Pea Fusarium Wilt Races in Western Algeria

AOUMRIA MERZOUG¹, LAKHDAR BELABID¹, MOKHTAR YOUCEF-BENKADA², FOUZIA BENFREHA¹ and BASSAM BAYAA³

¹Laboratory of Research on Biological Systems and Geomatics (LRSBG), Department of Agronomy, University of Mascara, Mascara, Algeria; ²Plant Protection Laboratory, University of Mostaganem, Mostaganem, Algeria; ³Faculty of Agriculture, University of Aleppo, Aleppo, Syria

Abstract

Merzoug A., Belabid L., Youcef-Benkada M., Benfreha F., Bayaa B. (2014): **Pea Fusarium wilt races in** western Algeria. Plant Protect Sci., **50**: 70–77.

The fungus *Fusarium oxysporum* f.sp. *pisi* (FOP), the pea wilt pathogen, causes appreciable yield losses under favourable environmental conditions in Algeria. Studies on the pathogen variability and distribution of races are essential to identify effective sources of resistance to this disease. In this study, a survey was conducted during the period 2007–2011 in four different agro-climatic zones. Pathogenic variability in 52 isolates of FOP, collected from different pea-growing areas of western Algeria, were evaluated using 7 genotypes as differential hosts. Results indicated that the disease was prevalent in all fields prospected and isolates obtained were assigned to Races 1, 2, 5 or 6 by their pathogenicity. It was found out that Races 1 and 2 were more common in all areas with 61.5 and 19.2%, respectively. This study is the first report of pea Fusarium wilt races distribution in Algeria.

Keywords: Fusarium oxysporum; physiological races; Pisum sativum; resistance

Pea (Pisum sativum L.) wilt, caused by Fusarium oxysporum f.sp. pisi Schlecht (Van Hall) Snyd. and Hans., has been reported wherever peas are grown commercially (KRAFT & PFLEGER 2001). The disease is often severe where short rotations with other crops are practiced. Under these conditions, when the pathogen has built up sufficient inoculum, and a susceptible cultivar is planted, severe crop losses occur (KRAFT 1995). Fusarium oxysporum f.sp. pisi (FOP) is a significant and destructive pathogen of field pea worldwide (HAGLUND & KRAFT 2001). The pathogen is soil-borne and survives as thick-walled chlamydospores, which remain viable in the soil for more than 10 years (KRAFT 1995). FOP penetrates pea roots and infects the vascular system at any growth stage (INFANTINO et al. 2006). Infected plants often show an orange or dark red discolouration in the vascular tissue of the root and lower parts of the stem. Above ground symptoms consist of leaves yellowing that wilt and curl downward during the flowering to pod-fill stages. Early infection often results in seedling death, which may be obscured by the growth of adjacent plants. However, wilted

mature plants are easily seen scattered throughout the field. The disease incidence may be reduced by using extended crop rotations and early planting, but the most practical and cost-effective management strategy is the use of resistant cultivars (HAGLUND & KRAFT 2001).

FOP is known for its pathogenic variability (KRAFT 1995). In addition, FOP is continually evolving, with new variants of the pathogen emerging (KRAFT & PFLEGER 2001). Eleven races of the pathogen have been described; however, considerable disagreement exists on races classification (NEUMANN & XUE 2002). The pathogen was named Race 1 of FOP Schl. (van Hall.) Snyd. and Hans. in 1935, Snyder described a new race of *F. oxysporum* that was capable of causing wilting to plants resistant to Race 1, and they labelled the pathogen Race 2. The disease was called "nearwilt" because it appeared later in the growing season, often only at full pod development. Plants infected with Race 2 are most often scattered throughout the field rather than being concentrated in specific areas as with Race 1. In addition, Race 2 is most prevalent in coarser-textured soils when soil temperatures are near 25°C. Because symptoms caused by the Race 2 pathogen do not usually occur until plant maturity, the likelihood of seed transmission is greatly increased. In 1970; Race 5 was described in north-western Washington (HAGLUND & KRAFT 1970), where all commercial cultivars resistant to Races 1 and 2 were susceptible. Because of the short crop rotations and favourable climate in that area for wilt evolution, a new race of wilt was again described from western Washington, which was pathogenic on cultivars and breeding lines resistant to Races 1, 2, and 5, and was named Race 6 (HAGLUND & KRAFT 1979). Races 1 and 2 occur worldwide, while Races 5 and 6 have so far been important only in western Washington State, USA (INFANTINO et al. 2006; BANI et al. 2011).

The pathogenicity of Races 1, 2, 5, and 6 of FOP can be detected by their reaction on the differential varieties. The disease reaction of these differentials is based on a resistant response (no observable disease) and a susceptible reaction (dead or severely stunted chlorotic plants). Different screening methods for FOP resistance have been described although most of them only consider the disease incidence or the proportion of symptomless plants to classify accessions as resistant or susceptible (SHARMA et al. 2010). Classification of isolates of FOP based on host-pathogen interactions is governed by the genetic makeup of both the host and pathogen (KRAFT 1995). Four races of FOP are recognised based on differential pathogenicity on pea cultivars (Mc-CLENDON et al. 2002).

As for many soil-borne pathogenic fungi, the use of fungicides is not necessarily effective in controlling Fusarium wilt (SHARMA *et al.* 2010). As a consequence, control of this disease is achieved mainly by integration of different disease management procedures including agronomic and farming practices, soil disinfestation (MOMMA *et al.* 2010), biocontrol (ALABOUVETTE *et al.* 2009), and breeding for resistance (SHARMA *et al.* 2010).

The aim of the study was to identify and evaluate the importance and frequency of pea wilt disease, characterise physiological races of FOP and their geographical distribution in western Algeria.

MATERIAL AND METHODS

Survey and collection of isolates. The surveys were conducted from January to June in four different agro-climatic zones in western Algeria (coastal plains, interior plains, the High Plateaus, and the Sahara) (Table 1). Several pea fields were surveyed during the campaigns 2007-2011 at different stages of plant growth (seedling stage, flowering, and podformation). At each site (area), the percentage of diseased plants was calculated; the various symptoms were described as well as the stage of the plant was recorded (RANA et al. 2009). From each field, 10 plants showing wilting and yellowing symptoms were taken to be fully analysed in the laboratory. Wilt-affected plants were collected from all regions. They were dried in paper towels and transported to laboratory for pathogen isolation. Isolations were made from the rhizosphere, root, and stem pieces (five per plant). The pathogens associated with pea wilt samples were isolated, cultured on PDA, and incubated at 25°C for 7 days (Belabid & Fortaz 2002). The isolation method from the rhizosphere soil was the plate dilution method for the soils that easily detach from the roots. Fungi were purified by single sporing and identified (WATANABE 2002; Leslie & Summerell 2006).

To confirm the identity of FOP, the pathogenicity test of each isolate was performed by inoculating a susceptible variety (Little Marvel) as described by HAGLUND (1989).

Differential pea genotypes. The pathogenicity of Races 1, 2, 5, and 6 of FOP can be distinguished by their reaction on a set of differential lines. The differential lines of pea were originally obtained from the Plant Germplasm Introduction and Testing Research Station in Pullman, Washington, USA and the Morden Research Station, Agriculture and Agri-Food Canada. Seven differential lines of pea were used to determine the races of 52 FOP isolates. Race 1 causes wilting to the cultivar Little Marvel; Race 2 causes wilting to Little Marvel, Darkskin Perfection, and WSU 28, but not to New Era, New Season, WSU 23, and WSU 31; Race 5 causes wilting to all the above except WSU 23, WSU 28, and WSU 31; Race 6 causes wilting to all the above except New Season, WSU28, and WSU 31 (HAGLUND 1984).

Inoculum production. FOP isolates used for the determination of races are most aggressive on the susceptible variety. All cultures were single spored on 2% water agar, then increased on fresh PDA. To produce the inocula, the selected isolates were grown for 4 days on water agar at 12 h light (25°C) and 12 h dark (20°C) cycle. The cultures were then transferred to liquid sucrose medium (PS: potato extract from 200 g potato and 15 g sucrose) and incubated for 10 days on an orbital shaker at 200 rpm at room temperature (22°C). Conidia were recovered

Table 1. Frequencies	(%) of pathogenic fungi	species isolated fror	n diseased pea over	the 2007–2011	period by agro
climatic zone					

Regions	Departments	Wilt	F. oxysporum	FOP	F. solani	<i>Rhizoctonia</i> sp.	Fusarium sp.	Ascochyta sp.	Cladosporium sp.	Alternaria sp.	Stemphylium sp.	Sclerotinia sp.	Pythium sp.
	Ain Temouchent	27.93	48.50	38.50	19.00	9.25	10.16	18.20	30.05	8.70	14.60	0.77	10.25
Coastal	Mostaganem	7.30	27.37	17.37	2.42	5.35	8.60	16.46	25.42	3.86	18.35	0.50	5.25
plains	mean	17.62	37.94	27.94	10.71	7.30	9.38	17.33	27.74	6.28	16.48	0.64	7.75
	Tlemcen	11.02	44.50	31.45	21.00	10.20	17.50	15.35	6.20	11.50	5.66	3.75	4.02
	Cheliff	16.58	5.20	7.20	12.75	34.58	7.20	13.70	0.00	5.50	3.40	3.00	0.25
Interior	Relizane	33.98	22.35	18.35	19.60	16.20	12.25	2.75	2.34	9.37	5.58	2.50	0.66
plains	Mascara	14.93	15.38	12.38	20.61	1.53	20.35	11.53	12.30	7.69	4.16	4.08	3.07
	Sidi Belabes	16.58	19.25	15.25	12.80	15.30	14.00	14.56	5.20	10.20	4.12	1.30	0.77
	mean	18.62	21.34	16.93	17.35	15.56	14.26	11.58	5.21	8.85	4.58	2.93	1.75
High Plateaus	Tiaret	14.70	14.00	13.30	25.00	9.00	9.60	2.90	0.00	2.70	0.00	3.20	0.00
	Saida	9.66	12.78	6.20	22.60	9.75	12.06	5.85	2.15	6.05	2.00	3.60	0.82
	mean	12.18	13.39	9.75	23.80	9.38	10.83	4.38	1.08	4.38	1.00	3.40	0.41
Sahara	Adrar	13.75	32.50	10.50	20.00	2.05	12.75	1.25	0.00	2.75	0.00	0.00	0.00
	mean	13.75	32.50	10.50	20.00	2.05	12.75	1.25	0.00	2.75	0.00	0.00	0.00
Total mean		15.54	26.29	16.28	17.97	8.57	11.81	8.63	8.50	5.56	5.51	1.74	2.48

Wilt – frequencies (%) of yellowing-wilting symptom in all fields prospected; FOP – frequencies (%) of forma specialis *pisi* among *Fusarium oxysporum* isolated

and adjusted to a concentration of approximately 5×10^6 conidium/ml by the aid of a haemocytometer (HAGLUND & KRAFT 2001). The spores were tested for germination and viability on 2% water agar.

