year (Morettini, 1950; Chaux, 1955; Magherini, 1971; Moundi, 1974; Chahbar, 1976; Walali, 1977; Filali, 1978; Villemur, 1981; Boulouha, 1986; Bini, 1986; Esna-Ashari and Gholami, 1989; Loussert, 1993; Walali, 2001). Ovary abortion is affected by several factors respectively, cultivars (genetic); environnemental (insufficient light, winter cold) and exogenous (soil nutriments, water stress, nitrogen deficiency, foliar diseases) modifying the balance of endogenous growth substances and the physiological status between fruiting and vegetative growth, competition between flowers (ovaries, future fruits) to get resources, which are insufficient for the development of all flowers, given the redundant flowering and high yield in previous year (Rallo *et al*., 1981; Rapoport and Rallo, 1991; Lavee, 1996; Cuevas *et al.*, 1994), abundant flowering in current year (Rallo *et al*., 2006); and unfavorable inflorescence position in the canopy (Cuevas and Polito, 2004; Seifi *et al.*, 2008). So it occurs early during flowers development (Pirotta De Pergola, 1913), mostly 30-40 days before bloom when increase pistil abortion , decrease fruit set and it's related to agricultural technics as irrigation(Morettini, 1952;Magherini,1972; Uriu, 1959;Hartmann,1962;Spiegel Roy,1965; Moundi, 1974;Chahbar, 1977; Villemur, 1981; Chmitah, 1983; Bini, 1986; Lavee, 1997; Cuevas *et al*., 1999; Lavee, 2002; Rallo *et al*., 2006), whether the influence of the year, branches and shoot, inflorescence and useful of varieties (table, oil).The oil varieties are more fertile than large-fruited cultivars which have greater ovary abortion, but similar number of flowers (Morettini *et al*., 1972). In the Manzanile variety, imperfect flowers fall began and reached the maximum, respectively 8 and 15 to 21 days after full bloom (Rapoport and Rallo, 1991).

The obtained results for this character for all studied varieties and local types are shown as histograms (figure 3). It's remarked that the differences among studied varieties and local types and those between the considered years of observations are highly significant. The average pistil abortion rates obtained for varieties and local types appeared very high, they varied from 9.904% to 81.531% and the coefficients of variation between the experimented years of observations varied from 2.52 to 35.6%.

However, over the years of study, it's established that the lowest abortion rates were observed during years of low

production (year off). This decrease was compensated by an increase in the number of hermaphrodite flowers per inflorescence, ensued in a high fertility ovarian rate, until 90% of the flowers that are pollinated and becoming fruit. It was noticed that the decrease in abortion rates one of a cultivar is explained by the availability of water in the soil during the period of floral differentiation (irrigation, rainfall), or due to the action of low winter temperatures, inductive condition (January, February, March), or as a result of a decrease in nutrient stock of the tree (Uriu, 1959; Hartmann and Panetsos, 1961; Spiegel Roy, 1965; Aggabio, 1974; Villemur, 1976).
Thus, after a heavy harvest, even when favorable climatic conditions allowed a profuse flowering, there is generally a greater increase in number of aborted flowers per inflorescence (male or staminate flowers) (Lavee *et al*., 2002).

A higher pistillated flowers rate enfeeble the tree during floral induction and phase of growth of inflorescence (Boulouha, 1986). Removing part of the inflorescences reduces the ovary abortion in olive (Seifi *et al.*, 2008).

In the oil variety Chetoui, the defoliation of branches (January, March), promoted the normal development of inflorescences, but their flowers showed a higher percentage of aborted pistils, the maximum is observed 9 weeks before full bloom (November, December) and accentuated the drop of young fruits formed after fruit set (Msallem and Hellali,1988).

At the Mission variety, removing leaves of twigs, operated after the critical period of floral differentiation (mid-April), imposed unfavorable or poorer nutriment conditions (leaf on low bud ratio) has led to considerable increase in the ovary abortion (Uriu, 1959). The highest abortion percentage (59.632 to 86.252%), were recorded in varieties Bouchouk Laghlide, Picual, Ascolana Tenera, Gordal, oleaster BM4, Bakhboukh Beldi, Ascolana Tenera and Picholine Marocaine type S1 and S2. Moroccan Picholine types M1 and G10, M6, G9, oleaster BM2, and Cucco variety, had abortion rate, which reached from 50.203 to 58.411%. Whereas varieties Picholine of Languedoc, Manzanille, Bouchouika, Dahbia, Bouchouk Rkike, BMM, BMK, BM3, showed only a low levels in the order of 9,904 to 41,866%%. The abortion rate varied between 24% and 72.5% in the Moroccan Picholine variety, from 11.5 to 27% in Picholine of Languedoc, and from 16.4 to 59.4% for the Manzanille variety.

