

Systematic, phytoecological and agronomic survey of citrus fruits weed flora in the North-eastern Morocco

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Abstract

A better knowledge about weeds species biology, ecology, impacts on crops, and their developmental stages, can be used to improve the control of weeds. Supporting the appropriate choice of weed control method in citrus orchards is the main objective of this systematic, phyto-ecological and agronomic study. Citrus fruits orchards weeds were collected in north-eastern Morocco and studied during the growing seasons 2007/2008 and 2008/2009. In the 150 weeds samplings, we have recorded a total of 331 species belonging to 50 botanical families. The *Asteraceae*, *Poaceae*, *Fabaceae*, *Brassicaceae* and *Caryophyllaceae* are the most predominant amounting to more than 50% of species. The most abundant life forms in the studied orchards are Dicotyledonous (80.9%), annuals (69.25%) and the Mediterranean floristic element (66.77%) which characterise this flora. The weeds noxiousness was assessed based on their predominance. Results obtained show that *Cynodon dactylon* (L.) Pers., *Cyperus rotundus* L. and *Convolvulus arvensis* L. are the most common species. This work provides a brief overview of several noxious weeds in the north-eastern Morocco in order to look for possible control strategies.

Keywords: Weeds, citrus orchards, North-eastern Morocco, Oriental.

Introduction

In Morocco, citrus fruits are grown on about 80000 hectares, covering 9.2% of the total fruit plantations. These orchards are the third most important after those of the olives and the almonds in terms of area and production (El-Otmani & Zouhri, 2004). Citrus fruit-producing regions are essentially the Souss, the Gharb, the Oriental (North east of Morocco), the Tadla and the Haouz. The annual production is close to 1500000 tons which place Morocco at the fifth rank of Mediterranean producers and the second exporter after Spain (Anonymous, 2004). In the Oriental, the surface

reserved to arboriculture is about 7%, half of it is under citrus fruits and are considered as the main crop production in the perimeter irrigated by the Moulouya. The citrus orchards represent 20% of the surface irrigated which corresponds to 44% (13800 hectares) of the arboreal surface with production of about 220 thousand tons annually. The contribution of this sector in the economy of the region is significant and provides more than two million working days (Anonymous, 2009).

To protect this national heritage, it is necessary to stimulate further the productivity and to think about a

continuous improvement of the production. However, some biotic and abiotic factors might slow down the development and the productivity of citrus fruits in the region. Among these factors are weeds which pose serious problems limiting the production (Cramer, 1967; Koch *et al.*, 1982; Terry, 1983; Fageiry, 1987). The problem of weeds in the citrus fruits orchards in the Oriental is mainly related to their evolution under the pressure of farming techniques, climatic conditions and time of their emergence, hence affecting the floral composition of the weed communities (Vecchio *et al.*, 1980; Maillet, 1981). In order to limit this problem, it is necessary to reason the weeds fight. This can be possible only by the perfect knowledge

of the floral and ecological aspects of the weeds flora, in particular for those of high negative impact. Therefore, the chief aim of the present work is the inventory of the weed flora of the citrus fruits orchards in the Oriental and the study of its phyto-ecological and agronomic aspects.

Material and Methods

The Oriental is divided into six provinces namely Oujda (the capital), Berkane, Figuig, Jerada, Tourirt and Nador. It is bounded on the north by the Mediterranean Sea, on the east by Algeria, on the south by the mid south of Morocco and on the west by the mid north of Morocco (fig.1).

