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INFLUENCE OF CLIMATIC FACTORS ON THE DEVELOPMENT OF THE *OLIVE PEACOCK SPOT* IN MOROCCO

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Abstract

The present study is conducted to know the effect of certain cultural practices and the variation of temperature and humidity (continentality, altitude, slope exposure) on the distribution and importance of Peacock Spot, caused by *Spilocaea oleaginea,* in the region of Gharb and Ouazzane (Morocco).

The study was conducted in olive orchards growing in different geographical situations with varying climatic conditions. The intensity and the presence of the disease were evaluated respectively by calculating leaf area index and the percentage of diseased trees.

The obtained results showed that as far as continentality augments the severity of the disease decreases and is increasing in height. The disease is important in the region of Ouazzane than in Gharb. These variations are due to the humidity and temperature variations. The olive trees cultivated at the western slope are the most attacked, Leaf area index is 4.54, followed by those of the North, South and East. Disease decreases in the low slope to the high slope. The presence of rivers leads to increase the intensity of the disease in South and East slopes, considered as dry slopes. Tillage reduces the intensity of the olive spot diseases in the grafted olive and cuttings (Leaf alteration index ranged from 1.84) but, increases in the unmaintained orchards (L.I. is 3.66).

This study allowed us to know the influence of variations of the main climatic factors (humidity and temperature) and cultural practices (tillage orchards, olive trees origin) on the development of Peacock Spot disease in Morocco. Taking into consideration of all these factors and the integration of other factors allow mapping the distribution of the disease in the olive-growing areas and to know those at high risk.

Key words : Olive tree, Peacock Spot, *Spilocaea oleaginea,* Leaf alteration index, humidity, altitude, temperature, soil, intensity, orchards.

Introduction

In Morocco, the olive sector has a great social and economical importance, with a production of 1,483,510 tons of olives per year (Anonyme 2012), actively contributes to the fixation of the rural population by creating more than 11 million working days (MAMVA, 1996).

Phytosanitary problems of the olive tree are the main obstacle to the crop productivity. These are the pests and diseases that commit the most damage by attacking different organs of the olive tree (Sergeeva *et al.,* 2008; Lachqer and Sedra, 1996; MacDonald *et al.,* 2000; Sanei and Razavi, 2011). Among the foliar fungal diseases of the olive tree is the Peacock Spot or the olive leaf spot, caused by *Spilocaea oleaginea* (*Cycloconium oleaginum* or *Fusicladium oleagineum*), is considered among the most redoubtable foliar fungal diseases that may cause the concern of farmers when the climatic conditions are favorable for the fungus (Bourbos and Skoudridakis, 1993). This disease is widespread in the Mediterranean area and in the areas of the olive tree crops (Shabi *et al.,* 1994, Graniti, 1993; Corda *et al.,* 1993; Tous and Romero, 1998; Lopez Doncel *et al.,* 2000; Mekuria *et al.,* 2001; Obanor *et al.,* 2005).

In Morocco, the Peacock Spot disease is considered among the most important diseases of the olive tree (Jaidi,

1968; Renaud, 1968; Outassourt, 1983; Besri and Outassourt, 1984). The life cycle of the causative agent, *Spilocaea oleaginea* is dependent on climatic conditions (Obanor, 2008), which the most important are temperature and humidity (Tenerini, 1964; Salerno, 1965). When the attack is severe, the leaves fall prematurely, which results in the general weakening of the tree and the reduction of the yield (Tajnari, 1999). The fungus can cause early loss of olives when it grows on peduncles (Rahmani, 1999).

Renaud (1968) reported that outbreaks of the olive leaf spot disease always appear the least sunny side of the tree. Besri and Outassourt (1980) observed the effect of exposure of the canopy on the distribution of the disease. The present study reports information on the effects of changes in climatic factors (continentality, altitude and slope exposure) and some cultural practices on the development of this disease in the olive groves in North West regions of Morocco. Indeed, the region of Ouazzane is an excellent olive growing region, shows a variable topography, which allowed to study the effect of these variations in climatic factors.