As for varieties Dahbia, Ascolana Tenera, Gordal and Cucco they gave an ovary abortion rate respectively of 12.81%; 69%, 34% and 66.3% (Moundi, 1974; Chahbar, 1977; Filali, 1978; El Mekkaoui, 1984; Sillou, 1984; Boulouha, 1986; Lamhamedi, 1986; Zair, 1987; Ait Haddou, 1992; Nait Taheen, 1993; Ghrissi, 2001). Ovarian abortion showed differences depending on the location of inflorescence on the floral shoot (twigs) and the position of flowers on the inflorescence (Bini, 1986).

Influence of the inflorescence location at the floral shoot (twig) on the ovary abortion

It's showed a highly significant difference in the ovary abortion percentage, firstly between the three zones of floral shoot (apical, medium, basal), secondly between the experimented years. It's verified for all treated varieties and local types, that the inflorescence at the basal zone of the twigs gave the highest ovary abortion percentage (15.75 to 81.79 %) compared to the inflorescences located at the apical zone (7.78 to 82.55%) and at the medium zone of the twig (8.21 to 82.55%).

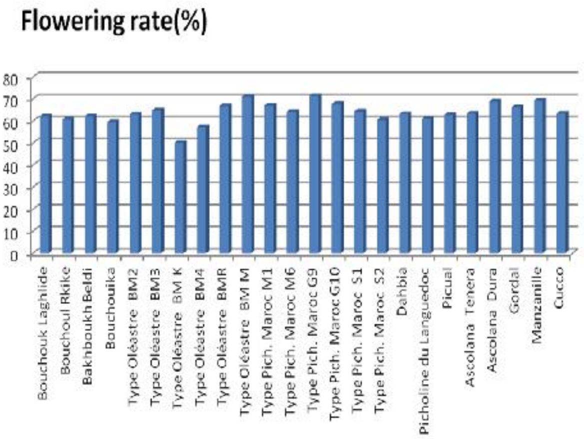


Figure 2 Pistil abortion rate of studied foreign and local varieties and local types of olive.

It's reported that the percentage of aborted flowers is higher at the basal zone of the twig compared to their apical zone (Vidal, 1969; Chahbar, 1977). The lowest abortion percentage is recorded at the inflorescence of the medium zone of the floral shoot (N'Seir, 1977). For the Moroccan Picholine, Sévillane and Mission, the percentage of imperfect flowers varied according to the position of inflorescence in the twigs and branches of the same tree (Chahbar, 1977).

This phenomenon is explained by the existence of apical dominance, which leads to a competition to get trophic factors (water, nutrients) between the inflorescence of the top of branches, which forms the first and turn aside the trophic flows to their advantage, and those that have evolved lately in the basal zone of the branches (Vidal, 1969; Zair, 1987). Regarding the position of inflorescences on the canopy of the tree, upper shoot and branches better exposed to light, gave a lower percentage of aborted flowers than the inferior (lowest), and confirms the great influence of the light in the ovary abortion (Cimato, 1980; Bini, 1986).

Influence of the flowers location at the inflorescence on the ovary abortion

The ovary abortion percentage was determinated in the three zones of the inflorescence as, the terminal flowers (Order I), flowers of secondary axes of the base (Order III) and others interiorly flowers at inflorescence (Order II).

It's showed a highly significant difference between the abortion rate of three zones (I, II, III) of the inflorescence and between considered years of observations. Thus, lowest abortion rates were observed in the flowers situated at the apex of the inflorescence and the highest or elevated abortion rates is recorded in the lateral flowers (Barata *et al*., 1986).In fact, the tip flowers of inflorescence are perfect and the trophic flows are always oriented in their advantage (Vidal, 1969; Cimato, 1980; Zair, 1987). Fertility of flowers of the third order is low (17.3% to 25.4%) and in this zone of inflorescence are located most aborted flowers. The fertility is very high in flowers of the second order (60-70%) and in tip flowers of the first order (80%)(Bini, 1986).