Inoculation and disease scoring. The pathogenicity of 52 isolates of FOP and one non-pathogenic isolate was determined by inoculating each of the differential lines. Seeds of each test line were surfacedisinfested with a 2% sodium hypochlorite solution for 5 min before planting them in autoclaved vermiculite, and inoculated using the root prune and dip technique (NEWMAN & XUE 2002). When seedlings grown in vermiculite were 10-days old and had produced 4-5 nodes, they were inoculated as follows: plants were pulled out from vermiculite, and the roots were cut at approximately 4 cm below the cotyledon attachment, dipped into the inoculum to cover the cotyledons for 5 min and then transplanted into pots containing soil-sand-peat (1:1:1, v/v/v); plants were watered as needed. Control plants were treated in the same way and were immersed in sterile water. Greenhouse temperatures were maintained at 20-24°C, and all plants were grown under available light. Susceptible lines died 21-28 days after inoculation (NEWMANN & XUE 2002; BANI et al. 2011). Plants were visually assessed at the 10-12 nodes stage, 28 days after inoculation, using the following 0-5 rating scale: 0 = no symptoms; 1 =chlorosis or wilting of one basal leaf, pale yellow green, downward curling of leaf margins and stipules; 2 = chlorosis or wilting of some basal leaves, no stunting; 3 = chlorosis or wilting of several basal leaves, slight stunting and yellowing of most leaves; 4 = chlorosis or wilting of most leaves, heavy stunting and drying of lower leaves, and 5 = death of the seedling. The scale was modified (NEWMANN & XUE 2002). Values were averaged for the four plants per pot and three pots were used for each isolate/ line combination. Disease scores of 0, 1, and 2 were considered resistant (R) responses, while scores of 3, 4, and 5 were considered susceptible (S). After the evaluation of the reaction of the differential lines, the isolation of pathogen was performed in order to confirm the nature of the symptoms.

RESULTS

Surveys that were carried out in the four different agro-climatic zones in western Algeria have identified the presence of wilting symptoms; plant symptoms consisted in chlorotic leaflets, which curl downward and become flaccid. The plant eventually wilts and turns a yellowish-brown colour. Often, the above- and below-ground vascular system turns a light yellow to brick-red colour and the lower subterranean portion of the stem becomes larger than normal. The disease can attack pea plants at any growth stage, we have observed it attacking plants at a very young stage. In growing regions, it appears to be worse during hotter periods of the growing season, early infections may cause plant death; late infections reduce the number of harvests.

Significant differences in the frequencies of the disease are observed between vegetative stages of the plant and the regions, there is an increase in the percentages of diseases in all areas with the age of the plant (MERZOUG *et al.* 2009, 2011). Yellowing-wilting symptom is observed during all stages of the plant growth, in the majority of fields and in all the years of prospecting with frequencies ranging 7.30–33.98% for the entire western region of Algeria. Pea culture at the internal plains is the most vulnerable with 18.61% (33.98% being the maximum in Relizane) (Table 1).

The study of the microflora showed significant variation, quantitatively and qualitatively, in the fungal population in pea rhizosphere. Some number of pathogens was associated with wilting and yellowing symptoms. The most dominant species for all regions surveyed was F. oxysporum with an average of 26.29%, followed by F. solani (17.97%). The coastal plains have the highest percentage of F. oxysporum (37.94%), in the High Plateaus F. solani predominated (23.80%). In addition to the species of Fusarium, the analysis allowed us to detect a significant number of fungal species that are located at the rhizosphere and stem of diseased plants with variable frequencies from one region to another. The Sahara is the most species-poor area quantitatively as well as qualitatively (Table 1).

The first symptoms of artificial inoculation on the susceptible line with isolates of *F. oxysporum* collected from different fields surveyed appeared after 7 days, the plants were completely destroyed between the 10th and 26th day, the symptoms were similar to those described in the field. Similarly, cultures derived from re-isolations made from inoculated seedlings were

morphologically identical to their respective parent cultures. We confirmed the presence of f.sp. *pisi*. Among isolates of FO, 16.28% proved to be forma specialis *pisi* (Table 1). From more than one hundred isolates characterised, 52 isolates were selected for the study of races characterisation based on regions and cultural variability.

Characterisation of races of FOP. Variability in cultural characteristics which was observed among isolates varied from sparse to abundant, whereas the mycelium in culture remained cottony-floccose, cottony-dense, aerial, felted or mucous (ropy). The majority of the isolates had abundant and floccose cultural growth. Colour of the mycelium also varied from white, whitish pink, whitish yellow, dark purple, light purple to purplish red. The results obtained show the predominance of aerial type followed by a cottony type with light pigmentation (white or purple), there was also the presence of mucous (ropy) types with mauve pigmentation which becomes increasingly dark (dark purple or violet to black) in the medium (Table 2).

Occurrence and distribution of races of FOP. Current classification of pathogen races is based on host response using differential lines and defined reproducible inoculation procedures. Wilt ratings were taken 5 weeks following planting of pea seeds and 3-4 weeks following inoculation with cultures of FOP, ratings were based on the number of plants killed or expressing typical symptoms. In our study the majority of susceptible plants were killed by the isolates of FOP. Results obtained showed the presence of four races (1, 2, 5 and 6) of FOP, which have been identified in western regions of Algeria. The levels of the races found in western Algeria from isolates collected from infected peas plants are shown in Table 2. Races 1 and 2 were more common in all areas with 61.47 and 19.2%, respectively. Race 6 is represented by 11.52%, it is absent at the Sahara. For Race 5, only two isolates (A21 and M42) were identified in coastal plains where the pea crop is early sown compared to other regions.

In addition to the four previously described races, two new or unknown types of FOP were recovered, they were identified in the interior plains only. Although these two unknowns (UR1 – isolate C24 and UR2 – isolate SB5) were similar in cultural morphology to Race 1, they were quite different in their reactions with the differential lines and may, therefore, be new races. Their differential reactions require further study before any definitive descriptions can be made. The isolate UR1 caused the death of all differential lines. For isolate UR2, only two