Materials and Methods

Sampling

A field survey was conducted during the summer 2013. To study the effect of continentality on the development of the Peacock spot disease, several stations in the Gharb region were visited.

Continentality increases from the West to the East, the nearest sea station was the city of Kénitra, which is not known by the cultivation of olive trees but there are scattered trees in the city. The farthest station is that of Bork located 2 km north of Souk El Larbaa, intermediate stations were respectively: Bakara, Howafat, Souk Larbaa, Jamaa Lalla Mimouna.

The action of the altitude on the development of the disease was surveyed in different mountain stations. Ranging from from Tnin Srafah with semi arid climate to Zoumi in altitude, subhumid climate, humidity increases.

To study the effect of slopes on the development of peacock spot disease, two mountains have been chosen. Sometimes depressions surrounding mountains of the Ouazzane region are crossed by rivers. The mountain station is Sabt Masmoda away from these rivers. For cons, in the station of Zoumi two mountains A and B, separated by a river, were selected. In this last station, the effect of dry mountain side A, facing east, and the wet side, West facing, mountain B and the effect of the humidity of the river were observed on the development of the olive leaf spot in the olive groves of these slopes.

Each slope is divided into three levels: A (low slope), level B (mid-slope) and level V (high slope). For each level, an olive orchard was chosen and sampling of diseased leaves was carried out from three trees / orchard.

Certain practices and transactions in olive orchards may influence the development of the olive leaf spot. In the Ouazzane area, sometimes the same olive orchard has two different origins. There are olive trees derived from cuttings, other from the grafting and the rootstock in this case is the oleaster. The olive leaf spot was observed in both types of olive trees and was also sought in orchards that are well crafted and other none maintained.

The disease estimation

For each case, three orchards, same soil and same altitudinal level were selected and in each orchard, three trees are randomly selected. On each tree, a number of 100 leaves has been removed from all four sides, according to the method of Salman *et al.* (2011), while rotating around the tree. Sampling is performed at almost 1.5 meters above the ground. 300 leaves, with or without symptoms, were collected from each orchard. These leaves were brought to the laboratory, mixed and 100 of them, taken at random, were used to determine the intensity of the peacock spot estimated by calculating a leaf area index (L.A.I.).

L.I.= 6 " (Ni Si)/Nt

Ni: Number of plants in the severity class. (Table 1).

Nt: Total number of leaves

Si: severity class.

Table 1: Rating Scale for calculating the LAI.

Notation	Spots number	Alteration percentage
0	0	0
1	1 to 3	10
2	4 to 7	20
3	More than 7 / cloud of spots	40
4	Chlorosis	60
5	Necrosis	More than 70

A damaging level was adopted: 10% of the stained leaves. Beyond this level the disease constitutes a danger.

Statistical analysis

All analyzes were performed using Statistica software and software Statistics for Social Sciences (SPSS, version 17.0). The data were represented as average ± standard deviation (SD), and the extreme

(minimum and maximum). The normality distribution was tested by the Kolmogorov-Smirnov test. The Student's test for independent samples where the ANOVA test with a factor between several independent samples were used to compare mean. The values $P<0.05$ were considered significant.

Results and Discussion

Spilocaea oleaginea, produces, on the upper side of leaf blade, more or less numerous spots those are irregularly distributed. The spots are circular and their color varies with the development state of the attacked organs, while their perimeter, their peripheral zone retains a brownish tinge. The central part of the spots, the contrary, provides a less intense color, gray in summer, then passing to brown, turning yellow even becoming green and finally the same time as the leaf itself which, at that time, become detached from the tree and fell. The disease also occurs with lesions on the petioles, peduncles fruits and on the fruits leading to their downfall. The development of these symptoms and their amplification from one year to another cause weakening of the trees and their productivity. The symptoms induced by *Spilocaea oleaginea* on the olive tree are well described in the literature (Wilson and Ogawa, 1979; Graniti and Laviola, 1981; Andrés, 1991; Tjamos *et al.,* 1993; Graniti, 1993; Sanchez *et al.,* 1998; Trapero and Blanco, 2001).