Statistical analysis (PCA), considering the morphological characters of flowering individually allowed to constitute in the agglomeration level of 75% of similarity, the groups of tested varieties and local types and the morphological characters involved in these groupings (figures 3 and 4), which are based on the euclidean distances analysis based on the treatment of all the determined morphological characters. Thus, the three characters retained as, the number of flowers and perfect flowers per inflorescence and ovaries abortion rates, authorized to construct three distinct groups (figures 4 and 5).

- Group 1,constituted of oleasters types BM3, BMR, BMK, and varieties Picholine of Languedoc, Manzanille, Bouchouk Rkike, Bouchouika and Dahbia, with a higher number of perfect flowers per inflorescence and a lower ovarian abortion percentage.
- Group 2, which has given a higher number of flowers and perfect flowers per inflorescence and also lower ovary abortion percentage.
- Group 3, contained oleaster type BM4, types Picholine Marocaine G9, G10, M1, M6, S1, S2, varieties Bouchouk Laghlide, Picual, Cucco, Ascolana dura, Ascolana Tenera, Gordal and Bakhboukh Beldi, which are gathered by higher ovarian abortion percentage exceeding 50% and by a lower number of flowers and perfect flowers per inflorescence.

Moreover, it's noticed that the number of perfect flowers per inflorescence and ovary abortion percentage, in consideration of their situations diametrically opposite, are markedly and negatively correlated each others. This indicates that if one of these parameters increases, the other decrease and inversely. This also explains the opposite emplacement of group 1 and group 3 of studied varieties and reconstituted local types (figure 4).

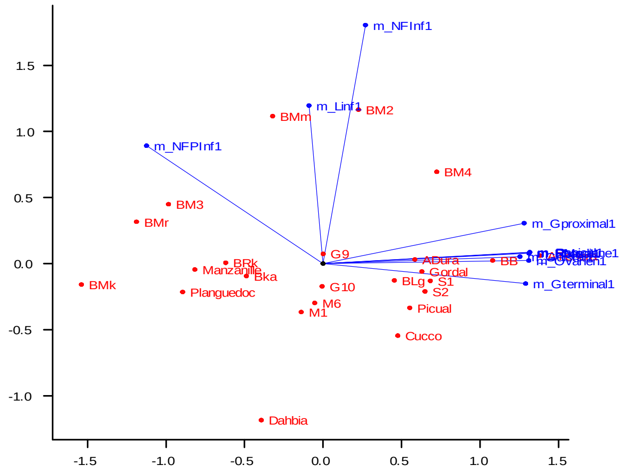


Figure 3 Principal Component Analysis (PCA) of flowering morphological characters of studied olive varieties and local types.

Self-compatibility degree

In self-pollination, fruiting set varied from 0.56 in the type Picholine Marocaine S1to 6.836 at the oleastre BMM and in free-pollination, it's varied from 0.90 in the type Picholine Marocaine S1 and 4.4975 in the oleaster type BMR (table 1). It's also depended on the type of pollination adopted. Thus, for the same variety the fruiting rate obtained by self-pollination in most of cases is different from that obtained by free-pollination. This rate also has varied with environmental conditions (Rallo et Escobar, 1985) and has varied markedly in self-pollination than in free-pollination (Esna-Ashari and Gholami, 1989). Certainly, such as its difference is dependent

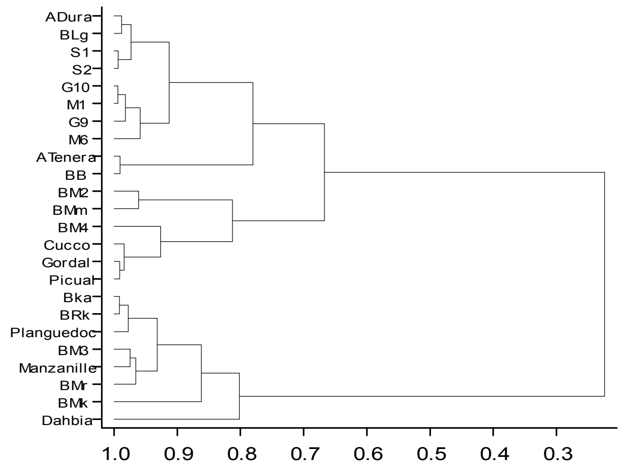


Figure 4 Euclidean Distances of flowering morphological characters of studied olive varieties and local types.

on the degree of self-compatibility of the treated varieties. But in any olive cultivars (cv Manzanillo), high temperatures (above 30°C) during flowering diminished the ability of self-pollination attributed to the inhibition of pollen tube elongation in the style (Bradley *et al*., 1961and 1963; Griggs *et al*.,1975; Fernandez-Escobar *et al*., 1983).

