

Review Article

Symptomology of Major Fungal Diseases on Olive and Its Management

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The olive tree count among the most important oil-producing crops throughout the Mediterranean region. It has nutritional, social, economic, phytotherapeutic and ecological importance. All of the olive tree diseases cause considerable drops in yield and represent a permanent threat to olive growing in the world. The main fungal diseases of the olive are: Verticillium wilts, Root rot fungi, Sooty mold, Peacock spot, Anthracnose, Cercospora leaf spot of olives and Dalmaticosis of the olive. In this article we have cited for each disease the main symptoms and their means of control.

Keywords: Olive Tree; Verticillium Wilt; Root Rot Fungi; Sooty Mold; Peacock Spot; Anthracnose; Cercospora Leaf Spot of Olives and Dalmaticosis**Introduction**

The olive tree (*Olea europaea* L.) is one of the oldest cultures in the Mediterranean. The olive tree is the main cultivated fruit species since it represents 65% of the national arboreal sole in Morocco. It occupied an area of 1 020 570 hectares in 2016/2017, of which 34910 ha were in the irrigated area and 212880 ha in Bour. It should be noted that total olive-growing area in 2016/2017 was composed of 64% in Bour and 36% in irrigated. National holdings totaled around 1.56 million tonnes of olives in 2017/2018 (Anonyme 1). However, this production experiences significant interannual fluctuations due to the alternation of olive trees, the irregularity of rainfall and the lack of maintenance of orchards driven in Bour which affect productivity. Morocco also produces 160000 tonnes of olive oil and 90000 tonnes of table olives. In terms of exports, 17000 tonnes of olive oil and 64000 tonnes of table olives are found on international markets (Anonyme 2). Moroccan olive growing is made up of 96% of the population variety « Moroccan Picholine ». The rest of the heritage consists of Meslala, Canned Olive, Picholine from Languedoc, Dabha Houwzia and Menara. There are also other varieties from other countries such as Arbequina or Manzanilla from Spain and Leccino from Italy (Anonyme 1).

World olive oil production would reach 3135000 tonnes according to the International Olive Council for 2018. Olive oil production is concentrated around the Mediterranean : Spain (1550000 tonnes), Italy (270000 tonnes), Greece (240000 tonnes), Turkey (183000 tonnes), Portugal (130000 tonnes), Morocco (145000 tonnes) and Tunisia (120000 tonnes). These countries alone represent more than 90% of world production in 2018.

The olive tree is used as a medicinal plant, in particular for its leaves which have a diuretic, hypotensive and vasodilation effect and are used in the composition of pharmaceutical specialties. For pharmacologist it is oleuropein which is hypotensive and to a lesser extent triterpene compounds derived from oleanic acid. Oleuropein is a seco-iridoid, a fairly bitter compound that breaks down fairly

quickly, therefore it seems preferable to use standardized extracts from the olive leaf (Glycerin maceration, stabilized extract) rather than a decoction or aqueous infusion. Olive leaf is also anti-diabetic and clinical studies confirm its indication to prevent atherosclerosis (Lakache et al., 2019, Lamzira et al., 2014, Susalit et al., 2011).

Olive growing faces several problems, in particular attacks caused by microorganisms (Bacteria and Fungi) or viruses. All of the olive tree diseases cause considerable yield losses and represent a threat to olive growing. Olive pathogens exceed one hundred, but only a small number among them that cause serious economic losses to olive groves (Trapero and Blanco, 2010). The most important diseases of the olive tree known in the world are presented in this article. An important group of diseases is the complex of leaf and fruit fungal diseases, mainly scab caused by *Fusicladium oleagineum*; anthracnose caused by *Colletotrichum* spp. and Cercospora leaf spot of olives due to *Pseudocercospora cladosporioides*. These three diseases cause significant defoliation, weakening of the tree and reduction of the productivity and quality of the olive tree (Trapero and Blanco, 2010).