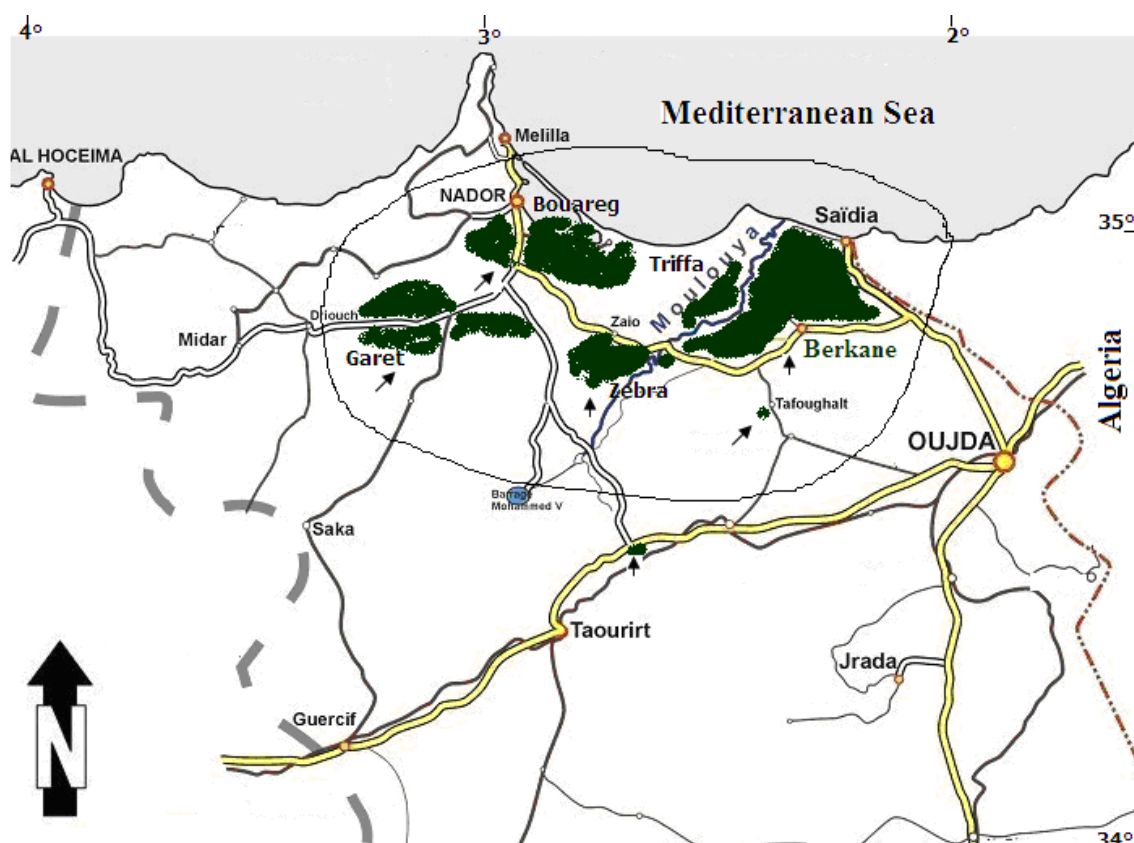


Figure 1. Location of the Oriental and overview of the study areas (dark green shown with arrows).

The Oriental is recognised as a semiarid to arid Mediterranean type

climate. The mean rainfall is irregularly distributed, ranging from 200 mm to

350 mm and characterised by huge variability between years and within the same year according to areas. The average annual number of rainy days is ranging from 35 to 50 days. The first rains fall in September and the last in June, however 60% to 75% of these rains fall between December and April. The monthly mean temperature is about 20°C, with an average low at 12°C and an average high at 28°C. The yearly thermal amplitudes vary between 10°C and 20°C (Anonymous, 2009).

The survey has been achieved with samples collected from all perimeters of the region, in order to have a precise idea on the weeds flora associated to citrus fruits. The orchard does not shelter homogeneous weeds vegetation because of the varied biotopes and farming techniques (Gounot, 1969). According to Maillet (1981), the field border sampling is the most adapted to this context. It permits to prospect a surface of 1 to 2 m², by moving down and moving back the sampling area lines until the number of species stop increasing.