Manzanillo trees with lighter flowers when low flowering year occurred (year off) showed higher percentage of pistilated inflorescence and enhancement of female flowers quality witch had greater ovule longevity than the tree with the heaviest flower load and an increase in fruit set (Cuevas *et al*., 1994; Cuevas *et al*., 2001). In order to appreciate this self-compatibility, the degree of self-compatibility was measured (self-incompatible: 0-15%, partially self-compatible: 0.15 to 30%, self-compatible, the self-pollination exceeds the free-pollination).

Within the studied sample, 78% of varieties and local types have given a high degree of pollen self-compatibility, varied between 0.613 and 1. In traditional varieties Bouchouk Laghlide, Bouchouk Rkike, Bakhboukh Beldi, Bouchouika, types oleasters BM2, BM3, BMK, Picholine Marocaine types S1, S2, M1, M6, G9 and G10 and Dahbia and Picual varieties, the superiority of obtained fruitful rate in self-pollination over that obtained in open-pollination is little significant. These types and Picual and Dahbia varieties can be considered as self-compatible. Type's oleasters BM4, BMM and BMR and Picual variety showed a significant increase in set fruiting in self-pollination compared to that recorded in free-pollination. Thus, an increase was recorded for the oleasters types BM4, BMM, the Picual variety and type oleastre BMR. These oleastre types and Picual variety can be qualified as highly self-compatible.
The favorable response of these types and the variety Picual in self-pollination does not normally required their association with others pollinators cultivars in planted orchards tree. The pollen-pistil interaction and the aptitude to gametic association or differential receptivity are not systematically to

be in the disfavor of self-pollen (Pernes, 1984). However in the olive considered as self-fertile species and as cross-pollination preferred, and in objective to increase the productivity of trees, a dress witch to set of a satisfactory scheme of pollination, to determinate and to select the potentially compatible and an efficient pollinizers for each variety is necessarily proved.

This agreed the priority to obtain varieties and local types strongly self-compatible to control pollination and fruit set in olive orchards (cases of local types BM4, BMM, BMR and Picual variety). According to the results of El Mekkaoui (1984), the variety Dahbia self-compatible under agro-climatic conditions of the Meknes region, revealed also self-fertile under agro-climatic conditions of the Ouazzane region.

It's the same for the Picual variety showed self-compatible both in its microclimate origin (Rallo and Fernandez-Escobar, 1985; Barranco *et al.*, 2000) and under the Ouazzane agro-climatic conditions. Inversely, this variety is classified self-incompatible in orchards of Andalusia (Cuevas *et al.*, 2001). Is it a clone of Picual? It's still unknown on this question. In the sample of local types named Picholine Marocaine (Zitoun Beldi, Zitoun ElHor) to evaluate of fruiting rate in self and free-pollination showed the presence of different levels of self-compatibility. In fact, no types have shown an average self-compatibility (as example of types S1, S2), while others have presented a high level self-compatibility (as examples of type M1, M6, G9, G10). The genotypic heterogeneity of the population variety named Picholine Marocaine (Zitoun Beldi, Zitoun ElHor) was confirmed (Moundi 1974; Chahbar 1977; Filali, 1978; Walali *et al.*, 1977 and 1984; Zair, 1987; Boulouha *et al.*, 1992) and the self-fertility is highly dependent on genetic constitution of cultivar. In fact, in the gametophyte, transcription and post meiotic traduction, a group of genes involved in the metabolism of pollen are concerned (fertility, germination, rapidity of pollen tube growth), and that are not neutralized regarding to the pressures of selection and pistillary environmental conditions.

It's resulted, each gametophyte, may be characterized by a selective value (rapidity of pollen tube growth), and the gametic associations reflect pollen competitions and the selection process on the gametophyte during its contact with the pistil (stigma) (Pernès, 1983 and 1984; Lavee, 1997).

