Evaluation of the incidence and severity of peacock eye caused by Fusicladium oleagineum in different olive cultivars in Algeria

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Research Article

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Abstract

The peacock's eye of the olive tree is a very feared disease in orchards of susceptible varieties, especially in the affected olive growing regions of the West and the Center of Algeria. Eleven olive (*Olea europaea* L.) cultivars including Chemlal, Sylviane, Rougette, Limli, Sigoise, Bounguergueb, Cœur de bœuf, Zaîti, Khodeiri, Terrella and Sorani, were studied for their susceptibility to *Fusicladium oleagineum*, the causal agent of peacock's eye disease on olive tree in Algeria. Investigations were carried out during the periods of risk of contamination: one in spring and the other in autumn or autumn to winter to measure the incidence and severity of the disease in the affected olive-growing regions (El Hamadna, Ain Nouissy, Bouhenni, Bentalha, Bir Touta and Tessala El Merdja). “Chemlal” and “Sigoise” are the most dominant olive cultivars in Algeria and varieties originated from Syria (Zaîti, Khodeiri, Terrella and Sorani) were classified as the most susceptible to the pathogen. While Bounguergueb, Cœur de bœuf and Limli were found to be moderately tolerant. Sylviane and Rougette were classified as the most tolerant cultivars. Disease incidence varied greatly among the cultivars ($F=28.7$, $df= 7$, $P<0.000$); and was correlated with the severity ($y=2.04+104.9$, $R^2= 0.32$). Disease severity also varied among different cultivars ($F= 72.6$, $df= 7$, $P<0.000$). Analysis of variance shows a non-significant difference in the variation of incidence with exposure with probability values ($F=0.43$, $df=278.2$, $P>5\%$).

Introduction

In Algeria, the olive tree is the most widespread fruit species, out of the 1541 municipalities in Algeria, 1336 cultivate olive trees from which more than 83% are located in the Eastern country (Bordj Bou Arreridj, Sétif and Jijel) and Center-East zones of the country (Bejaia, Tizi-Ouzou and Bouira), mainly intended for the production of oil. The rest of the olive groves are located in the western regions (Mascara, Sidi Bel Abbès, Relizane and Tlemcen) with 17%, and concern the production of table olives (Karboua, 2003).

The olive tree is affected by several pests and diseases (Mekuria et al. 2001; Viruega et al. 2013). *Fusicladium oleagineum*, described for almost a century, is reported in all olive-growing regions of the world (Obanor et al. 2005), especially in the Mediterranean. In the Algerian climate, it has been reported in all olive-growing regions except southern Algeria.

When the attack of *F. oleagineum* is severe, it can lead to serious defoliation of the tree, reduction of productivity and oil quality. The damage is observed in two periods of the year; one in spring and the other in autumn (Trapero, 1994) or from autumn to winter (Viruega and Trapero, 1999). In contrast, according to Ferguson and Vossen (2009b), damage can occur at any time of the year when weather conditions are favorable. In dry climatic conditions, they rarely occur because the growth of the pathogen is limited or inactivated (Saad and Masri, 1978).

The peacock eye of the olive tree has been the subject of several research works both on the biological and ecological aspects, notably in order to control the pathogen and to reduce the phytosanitary

interventions, knowing that the olive groves are generally located in fragile ecosystems. Symptoms of the disease occur usually on the upper surface of the leaves (Sergeeva et al. 2009; MacDonald et al. 2000). The parasite causes dark brown lesions surrounded by concentric yellowish or pale green haloes. When the pathogen develops conidia, these lesions turn black (Obanor et al. 2005; Sultana and Nwara, 2010). Young leaves are more susceptible to the disease than older leaves, which become possible future infections (Trapero and Lopez-Doncel, 2005). The disease can also affect fruits in some cases when conditions are favorable for fungal activity.