Fig. 1: Symptoms of the Peacock spot on the olive leaves. A: Brown circular spots. B: Brownish gray spots. C: Leaf chlorosis: advanced stage of the disease. D: Leaf necrosis and conidia liberation.

The continentality influences the presence and severity of the olive leaf spot disease; it decreases with increasing distance from the sea. In Kénitra, close to the sea, the percentage of infection was 12.1%, and 0.83% in the Bork station, far from the sea. The percentage of infection was 6.5% in the Jamaa Lalla Mimouna station, exposed to oceanic influences (Table 2).

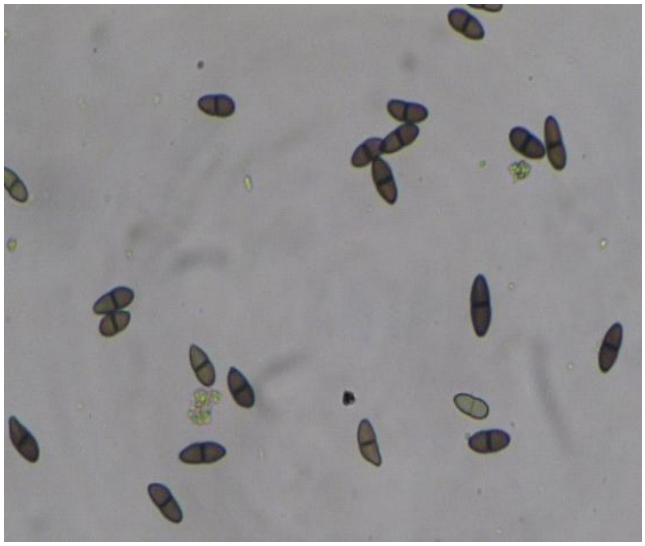

Fig. 2: Conidia, oblong shape, light brown color, at maturity have a transverse partition forming two dissimilar cells (asymmetric two-celled) : Basal cell is globular, the terminal is piriform.

Altitude compensates for the lost humidity due to the remoteness of the sea. The severity of the disease, estimated by calculating the leaf area index, increases with altitude and each altitudinal level, it appears in the disease level. In the Ouazzane station, located 300 m of altitude, leaf area index of the Peacock spot disease is 1.16 and it is 4.24 in the station Masmouda (400 m of altitude). For cons, the leaf area index is about 5.62, at Zoumi station, located at 620 m of altitude.

It is clear from these results that the olive leaf spot is present in all surveyed stations with a variable infection percentage from one station to another. The humidity is a major factor in the development of the disease. In the stations influenced by the sea, the disease is important, but decreases with increasing continentality. The disease also is gaining momentum in altitude.

The life cycle of *Spilocaea oleaginea* depends on climatic conditions. Graniti (1993) indicated that environmental factors such as temperature and humidity are the driving forces of infection and spread of the disease. Conidial germination occurs during a cold and rainy weather (Tajnari, 1999). The excess of free water increases the humidity in the foliage of the olive trees, the leaf surface becomes wet which promotes the dissemination, contamination and germination of conidia (Laviola and Scarito, 1993; Agostino *et al.,* 2007). In the absence of rain and if the humidity is above 70%, there is a dispersion of conidia by wind (De Marzo *et al.,* 1993).

Table 2: Variation in the severity of the olive leaf spot in function to continentality and altitude in olive orchards in Gharb and Ouazzane regions.