Even, most of these individuals were selected in groves constituted only of the local types named Picholine Marocaine and regarded partially self-fertile (Zitoun Beldi, Zitoun ELHor). Also, the majority of these individuals have reacted well to the free-pollination; which was more efficient compared to self-pollination to induce set fruiting and the too highly rate of set fruiting is obtained (table 1).

The olive tree is allogamous species were allo-pollination predominated, and the character of its anemophilous abundant pollen, produced by its stamens of opened flowers, dispersed at the anthesis (flowering), and mediated by the wind, that transports and distributes pollen flows over long distances (Msallem *et al.,* 1996). It's presumed that crosses pollination is generated between cultivated forms and different local genotypes and wild witch give rise to high genetic variability between and within cultivars around mediterranean regions (Besnard *et al.*, 2001).

Table 1 Set fruiting rate in self and free-pollination of any studied olive varieties and local types.

Varieties and local types	Self-pollination (%)	Open-pollination (%)	self-compatibility Degree (%)
Bouchouk Laghlide	1.53	2.08	0.735
Bouchouk Rkike	1.93	2.5	0.772
Bakhboukh Beldi	1.79	1.83	0.978
Bouchouika	2.78	3.12	0.891
Dahbia	1.372	1.73	0.793
Picual	2.723	2.04	1.335
Type Oleastre BM2	3.12	3.6	0.866
Type Oleastre BM3	2.72	2.71	1.003
Type Oleastre BM K	4.17	4.06	1.027
Type Oleastre BM4	6.72	3.18	2.1132
Type Oleastre BMR	5.4675	4.4975	1.2157
Type Oleastre BM M	6.836	3.307	2.067
Type Pich.Maroc M1	1.2	1.82	0.659
Type Pich.Maroc M6	2.85	2.94	0.969
Type Pich. Maroc G9	1.47	1.75	0.84
Type Pich.Maroc G10	1.34	1.41	0.95
Type Pich. Maroc S1	0.56	0.9	0.622
Type Pich. Maroc S2	1.14	1.86	0.613

In addition, its reveled that he variety population named Picholine Marocaine, are more receptive for a wide range of traditional Moroccan pollinators cultivars (Meslala, Dahbia) and foreign varieties (Picholine of Languedoc, Manzanille, Ascolana)(Moundi, 1974;Chahbar, 1977; Filali, 1978; Walali *et al.*,1977,1984; El Mekkaoui, 1984; Nait Taheen, 1993).

It's extremely indispensable to determinate the potential and efficient pollinizers cultivars chosen among autochthonous varieties (indigenous,domestic) planted in traditional commercial orchards tree for type Moroccan Picholine most preferred, widespread and dominate cultivar given by olive growers in Ouazzane territories.

Cross-pollination

Cross-pollination was performed to determine the all local potential pollen donor's cultivars, which are grown in the same location and could participate as potential pollinizers for type Moroccan Picholine partially self-incompatible. 10 twigs with flowers not yet opened were bagged and covered in specific pollination paper (white flowers stage). At the beginning of flowering, a bouquet of shoots with blowing and opening flowers preleved on selected pollinizers trees was introduced in the early morning by the upper part of the bags and is closed rapidly to avoid entry of foreign pollen grains. The bags are removed out at petal fall. Developed fruits are counted after physiological drop (June). The fruiting rate is determined (number of fruits developed/total number of flowers counted). The efficaciousness of cross-pollination and of different specifics recombinations of tested pollinizers cultivars was measured (3 to 4 years)(fruiting rate obtained in cross-pollination/fruiting rate obtained in self-pollination)(Carles, 1983; Moutier *et al.*,2001). Data in table 2 showed that the Bakhboukh Beldi variety of which their inflorescences at opening flowers, throwing out very abundant pollen grains which possessed a low efficiency, it's averred being a bad pollinizer cultivar for types Picholine Marocaine S1 and S2 and can't fertilize each other. While indigenous varieties Bouchouk Rkike and Bouchouk Laghlide with flowers at stamens dehiscence, produced a large number of pollen grains are possible potential pollinizer's cultivars for types Picholine

Marocaine M1and M6. The local variety Bouchouika, whose anthers of opening flowers are very rich in pollen grains, is an excellent potential and more effective compatible pollinizer cultivar for the Picholine Marocaine types G9 and G10 (efficacy: 66% to 100%).