Peacock eye attacks start with low branches before spreading throughout the tree. Infections can remain latent (asymptomatic) during the summer, making them difficult to detect. Infections then become evident in the spring. Under favorable conditions of temperature and humidity, peacock's eye constitutes a source of inoculum infection in the next season (Obanor et al. 2005, Graniti, 1993). It is known that the parasite can survive under unfavorable conditions (dry and hot weather), and that its activity begins when humidity is high (70–80%) and temperatures between 16–21°C (Obanor et al. 2005).

The disease is chemically controlled by application of coppers fungicides directly after harves tingalthough their effectiveness has not been proven (Graniti, 1993), knowing that copper causes disturbances in the metabolism of the plant, due to its accumulation in the soil (Zine El Aabidine et al. 2010). Therefore, the use of resistant cultivars remains the most efficient method that we can use in order to reduce the impact of this disease on orchards.

There are limited data on this pathogen in Algeria particulaly studies on the cultivars susceptibility to disease. On the basis of this, we consider that it is useful to start a study on the peacock's eye in two regions, in West and in Center of Algeria where the olive tree is common. The study is based on the incidence and severity of the disease on 11 cultivars, Sigoise, Chemlal, Sylviane, Rougette, Limli, Bounguergueb, Cœur de bœuf, Zaiti, Khodeiri, Terrella and Sorani. The aim of this study was not only to evaluate the incidence and severity of the disease, but also to select cultivars that are tolerant to the pathogen. The resistant cultivars can be identified and should be used in future programs of plantation.

Materials And Methods

Sampling sites

A filed survey was conducted during the main periods of infection of 2014 and 2015. Six regions were randomly selected. They are distributed in western Algeria: Relizane (El Hamadna), Mostaganem (Ain Nouissy), Mascara (Bouhenni) and in the Center: Algiers (Bentalha, Tessala el Merdja and BirTouta), as shown in Fig. 1. Those young orchards were under 20 years old and an orchard over 80 years old. The surveyed grove included 11 olives cultivars (Sigoise, Chemlal, Sylviane, Rougette, Limli, Bounguergueb, Cœur de bœuf, Zaiti, Khodeiri, Terrella and Sorani).

Sample collection

Autumn 2014 and winter early spring 2015 were used to identify the most favorable periods for infections by *Fusicladium oleagineum*. About 220 olive trees of different cultivars were sampled monthly from April to October. Sampling was performed using the four-repeat complete random block technique where each block contains five trees taken at random. 100 leaves/tree (symptomatic or asymptomatic) were sampled according to the four cardinal points (Salman et al. 2011; Tajnari, 1999). The aim is to highlight the part of the tree most affected by the disease.

176 samples were collected. Each sample is put in a paper bag accompanied by a label bearing all the information concerning its region, variety, age, area and date of collection, stored at 4°C, and then transported to the laboratory to evaluate the incidence and severity. Average monthly temperatures and precipitation are recorded from September 2014 to April 2015. These data will indicate the most favorable climate conditions for *Fusicladium oleagineum* infections.

Determination of disease incidence and severity

Leaves with visible and invisible symptoms were collected for evaluation of disease incidence and severity. The disease incidence was assessed by determining the percentage of infected leaves out of the total number of leaves collected (Abuamsha et al. 2013; Hajjeh et al. 2014).For severity rating in the laboratory, asymptomatic leaves were immersed in 5% sodium hydroxide (NaOH) for 20 minutes at room temperature. After treatment, leaves with visible symptoms were collected to evaluate the severity of peacock's eye by visually estimating the area (percentage) covered with lesions and counting the number of lesions on each leaf. Severity was recorded as 5, 12.5, 25, 37.5, 50, 75, 90 and 100% area covered with peacock's eye and classified as follows0 (healthy leaves), 1 (1 lesion), 2 (2 lesions), 3 (3–5 lesions), 4 (6–10 lesions) and 5 (> 11 lesions) (MacDonald et al. 2000).

Statistical analysis

The data collected on the percentage of infected leaves will allow us to carry out a series of analyzes on the presence of peacock's eye in the eleven cultivars studied. All data were analyzed for variance by Analysis of Variance (ANOVA). Significant differences between treatments were calculated based on the Tukey HSD test at $P < 0.05$.