In the 150 sampled fields, we have conducted the survey with the assistance of producers to collect precise information about local environmental factors that describe the sampling sites existing edaphic and geographical factors as well as the used maintenance techniques. For each harvested species, one notes the abundance-dominance indication, the dominant phenological stage and the distribution of the species within the field. In order to analyse weeds flora composition in citrus orchards, we have used the cover-abundance scale Braun-Blanquet method (1952) (Mueller-Dombois & Ellenberg, 1974; Moore & Chapman, 1986). The technique was used with minor modification in synonymic index of taxa present in

cultivated or controlled environments field in mid and west of Morocco by Boulet et al., (1989).

Results

Systematic aspect

On the basis of data collected in citrus fruits orchards in the Oriental, 331 weeds species have been found to belong to 50 botanical families. Monocotyledons represented by 6 families containing 36 gender and 63 species accounted for 19.1%. The dicotyledons represented by 42 families with 169 genders and 268 species accounted for 80.9% (Table1). *Ephedraceae* family was represented by only one specie, namely *Ephedra fragilis* L., *Chlamydosperm* *Spermatophyta*. The most abundant weeds botanical families in the surveyed orchards were as follows: *Asteraceae*, *Poaceae*, *Fabaceae*, *Brassicaceae*, *Caryophyllaceae*, *Apiaceae*, *Lamiaceae*, *Liliaceae* and *Boraginaceae*. We have recorded 291 species representing over 66% of the total specific number of species. In terms of number of species, *Asteraceae* and the *Poaceae* were the dominant ones with 52 (16.00%) and 46 species (13.90%) respectively.

Biological aspects

The species ethology was characterised using Raunkiaer's classification of life forms (1905 & 1934) which is based on the position relative to the surface that meristems occupy under unfavourable seasons. Table 2 shows that weeds of citrus fruits plantations in the Oriental include high level of therophytes with 226 species representing 68.3% of the total number of species, followed by hemicryptophytes with 48 species corresponding to 14.5%, geophytes with

43 species corresponding to 13.0%, 8 species of nanophanerophytes (2.4%), 4 species of chamaephytes and 2 parasitic species corresponding to 1.2% and

0.6% of the set of the inventoried species respectively.

Table 1. List of weeds families in the survey classified according to the number of species found.

Family	Number of species	Species percentage (%)	Family	Number of species	Species percentage (%)
<i>Asteraceae</i>	53	16.00	<i>Valerianaceae</i>	02	0.60
<i>Poaceae</i>	46	13.90	<i>Araceae</i>	02	0.60
<i>Fabaceae</i>	29	8.76	<i>Resedaceae</i>	02	0.60
<i>Brassicaceae</i>	24	7.25	<i>Plumbaginaceae</i>	02	0.60
<i>Apiaceae</i>	16	4.83	<i>Primulaceae</i>	02	0.60
<i>Caryophyllaceae</i>	15	4.53	<i>Zygophyllaceae</i>	02	0.60
<i>Lamiaceae</i>	14	4.23	<i>Crassulaceae</i>	02	0.60
<i>Liliaceae</i>	12	3.63	<i>Iridaceae</i>	01	0.30
<i>Borraginaceae</i>	10	3.02	<i>Guttiferae</i>	01	0.30
<i>Euphorbiaceae</i>	09	2.72	<i>Cucurbitaceae</i>	01	0.30
<i>Scrophulariaceae</i>	09	2.72	<i>Cyperaceae</i>	01	0.30
<i>Chenopodiaceae</i>	07	2.12	<i>Campanulaceae</i>	01	0.30
<i>Polygonaceae</i>	06	1.81	<i>Caprifoliaceae</i>	01	0.30
<i>Plantaginaceae</i>	06	1.81	<i>Asclepiadaceae</i>	01	0.30
<i>Geraniaceae</i>	06	1.81	<i>Anacardiaceae</i>	01	0.30
<i>Papaveraceae</i>	05	1.51	<i>Aizoaceae</i>	01	0.30
<i>Rubiaceae</i>	05	1.51	<i>Linaceae</i>	01	0.30
<i>Amaranthaceae</i>	04	1.21	<i>Orobanchaceae</i>	01	0.30
<i>Solanaceae</i>	04	1.21	<i>Oxalidaceae</i>	01	0.30
<i>Urticaceae</i>	04	1.21	<i>Portulacaceae</i>	01	0.30
<i>Convolvulaceae</i>	04	1.21	<i>Palmaceae</i>	01	0.30
<i>Malvaceae</i>	03	0.91	<i>Rhamnaceae</i>	01	0.30
<i>Rosaceae</i>	03	0.91	<i>Ephedraceae</i>	01	0.30
<i>Cistaceae</i>	03	0.91	<i>Meliaceae</i>	01	0.30
<i>Ranunculaceae</i>	03	0.91	<i>Verbenaceae</i>	01	0.30