isolate Keginis Depariment Alia Ain Ain Toba-1 2010 stem cottony-floccose whitish RI A1 Ain Toba-2 2010 stem cottony-floccose whitish RI A16 Ain Benisaf-1 2010 stem cottony-floccose whitish RI A17 Coastal Benisaf-2 2010 stem cottony-floccose whitish RI A12 coastal Benisaf-3 2010 stem cottony-floccose whitish RI A22 plains Bonguint 2009 stem aerial dark purple RS M44 Mostaganem Bonguint 2009 stem aerial whitish pink RI T129 Tlencen Sebdoul 2010 rhizosphere cottony-floccose whitish purple RI T132 Tlencen Aine finae 2009 root field whitish purple RI R12 <th>No. of</th> <th>Dogiong</th> <th>Donoutro on ta</th> <th>Location of</th> <th>Dates of</th> <th>Isolated</th> <th>Cultural va</th> <th>Dacor</th>	No. of	Dogiong	Donoutro on ta	Location of	Dates of	Isolated	Cultural va	Dacor	
A1 A1 Ain Tolba-1 2010 stem cottom-faccose whitish yellow R1 A16 Ain Tolba-2 2011 stem cottom-faccose whitish yellow R1 A19 Temouchent Benisaf-3 2010 stem cottom-faccose whitish R1 A21 plains Benisaf-4 2010 stem cottom-faccose whitish R1 A22 plains Benisaf-4 2010 stem aerial datr purple R5 M44 Plains Farnaka 2009 stem aerial whitish plain R1 M45 Anonyme-1 2007 rot cottomy-faccose whitish plain R1 M45 Nanoyme-2 2007 rot cottomy-faccose whitish plain R1 T127 Sebdou2 2010 rhizosphere cottomy-faccose whitish plain R1 T128 Temcen Ouled Mimoune2 2010 rhizosphere cottomy-faccose whitish plain R1 T129 Aine Mrane-1 2009 stem aerial light purple R1 C21 Chef Aine Mrane-2 2009 stem aerial light purple	isolate		Departments	sampling areas collection		portion	morphotype	pigment	Kaces
A2 Ain Tolba-2 2011 stem cotony-floccose whitish yellow R1 A16 Ain Benisaf-1 2010 stem cottony-floccose whitish R6 A18 plains Benisaf-2 2010 stem cottony-floccose whitish R1 A22 plains Benisaf-3 2010 stem cottony-floccose whitish R1 A23 Mostaganen Benisaf-4 2010 stem aerial light purple R5 M44 Mostaganen Bouguirat 2009 stem aerial whitish R1 M45 Sebdou1 2010 rhizosphere cottony-floccose whitish purple R6 T129 Termenen Ouled Mimoune1 2010 rhizosphere cottony-floccose whitish purple R1 T131 Ouled Mimoune1 2009 stem aerial light purple R1 C24 Culef Aine Mrane-1 2009 stem aerial light purple R1 C31 Culef Aine Mrane-1 2009 root mucous light purple R2 R24 Aine Mrane-1 2009 stem aerial light purple R1 <td>A1</td> <td></td> <td></td> <td>Ain Tolba-1</td> <td>2010</td> <td>stem</td> <td>cottony-floccose</td> <td>whitish</td> <td>R1</td>	A1			Ain Tolba-1	2010	stem	cottony-floccose	whitish	R1
A16 Ain Tennouchent Benisaf-1 2010 root aerial whitish 86 A19 outsid Benisaf-2 2010 stem cottony-floccose whitish R5 A21 plains Benisaf-4 2010 stem cottony-floccose whitish R5 M42 Benisaf-5 2010 stem cottony-floccose whitish R1 M43 Mostaganem Farnaka 2009 stem 	A2			Ain Tolba-2	2011	stem	cottony-floccose	whitish yellow	R1
Alls Ann Temouchent Benisaf-2 2011 stem cottony-dense dark purple R2 A21 plains Benisaf-4 2010 stem cottony-dense whitish R1 A22 Benisaf-5 2010 stem aerial light purple R5 M43 Mostaganen Benisaf-2 2009 stem aerial light purple R5 M44 Mostaganen Bouguirat 2009 stem aerial whitish R1 M45 Sebdoul 2010 ribrosphere cottony-doccese whitish pullew R1 T1.29 Sebdoul 2010 stem felted whitish pullew R1 T1.31 Ouled Mimoune3 2011 ribrosphere cottony-doccese whitish pullew R1 T1.32 Chief Aine Mrane-1 2009 stem aerial light purple R1 T1.32 Chief Aine Mrane-3 2009 stem aerial light purple <	A16		Ain	Benisaf-1	2010	root	aerial	whitish	R6
Al9 constal Remination Benisaf-3 2010 stem cottony-florcose whitish Ri A21 plains Benisaf-5 2010 stem aerial dark purple R6 M42 Farnaka 2009 stem aerial dark purple R2 M44 Mostaganem Farnaka 2007 root cottony-denes whitish R1 T124 Anonyme-1 2007 root cottony-denes whitish R1 T124 Sebdou1 2010 rikers aerial light purple R6 T127 Sebdou2 2010 rikrosphere cottony-doccose light purple R6 T123 Ouled Mimoune2 2010 rikrosphere cottony-doccose light purple R1 T132 Ouled Mimoune3 2011 stem eifeld whitish R1 R20 Chlef Aine Mrane-1 2009 root mucous dark purple R2	A18		Alli Tomouchont	Benisaf-2	2011	stem	cottony-dense	dark purple	R2
A21 Constant plains Benisaf-4 2010 stem felted whitish R5 A22 Farnaka 2009 stem aerial light purple R6 M43 Mostaganem Bouguirat 2009 stem aerial light purple R2 M44 Mostaganem Bouguirat 2007 stem aerial light purple R6 M45 Anonyme-1 2007 stem aerial light purple R1 T124 Sebdou1 2010 rhizosphere cottony-floccose whitish plak R1 T129 Temcen Ouled Mimoune1 2010 rhizosphere cottony-floccose whitish purple R1 T131 Ouled Mimoune3 2011 rhizosphere cottony-floccose whitish purple R1 T132 Ouled Mimoune3 2010 rhizosphere cottony-floccose whitish R1 C24 Aine Mrane-1 2009 rott mecous light purple R1 R2 Aine Krane-3 2009 rott mecous dark purple R2 R24 Aine Krane-3 2009 rott mecous dark purple R2 R24	A19	1	Temouchem	Benisaf-3	2010	stem	cottony-floccose	whitish	R1
A22 pulants Benisaf-5 2010 stem aerial light purple R6 M43 Mostaganem Farnaka 2009 stem aerial light purple R5 M44 Mostaganem Bouguirat 2007 stem aerial whitish pink R1 M45 Sebdou1 2007 stem aerial whitish pink R1 T128 Sebdou2 2010 rhizosphere cottony-floccose hitish pink R1 T129 Ouled Mimoune2 2010 rhizosphere cottony-floccose whitish pink R1 T131 Ouled Mimoune3 2010 rhizosphere cottony-floccose whitish pink R1 C21 Chlef Aine Mrane-1 2009 rem aerial light purple R1 C24 Aine Mrane-3 2010 rotto mucous dark purple R1 C24 Aine Mrane-3 2009 rott mucous dark purple R2 R26 </td <td>A21</td> <td>coastal</td> <td></td> <td>Benisaf-4</td> <td>2010</td> <td>stem</td> <td>felted</td> <td>whitish</td> <td>R5</td>	A21	coastal		Benisaf-4	2010	stem	felted	whitish	R5
M43 Farnaka 2009 stem aerial light purple R5 M43 Mostaganen Bouguirat 2009 stem felted dark purple R5 M45 Anonyme-1 2007 stem aerial light purple R1 TL24 Sebdou1 2010 rhizosphere cottony-floccose whitish yellow R1 TL28 Sebdou2 2010 rhizosphere cottony-floccose whitish purple R6 TL29 Ouled Mimoune3 2011 rhizosphere cottony-floccose whitish pink R1 TL31 Ouled Mimoune4 2010 rhizosphere cottony-floccose whitish pink R1 C21 Aine Mrane-3 2009 stem aerial light purple R1 R26 Aine Mrane-3 2009 root mucous light purple R2 R27 Aine Frahma-1 2009 root mucous light purple R3 R28 Inierrahma-1 2009<	A22	plains		Benisaf-5	2010	stem	aerial	dark purple	R6
M43 Mostagamem Bouguirat Anonyme-1 2007 rote cottony-dense whitish pink R1 M45 Anonyme-1 2007 rote catral whitish pink R1 T1.24 Sebdou1 2010 ritzosphere cottony-dense whitish pink R1 T1.27 Sebdou2 2010 ritzosphere cottony-floccose whitish purple R6 T1.28 Ouled Mimoune2 2010 ritzosphere cottony-floccose whitish pink R1 T1.31 Ouled Mimoune3 2011 ritzosphere cottony-floccose whitish pink R1 C20 Aine Mrane-3 2009 rote mectony-floccose whitish R1 C24 Aine Mrane-3 2009 rote mectony-floccose whitish R1 R26 Aine Mrane-3 2009 stem aerial whitish R1 R26 Mazouna-1 2009 stem aerial whitish R1 R28 Main Errahma-1 <td>M42</td> <td></td> <td></td> <td>Farnaka</td> <td>2009</td> <td>stem</td> <td>aerial</td> <td>light purple</td> <td>R5</td>	M42			Farnaka	2009	stem	aerial	light purple	R5
M44 Mostaganem Anonyme-1 2007 root cottony-decase whitish pink R1 M45 Anonyme-2 2007 stem aerial ight purple R6 T127 Sebdou1 2010 rhizosphere cottony-doccese whitish purple R6 T128 Ouled Mimoune1 2010 rhizosphere cottony-doccese whitish purple R1 T131 Ouled Mimoune2 2011 rhizosphere cottony-doccese whitish purple R1 T132 Ouled Mimoune3 2011 rhizosphere cottony-doccese whitish purple R1 C24 Aine Mrane-1 2009 root mucous light purple R1 R27 Aine Mrane-3 2010 rhicosphere rotony-doccese whitish R1 R38 interrior plains Ain Errahma-1 2009 root mucous dark purple R2 R43 Mascara Elbordj 2009 stem aerial whitish	M43		M	Bouguirat	2009	stem	felted	dark purple	R2
M45Anonyme-2207stemaerialwhitishR1TL27Sebdou12010ritzospherecottony-floccoswhitish yellowR1TL28Ouled Mimoune12010rhizospherecottony-floccoswhitish yellowR1TL31Ouled Mimoune22010rhizospherecottony-floccoswhitish yellowR1T132Ouled Mimoune32011rhizospherecottony-floccoswhitish yellowR1C20Aine Mrane-12009rootmucouslight purpleR1C21ChlefAine Mrane-32009rootmucouslight purpleR1C24Aine Mrane-32009rootrottony-floccosewhitish pinkR1R27SidiMhamed BenAli2009rootmucousdark purpleR1R28Mazouna-12009rootmucousdark purpleR1R31Ain Errahma-12009stemcottony-floccosewhitishR1R32MascaraElgattar2009stemaerialwhitishR1R31MascaraElgattar2009stemaerialwhitishR1R32MascaraFighennif2007ritzosphererottony-floccosewhitishR1R33MascaraElgattar2009stemaerialwhitishR1R43MascaraSifisef-12009rottony-floccosewhitishR1R44MascaraSifisef-2 <td>M44</td> <td></td> <td>Mostaganem</td> <td>Anonyme-1</td> <td>2007</td> <td>root</td> <td>cottony-dense</td> <td>whitish pink</td> <td>R1</td>	M44		Mostaganem	Anonyme-1	2007	root	cottony-dense	whitish pink	R1