Prospected regions	Station	Altitude (m)	Severity percentage	Evaluation of risk
Continentality	Kénitra	31	12.1	+/-
	Bakari	42	8.33	-
	Howafat	15	3.66	-
	Souk larbaa	37	2.33	-
	Jamaa mimouna	43	6.5	-
	Bork	42	0.83	-
Altitude	Tnin srafah	236	9.5	+/-
	Sabt masmoda	400	13	+/-
	Ouazzane	300	5.5	-
	Kharrouba	360	18.5	+
	Zoumi (East)	600	22.66	+
	Zoumi (west)	620	32.5	+

- : No risk ; + : Serious danger

Table 3: Leaf area index (L.A.I.) in olive orchards attacked by the olive peacock spot in the two regions of Gharb and Ouazzane.

Prospected regions	Station	Altitude (m)	(L.A.I.)
Continentality	Kénitra	31	4.15^{a}
	Bakari	42	3.00^{ab}
	Howafat	15	1.32^{cd}
	Souk Larbaa	37	0.84^{cd}
	Jamaa Mimona	43	2.34^{bc}
	Bork	42	0.30^{d}
Montain	Tnin Srafah	236	3.42^{ab}
	Sabt Masmoda	400	4.24^{ab}
	Ouazzane	300	1.16^{b}
	Kharrouba	360	3.97^{ab}
	Zoumi (East)	600	5.32^{a}
	Zoumi (West)	620	5.62^{a}

The severity of the olive leaf spots depends on other factors (Macdonald *et al.,* 2000): cultivar types, density and age of plantations.

In the mountainous stations, the disease intensity depends also on the slope exposure. The olive trees cultivated in the west are more attacked, the mean index is 4.54 (±0.45), followed by those in the North, South and in the East, respectively with indexes 3.97 (±1.51), 1.90 (±0.90), 0.81 (±0.09).

The severity of the disease is also important in the lower slopes (L.A.I. = 5.18) and decreases upward slope (L.A.I. = 2.28), especially in the case of exposed slopes in the north (L.A.I. = 5.18).

In the station of Zoumi, leaf area indexes calculated in olive orchards growing in lower slopes of East and West traversed by a river (L.A.I. respectively 8.1 and 8.57) are almost identical. By cons, altitude and extending away from the river, the disease intensity decreases. At high slopes, leaf area indexes are 3.12 (slope exposed to the West) and 3.13 (slope exposed to the East); At mid-west and east side, leaf area indexes are respectively 4.14 and 5.64.

In Morocco, Besri and Outassourt (1984) have worked on the olive leaf spot distribution on two faces (North and South) of the some trees canopy in two olive-growing regions: Béni Mellal and Marrakech. Both authors noted that the percentage of leaves infection exposed to North is significantly higher than leaves exposed to South. Tajnari (1999) also studied the disease distribution in the region of Kelaa Sraghna. He noted that the exposed face of the olive tree in the North is the most contested, followed by the West, South and East. The interior of the canopy is more attacked than the outside and the bottom of the canopy is more infested than the top.

In the region of Ouazzane, we have noted that the olive orchards of western slopes are the most attacked followed by North slopes, South and East. The presence of rivers or oueds may increase the intensity of the disease in South and East slopes, considered as dry slopes.

It is known that climatic conditions influence the development of the olive leaf spot. The disease is very grave in humid areas (Graniti and Laviola, 1981) and causes very significant yield losses (Wilson and Owaga, 1979; Graniti *et al.,* 1993). The fruit rot caused by *Spilocaea oleaginea* was observed in the humid zones, case of Calabria region (Southern Italy) characterized by environmental conditions favoring the development of the epidemic (Graniti *et al.,* 1993).

The intensity of the disease can also be influenced by the tillage. Indeed, leaf area index calculated in olive trees growing on well tilled soil is 1.84 (±2.04) and the one noted in olive trees badly maintained is 3.66 (±0.39) (Table 3). Similarly, the Peacock spot disease was observed with almost the same intensity in olive trees from cuttings and those grafted on the oleaster. Agostino et *al.,* (2007) reported that the adventitious that grow in the vicinity of olive trees increase environmental humidity and promotes the presence of *Spilocaea oleaginea*.