Cosmopolites and sub-cosmopolites were moderately frequent (8.7%) as a result of a chemical weeding practices applied to citrus fruits, hence permitting the invasion of such a flora. Finally the survey has revealed the existence of 3.9% Moroccan, Algero-Moroccan and African endemic species.

Floral aspect and specific noxiousness

The number of species found in the surveyed citrus fruits orchards is ranging between 30 and 79 with an

Geographical origin

Geographical origin of species has been established according to the three manuscripts entitled the 'new flora of the desert and southern regions of Algeria' data (Quezel & Santa, 1962-1963), the 'ecology and distribution of native forage and pasture species in the arid regions of Morocco' (Nègre, 1961-1962) and the 'Moroccan plants catalogue' (Jahandiez & Maire, 1931-1934). Results obtained showed that weeds with bio-geographical distribution were the major group within the Mediterranean Basin accounted for 66.77% of the total. The result also showed that in the citrus fruits flora collected in the Oriental the presence of the northern element (14%), essentially the European and Eurasian one.

Table 2. Ethological types of citrus weeds flora in the Oriental.

Biological Type	Number of species	Species percentage (%)
Therophytes	226	68.28
Hemicryptophyts	48	14.50
Geophytes	43	13.00
Nanophanerophyts	8	2.41
Chamephyts	4	1.21
Parasites	2	0.60

average of 42 species in each surveyed orchards. Taking into account the abundance-dominance index of each species, we could assign for each of them a partial index of noxiousness (PIN) (Bouhache & Boulet, 1984). This index is obtained by transforming the abundance-dominance index into the average covering ratio (table 3). The calculation of partial index of noxious weeds species showed the existence of 11 ominous species because of their high partial noxiousness index in addition to their biological type. Therefore they are considered as highly destructive (table 3). Among these species are *Cynodon dactylon*. (L.) Pers., *Cyperus rotundus* L. and *Convolvulus arvensis* L. that were declared as the most noxious weeds which were highly destructive with respect to farm in different regions of Morocco (Berrichi, 1995; Wahbi & Taleb, 1995; Talibi, 1999; Taleb *et al.*, 1996; Bensellam *et al.*, 1997; Talibi, 1999; Taleb *et al.*, 2004; Chafik *et al.*, 2010). The annual plant (therophytes) *Malva parviflora* L., *Hordeum murinum* L., *Bromus rubens* L., *Polygonum aviculare* L., *Anagallis foemina* Millar., *Brachipodium dystachium* (L.) Beauv., *Erodium triangulare* (Forsk) Musch., *Chenopodium murale* L., *Urtica urens* L., are more frequent and can cause serious problems in citrus fruits orchards in the Oriental. Similarly, the Silverleaf Nightshade (*Solanum elaeagnifolium* Cav.), which is considered by the FAO as invasive plant in the Mediterranean regions (Taleb, 2009) is starting to cause serious problems in some citrus fruits orchards in the region.