To study the reciprocal cross-pollination (back-crossing), four local varieties were used as receptors of pollen that proceed of types of Picholine Marocaine. It's noticed in all cases experimented, that these varieties have responded positively to the pollen carried out of types Picholine Marocaine, which had a marginally significant effect on the set fruiting, which increases it up to a certain limit, but these pollinizers cultivars are less efficiency.

Evidence degrees of pollen efficiency, varied according year to year, the environmental factors (temperature, rainfall, wind), and depended on the gametophytes and sporophytic specific recombination between types Picholine Marocaine and local varieties gathered in sympatric situation in the same ecological areas.

The opposite recombinations Picholine Marocaine M6 x Bouchouk Laghlide and Picholine Marocaine M1 x Bouchouk Rkike are very effective and more interesting. Furthermore, in calculated efficiency degree in cross-pollination and although annual variations observed, it's argued that cross-pollination was more effective and has a high degree of efficacy in the Picholine Marocaine, which the degree of self-compatibility is low (M1, S1, S2, partially self-incompatible), when pollinated with pollen proceeding of indigenous varieties and less effective or had no significant effect when the autochthonous varieties (self-compatible), are reciprocally pollinated by pollen proceeding of the Moroccan Picholine types.

In the olive, the importance of production and diftheferences between set fruiting cultivars are closely related to a varying degree of self-fertility, cross-pollination requirement, and floribondity and climatic condition of site of geographical implantation. In Spain, the Manzanille variety, although self-fertile and her extraordinary compatibility with Gordal, required cross-pollination to produce in United States. Varieties of a grouped flowering gave a greater production, whereas when those layed out flowering, production is less (Androulakis and Loupassaki, 1990; Msallem *et al*., 1996).

The pollen-compatibility appeared to be determined by the fertility of the flower, the specific interaction of pollen-pistil (stylus), aptitude to the association or differential susceptibility and the weather conditions (temperature, excessive drought, hot and dry wind or 'chergui', deficit of water and nutriment, rainfall), except its genetic or varietal characters (Rallo *et al*.,1990). These major climatic factors reduced the abundance and atmospherically distribution of pollen by the wind and its viability (drying up of the stigma), longevity and life of viable

Table 2 Cross-pollination and determination of the best potential pollinizers of tested olive varieties and local types.

Pollinated varieties and local types	Types of pollination	Pollinizers cultivars or local types	Set fruiting rate	Indices of efficacy (X)*
	Self-pollination	Type PM M1	1.10	-
	Free-Pollination	Free	2.63	-
Type PM M1	Cross-pollination	Bouchouk Rkike	1.19	(0.65)*
	Cross-pollination	Bouchouk Laghlide	2.74	(1.04)*
	Self-pollination	Type PM M6	1.85	-
	Free-pollination	Free	2.21	-
Type PM M6	Cross-pollination	Bouchouk Rkike	1.13	(0.51)*
	Cross-pollination	Bouchouk Laghlide	1.17	(0.53)*
	Self-pollination	Type PM S1	0.61	-
	Free-pollination	Free	1.40	-
Type PM S1	Cross-pollination	Bakhboukh Beldi	0.62	(0.44)*
	Self-pollination	Type PM S2	0.63	-
	Free-pollination	Free	3.85	-
Type PM S2	Cross-pollination	Bakhboukh Beldi	0.62	(0.16)*
	Self-pollination	Type PM G9	1.10	-
	Free-pollination	Free	1.95	-
Type PM G 9	Cross-pollination	Bouchouika	1.90	(0.97)*
	Self-pollination	Type PM G10	0.82	-
	Free-pollination	Free	0.73	-
Type PM G 10	Cross-pollination	Bouchouika	0.79	(1.08)*
	Self-pollination	Bouchouika	1.47	-
	Free-pollination	Free	2.70	-
Bouchouika	Cross-pollination	Type PM G10	1.30	(0.48)*
	Self-pollination	Bouchouk Rkike	2.34	-
	Free-pollination	Free	2.75	-
Bouchouk Rkike	Cross-pollination	Type PM M1	1.74	(0.63)*
	Self-pollination	Bouchouk Laghlide	0.84	-
Bouchouk Laghlide	Free-pollination	Free	0.66	-
	Cross-pollination	Type PM M6	0.58	(0.88)*
	Self-pollination	Bakhboukh Beldi	2.24	-
Bakhboukh Beldi	Free-pollination	Free	4.38	-
	Cross-pollination	Type PM S1	0.48	(0.11)*
Dahbia	Self-pollination	Dahbia	1.14	-
	Free-pollination	Free	1.81	-
	Cross-pollination	Type PM S1	1.59	(0.88)*
Picual	Self-pollination	Picual	2.72	-
	Free-pollination	Free	2.04	-
	Cross-pollination	Type PM M6	2.62	(1.28)*