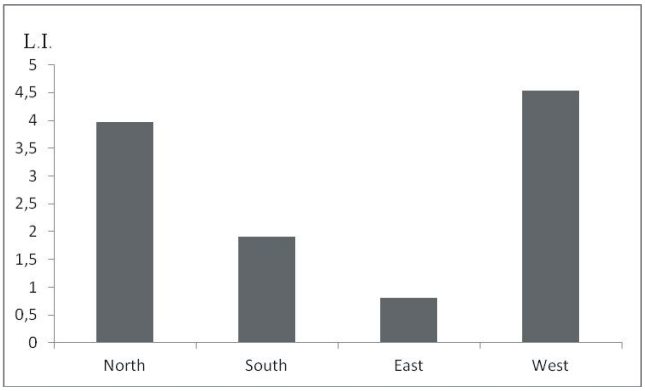

Fig. 3: Graphical representation of the leaf area index calculated in the mountainous olive slopes in the area of Masmouda in the lack of humidity (Ouazzane).

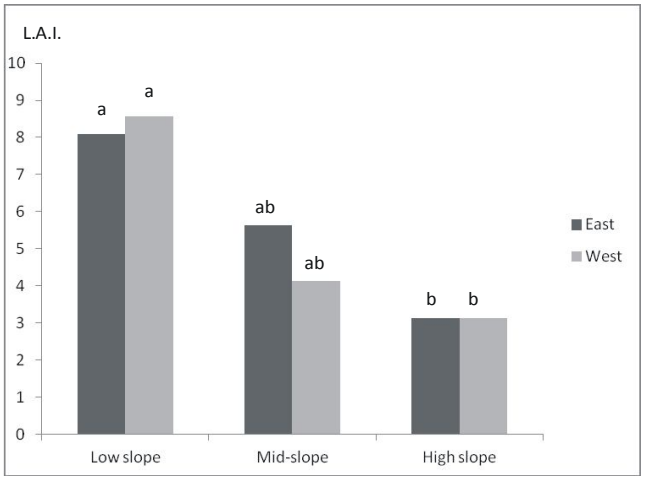

Fig. 4: Graphical representation of the average leaf index in Zoumi in the presence of humidity. East : Dry mountain slope B; West : humid slope of the mountain A.

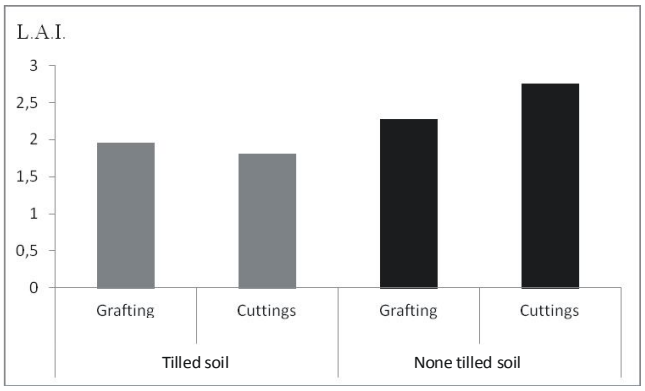

Fig. 5: Leaf area index calculated of olive cuttings and grafts cultivated in a tilled and none tilled soil.

Conclusion

The Peacock spot disease is widespread in all orchards surveyed the North West of Morocco: Gharb and Ouazzane. The importance of the disease varies according to geographical situations of the olive orchards. It decreases by moving far from the sea and increases in altitude. In the mountainous stations, the intensity of the disease is important among olive trees cultivated at the wet side exposed to the north and west and decreases in the dry slopes exposed to the south and east. The presence of rivers increases the intensity of the disease in olive groves of the dry slopes facing south and east. The olive leaf spot depends also on certain cultural practices. Indeed, it is less important in olive groves grafting or cuttings growing on well-tilled soils. For cons, the index of the disease increases in olive groves orchards those are not maintained.

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