Discussion

A systematic investigation undertaken in the Gharb valley of

Morocco revealed the presence of 216 species belonging to 47 botanical families (Bensellam *et al.*, 1997). The ratio of the number of monocotyledons species versus the number of species dicotyledons (M/D%) obtained in this study is 23.5%; it shows a meaningful floristic richness when compared with result obtained in orchards under other cultures types (Taleb & Maillet, 1994; Talibi, 1999; Saffour *et al.*, 1998; Taleb *et al.*, 2004; Zidane *et al.*, 2010). Among species counted in orchards of citrus fruits in the Oriental, we have noted the presence of the Silverleaf Nightshade (*Solanum elaeagnifolium* Cav.) which begins to become noxious in the region.

The most abundant weeds botanical families, having a Mediterranean biogeographical distribution area, occupy an important place within the Moroccan flora and show the ability to adapt different biotopes (Boulet *et al.*, 1989). Previous works in the Gharb, Haouz, Moulouya and Souss regions of Morocco showed that weeds citrus fruits flora were represented by 76.4%, 77%, 53% and 74.3% of annuals respectively in which 54%, 61%, 58% and 50% were with Mediterranean elements respectively (Talibi, 1999; Bensellam *et al.*, 1997; Taleb *et al.*, 1996; Wahbi & Taleb, 1995). *Asteraceae* and the *Poaceae* are considered as being the richest families in terms of species worldwide thanks to the high number of weed species (Watson & Dallwitz, 1992). It is worth mentioning that more than half of the recorded families (29 families) were represented by only 1 to 3 species, contributing hence to the enrichment and the diversification of the weed flora.

Results obtained concerning ethological types are in agreement with previous results which showed that therophytes

were the most abundant weed found in Morocco (Nègre, 1961-1962) and worldwide (Montegut, 1974). This was most probably due to farming practices adopted in the orchards. Geophytes adapt better to superficial ploughing practices as a result to their underground vegetative organs on the

one hand and to the herbicidal pressure on weeds flora on the other (Montegut, 1980; Loudiyi, 1985). Hemicryptophytes, chamephyts and nanophanerophytes characterise biotopes where farming practices are weak or eventually absent (Maillet, 1981).

Table 3. Composition of weeds species surveyed in citrus orchards in the Oriental indicating ranking as function of noxiousness.

Species	PIN	Life form
Group 1 : PIN > 1000		
<i>Cynodon dactylon</i> (L.) Pers.	5475	Geophyte
<i>Cyperus rotundus</i> L.	5420	Geophyte
<i>Convolvulus arvensis</i> L.	5340	Geophyte
<i>Malva parviflora</i> L.	5110	Therophyte
<i>Hordeum murinum</i> L.	5024	Therophyte
<i>Bromus rubens</i> L.	4998	Therophyte
<i>Polygonum aviculare</i> L.	4600	Therophyte
<i>Anagallis foemina</i> Millar.	4330	Therophyte
<i>Chenopodium murale</i> L.	3980	Therophyte
<i>Oxalis pes-caprae</i> L.	3770	Geophyte
<i>Urtica urens</i> L.	3670	Therophyte
<i>Paspalum paspalodes</i> (Michx) Scribn	3430	Geophyte
<i>Beta macrocarpa</i> Guss.	3110	Therophyte
<i>Bromus rigidus</i> . Roth.	2890	Therophyte
<i>Emex spinosa</i> (L.) Campd.	2512	Therophyte
<i>Poa annua</i> L.	1987	Therophyte
<i>Lolium rigidum</i> Gaudin.	1802	Therophyte
Group 2 : 500 < PIN < 1000		
<i>Medicago polymorpha</i> L.	988	Therophyte
<i>Bromus mollis</i> L.	918	Therophyte
<i>Plantago lagopus</i> L.	802	Hemicryptophyte
<i>Asphodelus fistulosus</i> L.	796	Therophyte
<i>Cardaria draba</i> (L.) Desv.	780	Geophyte
<i>Conyza cadensis</i> (L.) Cronq.	743	Therophyte
<i>Solanum nigrum</i> L.	640	Therophyte
<i>Misopates orantium</i> (L) Raphin	613	Therophyte
<i>Anagallis arvensis</i> L.	602	Therophyte
<i>Fumari agraria</i> Lag.	589	Therophyte
<i>Fumaria parviflora</i> Lam.	570	Therophyte
<i>Amaranthus retroflexus</i> L.	520	Therophyte
Group 3 : PIN < 500		
<i>Sonchus oleraceus</i> L.	447	Therophyte
<i>Phalaris minor</i> Retz.	433	Therophyte
<i>Papaver rhoeas</i> L.	402	Therophyte
<i>Melilotus sulcata</i> Desf.	342	Therophyte
<i>Convolvulus althaeoides</i> L.	313	Geophyte
<i>Glaucium corniculatum</i> (L.) J.H. Rudolph	294	Therophyte
<i>Calendula aegyptiaca</i> Desf.	241	Therophyte
<i>Erodium triangulare</i> (Forsk.) Musch.	241	Therophyte
<i>Brachypodium distachium</i> (L.) Beauv.	116	Therophyte