ovule and if the effective period of pollination was shorter, pollen tube growth, issued from the germination of the pollen grains specific, in the style will be blocked or inhibited, and it can't arrive or attain to in legitimate time at ovule and assured its fertilization (degenerated ovary or shotberries fruits development).

Cross-pollination averred necessary to allow early fertilization and improve the initial fruit set and production at least at an acceptable degree, considering that the periods of full pollination it's occurred when the air temperature is between 19 and 22°C (Msallem *et al*., 1996). The foreign pollen tube growth to longer be vigorous and competitive and its ovular penetration always occurred quickly and normally to fecundate usually single ovule per flower even in higher temperatures conditions (Cuevas *et al*., 1993). At most, it's showed that cross-pollination, determined the optimal pollen-pistil interaction, and markedly increased the percentage of fruit set (number of inflorescence and percentage of inflorescence with fruits) and commercial harvest yield or potential compared to self-pollination, for most of olive varieties (Kar and Singh, 1984; Suarez and Rallo, 1987; Cuevas and Rallo, 1990; Rallo *et al*., 1990).

Any gametophytic selection (inter gametophytic pollen competition), due of greater competitivity or efficiency of pollen, promoted the aptitude of homogamy fertilization (self-pollen), whatever the foreign pollen, which its confronted, influenced by biological parameters and environmental conditions (receptivity of the pistil, stimuli, temperatures) occurred in olive tree, especially when preferential out-crossings between genotypes or confrontations between pollen proceeding from wild and cultivated forms on the same stigma (stylus). Pollen competition helped to maintain the phenotypic integrity of both forms (wild, cultivated) which coexist together nevertheless the pollen flow between them.

However, it's showed that for self-pollinated species (self-fertilitizing), the impact of pollen competition on maintained phenotypic integrity of wild and cultivated forms adjacent is low and that self-fecundation (inbreeding) reduced gene flow and amended reproductive isolation between the two forms in sympatric situation and influenced the success of domestication and the organization of the genetic structure of populations in this preferentially out-crossing species (cross-breeding).

The predominant and prioritary out-crossing in olive allowed a quick introgression than self-pollination, of genes involved in the adaptation process (gene of resistance to pathogens) in cultivated varieties proceeding from wild forms, and consequently a more quickly adaptation to stress conditions and changes environmental factors than in self-pollinated varieties.

Moreover, the tendency for a wind fertilization by foreign pollen and a stronger multi-paternities on seeds collected from trees olive Laperrinei (Hoggar) and the variety Istrska belica (Slovenia), was revealed by microsatellite techniques (ISSR)(Vidal, 1969; Tombesi, 1971; Griggs *et al*., 1975; Villemur *et al*., 1976; Lavee and Datt, 1978; Loussert and Brousse,1978; Loussert, 1993; Pernès, 1983 and 1984; Trigui and Mssalem,1995; Lavee, 1997; Cuevas *et al*., 2001; Rallo and Cuevas, 2001; Lavee *et al*.,2002; Besnard, 2009; Alenca *et al*., 2014).

These donors local cultivars of pollen and tested as the most frequent pollinating varieties (pollinators)(Bouchouk Rkike, Bouchouk Laghlide, Bouchouika) and only studied types Picholine Marocaine as receptors of pollen (M1, M6, G9, G10) was qualified as well as inter-compatible or inter-fertile varieties.

Moreover, the period of flowering of these tested local types coincided for a greater party of the flowering period (14 days), with the three retained male gametophyte and pollinators cultivars. Effectively, when we visit traditional and ancient and oldest olive groves at the Ouazzane region any branches tacked out on these local varieties are grafted on oleastre or ingrafted on a tree of the variety population Picholine Marocaine, dominating in orchards trees, in aimed goal to being pollinated efficiently by surrounding cultivars or even by sylvestris reducing ovary abortion or fruit drop (Besnard *et al*., 2001) and to improve pollination and fruit set and increasing productivity and yields of olive trees.