Verticillium Wilt

It is a disease caused by telluric fungi, *Verticillium dahliae*, it is a vascular disease known in many regions of the world (Lopez Escudero and Mercado-Blanco, 2010, Bellahcene et al., 2000)). *Verticillium dahliae* penetrates first affects the roots of young plants, colonizes them xylem and phloem cells, then stems and leaves through the sap flow (Chliyah et al., 2014). This causes vascular lesions with circulatory disturbances which result in two types of symptoms (Jabnoun-Khiareddine et al., 2007): The acute rapid dieback in young trees and the chronic dieback in old trees. Fast acute dieback in young trees and chronic slow in old trees (Bubici et Cirulli, 2011).

- Rapid decline: the leaves turn yellow, then dry up while remaining attached to the branch. The bark turns brown and the twig or branch dries (Tombesi et al., 2007, Bellahcene, 2004).

- Slow decline: the color of the leaves becomes tarnished and the terminal buds necrotic, but the branches do not dry completely.

Table 1: Integrated Management of Major fungal Diseases of Olive.

Diseases	Cultural practices	Chemical Practices	Biological Practices
Verticillium wilt	Plant material must be certified. Avoid soil with previous crops favorable to this disease. Balance fertilization and irrigation. Disinfection of agricultural implements before and after use. Avoid weeds and planting susceptible to <i>Verticillium dahliae</i> around trees. During winter pruning remove and burn all twigs and branches dried out (Tombesi et al., 2007).	The injection of Carbendazim into the trunk seems to stop the attack for five months (Tombesi et al., 2007). Injection with benomyl, phosetyl-Al, their mixtures with quinazol or prochloraz (Trapero and Blanco-Lopez, Mule et al., 2002)	Use of organic amendment against <i>Verticillium dahliae</i> (Vitullo et al., 2013, Varo-Suarez et al., 2018) Use of non pathogenic strain of <i>Fusarium oxysporum</i> , fungi <i>glomus intradices</i> and <i>Pseudomonas fluorescens</i> against this disease (Mulero-Aparicio et al., 2019, Varo et al., 2016, Mercado-Blanco et al., 2004).
Root rot fungi	Avoid waterlogging and excessive irrigation. Avoid soil movement from infected areas to non-infected areas. Avoid planting in sites with previous history of root fungal disease. Avoid intercropping with susceptible plants Use disease free planting material.	Use the fungicides : pyraclostrobin, tebuconazole+trifloxystrobin , mancozeb, bioproducts included copper oxychloride and sulphur-based product (Nitro et al., 2018). Treat with Ridomil gold	Use of <i>Bacillus subtilis</i> against this disease (Nigro et al., 2018) Use of <i>Bacillus cereus</i> , <i>Azotobacter sp.</i> , <i>Bacillus megaterium</i> and <i>Bacillus subtilis</i> against this disease (Abdel-Monaim et al., 2014) Use of <i>Bacillus subtilis</i> and <i>Trichoderma harzianum</i> (Mousa et al., 2006)
Sooty Mold	Make sure the plant is well nourished and well watered. A plant weakened by poor soil or lack of water is a vulnerable plant. Diversity the plants and flowers in your garden, this is the best way to offer them natural protection against diseases.	Spray in the leaves with Bordeaux mixture should be enough to remove the sooty mold. An effective remedy against sooty mold is also to fight against the insects which are responsible for it.	
Peacock spot	Apply cultural practice that provides well aerated trees. This can be achieved with contoured planting to encourage air drainage through the grove followed by selective pruning to avoid dense canopy (Roca et al., 2010)	Copper An-Tracol can be viewed as the best choice for the control of the disease (Salman et al., 2014). Copper-based fungicides (Copper sulfate, Cu at 3.5kg/ha) were applied during the spring and autumn to limit fungal foliar and fruit diseases (Trapero et al., 2010).	Use of <i>Pseudomonas spp.</i> , <i>Bacillus spp.</i> and <i>Microbacterium spp.</i> against this disease (Salman, 2017)
Anthracnose	Prune to aerate the canopy Copper can be applied as a protectant and there is also a permit for amistar, which should also be applied as a protectant	Use the fungicides : pyraclostrobin, tebuconazole+trifloxystrobin , mancozeb, bioproducts included copper oxychloride and sulphur-based product (Nigro et al., 2018)	Use of <i>Bacillus subtilis</i> against this disease (Nigro et al., 2018)
Cercospora leaf sport of olives	Apply cultural practice that provides well aerated trees. This can be achieved with contoured planting to encourage air drainage through the grove followed by selective pruning to avoid dense canopy (Roca et al., 2010)	Copper-based compounds or mixtures of these compounds with systemic fungicides, such as difenoconazole, tebuconazole and strobilurin have had successful results in controlling olive aerial diseases (Nigro et al., 2018, Obanor et al., 2008, Viruega et al., 2002)	Use of <i>Bacillus subtilis</i> against this disease (Nigro et al., 2018)
Dalmaticosis of the olive	Reason irrigation and fertilization, moderate nitrogen supply. Effective control of the olive fly seems essential to limit the development and spread of the disease : the entry and exit holes it causes have a definite impact on the development of these diseases. In order to decrease the primary inoculum rate, it is strongly advised to collect and incinerate dropped olives on the ground. (CIO, 2007)	Use Two fungicides (Nordo and Mancozebe) against the fungi <i>C. dalmaticum</i> (Margier et al., 2014) Copper-based compounds or mixtures of these compounds with systemic fungicides, such as difenoconazole, tebuconazole and strobilurin have had successful results in controlling olive aerial diseases (Nigro et al., 2018)	Use of <i>Bacillus subtilis</i> against this disease (Nigro et al., 2018)