Results

The results obtained on the susceptibility or resistance to peacock's eye disease on olive cultivars are based on laboratory observations. Assessment of disease is usually expressed by incidence and severity confirmed the degree of infection recorded by region. Therefore, it does seem that the greatest degrees of infection are given by the fall and early spring samples as has been pointed out by Viruega and Trapero, (1999) and Trapero, (1994). These results were also similar to the work of some authors (Gorter, 1943; Asawah, 1967) who showed that a strong infection of the disease appears in spring in Egypt, Kobras and North Africa. On the contrary, the samples taken on late summer to early winter gave a low degree of infection.

The results of this study showed variations of peacock's eye disease on cultivars of olive trees planted in different olive growing regions. It was found that the development of the disease during the investigation show a very highly significant difference ($F = 28.7$, $df = 7$, $P < 0.000$ and $F = 72.6$, $df = 7$, $P < 0.000$) for the incidence and severity of the disease, respectively (Fig. 2a and b) according to the different cultivars studied during the period from September 2014 to April 2015, with probability values less than 1‰. Cultivars Sylviane and Rougette showed very significant tolerance to peacock eye infection, while Sigoise, Chemlal and Syrian varieties showed very high susceptibility. Bounguergueb, Cœur de bœuf and Limli were found to be moderately tolerant.

The eleven cultivars vary in their susceptibility as shown by assessment and screening for disease incidence and severity ($F = 98.6$, $df = 10$, $P < 0.000$ and $F = 174$, $df = 10$, $P < 0.000$) for incidence and severity (Table 1 and Fig. 3). Cultivars Sigoise, Khodeiri, Sorani, Chemlal, Terrella and Zaiti were the most susceptible cultivars; they showed the highest incidence and severity (66.4% and 167.5%; 58% and 209.6%; 57% and 214.6%; 54.4% and 226.9%; 53, 3% and 233.4%). As shown in Table 1, Rougette and Sylviane were found the highest resistant cultivars (6.7 and 453.5; 5.8 and 470.5 disease incidence and severity; respectively). Other cultivars (that Bounguergueb, Cœur de bœuf and Limli) were moderately susceptible to peacock's eye disease.

Table 1
Effect of cultivars on peacock eye infection in different olive-growing regions affected in Algeria during the periods from September 2014 to April 2015.

Cultivars	% Incidence			% Severity
Sylviane	5,85 ±	0,94	470,5±	6,777572122
Rougette	6,7875 ±	2,50	453,5625±	75,15958828
Sigoise	66,4875±	17,94	167,5625±	89,71961252
Chemlal	56,9±	22,80	157,96875±	63,41389101
Bonguergueb	42,3125±	8,67	288,75±	43,23529025
Coeur de bœuf	30,5625±	5,92	347,1875±	29,61629619
Limli	30,1375±	8,60	349,375±	42,89653719
Terrella	54,4375±	20,23	226,90625±	103,0957461
Sorani	57,0625±	21,26	214,6875±	106,3170661
Khodeiri	58,075±	19,95	209,625±	99,76383403
Zaiti	53,3125±	13,20	233,4375±	66,0058343

The variation in susceptibility of olive trees in the field is due to the effect of the environmental conditions such as temperature, humidity and light (Obanor et al. 2008a; Al-Khatib et al. 2010). However, the

influence of environmental and host conditions were very highly correlated R^2 = 0,32. The number of lesions found on the leaves depended on disease incidence (y = 2,04 + 104,9) (Fig. 3).

In our study, previous results also indicated that the incidence and severity of the disease of peacock's eye depend on the susceptibility of the cultivars. The infection rate increases in all cultivars in late fall and early spring with the exception of Rougette and Sylviane (Fig. 4a and b). These results are in the same direction as those of Obanor et al. (2005); Guechi and Girre (1994) and Graniti (1993). Infections can occur throughout the year, except during the hot and dry summer (Razavi & Jahany, 2009).