T124 Sebdou1 2010 stem aerial light purple K6 T127 Sebdou2 2010 rhizosphere cottony-floccose whitish pellov R1 T128 Ne Ouled Mimoune2 2010 stem felted whitish pellov R1 T131 Ouled Mimoune2 2011 rhizosphere cottony-floccose whitish pellov R1 T132 Ouled Mimoune3 2011 rhizosphere cottony-floccose whitish purple R1 C20 Aine Mrane-1 2009 root mucous light purple R1 C21 Chef Aine Mrane-2 2009 stem aerial light purple R1 R26 Mazouna-1 2009 root mucous dark purple R2 R28 interior R1 Aine Errahma-1 2009 stem aerial light purple R1 R31 plains R4 Aine Errahma-2 2010 stem aerial whitish R1 R32 Mascara Elgattar 2009 stem aerial whitish R1 R33 Mascara Marounia-1 2009 stem aerial whitish <td< td=""><td>M45</td><td></td><td></td><td>Anonyme-2</td><td>2007</td><td>stem</td><td>aerial</td><td>whitish</td><td>R1</td></td<>	M45			Anonyme-2	2007	stem	aerial	whitish	R1
TL27Sebdou22010rhizosphere rhizospherecottony-floccose cottony-floccoseikits ikits ikits pellowR1TL28 Culed Mimoune12010stem rhizospherecottony-floccose cottony-floccoselight purple whitish pillowR1TL31 Culed Mimoune32011rhizosphere rhizospherecottony-floccose rhizospherewhitish pillowR1TL32 	TL24			Sebdou1	2010	stem	aerial	light purple	R6
T1.28 Themen Ouled Mimoune1 2010 rhizosphere cottony-floccose light purple R1 T1.21 Ouled Mimoune2 2010 stem felted light purple R1 T1.32 Ouled Mimoune4 2011 rhizosphere cottony-floccose whitish pikl R1 C20 Aine Mrane-1 2009 rot mearial light purple R1 C21 Chlef Aine Mrane-3 2010 rhizosphere cottony-floccose whitish pikl R1 C24 Aine Mrane-3 2010 rhizosphere cottony-floccose whitish pikl R1 R26 Mazouna-1 2009 rot mecous dark purple R2 R27 Fligattar 2009 stem aerial light purple R1 R31 interior Pallel 2009 stem aerial whitish R1 R32 Ain Errahma-1 2009 stem aerial whitish pikl R1 R32 Mascara Elbordj 2008 stem aerial whitish pikl R1 R34 Mascara Elbordj 2009 stem aerial light purple R2 Ma	TL27			Sebdou2	2010	rhizosphere	cottony-floccose	whitish yellow	R1
TL29Hencen Ouled Mimoune22010stem feltedfeltedlight purpleR1TL31Ouled Mimoune32011rhizosphere rottocotton-foccosewhitish pinkR1C20Aine Mrane-12009rottmucouslight purpleR1C21ChlefAine Mrane-22009stemaeriallight purpleR1C24Aine Mrane-32010rhizospherecottony-floccosewhitish pinkR1R17SidiMhammed Ben Ali2009rootmucousdark purpleR1R26Mazouna-12009rootmucousdark purpleR1R27Flgatar2009stemaeriallight purpleR1R28interior plainsRelizaneMazouna-22010stemcottony-floccosewhitishR1R31MascaraMazouna-22010rootaerialpurplish redR6Ma49MascaraElbordj2009stemaerialdark purpleR2Ma13MascaraElbordj2009rizospheremucousdark purpleR2Ma143MascaraElbordj2009stemaeriallight purpleR1Sb1MascaraElbordj2009stemaerialwhitish nikR1Sb3Sifisef-22009rootfeltedwhitishR1Sb4Ratara-22010stemfeltedwhitish nikR1Sb5 <td< td=""><td>TL28</td><td></td><td></td><td>Ouled Mimoune1</td><td>2010</td><td>rhizosphere</td><td>cottony-floccose</td><td>light purple</td><td>R6</td></td<>	TL28			Ouled Mimoune1	2010	rhizosphere	cottony-floccose	light purple	R6
TL31Ouled Mimoune32011rhizospherecottony-floccosewhitish pinkR1TL32Ouled Mimoune42011stemfeltedwhitish pinkR1C20Aine Mrane-12009rotmucouslight purpleR1C21ChlefAine Mrane-32010rhizospherecottony-floccosewhitishR1C24Aine Mrane-32010rhizospherecottony-floccosewhitishR1C24Mazouna-12009rotfeltedwhitishR1R17RelizaneMazouna-12009rotmucousdark purpleR1R26Mazouna-12009stemcottony-densewhitishR1R28interiorFelizaneMazouna-22010stemcottony-densewhitishR1R31PlainsAin Errahma-12009stemaerialwhitishR1R32Ain Errahma-12009stemaerialdark purpleR2Ma6MascaraElbordj2007ritospheremucousdark purpleR2Ma13MascaraElbordj2009stemaerialwhitishR1Sb1Sidi BelabesSfisef-12009stemaeriallight purpleR1Sb1Lamtar-22010rhizospheremucousviolet tolackR2Sb1Lamtar-22009stemaeriallight purpleR1Sb1Lamtar-22009st	TL29		Hemcen	Ouled Mimoune2	2010	stem	felted	light purple	R1
T1.32 Ouled Mimoune4 2011 stem felted whitish yellow R1 C20 Aine Mrane-1 2009 root moucous light purple R1 C21 Chlef Aine Mrane-2 2009 stem aerial light purple R1 C24 Aine Mrane-3 2010 rhizosphere cottony-floccose whitish pink R1 R26 Razouna-1 2009 root mucous dark purple R2 R27 Elgatar 2009 stem aerial light purple R1 R28 interior Plains Mazouna-1 2009 stem cottony-dense whitish nk R1 R28 interior Yallel 2009 stem cottony-dense whitish nk R1 R31 Mascara Tighennif 2007 stem cottony-doccose whitish pink R1 R413 Mascara Elbordj 2008 stem aerial dark purple R2 Ma13 Mascara Elbordj 2009 stem aerial	TL31			OuledMimoune3	2011	rhizosphere	cottony-floccose	whitish pink	R1
C20Aine Mrane-12009rootmucouslight purpleR1C21ChlefAine Mrane-22009stemaeriallight purpleR1C24Aine Mrane-32010rhizospherecottony-floccosewhitish pinkR1C24Sidi/Mhammed Ben Ali2009rootfeltedwhitish pinkR1R26Mazouna-12009stemaeriallight purpleR2R27RelizaneMazouna-22010stemcottony-floccosewhitishR1R31PlainsRelizaneMazouna-22010stemcottony-floccosewhitishR1R31PlainsRain Errahma-12009stemcottony-floccosewhitishR1R31Ain Errahma-12009stemcottony-floccosewhitishR1R33MascaraElbordj2008stemaerialdark purpleR2Ma13MascaraElbordj2009rottofeltedwhitishR1M315MascaraElbordj2009stemaeriallight purpleR2M313MascaraSifsef-12009stemaeriallight purpleR1Sb1Sidi BelabesSifsef-22009stemaeriallight purpleR1Sb1Lamtar-22010stemfeltedwhitishR1Sb1Lamtar-22009stemfeltedlight purpleR1Sb1Lamtar-2<	TL32			Ouled Mimoune4 2011 stem felted		whitish vellow	R1		
C21ChlefAine Mrane-22009stemaeriallight purpleR1C24Aine Mrane-32010rhizospherecottony-floccosewhitishUR1R17SidiMhammed Ben Ali2009rootfeltedwhitish pinkR1R26Mazouna-12009rootmucousdark purpleR2R27Flgattar2009stemaeriallight purpleR1R28interiorYallel2009stemaerialwhitishR1R31PlainsAin Errahma-12009stemcottony-densewhitishR1R33Ain Errahma-22010rootaerialpurplish redR6Ma6MascaraElbordj2008stemaerialdark purpleR2Ma13MascaraElbordj2009rbizospheremucousviolet to blackR2Ma13MascaraElbordj2009stemaerialdark purpleR1Sb1Sfisef-12009rbizospheremucousviolet to blackR2Sb1Sfisef-12009stemaerialdark purpleR1Sb1Sfisef-22010stemfeltedwhitishR1Sb1Lamta-12010rhizospherefeltedwhitishR1Sb1Lamta-12009stemaerialdark purpleR2Sb1Lamta-22009rootaeriallight purpleR1Sb1	C20			Aine Mrane-1	2009	root	mucous	light purple	R1
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	C21		Chlef	Aine Mrane-2	2009	stem	aerial	light purple	R1
R17SidiMhammed Ben Ali2009rotfeltedwhitish pinkR1R26Mazouna-12009rootmucousdark purpleR2R27Elgattar2009stemaeriallight purpleR1R28interiorRelizaneMazouna-22010stemcottony-densewhitishR1R29plainsRelizaneYallel2009stemcottony-densewhitishR1R31plainsAin Errahma-12009stemcottony-densewhitish pinkR1R32Ain Errahma-22101rootaerialwhitish pinkR1R33MascaraElbordj2007stemaerialwhitishR1Ma13MascaraElbordj2008stemaerialwhitishR1Sb1Mamounia-12009rhizospheremucousdark purpleR2Ma19Mamounia-22009rootfeltedwhitishR1Sb1Sfisef-12009stemaerialdark purpleR1Sb1Lamtar-12010rhizospherecottony-densewhitishR1Sb1Lamtar-12010stemfeltedwhitishR1Sb1Lamtar-12009stemfeltedwhitishR1Sb1Rahouia-22009rootfeltedwhitishR1Sb1Rahouia-22009stemfeltedwhitishR1Sb1La	C24			Aine Mrane-3	2010	rhizosphere	cottony-floccose	whitish	UR1
R26 R27 R27 R29 interior plainsRelizane RelizaneMazouna-1 Elgattar2009 stemroot aerialmucous dark purpleR2 R2 R2 R2R28 R29 plainsRelizane plainsMazouna-2 Yalle2010stem cottony-floccosewhitish whitishR1 R1R31Ain Errahma-1 Ain Errahma-22009stem cottony-floccosewhitish whitishR1R32Ain Errahma-2 Masadia2007rstem rstemaerial cottony-floccosewhitish whitishR1R32MascaraElbordj2007stem rstemaerial aerialdark purple whitishR2Ma13 Ma15MascaraElbordj2008stem rstemaerial aerialwhitish whitishR1R15 Sb1Mamounia-1 Sfisef-22009rstem rstemaerial aerialwhitish whitishR1R4 Sb5Sidi BelabesSfisef-2 TGC Sbelabes2010 rhizosphererstem aerialdark purple whitishR1Sb14 T47 T47 T47Lamtar-2 Rahouia-12009stem rhizospherefelted whitishwhitish whitishR1R40 Sb3Figh Sebaine-12009stem rhizospherefelted cottony-densewhitish whitishR1R40 Sb4 Sb5Figh R40 R40Rahouia-3 R400ia-32009root rhizospherefelted cottony-densewhitish whitishR1R44 Sb5Figh R400ia-32009<	R17			SidiMhammed Ben Ali	2009	root	felted	whitish pink	R1