Only the floral clusters are very affected and dry up (Tombesi et al., 2007).

Symptoms appear at the end of winter, as soon as temperatures rise during the day and spread out during the growing season. Generally it is in March and April that drying out is most spectacular (Jiménez-Díaz et al., 1998).

The internal pathological symptoms of Verticillium wilt of the olive tree are manifested by browning of the xylem of the infected branches (Tombesi et al., 2007) and of the central cylinder of the root system (Triki et al., 2006).

Verticillium dahliae can survive in the soil for several years, up to 20 years, in the form of free microsclerotia or in infected tissue (Triki et al., 2006). This fungus spreads through the transport of contaminated tissue, whether it is vector plants or pruned wood. To a lesser extent, sawdust (Cutting tools), soil (Tillage tools), water (gravity irrigation) or wind can also contribute to the spread of the disease (Klosterman et al., 2009, Chawla et al., 2012).

Root Rot Fungi

It is a fatal vascular disease for the olive tree, it is caused by a complex of telluric fungi (Tombesi et al., 2007) : *Macrophomina*

phaseolina (*Rhizoctonia bataticola*), *Armillaria mellea* Kumm (Glynn *et al.*, 2011), *Fusarium solani* sacco, *Corticium rolfsi* curzi, *Fusarium oxysporum*, *Phytophthora megasperma*, *Corticium solani*, *Rosellinea necatrix*. The fungi act in synergy, each taking its share of the infection (Boulila, 1994 et 2001). Symptoms of root rot are generally manifested by slender olive trees the branches bear leaves reduced in size and number. The latter take on a yellowish appearance in spring and which later becomes accentuated to become golden yellow. This color persists throughout the summer season but with the arrival of autumn the plant begins to more or less regain its normal appearance. Indeed, its foliage becomes pale green in color; however, it keeps its weak and bald appearance (Boulila, 1994). For a strong attack, the leaves begin to necrose at their tips and eventually dry out. There follows a significant fall which affects the inflorescences which become dehydrated, turn brown and die (Boulila, 1994, Sanchez-Hernandez *et al.*, 2001, Bareto *et al.*, 2002, Moussa *et al.*, 2006, Barrera *et al.*, 2003).

Sooty Mold

The sooty mold also called « Olive black » is one of the diseases that can suffer the olive tree. The sooty mold is the cause of the performance of genera fungi *Capnodium sp.*, *Fumago sp* and *Aureobasidium spp*. It develops on honeydew secreted by insects such as mealybugs and aphids. Mycelia settle on the surface of woods, leaves and fruits to form a black film that causes premature aging by suffocation by blocking the photosynthesis and by reducing gas exchanges. It slows growth and leaves a blackish layer on the leaves. Tree growth and production olives are reduced. The development of sooty mold weakens trees already affected by persistence of sooty mold can cause defoliation. The exact repercussions of sooty mold on olive production remain difficult to assess but it's not trivial (LeVerge *et al.*, 2016).