It's noticed that the types Picholine Marocaine are efficient pollinators for Dahbia and Picual varieties (table V). The variety population named Picholine Marocaine has already or previously manifested intercompatibility with variety Dahbia under agro-climate conditions of Meknes (ELMekkaoui, *1984*). It's was ascertained that some local varieties, although self-compatible, has developed parthenocarpic fruits (shotberries) in their growing area and that the most considered years (Bouchouk Rkike: 4.26%, Bakhboukh Beldi : 10.21%).

Others local types such as oleaster types, BM4, BMM, BMK (4.05%, 4.05%, 10.21% respectively) and Moroccan Picholine types, M1,G10, and M6 (6,13%, 8,33%, 11,11% in the respective order), tends to develop parthenocarpic fruits (shotberries), with normal fruits (issued from the growth of a alone viable and functional ovule in normal fertilizated ovaries), any years and in specific climatic conditions.

In effect, under water stress (warmers or hot and dry climates, or cold and sweet conditions) occurred even for a short period of the flowering (where the flowers are possibly fertilized) and of the critical growth period of floral organs (March, April) (case of Ouazzane region), a deficiency in nitrogen, potassium and boron, provoked an increase in the number of parthenocarpic fruits (Lavee, 1997), fruits issued from uncompleted development of all 4 ovules of embryo sac or of unfertilized ovaries and of a self-incompatibility fertilization by self-pollen of variety (Rallo *et al*., 1981; Rapoport and Rallo, 1990). Set fruiting and seed development accelerated the degeneration of unfertilized flowers in the same flowers and those of others flowers adjacent (Cuevas *et al*., 1994).

Solely, efficacious pollinators cultivars must be interplanted with partially self-incompatible (Moroccan Picholine) and even with self-compatible varieties (Manzanille) in newly planted orchards(10% of trees), in objective to obtain a positive reaction to the cross-pollination, to improve its efficiency and to reduce the incidence of parthenocarpic fruits developement (shotberries) and to ensure attended optimal production (commercially profitable yield), diversification of oil quality, spreading harvest (Sibbett *et al*., 1992).

Changes in topography (altitude, location) within the region, directly affects climate condition (temperatures prevailing during the flowering period (March-April, rainfall), the pollination characteristics (opening flowers time, pollen quantities in the air) and the nature of the winds (hot, chergui) are a risk of environmental factors variability to be taken in account then of the determination of efficient and appropriate pollinizers cultivars and their trees distribution in the created orchards to minimize the parthenocarpic fruit development (shotberries) and changing market preference (Boulouha, 1986; Villemur, 1989; Sibbett *et al*., 1992; Msallem *et al*., 1996).

CONCLUSION

A greater variation between tested local and foreign varieties and local types of olive in the evaluated agronomical parameters, was recrded which have surely of origin a genetically determinism certainly represented by a variation in the genetic patrimony of each variety and local types. The evaluation of self-compatibility of studied varieties and local types is came an indispensable step in objective to create of new olive orchards, where it is necessary to consider the possible of self-compatibility and inter-compatibility between preserved varieties and local types and intended to be planted in monovarietal orchards or associated with more than one cultivar in orchards. Benefit cross-pollination constitute one of the factors able to increase the productivity of varieties and local types of olive and it is best to intersperse regularly into orchards (olive groves) at least three to four different efficacy pollinating cultivars (10% of trees) in order to assure better cross-pollination and to optimize fruit set (Lavee, 1997; Cuevas *et al*., 2001).

Finally this work, must be continued, constitutes a necessary step to preserve the main olive varieties and also to safeguard minor genotypes, in order to avoid a loss of genetic diversity as a as technical reference database for the olive orchards and selection of the most suitable varieties for diversification of its varietal assortment, the establishment of new specialized olive orchards, to promoting and to valorizing the origin and the qualitative characters of the competitive production of olive oil,directly sanded or transmitted on useful values and more prominent visible practical uses (artistic, ritualistic expressions and cultural symbols of identity) for the communication of the civilization of the olive oil expressed in nutrition, health, environment, agricultural highland, oleo tourism, material culture and immaterial richness in the appropriate areas to olive grown (Northwestern Morocco).

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