Such weeds are met in non-maintained fields or found in specific biotopes as is the case with orchards spread to nearby forests or rivers. Importantly enough, only two parasitic species were found.

The first one was present in some areas of the region as a result of the frequent use of infested manure which is *Cuscuta monogyna* Vahl.. The second is *Orobanche mutellii* F. W. Schultz., which was considered as accidental specie.

Geographical origin of species is in accordance with weeds floral position which is widely distributed throughout Morocco as reported in previous studies (Loudiyi, 1985; Taleb, 1989; Taleb & Maillet, 1994; Wahbi, 1994; Taleb, 1995; Talibi, 1999; Bensellam *et al.*, 1997; Taleb *et al.*, 2004; Chafik *et al.*, 2010).

The significant specific diversity may have appeared in fields as result of farming

techniques types, the soil type, the type and the quality of water irrigation, the nature of weeding and the ways how orchards are managed. The sustainable weeds invasion appeared under favourable field conditions because of the absence or the rarity of herbicidal treatment, especially during canopy management. The weeds problems in citrus fruits orchards in the Oriental are related to farming techniques which disturb dramatically weeds community floral composition (Maillet, 1981). Indeed, citrus orchards under frequent cover-crop show an abundance of vivacious species, such as *Convolvulus arvensis* L., *Convolvulus althaeoides* L., *Cyperus rotundus* L., *Cynodon dactylon* (L.) Pers. and *Oxalis pes-caprae* L. The pressure of this type of soil work favours the abundance of geophytes. In addition, orchards at rest or treated excessively with organic manure showed a floral richness with an increase of nitrophilous, namely *Malva parviflora* L., *Urtica urens* L., *Chenopodium murale* L., *Chenopodium album* L. and *Solanum nigrum* L.

Therophyte such as *Ammi majus* L., *Calendula arvensis* L., *Lamarckia aurea* (L.) Moench., *Melilotus sulcata* Desf., *Setaria verticillata* (L.) Beauv., were found in the newly installed orchards, whereas the rarely worked orchards showed a relatively rich flora which are *Aster squamatus* (Sprengel) Hieron., *Chrysanthemum coronarium* L., *Sisymbrium irio* L., *Echium horridum* Batt., *Conyza canadensis* (L.) Cronq., *Euphorbia peplus* L., *Plantago albicans* L., *Lamium amplexicaule* Cav., *Reseda alba* L. This kind of flora was sensitive to farming practices.

Conclusion

The surveyed citrus fruits orchards in the Oriental showed a rich

flora. The most predominant biological types were therophytes followed by hemicryptophytes and geophytes. Mediterranean species were very frequent and represented the two third of the recorded weeds flora. 17 weeds species were considered as the most noxious ones of which *Cynodon dactylon* (L.) Pers., *Cyperus rotundus* (L.), *Convolvulus arvensis* (L.) and *Oxalis pes-caprae* L. were geophytes which required a special control. These results demonstrated that systematic phyto-ecological and agronomic study of weeds in citrus fruits orchards in the Oriental provide the first step to find out the most noxious among them and thus choose an appropriate weed management plan in these areas.

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