R27 R28 interior plainsRelizane RelizaneElgattar Mazouna-22009stem stemaeriallight purple whitishR1R29 plainsRelizaneMazouna-22010stem cottony-densewhitishR1R31 R31Ain Errahma-12009stem cottony-floccosewhitish pinkR1R32 Ma6Ain Errahma-22010root rootaerialpurplish redR6Ma6 Ma6MascaraTighennif2007stem rhizospheremucousdark purpleR2Ma13 Ma13MascaraElbordj2008stem rhizospheremucousdark purpleR2Ma19 Sb1 Sb3MascaraElbordj2009root rhizosphereviolet to blackR2Ma19 Sb1 Sb5Sidi BelabesSfisef-12009stem rhizosphereeerialwhitishR1Sb1 Sb1 Sb1 Sb1 Sb1 Sb1 Sb1 Sb1ITGC Sbelabes2010rhizospherefeltedwhitishR1Sb4 Sb1 Sb1 Sb1 Sb1 Sb1FildeRahouia-12009stem rhizospherecottony-densewhitishR1Sb1 <br< td=""><td>R26</td><td></td><td></td><td>Mazouna-1</td><td>2009</td><td>root</td><td>mucous</td><td>dark purple</td><td>R2</td></br<>	R26			Mazouna-1	2009	root	mucous	dark purple	R2
R28 R29 plainsRelizane VallelMazouna-2 Yallel2010stem stemcottony-dense aerialwhitish whitishR1R31 R32Ain Errahma-12009stem cottony-floccosewhitish whitishR1R32Ain Errahma-12009stem cottony-floccosewhitish whitishR1R33Mas MascaraAin Errahma-22010root stemaerialpurplish red dark purpleR2Ma9 Ma15MascaraElbordj2008stem rhizospheremucousdark purpleR2Ma15MascaraElbordj2009root rhizospheremucousviolet to blackR2Ma15Mamounia-12009root rhizospheremucousviolet to blackR2Ma16Mamounia-22009root rootfeltedwhitish whitishR1Sb1Sfisef-12009stem rhizosphereaerialdark purpleR1Sb4Sidi BelabesSifsef-22009stem rhizospherefeltedwhitishR1Sb11Lamtar-12010rhizosphere rhizospherefeltedwhitishR1Sb14Lamtar-22011stem rhizospherefeltedlight purpleR1Sb14Lamtar-22010rhizosphere rhizospherefeltedlight purpleR1Sb14Lamtar-22011stem rhizospherefeltedlight purpleR1Sb14Lamtar-22019ro	R27			Elgattar	2009	stem	aerial	light purple	R1
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	R28		Relizane	Mazouna-2	2010	stem	cottony- dense	whitish	R1
R31plainsAin Errahma-12009stemcottony-floccosewhitish pinkR1R32Ain Errahma-22010rootaerialpurplish redR6Ma6Tighennif2007stemaerialdark purpleR2Ma9MascaraElbordj2008stemaerialwhitishR1Ma15MascaraElbordj2009rhizospheremucousviolet to blackR2Ma19Mamounia-12009rootfeltedwhitishR1Sb1Sfisef-12009stemaeriallight purpleR1Sb3Sfisef-22009stemaerialdark purpleR2Sb4Sidi BelabesITGC Sbelabes2010rhizospherefeltedwhitishR1Sb1Lamtar-12010rhizospherecottony-densewhitishR1Sb1Lamtar-22011stemfeltedlight purpleR1Sb1Lamtar-22010rhizospherecottony-densewhitishR1Sb1Lamtar-22011stemfeltedlight purpleR1Sb1Lamtar-22019rootaerialdark purpleR1Sb1Lamtar-22010rhizospherecottony-densewhitishR1Sb1SiSiSiRahouia-12009stemfeltedlight purpleR1Sb1SiSiSiSiRahouia-12009stem<	R29	interior		Yallel	2009	stem	aerial	whitish	R1
R32Ain Errahma-22010rootaerialpurplish redR6Ma6Tighennif2007stemaerialdark purpleR2Ma9MascaraElbordj2008stemaerialdark purpleR2Ma13MascaraElbordj2008stemaerialwhitishR1Ma15Mamounia-12009rhizospheremucousviolet to blackR2Ma19Mamounia-22009rootfeltedwhitishR1Sb1Sfisef-12009stemaeriallight purpleR1Sb3Sidi BelabesSfisef-22009stemaerialdark purpleR2Sb4Sidi Belabes2010stemfeltedwhitishUR2Sb1Lamtar-12010rhizospherecottony-densewhitishR1Sb14Lamtar-22011stemfeltedlight purpleR1T46Rahouia-12009rootaerialdark purpleR2T48Rahouia-32009rootfeltedlight purpleR1T47Rahouia-32009stemcottony-floccosewhitish pinkR6T50HighTiaretITGC Sebaine2009stemaeriallight purpleR1T51Sebaine-12009stemcottony-floccosewhitish pinkR1S58SaidaITGC Sebaine2009stemaeriallight purpleR1 <t< td=""><td>R31</td><td>plains</td><td></td><td>Ain Errahma-1</td><td>2009</td><td>stem</td><td>cottony-floccose</td><td>whitish pink</td><td>R1</td></t<>	R31	plains		Ain Errahma-1	2009	stem	cottony-floccose	whitish pink	R1
Ma6Tighennif2007stemaerialdark purpleR2Ma9MascaraElbordj2008stemaerialdark purpleR2Ma13MascaraElbordj2008stemaerialwhitishR1Ma15Mamounia-12009rhizospheremucousviolet to blackR2Ma19Mamounia-12009rhizospheremucousviolet to blackR2Sb1Sfisef-12009stemaeriallight purpleR1Sb3Sfisef-22009stemaerialdark purpleR2Sb4Sidi BelabesITGC Sbelabes2010stemfeltedwhitish pinkR1Sb1Lamtar-12010rhizospherefeltedwhitishR1Sb1Lamtar-22011stemfeltedlight purpleR1Sb1Rahouia-12009stemfeltedlight purpleR1Sb1Rahouia-22009rootaerialdark purpleR2Sb1Rahouia-12009stemfeltedlight purpleR1Sb1FiretITGC Sbaine2009rootaeriallight purpleR1Sc5Sebaine-12009stemcottony-floccosewhitish pinkR1Sc5SaidaITGC Saida2008stemaeriallight purpleR1Sc5SaidaITGC Saida2009stemaeriallight purpleR1Sc	R32			Ain Errahma-2	2010	root	aerial	purplish red	R6
	Ma6			Tighennif	2007	stem	aerial	dark purple	R2
	Ma9			Messaâdia	2007	rhizosphere	mucous	dark purple	R2
Ma15Mamounia-12009rhizospheremucousviolet to blackR2Ma19Mamounia-22009rootfeltedwhitishR1Sb1Sfisef-12009stemaeriallight purpleR1Sb3Sfisef-22009stemaerialdark purpleR2Sb4Sidi BelabesITGC Sbelabes2010stemfeltedwhitishW12Sb1Lamtar-12010rhizospherefeltedwhitishR1Sb14Lamtar-22011stemfeltedlight purpleR1T46Rahouia-12009stemfeltedlight purpleR1T47Rahouia-12009stemfeltedlight purpleR1T48Rahouia-32009rootaerialdark purpleR2T48TiaretITGC Sbelahe2009stemcottony-floccosewhitish pinkR6T50PlateausTiaretITGC Sbelahe2009stemcottony-floccosewhitish pinkR1T51Sebaine-12009stemcottony-floccosewhitish pinkR1S58SaidaITGC Saida2008stemaerialwhitish pinkR1S58SaidaAugroute-12009rootcottony-floccosewhitish pinkR1Ad60Aougroute-22009stemaerialwhitish pinkR1Ad62Aougroute-22009stemaerialpurplish re	Ma13		Mascara	Elbordi	2008	stem	aerial	whitish	R1
Ma19Mamounia-22009rootfeltedwhitishR1Sb1Sfisef-12009stemaeriallight purpleR1Sb3Sfisef-22009stemaerialdark purpleR2Sb4Sidi BelabesITGC Sbelabes2010stemfeltedwhitish pinkR1Sb5Sidi Belabes2010rhizospherefeltedwhitishW122Sb11Lamtar-12010rhizospherecottony-densewhitishR1Sb14Lamtar-22011stemfeltedlight purpleR1T46Rahouia-12009stemfeltedlight purpleR1T47Rahouia-22009rootaerialdark purpleR1T47Rahouia-32009rootfeltedpurpleR1T49High PlateausTiaretITGC Sbelahe2009stemcottony-floccosewhitish pinkR6T50PlateausSebaine-12009stemcottony-floccosewhitish pinkR1S56Sebaine-12009stemaeriallight purpleR1S58ITGC Saida2008stemaerialwhitish yinkR1S58SaidaITGC Saida2009rootcottony-floccosewhitish yinkR1Ad60Aougroute-12009rootcottony-floccosewhitish NPRR4Ad62Aougroute-22009rootcottony-floccosewhitish	Ma15			Mamounia-1	2009	rhizosphere	mucous	violet to black	R2
Sb1Sfisef-12009stemaeriallight purpleR1Sb3Sidi BelabesITGC Sbelabes2010stemaerialdark purpleR2Sb4Sidi BelabesITGC Sbelabes2010stemfeltedwhitish pinkR1Sb5Lamtar-12010rhizospherefeltedwhitishUR2Sb11Lamtar-12010rhizospherecottony-densewhitishR1Sb14Lamtar-22011stemfeltedlight purpleR1T46Rahouia-12009stemfeltedlight purpleR1T47Rahouia-22009rootaerialdark purpleR2T48Rahouia-32009rootfeltedpurpleR1T49HighTiaretITGCSebaîne2009stemcottony-floccosewhitish pinkR6T50PlateausTiaretITGCSebaîne2009stemcottony-floccosewhitish pinkR1T51Sebaîne-12009stemaeriallight purpleR1S56SaidaITGCSaida2008stemaerialwhitish yellowR1Ad60Aougroute-12009rootcottony-floccosewhitishNPRAd62Aougroute-22009stemaerialpurplish redR2Ad63SaharaAdrarAougroute-32009rootcottony-floccosewhitishNPRAd66Zaouiet Kounta-2 <t< td=""><td>Ma19</td><td></td><td></td><td>Mamounia-2</td><td>2009</td><td>root</td><td>felted</td><td>whitish</td><td>R1</td></t<>	Ma19			Mamounia-2	2009	root	felted	whitish	R1
Sb3Sidi BelabesSfisef-22009stemaerialdark purpleR2Sb4Sidi BelabesITGC Sbelabes2010stemfeltedwhitish pinkR1Sb5Lamtar-12010rhizospherefeltedwhitish pinkR1Sb14Lamtar-12010rhizospherecottony-densewhitishR1T46Lamtar-22011stemfeltedlight purpleR1T47Rahouia-12009stemfeltedlight purpleR1T47Rahouia-32009rootaerialdark purpleR2T48TiaretITGC Sebaîne2009stemcottony-floccosewhitish pinkR6T50PlateausTiaretITGC Sebaîne2009stemcottony-floccosewhitish pinkR1T51Sebaîne-12009stemcottony-floccosewhitish pinkR1T52SaidaITGC Saida2008stemaeriallight purpleR1S56SaidaITGC Saida2008stemaerialwhitish yellowR1Ad60Aougroute-12009rootcottony-floccosewhitishNPRAd63SaharaAdrarAougroute-32009rootcottony-floccosewhitishNPRAd63SaharaAdrarAougroute-32009rootcottony-floccosewhitishR1Ad66Zaoujet Kounta-12009rootcottony-floccosewhiti	Sb1			Sfisef-1	2009	stem	aerial	light purple	R1
Sb4 Sb5Sidi BelabesITGC Sbelabes ITGC Sbelabes2010stemfeltedwhitish pinkR1Sb1 Sb14Lamtar-12010rhizospherefeltedwhitishUR2Sb14 T46Lamtar-22011stemfeltedlight purpleR1R46 T50Rahouia-12009stemfeltedlight purpleR1R47 T48 PlateausTiaretITGC Sbelabes2009rootaerialdark purpleR2R48 T50Right PlateausTiaretITGC Sbaine2009stemcottony-floccosewhitish pinkR6T51TiaretITGC Scbaine2009stemcottony-floccosewhitish pinkR1T52Sebaîne-12009stemcottony-floccosewhitish pinkR1S66SaidaSaidaITGC Saida2008stemaeriallight purpleR1R460AderaAougroute-12009rootcottony-floccosewhitish yellowR1Ad63SaharaAdrarAougroute-32009rootcottony-floccosewhitishR1Z50SaidaZoide2009rootcottony-floccosewhitishR1R46ITGC Saida2008stemaerialpurpleR1R460Aougroute-12009rootcottony-floccosewhitishR1R466AdarAougroute-32009rootcottony-densewhitishR1R	Sb3			Sfisef-2	2009	stem	aerial	dark purple	R2