The optimal weather conditions for the onset of the disease are autumn and early spring. Higher temperatures (> 27°C) were recorded during the months of May and August 2014. The decrease in temperature in November 2014 (> 20°C), allowed the development of the peacock's eye disease. The incidence reached higher values in the cultivars most susceptible to peacock's eye. And less than 15°C in January and February.

The highest level of disease severity for in most tested cultivars was recorded in March and April 2015 (18 to 25°C). As reported by Sistani et al. (2009); Viruega et al. (2011), the temperature is in a range of 5 to 25°C with an optimum between 15 to 20°C. This is explained by the increased infection rate in November, December and early spring (March to April).

The results of the leaves taken from the four cardinal points (North, South, East and West) of the tree showed no influence on the degree of attack. The intensity of the disease located on the four sides of the tree is explained by the microclimates surrounding the tree. The analysis of variance shows a non-significant difference in the variation of incidence according to exposure (North, South, East and West) with probability values (F = 0.43, df = 278.2, P > 5%; Fig. 5).

Discussion

The recorded results show that the attacks of the peacock's eye in the selected Algerian olive-growing regions differ from one region to another and from one campaign to another (Girre and Guechi, 1994a). Also, our observations have also indicated the sensitivity of some varieties to peacock's eye, including cultivars of Syrian origin (Terrella, Zaiti, Khodeiri and Sorani), Sigoise and Chemlal are considered the most sensitive, while the varieties Bounguergueb, Limli and Coeur de Bœuf seem less sensitive. On the other hand, Sylviane and Rougette seem to be more resistant to the disease, they recorded a lower incidence than all other cultivars.

However, the use of susceptible cultivars facilitates the appearance of peacock's eye with a higher infection rate in the presence of climatic conditions favorable to the development of the disease. This factor is a constraint for farmers. These results are in line with those of Serrhini and Zeroual (1995). These varieties represent a significant percentage in the olive groves of western and central Algeria. It should be noted that the orchards affected by peacock's eye are irrigated either by seguia or basin, or not irrigated affecting many colonial orchards or planted in mountainous areas but very few those irrigated

by drip. Another remark can be pointed out, it is the type of soil which has no influence on the appearance of the fungal disease.

Our results showed that the relationship between climatic conditions and incidence was positive, corroborating those of Salman et al. (2011). The climatic conditions during this fall-winter period are favorable for the development of the disease. These results are also in line with those of Viruega and Trapero (1994), when they explain that the main periods of infection occur during the fall and winter. Knowing that the humidity during this period varies between 80 and 85% and a temperature of 15 to 25°C favor the development of an epidemic of the pathogen. Obanor and al. (2005) and Graniti (1993) also reported that the infection with peacock's eye occurs during autumn to early spring and the pathogen is dormant during hot.

Regarding the results obtained on the exposure of the disease on the four cardinal points (North, South, East and West), they reveal that no significant difference was noted between the four sides of exposure. Exposure does not seem to influence the appearance of peacock's eye. Therefore, favorable climatic conditions affect the development of the disease. These results are in disagreement with Tajnari (1999), who reported that the north-facing side was the most affected by peacock's eye with a higher rate of leaf infection, followed by the west, south and east. The interior of the foliage is more attacked than the exterior. Our visual observations during the surveys showed that the lower part of the foliage is more infected than the upper part as already reported by Tajnari in 1999 and Viruega and Trapero (1999): *Fusicladium oleagineum* refers to the lower part of the tree where high heat exerts a thermotherapy effect.

Conclusion And Recommendation

Peacock's eye is an economically important disease in some regions of the West, notably Mostaganem, Relizane and Mascara, and in the Centre in Algiers, Bejaïa, Tizi-Ouzou and Bouira (Guechi, 2001). Our survey, which is the first one in Algeria, allowed us to evaluate the latent infection of the disease and its severity. The symptomatological observations made in the field and the climatic data (rainfall and average daily temperatures) collected by the meteorological stations were very favorable to the development of this pathogen with average temperatures between 17 and 24°C in autumn and early winter, late winter (late February) and early spring (March and April) with average temperatures between 19 and 24°C.