The development of sooty mold being linked to proliferation of the black scale of the olive tree, it is necessary to pay more attention to the factors favoring mealybug; the absence of size or sizes too spaced apart, insufficient spacing between foliage, excessive nitrogen fertilization, repeated applications of poorly selective insecticides lead to reduce the auxiliary fauna, mild temperatures in winter, higher humidity in summer (LeVerge *et al.*, 2016).

Peacock Spot

The disease is also known as the peacock eye or olive leaf spot (Macdonald *et al.*, 2000). It is due to the fungi *Venturia oleaginea* (Castagne) (Rossman et Crous, 2015) which is answered in the Mediterranean area and in the areas of live growing (Trapero *et al.*, 2017), it is responsible for serious yield losses in many olive growing regions all over the world (Graniti, 1993, Romero *et al.*, 2018). The fungi attacks all the vegetation of the plant in autumn and spring, but especially forms brownish spots distributed irregularly on the top of the leaves, these spots can vary between 0.5 to 1.2 mm in diameter. They then turn greyish brown surrounded by a yellow halo like the eye on the peacock's tail feathers. Diseased leaves fall faster causing imbalances in the plant and drying of its branches (Obanor, 2005, Trapero and Blanco, 2008, Alsalmiya *et al.*, 2010, Viruega *et al.*, 2013). The fungus overwinters as a mycelium mainly on the leaves attacked in previous years. Contamination occurs in cool weather

(12-15°C) and humidity, and the optimum germination is 20°C. High temperatures hinder the development of the disease. (Hajjeh *et al.*, 2014, Moral *et al.*, 2014, Rhimini *et al.*, 2014, Lopez *et al.*, 2000).

Anthracnose

Anthracnose may be regarded as the most damaging disease of olive fruit worldwide (Farr and Rossman, 2013). It is produced by fungi *Colletotrichum acutatum* and *colletotrichum gloeosporioides*. Initially it only affected olives, but currently fungi produce a toxin that weakens the olive trees by drying the affected branches. It is the rainy autumn when the fungi has a greater development and produces significant damage, especially in the olive varieties more sensitive to the disease. The olive anthracnose occurs in the branches with a significant amount of infected fruits and produces the dry of branches up to 5 centimeters in diameter (Achbani *et al.*, 2013). In the first stage of development, symptoms are only detected in olive (Agostero *et al.*, 2005). The first symptoms are round and necrotic spots with brown color (Oliveira *et al.*, 2005), ochre or brown. Initially the fruits have one or more round and growing spots. In the final phase, the spot grows and comes together, completely infecting the olive. When the humidity is high, on the spots it forms a jelly-like and orange substance with a lot of spores. As the infestation progresses, the olives fall to the ground or remain dry and mummified in the tree (Moral *et al.*, 2009, Moral and Trapero, 2009). Olives infected by the fungi emit a toxin that produces an effect similar to that of leaf chlorosis. These chlorotic spots expand covering almost the entire leaf. Finally, the leaves dry and fall to the ground, causing significant defoliation. Anthracnose develops well with conditions of temperature of 10-30°C and high relative humidity more than 93% (Moral *et al.*, 2011, Oliveira *et al.*, 2005). The main source of anthracnose inoculum is the mummified olives that remain in the top of the tree (Graniti *et al.*, 1993, Moral and Trapero, 2012).

Cercospora Leaf Spot of Olives

Cercospora leaf spot is a serious disease of olives it is caused by *Pseudocercospora cladosporioides* (Garcia Figueres, 1991). The disease primarily affects the foliage and more rarely the fruits symptoms in the foliage are generally observed from autumn to Spring on leaves over one year old. On the upper side of the leaves yellow chlorosis tends to gradually become necrotic, especially at the tip and on the sides, while the lower side is covered with a characteristic grayish felting linked to the multiplication of conidia. This felting may disappear due to the entrainment of conidia by the rains (Crous *et al.*, 2000, Trapero & Blanco 2004, Tombesi *et al.*, 2007).

The rare symptoms on the fruit correspond to more or less circular spots of 3 to 7 mm in diameter, the color of which varies according to maturity: on green olives, the lesions are ochre to brown in color while during ripening; the spots turn gray, sometimes with a pale or yellowish halo. Spores can be kept on crop waste and keep their temperatures between 10 to 20°C and high relative humidity. The pathogen spreads from a short distance, leaf by leaf, by conidia or mycelial fragments, favored by wind and rain (Avila and Trapero, 2010).