Sidi BelabesITGC Sbelabes2010rhizospherefeltedwhitishUR2Sb1Lamtar-12010rhizospherecottony-densewhitishR1Sb14Lamtar-22011stemfeltedlight purpleR1T46Rahouia-12009stemfeltedlight purpleR1T47Rahouia-22009rootaerialdark purpleR2T48Rahouia-32009rootfeltedpurpleR1T49TiaretITGC Sebaine2009stemfeltedlight purpleR1T50PlateausTiaretITGC Sebaine2009stemcottony-floccosewhitish pinkR6T51Sebaîne-12009stemcottony-floccosewhitish pinkR1S56SaidaITGC Saida2008stemaeriallight purpleR1S58SaidaITGC Saida2008stemaerialwhitish yellowR1Ad60Aougroute-12009rootcottony-floccosewhitishNPRAd63SaharaAdrarAougroute-32009rootcottony-densewhitishR1Ad66Zaouiet Kounta-22009rootcottony-densewhitish pinkR1Zaouiet Kounta-22009rootcottony-densewhitish pinkR1Ad66Zaouiet Kounta-22009rootcottony-densewhitish pinkR1Zaouiet Kounta-22009roo	Sb4			ITGC Shelabes	2010	stem	felted	whitish pink	R1
Sb11Lamtar-12010rhizospherecottony-densewhitishR1Sb14Lamtar-22011stemfeltedlight purpleR1T46Rahouia-12009stemfeltedlight purpleR1T47Rahouia-22009rootaerialdark purpleR2T48Rahouia-32009rootfeltedpurpleR1T49TiaretITGCSebaine2009stemcottony-floccosewhitish pinkR6T50PlateausTiaretITGCSebaine2009stemcottony-floccosewhitish pinkR1T51Sebaine-12009stemcottony-floccosewhitish pinkR1T52Sebaine-22009stemaeriallight purpleR1S56SaidaITGCSaida2008stemaerialwhitishR1S58Ad60Aougroute-12009rootcottony-floccosewhitishNPRAd62Aougroute-12009rootcottony-floccosewhitishR1Ad63SaharaAdrarAougroute-32009rootcottony-floccosewhitishR1Ad66Zaouiet Kounta-12009rootcottony-densewhitishR1Ad67Zaouiet Kounta-22009rootaerialdark purpleR2	Sb5		Sidi Belabes	ITGC Shelabes	2010	rhizosphere	felted	whitish	UR2
Sb14Lamtar-22011stemfeltedlight purpleR1T46Rahouia-12009stemfeltedlight purpleR1T47Rahouia-12009stemfeltedlight purpleR1T47Rahouia-22009rootaerialdark purpleR2T48Rahouia-32009rootfeltedpurpleR1T49HighTiaretITGCSebaîne2009stemcottony-floccosewhitish pinkR6T50PlateausSebaîne-12009stemcottony-floccosewhitish pinkR1T51Sebaîne-12009stemcottony-floccosewhitish pinkR1T52Sebaîne-22009stemaeriallight purpleR1S56SaidaITGCSaida2008stemaerialwhitishR1S58SaidaITGCSaida2008stemaerialwhitishR1Ad60Aougroute-12009rootcottony-floccosewhitishNPRAd62Aougroute-22009stemaerialpurplish redR2Ad63SaharaAdrarAougroute-32009rootcottony-densewhitishR1Ad66Zaouiet Kounta-12009rootcottony-densewhitishR1Ad67Zaouiet Kounta-12009rootaerialdark purpuleR2	Sb11			Lamtar-1	2010	rhizosphere	cottony-dense	whitish	R1
T46Rahouia-12009stemfeltedlight purpleR1T47Rahouia-22009rootaerialdark purpleR1T48Rahouia-32009rootfeltedpurpleR1T49HighTiaretITGCSebaîne2009stemcottony-floccosewhitish pinkR6T50PlateausTiaretITGCSebaîne2009stemcottony-floccosewhitish pinkR6T51Sebaîne-12009stemcottony-floccosewhitish pinkR1T52Sebaîne-22009stemaeriallight purpleR1S56SaidaITGCSaida2008stemaerialwhitishR1S58SaidaITGCSaida2008stemaerialwhitish yellowR1Ad60Aougroute-12009rootcottony-floccosewhitishR1Ad63SaharaAdrarAougroute-32009rootcottony-floccosewhitishR1Ad66Zaouiet Kounta-12009rootcottony-floccosewhitishR1Ad67Zaouiet Kounta-12009rootcottony-floccosewhitishR1Ad67Zaouiet Kounta-12009rootcottony-floccosewhitishR1Ad67Zaouiet Kounta-12009rootcottony-densewhitishR1	Sb14			Lamtar-2	2011	stem	felted	light purple	R1
T47Rahouia-22009rootaerialdark purpleR2T48Rahouia-32009rootfeltedpurpleR1T49HighTiaretITGCSebaîne2009stemcottony-floccosewhitish pinkR6T50PlateausITGCSebaîne2009stemcottony-floccosewhitish pinkR1T51Sebaîne-12009stemcottony-floccosewhitish pinkR1T52Sebaîne-22009stemaeriallight purpleR1S56SaidaITGCSaida2008stemaerialwhitishR1S58SaidaITGCSaida2008stemaerialwhitish yellowR1Ad60Aougroute-12009rootcottony-floccosewhitishR1Ad63SaharaAdrarAougroute-22009stemaerialpurplish redR2Ad63SaharaAdrarAougroute-32009rootcottony-floccosewhitishR1Ad66Zaouiet Kounta-12009rootcottony-floccosewhitishR1Ad67Zaouiet Kounta-12009rootcottony-floccosewhitishR1Ad67Zaouiet Kounta-12009rootcottony-densewhitishR1Ad67Zaouiet Kounta-12009rootfeltedwhitish pinkR1	T46			Rahouia-1	2009	stem	felted	light purple	R1
T48Rahoula 21000rootdefinitiondefinitiondefinitionrefT48Rahoula 32009rootfeltedpurpleR1T49High PlateausTiaretITGCSebaîne2009stemcottony-floccosewhitish pinkR6T50PlateausSebaîne-12009stemcottony-floccosewhitish pinkR1T51Sebaîne-12009stemcottony-floccosewhitish pinkR1T52Sebaîne-22009stemaeriallight purpleR1S56SaidaITGCSaida2008stemaerialwhitishR1S58SaidaITGCSaida2008stemaerialwhitish yellowR1Ad60Aougroute-12009rootcottony-floccosewhitishNPRAd62AdagAdagroute-22009stemaerialpurplish redR2Ad63SaharaAdrarAougroute-32009rootcottony-densewhitishR1Ad66Zaouiet Kounta-12009rootfeltedwhitish pinkR1Ad67Zaouiet Kounta-12009rootdark purpleR2	T47			Rahouia-2	2009	root	aerial	dark purple	R2
T49 T50High PlateausTiaretITGCSebaîne2009stemcottony-floccosewhitish pinkR6T50 PlateausTiaretITGCSebaîne2009stemcottony-floccosewhitish pinkR1T51Sebaîne-12009stemcottony-floccosewhitish pinkR1T52Sebaîne-22009stemaeriallight purpleR1S56SaidaITGCSaida2008stemaerialwhitishR1S58SaidaITGCSaida2008stemfeltedwhitish yellowR1Ad60Aougroute-12009rootcottony-floccosewhitishNPRAd62Aougroute-22009stemaerialpurplish redR2Ad63SaharaAdrarAougroute-32009rootcottony-densewhitishR1Ad66Zaouiet Kounta-12009rootfeltedwhitish pinkR1Ad67Zaouiet Kounta-12009rootdark purpuleR2	T48			Rahouia-3	2009	root	felted	purple	R1
High T50High PlateausITGCSebaine2009stemcottony indecodeMinistripingRiT51ITGCSebaine2009stemfeltedlight purpleRiT52Sebaine-12009stemcottony-floccosewhitish pinkRiT52Sebaine-22009stemaeriallight purpleRiS56SaidaITGCSaida2008stemaerialwhitishRiS58SaidaITGCSaida2009rootcottony-floccosewhitishNPRAd60Aougroute-12009rootcottony-floccosewhitishNPRAd62Aougroute-22009stemaerialpurplish redR2Ad63SaharaAdrarAougroute-32009rootcottony-densewhitishR1Ad66Zaouiet Kounta-12009rootfeltedwhitish pinkR1Ad67Zaouiet Kounta-12009rootaerialdark purpuleR2	T49		Tiaret	ITGCSebaîne	2009	stem	cottony-floccose	whitish pink	R6
FistPlateausFist of of of of of an end of a contract	T50	High	114100	ITGCSebaîne	2009	stem	felted	light purple	R1
T51Stepane 12009stemcottony increasewithish pinkR1T52Sebaîne-22009stemaeriallight purpleR1S56SaidaITGCSaida2008stemaerialwhitishR1S58SaidaITGCSaida2008stemfeltedwhitish yellowR1Ad60Aougroute-12009rootcottony-floccosewhitishNPRAd62Aougroute-22009stemaerialpurplish redR2Ad63SaharaAdrarAougroute-32009rootcottony-densewhitish pinkR1Ad66Zaouiet Kounta-12009rootfeltedwhitish pinkR1Ad67Zaouiet Kounta-22009rootgerialdark purpulaR2	T51	Plateaus		Sebaîne-1	2009	stem	cottony-floccose	whitish pink	R1
S56SaidaITGCSaida2009stemaerialngnt purpleR1S58SaidaITGCSaida2008stemaerialwhitishR1Ad60Aougroute-12009rootcottony-floccosewhitishNPRAd62Aougroute-22009stemaerialpurplish redR2Ad63SaharaAdrarAougroute-32009rootcottony-densewhitishR1Ad66Zaoujet Kounta-12009rootfeltedwhitish pinkR1Ad67Zaoujet Kounta-22009rootaerialdark purpulaR2	T52			Sebaîne-2	2009	stem	aerial	light purple	R1
SoloSaidaITGCSaida2000stemactualwithinR1S58ITGCSaida2008stemfeltedwhitish yellowR1Ad60Aougroute-12009rootcottony-floccosewhitishNPRAd62Aougroute-22009stemaerialpurplish redR2Ad63SaharaAdrarAougroute-32009rootcottony-densewhitishR1Ad66Zaoujet Kounta-12009rootfeltedwhitish pinkR1Ad67Zaoujet Kounta-22009rootaerialdark purpulaR2	\$56			ITGCSaida	2009	stem	aerial	whitish	R1
Ad60Aougroute-12009rotcottony-floccosewhitish yenowR1Ad62Aougroute-22009stemaerialpurplish redR2Ad63SaharaAdrarAougroute-32009rootcottony-densewhitishR1Ad66Zaouiet Kounta-12009rootfeltedwhitish pinkR1Ad67Zaouiet Kounta-22009rootaerialdark purpuleR2	\$58		Saida	ITGCSaida	2008	stem	felted	whitish vellow	R1 R1
Ad62Aougroute-12009rootcontrol control-noccosewhitishNPKAd63SaharaAdrarAougroute-22009stemaerialpurplish redR2Ad63SaharaAdrarAougroute-32009rootcottony-densewhitishR1Ad66Zaouiet Kounta-12009rootfeltedwhitish pinkR1Ad67Zaouiet Kounta-22009rootaerialdark purpuleR2	A 460			A ougroute_1	2008	root	cottony-floccoso	whitich	NDP
Add2Add3SaharaAdrarAougroute-22009stemaerialpurplish redR2Ad63SaharaAdrarAougroute-32009rootcottony-densewhitishR1Ad66Zaouiet Kounta-12009rootfeltedwhitish pinkR1Ad67Zaouiet Kounta-22009rootaerialdark purpuleR2	A d62			A ougroute 2	2009	stom	aprial	purplish rod	P0
AdosZaouiet Kounta-12009rootCottony-denseWillishR1Ad67Zaouiet Kounta-22009rootfeltedwhitish pinkR1	A d62	Sabara	Adron	A ougroute 2	2009	root	actial	whitich	R2 D1
Ad67 Zaoujet Kounta-2 2009 root aerial dark purpule R2	A d66	Jaildid	Aulai	Zaquiet Kounta 1	2009	root	foltod	whitish pink	R1
	Ad67			Zaoujet Kounta-?	2009	root	aerial	dark purpule	R2