The most dominant cultivars in Algeria Chemlal and Sigoise as well as the Syrian varieties (Zaîti, Khodeiri, Terrella and Sorani), which react differently to the disease, were classified as the most susceptible. As for the cultivars Bounguergueb, Cœur de bœuf and Limli show a moderate resistance compared to the other cultivars. On the other hand, the cultivars Sylvaine and Rougette showed resistance to the disease.

For this reason, the use of resistant varieties is strongly recommended to better control the disease. However, further studies are needed to identify bio-control agents for the treatment of peacock eye disease in Algeria.

Declarations

Author's contributions: Production and writing of the article, N. K-B; Methodology, Z.B; Statistical analysis and writing, A. B; Validation, K.M.

All authors have read and approved the published version of the manuscript.

Conflicts of Interest: The authors declared that present study was performed in absence of any conflict of interest.

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Figures

Figure 1

Location of olive-growing regions infected by *Fusicladium oleagineum*

in the West and in the Center (Algiers).

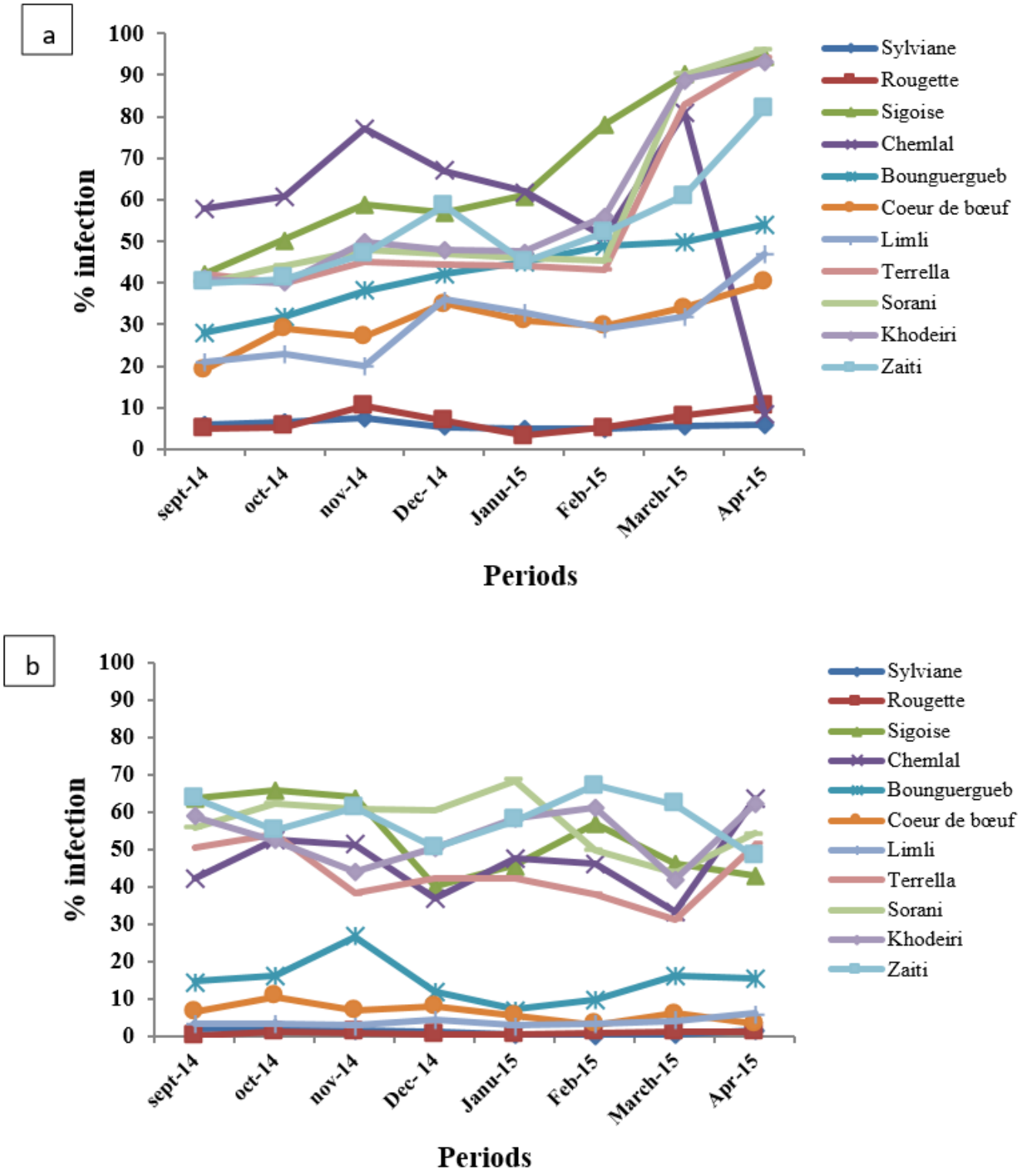

Figure 2

Assessment of disease incidence (a) and severity (b) of peacock eye in different cultivars in Algeria, during the period from September 2014 to April 2015.

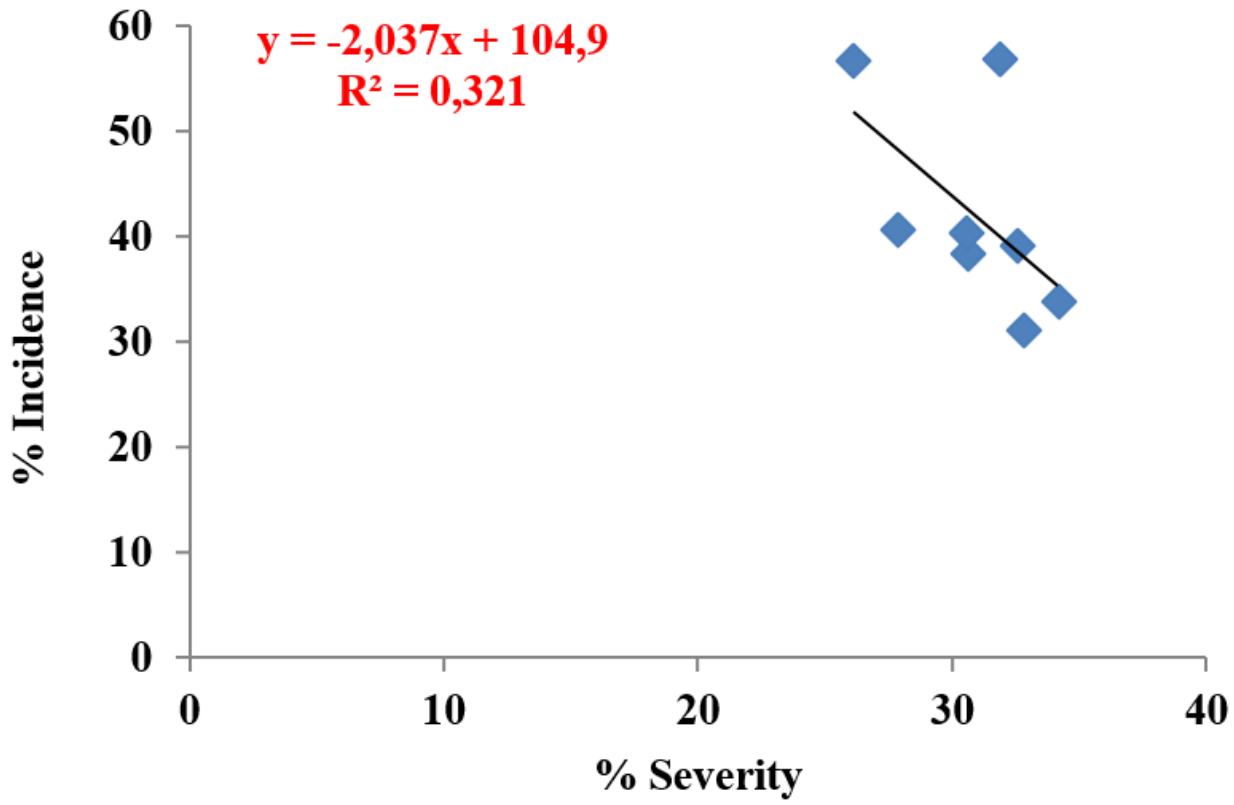

Figure 3

Relationship between incidence and severity (% Infection).