Dalmaticosis of the Olive

Dalmaticosis is an olive disease caused by the fungi *Botryosphaeria*

dothidea (formerly known as *Camarosporium dalmaticum*) (Arambourg, 1986, Phillips *et al.*, 2005). At the beginning of infection, dalmaticosis is manifested by a more or less circular spot of brown color, a few millimeters in diameter, forming a necrotic depression on the surface of the fruit. Once infected, the olive gradually dries up, mummifies and usually ends up falling. These symptoms appear during the summer, during the laying activity of the olive fly (*Bactrocera oleae*) (Margier *et al.*, 2014). The damage tends to intensify from the end of August. Dalmaticosis leads to a fall in olives, sometimes massive, with losses of up to more than half the harvest. The necrotic lesion makes the fruit unsuitable for processing for the table olive. When necrotic olives are harvest the quality of the oil is degraded (Jelena *et al.*, 2013).

The damage is very variable depending on the geographic location the varieties planted, the method of irrigation and the strategies used in the fight against the olive fly (Margier *et al.*, 2014).

References

- Abdel-Monaim M F, El-Morsi M E A, Hassan MAE. Control of root rot and wilt disease complex of some evergreen fruit transplants by using plant growth promoting rhizobacteria in the New Valley Governorate, Egypt. *Journal of Phytopathology and Pest Management*. 2014; 1(3): 23-33.
- Achbani EH, Benbouazza A, Douira A. First Report of Olive Anthracnose, Caused by *Colletotrichum gloeosporioides*, in Morocco. *Atlas Journal of Biology*. 2013; 2(3): 171-174.
- Agosteo GE, Macri C, Taccone P. Susceptibility of olive cv. Itrana to Anthracnose. *J. Plant Pathol.* 2005; 87: 287.
- Alsalmiya M, Lopez-Doncel L M, Navarro N, Roca L F, *et al.* El repilo del olivo y del acebuche. Grupo de Patología agroforestal de la Universidad de Córdoba. 2010.
- Anonyme 1. Evaluation de la filière oléicole, Rapport annuel de la Cour des comptes au titre de l'année. 2018: 257-286.
- Anonyme 2. <http://www.agriculture.gov.ma/pages/acces-filières/filière-oléicole>, page visitée le. 4/05/2020.
- Arambourg Y. *Entomologie oléicole*, 1986; 95-111.
- Avila A, Trapero A. El Emplomado del olivo y del acebuche. Grupo de Patología Agroforestal de la Universidad de Córdoba. 2010.
- Barrera VA, D Barreto, B Perez, M Roca, S Naito, K Kobayashi. Rhizoctonia root rot of olive trees in Argentina. *International Congress Plant Pathology (ICPP)*. 2003; page, 86.
- Barreto D, S Babbito, M Gally, BA Perez. First report of *Nectria haematococca* causing wilt of olive plant in Argentina. *Plant Dis.* 2002; 86(3): 326.
- Bellahcene Mn. La verticilliose de l'olivier: étude épidémiologique et diversité génétique de *Verticillium dahlia kleb*, Agent de la verticilliose. Thèse. Doct. D'Etat. Univ. Oran (Algerie), 2004; 144pp.
- Bellahcene M, Fortas Z, Geiger JP, Matallah A, Henni D. *Verticillium* wilt in olive tin Algeria: Geographical distribution and extent of the disease in *Olivae*, 2000. N°82, pp41 – 43.
- Boullila M, Mahjoub M. Inventaire des maladies de l'olivier en Tunisie. *Bulletin OEPP/EPPO Bulletin*. 1994; 24: 817-823.
- Boullila M. Decline of olive grown from herbaceous cutting in Tunisia. *Bull OEPP*, 2001; 31: 111- 112.
- Bubici G, Cirulli M, *Verticillium* wilt of olives. In Schena L, Agosteo GE, Cacciola SO (eds) *olive diseases and disorders*. Research signpost, Kerala, (India) ISBN: 2011; 1-14.
- Chawla S, Woodward J E, Wheeler T A. Influence of *Verticillium dahliae* infested Peanut Residue on Wilt Development in Subsequent Cotton. *International Journal of Agronomy*. 2012; 212075, 5 pages.