\mathbf{T}	1	1		C		1 .
Lable 7 (-oographical	origin and	charactorictice of	racos of Eucavilling	$\alpha m m \alpha m \alpha m m m + c$	n millin wortorn (laoria
Table 2. Ocultabilitar	Ully and		Iaces of I usurium	$0\lambda V S D U I M I I . S$	D Disi III WESTELII I	MECHA
						0

UR – unknown race; NPR – non-pathogenic race

cultivars, Little Marvel and Dark skin Perfection, were susceptible.

DISCUSSION

For the pathogens associated with wilt, *F. oxysporum* was the major cause of wilt disease in all agroclimatic zones followed by *F. solani*. The association of *F. oxysporum*, *F. solani*, *Rhizoctonia* sp. with wilt in legumes in Algeria and other countries has already been reported (BELABID et al. 2000; NEUMANN & XUE 2002; RANA et al. 2009). The widespread occurrence of the disease and association of soil-borne pathogens indicated the possibility of increased disease incidence in the future, if suitable management practices are not adopted. This study has demonstrated that the population of FOP in western Algeria was highly variable.

When isolates grown on acidified PDA (pH 5), Race 2 secreted a purplish black pigment into the medium whereas Races 1, 5, and 6 produced little or no pigment, similar results were observed (SHARMA et al. 2005). LIN *et al.* (1984) considered the mucous (ropy) types of isolates with a purplish red pigmentation might be one variant of Race 2, since it could be obtained from old cultures of the same group. In our study, we have noted that isolates A22 and R32 identified as Race 6 presented an aerial mycelium with whitish to light purple pigment during the first two weeks after which they began to secrete a dark purple pigment resembling that of Race 2. Similarly, this result was recorded for the Danish Race 6 isolates, which had floccose white to light peach aerial mycelium. The reverse of the colony was similar in colour for about 12 days subsequently; a dark purple pigment was excreted into the medium. In pigmentation the same result was observed for the English and Danish isolates, suggesting that they belong to the same phylogenetic group and that this group may be widespread in Europe (BODKER et al. 1993; KRAFT & PFLEGER 2001). In the literature, Race 1 has aerial mycelium with little or no pigmentation when grown on PDA medium adjusted to pH 4.5. The aerial mycelium may be in strands, and sporulation is sparse. Few to no macroconidia and only limited numbers of microconidia are produced on PDA. Race 2 is also aerial, and mycelium may form strands. Pigmentation, light purple to black in most cultures, occurs on acid PDA. Sporulation is profuse, with production of abundant macro- and microconidia. Linear growth rates of Races 1, 5, and 6 were approximately equal to each other and were slower than those of Race 2.

The differentials lines or cultivars used in this study have been used quite frequently, suggesting that they are particularly useful for evaluating pathogenic variability in various parts of the world. Races 1 and 2 of the wilt pathogen occur in most of the pea growing areas worldwide; they are present and significant in the European and Mediterranean region (OEPO/EPPO 1994). Race 6 has been reported in Europe, while all four races are found in Australia and the four specific races of pea Fusarium wilt have been identified and studied in the USA (HAGLUND & KRAFT 2001) and Canada (NEUMANN & XUE 2002). Races 1 and 2 were the only economically important ones in the United States until Race 5 appeared in north-western Washington in 1963, followed by Race 6 (HAGLUND & KRAFT 2001). Races 1 and 2 occur worldwide, while Races 5 and 6 are only important in western Washington State and their impact has lessened as fresh pea production has moved out of western Washington.