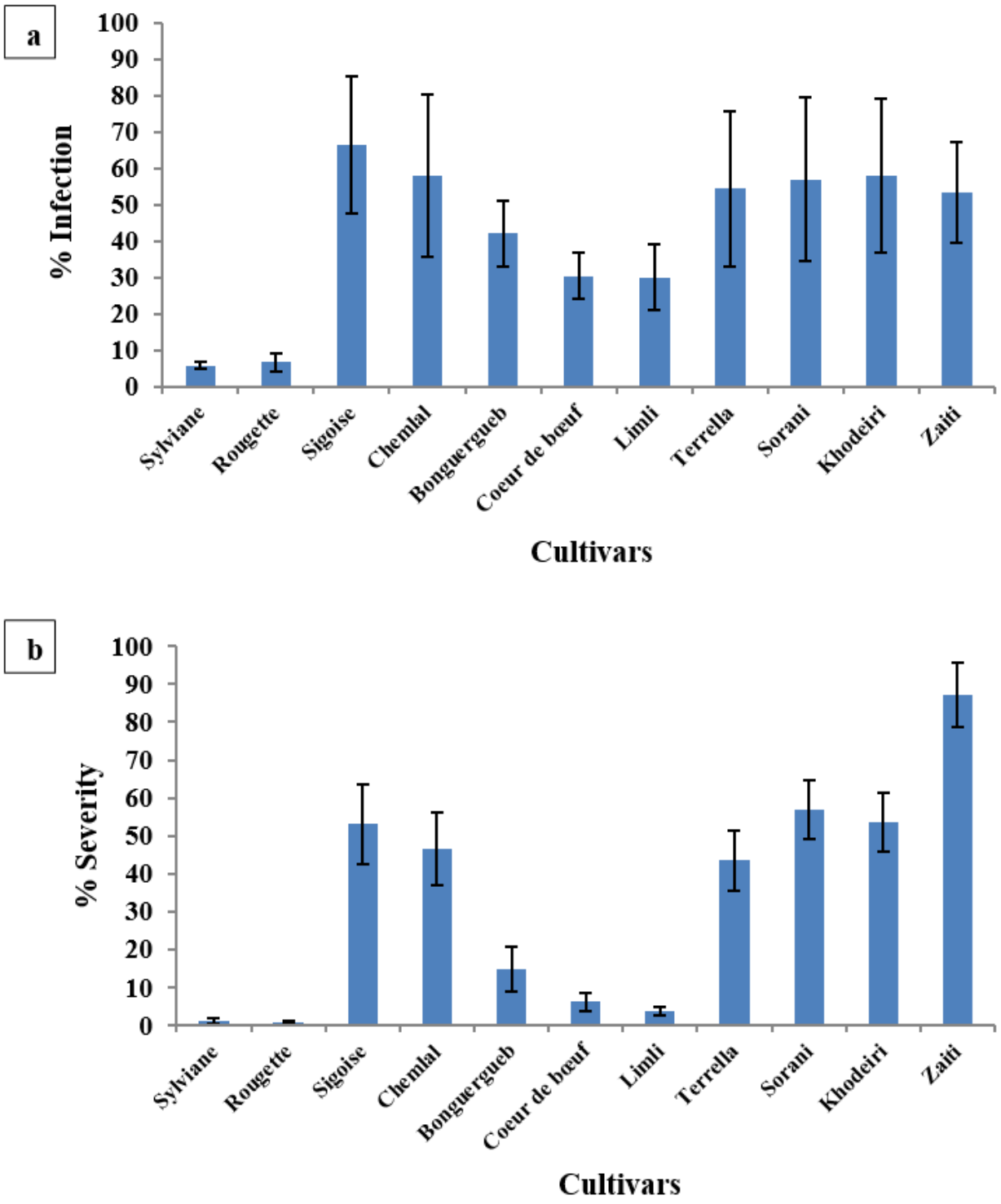

Figure 4

Incidence (% Infection) (a) and Severity (% Infection) (b) of peacock eye in the different cultivars in the affected olive growing regions.