- Chliyah M, Youssef Rhimini, Karima Selmaoui, Amina Ouazzani Touhami, Abdelkarim Filali-Maltouf, Cherkaoui El Modafar, *et al.* Comparative study of pathogenicity tests for *Verticillium dahliae* and *Phytophthora palmivora* causing wilt and decline of olive tree (*Olea europaea* L). *Int J Pure App. Biosci.* 2014; 2(2): 28-38.
- Crous P W, Aptroot A, Kang J C, Braun U, Wingfield M J. The genus *Mycosphaerella* and its anamorphs *Studies in Mycology*. 200; No 45: 107-121.
- Farr DF, Rossman AY. *Fungal Databases, Systematic Mycology and Microbiology Laboratory, ARS, USDA*. 2013.
- Hajjeh H, Salman M, Abuamsha R, Abueid M, Jawabreh M, Hawamda A, Rumaileh B. Latent Infection of Olive Leaf Spot Disease on Palestinian Olives. *Annu Res Rev Biol.* 2014; 4(15): 2517-24.
- García Figueres. *Repilos del olivo: ataque en fruto*. *Phytoma España*. 1991; 25: 31-36.
- Glynn C P, Smiley E T, Fox R T V. root collar excavation with *Trichoderma* inoculations as a potential management strategy for honey fungus (*Armillaria mellea*). *Arboricultural Journal*. 2011; 33: 267-280.
- Graniti A. Late damage to olive trees. *Bull. OEPP/EPPO, Bull.* 1993; 23: 489-491.
- Graniti A, Frisullo S, Penissi A, Magnano L. Infections of *Glomerella cingulata* on olive in Italy. *EPPO Bull.* 1993; 23: 457-465. <http://dx.doi.org/10.1111/j.1365-2338.1993.tb013537.x> .
- Jabnoun-Khiareddine H, Daami-Remadi M, Ayed F, Jebari H, El Mahjoub M. Incidence of *Verticillium* wilt of Melon in Tunisia. *Afr. J. Plant Science and Biotechnology*. 2007; 1(1): 10-15.
- Jelena L, Angelo M, Nedeljko L, Mirko I, Mark L G. Resistance of olive cultivars to *Botryosphaeria dothidea*, causal agent of olive fruit rot in Montenegro. *Crop Protection*. 2013; 48: 35-40.
- Jiménez-Díaz R. M, Tjamos E C, Cirulli M. *Verticillium* wilts of major tree hosts. In J. Hiemstra *et al.* Harris (Eds), *Compendium of Verticillium wilt in tree species*. Ponsen and Looijin Wageningen : Ponsen and Looijen. 1998; 55-57.
- Klosterman S J, Atallah Z K, Vallad G E, Subbarao K V. Diversity, pathogenicity and management of *Verticillium* species. *Annu Rev Phytopathol.*, 2009; 47: 39-62.
- Lakache Z, Tigrine C, Aliboudhar H, Kameli A. Composition chimique, activités anti-inflammatoire, antalgique et cytotoxique in vivo de l'extrait méthanolique des feuilles d'*Olea europaea*. *Phytothérapie*. DOI 10.3166/phyto-2019-0195. 2019; 1-10.
- Lamzira Z, Ghabbour N, Rokni Y, Thonnart P, Chihib N, *et al.* Characterization of Phenolic Profile of Moroccan Picholine Olive Variety. *JMES*. 2014; 5: 490-497.
- LeVerge S, Couanon W, Pintel C. *La fumagine de l'olivier*. 2016.
- Lopez-Escudero F J, Mercado-Blanco J. *Verticillium* wilt of olive: a case study to implement and integrated strategy to control a soil-borne pathogen. *Plant Soil*. 2010; 344(1): 1-50.
- López-Doncel LM, Viruega-Puente JR, Trapero-Casas A. Respuesta del olivo a la inoculación con *Spilocaea oleagina*, agente del repilo. *Bol San Veg Plagas*. 2000; 26: 349-63.
- Margier R, Artaud J, Pintel C. Cécidomyie de l'olivier et ses dégâts : la Dalmaticose. *Le Nouvel Olivier*. 2014; 97: 18-23.
- Mercado-Blanco J, Rodríguez-Jurado D, Herveas A, Jimeenez-Díaz RM. Suppression of *Verticillium* wilt in olive planting stocks by root-associated fluorescent *Pseudomonas* spp. *Biol Control*. 2004; 30: 474-486.
- Moral J, Alsalmiya M, Roca LF, Diez CM, León L, *et al.* Relative Susceptibility of New Olive Cultivars to *Spilocaea oleagina*, *Colletotrichum acutatum*, and *Pseudocercospora cladosporioides*. *Plant Dis*. 2014; 99: 58-64.
- Moral J, Trapero A. Mummified fruit as a source of inoculum and disease dynamics of olive anthracnose caused by *Colletotrichum* spp. *Phytopathology*.