The standard control differentials lines have been used successfully for many years; their reactions to Race 2 have recently been questioned. Intermediate reactions of the standard differential lines confound results from individual experiments.

In the majority of wilt diseases in the regions surveyed, peas are probably binds to the existence of a permanent inocula in the soil maybe due to the fact that crop rotation is very short or absent in most departments, poor sowing conditions, agriculture practices, the use of susceptible cultivars (Merveille de Kelvedon, Latcha local variety, Grand vert, Onward) to different races of FOP in most areas, infected seed is suspected of carrying the pathogen, it is not considered likely.

Considerable variation in the pathogenicity of different isolates of FOP has been reported. Most studies have not used the same, or the same number of differential genotypes, or have been conducted under different environmental conditions, so comparison of results between studies is difficult. The environmental factors, temperature, light, and humidity were stable in all trials and their effects were not examined in the present study. However, it has been shown that even slight changes in environmental conditions can significantly affect the expression of plant infection.

In this study, some races were specific to a single region while others were found in various regions. The most common race was recorded throughout all the regions. This might be due to seed transmission of FOP, since infected pea is important for natural spread of the pathogen. In Algeria, the transfer of pea seed from one region to another is common and uncontrolled. Seed transmission will only occur if growers keep seeds from known infected plants; Race 1 can be transmitted occasionally by seeds when harvested from wilt-infested fields. The probability of seed transmission of Race 2, when the pathogen attacks a pea plant at flowering to pod development stages, is much higher than for Races 1, 5, or 6 which usually kill a susceptible plant before blooming. MASHESHWARI et al. (1981) isolated FOP from surface disinfested seeds of six varieties grown in the Hoshiarpur district of Punjab (India), where pea root rot and wilt are a problem and climatic characteristics of the regions are in most cases favourable to the disease development. Infected plants may look normal at low temperatures, but at soil temperatures of 20°C and above, wilt develops rapidly, resulting in the collapse of the entire aerial part. The disease could cause appreciable yield losses under favourable environmental conditions; it is a major yield-limiting factor in the dry-temperate zone.

In conclusion, this study allowed us to put in evidence the presence of pea wilt in all regions surveyed, a geographic distribution map of four races of the FOP at the western Algerian regions has been compiled. Races of the fungus and the population types present in the area need to be evaluated for disease control management. Specifically this information assists when examining newly bred cultivars and for the development of new resistant cultivars. The first stage of any disease control program involves the examination of the disease and its distribution. Growers may choose cultivars according to the race predominating in the soil in a particular region. Resistance to Fusarium wilt is not a substitute for good cultural practices but must be used in combination with them, when possible and early to minimize future losses. Incorporation of useful resistance sources effective against diverse races into adapted genotypes will be necessary to minimise future losses. Effective seed hygiene is also very important in order to prevent spread and introduction of highly virulent strains of the pathogen into new areas.

Acknowledgement. We thank DAVE STOUT, Biological Science Technician (Plants) USDA, ARS, WRPIS, Plant Germplasm Introduction and Testing Research Station in Pullman, Washington University, USA, and Dr ROBERT CONNER, Modern Research Station Agriculture and Agri-Food, Canada for providing seeds of pea differential genotypes.

References

ALABOUVETTE C., OLIVAIN C., MIGHELI Q., STEINBERG C. (2009): Microbiological control of soil-borne phytopath-

ogenic fungi with special emphasis on wilt-inducing *Fusarium oxysporum*. New Phytologist, **184**: 529–544.

- BANI M., RUBIALES D., RISPAIL N. (2011): A detailed evaluation method to identify sources of quantitative resistance to *Fusarium oxysporum* f.sp. *pisi* race 2 within a *Pisum* spp. germplasm collection. Plant Pathology, **61**: 532–542.
- BELABID L., FORTAS Z., DALLI D., KHIARE M., AMDJAD D. (2000): Importance du flétrissement et la pourriture racinaire de la lentille dans le nord-ouest Algérien. Cahiers Agricultures, 9: 515–518.
- BELABID L., FORTAS Z. (2002): Virulence and vegetative compatibility of Algerian isolates of *Fusarium oxysporum* f.sp. *lentis*. Phytopathologia Mediterranea, **41**: 179–187.
- BODKER L., LEWIS B.G., CODDINGTON A. (1993): The occurrence of a new genetic variant of *Fusarium oxysporum* f.sp. *pisi*. Plant Pathology, **42**: 833–838.
- HAGLUND W.A. (1984): Fusarium wilts. In: HAGEDORN D.J. (ed.): Compendium of Pea Diseases. APS, St. Paul: 22–24.
- HAGLUND W.A. (1989): A rapid method for inoculating pea seedlings with *Fusarium oxysporum* f.sp. *pisi*. Plant Disease, **73**: 457–458.
- HAGLUND W.A., KRAFT J.M. (1970): *Fusarium oxysporum* f.sp. *pisi* race 5. Phytopathology, **60**: 1861–1862.
- HAGLUND W.A., KRAFT J.M. (1979): *Fusarium oxysporum* f.sp. *pisi* race 6: Occurrence and distribution. Phytopathology, **69**: 818-820.
- HAGLUND W.A., KRAFT J.M. (2001): Fusarium wilt. In: KRAFT J.M., PFLEGER F.L. (eds): Compendium of Pea Diseases and Pests. APS Press, St. Paul: 13–14.
- INFANTINO A., KHARRAT M., RICCIONI L., COYNE C.J., KEVIN E., PHEE M.C., GRUNWALD N.J. (2006): Screening techniques and sources of resistance to root diseases in cool season food legumes. Euphytica, 147: 201–221.
- KRAFT J.M. (1995): Fusarium wilt of peas (a review). Agronomie, 14: 561–567.
- KRAFT J.M., PFLEGER F.L. (2001): Compendium of Pea Diseases and Pests. 2nd Ed. The American Phytopathological Society, St. Paul.
- LESLIE J.F., SUMMERELL B.A. (2006): The Fusarium Laboratory Manual. Vol. 2, Issue 10. Blackwell Publishing Ltd., Oxford: 101–117.
- LIN Y.S., SUN W., PIE-HAN WONG (1984): Fusarium root rot and wilt of garden pea in Taiwan. Journal of Agricultural Research of China, **33**: 395–405.
- MASHESHWARI S.K., GUPTA J.S., JHOOTY J.S. (1981): Effect of various cultural practices on the incidence of the wilt and root rot of pea. Indian Journal of Agricultural Sciences, **15**: 149–151.
- MCCLENDON T., INGLIS A., MCPHEE E., COYNE J. (2002): DNA markers linked to Fusarium wilt race 1 resistance in pea. Journal of American Society and Sciences, **127**: 602–607.

- MERZOUG A., BENFREHA F., TALEB M. (2009): Les principales maladies fongiques du Petit Pois (*Pisum sativum*) et Pois chiche (*Cicer arietinum*) dans le nord ouest Algérien. In: Colloque international sur la gestion des risques phytosanitaires, 9–11 Novembre 2009, Marrakech, Maroc. Proceedings V1: 115–123.
- MERZOUG A., BELABID L., BENFEHA F. (2011): Recensement des principales espèces fongiques pathogènes sur la culture du petit Pois (*Pisum sativum*) dans le nord ouest Algérien. In: Colloque International «Nouvelles Espèces Végétales et Microbiennes décrites en Algérie de 1962–2010», 18–20 Octobre 2011, Oran, Algérie.
- MOMMA N., MOMMA M., KOBARA Y. (2010): Biological soil disinfestation using ethanol: effect on *Fusarium oxysporum* f.sp. *lycopersici* and soil microorganisms. Journal of General Plant Pathology **76**: 336–344.
- NEUMANN S., XUE A.G. (2002): Reactions of field pea cultivars to four races of *Fusarium oxysporum* f.sp. *pisi*. Canadian Journal of Plant Sciences, **83**:377–379.
- OEPP/EPPO (1994): Organisation Européenne et Méditerranéenne pour la Protection des Plantes: Principe de

bonne pratique phytosanitaire, pois. OEPP/EPPO Bulletin, **24**: 233–240. Available at http://onlinelibrary.wiley. com/doi/10.1111/epp.1994.24.issue-2/issuetoc

- RANA U., SHARMA A., PAUL Y., DEV SHARMA K. (2009): Survey for pea diseases and identification of fungi associated with wilt and root rot complex in Himachal Pradesh. Journal of Mycology and Plant Pathology, **39**: 416–421.
- SHARMA P., SHARMA K.D., SHARMA R., PLAHA P. (2005): Genetic variability in pea wilt pathogen *Fusarium oxysporum* f.sp. *pisi* in north western Himalayas. Indian Journal of Biotechnology, **5:** 298–302.
- SHARMA A., RATHOUR R., PLAHA P. (2010): Induction of Fusarium wilt (*Fusarium oxysporum* f.sp. *pisi*) resistance in garden pea using induced mutagenesis and *in vitro* selection techniques. Euphytica, **173**: 345–356.
- WATANABE T. (2002): Pictorial Atlas of Soil and Seed Fungi: Morphologies of Cultured Fungi and Key to Species. 2nd Ed. Lewis Publishers, CRC Press, Florida: 270–276.

Received for publication March 18, 2013 Accepted after corrections October 17, 2013

Corresponding author:

Dr AOUMRIA MERZOUG, University of Mascara, Department of Agronomy, Laboratory of Research on Biological Systems and Geomatics (LRSBG), P.O. Box 305, Mascara 29000, Algeria; E-mail: merzougaoumria@hotmail.com