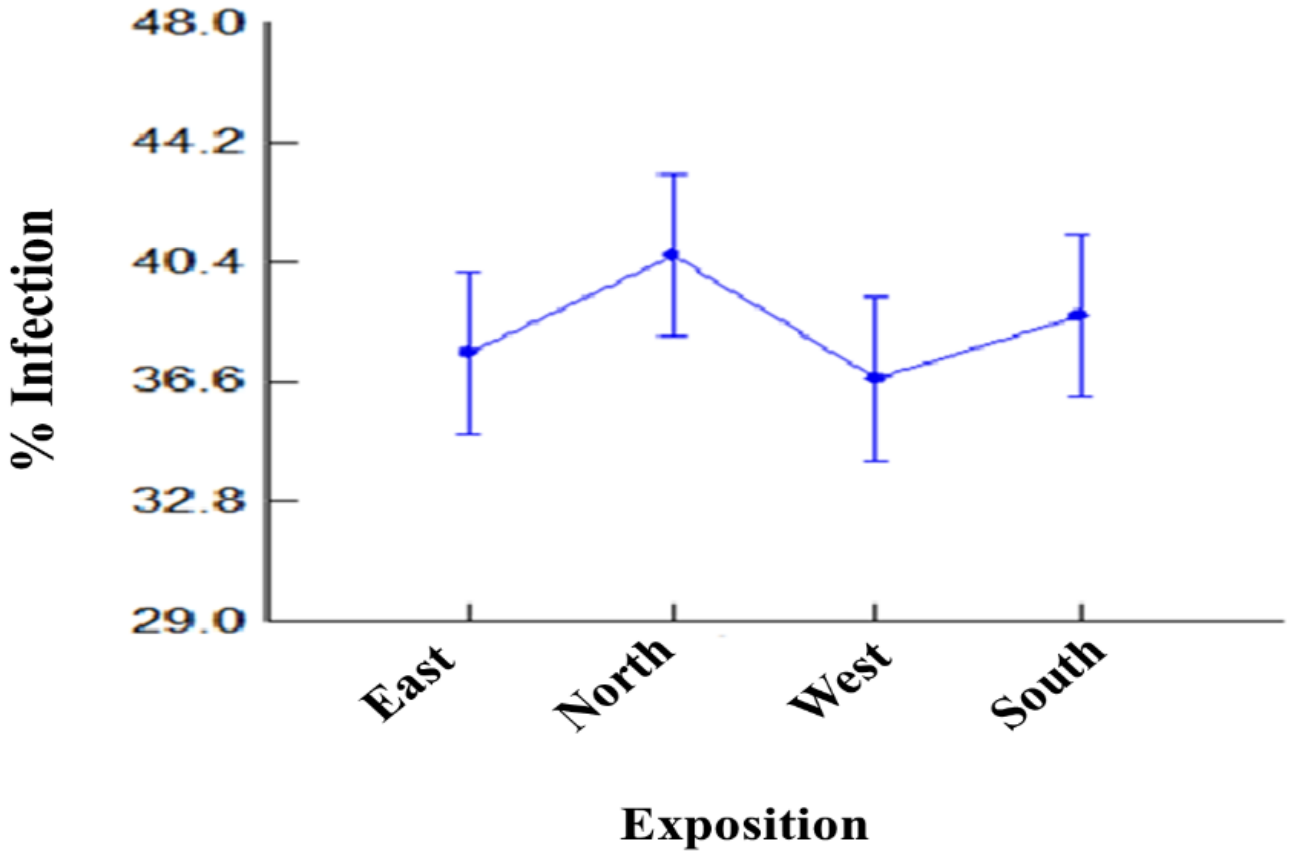

Figure 5

Distribution of peacock eye on olive tree (exposure effect)