- 2012; 102: 982–989.
38. Moral J, Jurado-Bello J, Trapero A. Effect of temperature and relative humidity on mycelial growth, conidial germination and fruit infection by *Colletotrichum* spp. causing olive Anthracnose. IOBC/WPRS Bull. 2011; 79: 14.
39. Moral J, Trapero A. Assessing the susceptibility of olive cultivars to anthracnose caused by *Colletotrichum acutatum*. Plant Dis. 2009; 93: 1028–1036. <http://dx.doi.org/10.1094/PDIS-93-10-1028>.
40. Moral J, Trapero A. Resistance of the olive tree to Anthracnose caused by *Colletotrichum* spp. Bulletin SEF 66. 2009; 22–30.
41. Mousa MS, MK Ali, AA Mousa, IS Elewa. Root rot disease of olive transplants and its biological control. Arab Univ J Agric Sci. Ain Shams Univ. Cairo, 2006; 14(1): 395-409.
42. Mule R, Fodale, AS, Tucci A. Control of olive *Verticillium* wilt by trunk injection with different doses of fosetyl-Al and benomyl. Acta Hort. 2002; 586: 761-764.
43. Mulero-Aparicio A, Agustí-Brisach C, Varo A, Lopez-Escudero FJ, Trapero A. A non-pathogenic strain of *Fusarium oxysporum* as a potential biocontrol agent against *Verticillium* wilt of olive. Biol Control. 2019. 139.
44. Nigro, F. Antelmi I. and Sion, V. Integrated control of aerial fungal diseases of olive. In Proceedings of the 8th International Olive Symposium; Acta Hort. 1199. 2018. DOI 10.17660/ActaHortic.2018.1199.51.
45. Obanor FO, Jaspers M V, Jones E E, Walter M. Greenhouse and field evaluation of fungicides for control of olive leaf spot in New Zealand. Crop Protec. 2008; 27: 1335-1342.
46. Oliveira R, Moral J, Bouhmid K, Trapero A. Morphological and cultural characterization of *Colletotrichum* spp. Isolates . causing anthracnose of the olive tree. Bol San Veg Pests. 2005; 31: 531–548.
47. Phillips AJL, Rumbos IC, Alves A, Correia A. Morphology and phylogeny of *Botryosphaeria dothidea* causing fruit rot of olives. Mycopathologia. 2005, 159(3): 433–439.
48. Roca LF, Viruega JR, López-Doncel LM, Moral J, Trapero A. Métodos culturales, químicos y biológicos de control del Repilo. Vida Rural. 2010; 304: 38-42.
49. Romero J. Desarrollo y validación del modelo epidémico “Repilos” en el olivar andaluz. PhD Thesis. ETSIAM, Universidad de Córdoba, Córdoba. 2017; 429.
50. Romero J, Carlos Agustí-Brisach, Luis F Roca, Juan Moral, Elisa Gonzalez-Dominguez, Vittorio Rossic, Antonio Trapero. A long-term study on the effect of agroclimatic variables on olive scab in Spain. Crop Protection. 2018; 114: 39–43.
51. Rossman AY, Crous PW, Hyde KD, Hawksworth DL, Aptroot A, et al. Recommended names for pleomorphic genera in Dothideomycetes. IMA Fungus. 2015; 6(2): 507-23.
52. Rhimini Youssef, Mohamed Chliyeh, Abdellatif Ouazzani Chahdi, Jihane Touati, Amina Ouazzani Touhami, et al. Influence of certain cultural practices and variable climatic factors on the manifestation of *Spilocaea oleagina*, olive peacock spot agent in the northwestern region of Morocco. Int J Pure App. Biosci. 2014; 2(5): 1-9.
53. Salman M. biological control of *spilocaea oleagina*, the causal agent of olive leaf spot disease, using antagonistic bacteria. Journal of Plant Pathology. 2017; 99(3): 741-744.
54. Salman M, Jawabreh M, Abu Rumaileh B. The effect of local fungicides on conidial germination of peacock disease caused by *Spilocaea oleagina* in Palestine. Palestine Tech Unive Res J. 2014; 2: 26-28.
55. Sánchez-Hernández ME, M MunozGarcía, CM Brasier, A TraperoCasas. Identity and pathogenicity of two *Phytophthora* taxa associated with a new root disease of olive trees. Plant Dis. 2001; 85: 411-416.
56. Susalit E, Agus N, Effendi I, Tjandrawinata R R, Nofiarny D, et al. Olive (*Olea europaea*) leaf extracts effective in patients with stage-1 hypertension: Comparison with Captopril. Phytomedicine. 2011; 18: 251–258.
57. Tombesi Agostino, Antonella Lavini, Milagros Saavedra Saavedra, Ricardo FernándezEscobar, Riccardo D'andria, et al. Techniques de production en oléiculture, Conseil oléicole international. 2007; 346.
58. Trapero A, López-Escudero FJ, Blanco MA. In: Barranco, D., FernándezEscobar, R., Rallo, L. (Eds.), Enfermedades. En: El cultivo del olivo. Ediciones MundiPrensa. Madrid. 2017; 733–798.
59. Trapero A, Blanco M A. Diseases. Pages 521-578 in: Olive Growing. D. Barranco, R. Fernández-Escobar, and L. Rallo, eds. Juntade. 2010.
60. Trapero A, Blanco-López M A. Enfermedades. in: El Cultivo del Olivo, 6th ed. D. Barranco, R. Fernández-Escobar, and L. Rallo, eds. Junta de Andalucía and Ediciones Mundi-Prensa, Madrid, Spain. 2008. 595-656.
61. Trapero A. Blanco M A. Enfermedades. In El Cultivo del Olivo (D. Barranco, R. Fernández-Escobar & L. Rallo, eds): 510–514. Mundi Prensa-Junta de Andalucía, Madrid. 2004.
62. Triki M A, Hassaïri A, Mahjoub M. Premières observations de *Verticillium dahliae* sur olivier en Tunisie. Bull EPPO Bull. 2006; 36(1): 69-71.
63. Varo A, Moral J, Lozano-Tovar MD, Trapero A. Development and validation of an inoculation method to assess the efficacy of biological treatments against *Verticillium* wilt in olive trees. BioControl. 2016; 61: 283–292.
64. Varo-Suarez A, Raya-Ortega MC, Agustí-Brisach C, García-Ortiz-Civantos C, Fernandez-Hernandez A, et al. Evaluation of organic amendments from agro-industry waste for the control of *Verticillium* wilt of olive. Plant Pathol. 2018; 67(4): 860–870.
65. Viruega JR, Moral J, Roca LF, Navarro N, Trapero A. *Spilocaea oleagina* in olive groves of southern Spain: survival, inoculum production, and dispersal. Plant Dis. 2013; 97(12): 1549-1556.
66. Viruega JR, Trapero A, Moreno S. Efficacy of kresoxim-methyl against olive leaf spot caused by *Spilocaea oleagina*. Acta Hort. 2002; 586: 801–804.
67. Vitullo D, Altieri R, Esposito A, Nigro F, Ferrara M. et al. Suppressive biomasses and antagonist bacteria for an ecocompatible control of *Verticillium dahliae* on nursery-grown olive plants. Int J Environ Sci. Technol. 2013; 10: 209–220.
68. Zachos DG, Tzavella-Klonari K. Research on the identity and systematic position of the fungus causing the olive disease attributed to *Macrophoma* or *Sphaeropsis dalmatica*. Ann Inst Phytopathol Benaki. 1979; 12: 59-71.