Emirates Journal of Food and Agriculture. 2017. 29(8): 639-642
doi: 10.9755/ejfa.2017-02-493
http://www.ejfa.me/

SHORT COMMUNICATION

Powdery mildew (*Erysiphe cruciferarum*) infection on camelina (*Camelina sativa*) under Mediterranean conditions and the role of wild mustard (*Sinapis arvensis*) as alternative host of this pathogen

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ABSTRACT

During the growing season 2014-2015, camelina (*Camelina sativa* (L.) Crantz) plants were naturally infected by powdery mildew at the province of Domokos in Central Greece. Moreover, wild mustard (*Sinapis arvensis* L.) plants, naturally occurring in camelina field, were infected by the disease. The environmental conditions that influence infection of camelina by powdery mildew were recorded. The anamorph as well as the teleomorph of the fungus pathogen were observed on symptomatic leaves, stems and fruits of camelina and wild mustard plants. Fungal specimens were examined. Conidiophores were cylindrical and comprised 3 cells, while conidia were produced singly; they were oblong to cylindrical and measured 21.8 to 40.5 × 9.4 to 18.4 μm (average 32.1 × 13.9 μm). Chasmothecia were also observed on the upper surface of camelina or wild mustard leaves and on wild mustard siliques. Immature chasmothecia were globose, yellow and turned dark brown as reached maturity. Each chasmothecium contained six asci that measured 47.6 to 74.5 × 29.8 to 44.7 μm. Based on these characteristics the pathogen was identified as *Erysiphe cruciferarum* Opiz ex L. Junell, being probably the first report of *E. cruciferarum* on camelina in Greece.

Keywords: Ascospores; Chasmothecia; Fungus plant-pathogen; Morphological characteristics; Weed

INTRODUCTION

Camelina or false flax (*Camelina sativa* L.) belongs to the Brassicaceae family and is an important oilseed crop (Waraich et al., 2013; Sintim et al., 2015; Yuan and Li, 2017). It is an annual plant, rich in omega-3 fatty acids and especially alpha-linolenic acid, usually cultivated for its seeds that have multiple-uses (Waraich et al., 2013; Guy et al., 2014; Feussner, 2015). Seeds have a high nutritional value due to their high protein (27-32%) and oil content (29.7–43%) (Gugel and Falk, 2006; Sintim et al., 2015; Guy et al., 2014).

Camelina is a low-input crop and is considered to be drought and cold tolerant (Feussner, 2015; Sintim et al., 2015). It exhibits resistance to alternaria black spot and other diseases (Séguin-Swartz et al., 2009; Feussner, 2015; Vollmann and Eynck, 2015), while is susceptible to a range of diseases such as downy mildew (*Hyaloperonospora camelinae* Gäum.) (Babiker et al., 2012), white rust (*Albugo candida* (Pers. ex Chev.) Kuntze) (Séguin-Swartz et al., 2009), stem rot (*Sclerotinia sclerotiorum* (Lib.) de Bary), and powdery mildew (*Erysiphe* spp.) (Föller et al., 1998). In the spring of 2015, a serious fungal disease was observed on camelina plants in Central Greece. The main symptoms were chlorosis followed by necrosis of the tissues and eventually, when a large area of the leaf lamina was infected, leaf drop occurred. Thus, the aim of this study was to identify the causal agent of this disease.

MATERIAL AND METHODS

Study site

Camelina was cultivated as winter crop at the province of Domokos (22.33E, 39.03N) in Central Greece in 2014-2015. At this location, the crop was sown at the beginning of

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Received: 28 February 2017; **Revised:** 24 September 2017; **Accepted:** 25 September 2017; **Published Online:** 11 October 2017

October, while wild mustard is a common weed in winter crops and camelina field was no exception. No herbicides or fungicides were applied. The climate in the region (Domokos, Central Greece) is characterized, in general, by rainy autumn, winter and spring with occasionally frost occurrence in the coldest months (December-March). The mean air temperature and precipitation during the growing season of camelina (October 2014-June 2015) are presented in Fig. 1. The total precipitation throughout the growing season was 537.8 mm.

Sampling and identification of causal agent

In the spring of 2015, on a number of both camelina and wild mustard plants similar symptoms and signs of a disease were observed and recorded. A total of 100 samples from each plant species showing similar symptoms and signs were collected and transferred to the Laboratory of Plant Pathology at University of Thessaly, where they were stored in the refrigerator (4°C) until examined.

For the identification of the causal agent, specimens of mycelium with conidiophores and conidia as well as chasmothecia bearing asci and ascospores were observed under a compound light microscope (Labophot-2, Nikon Instruments Europe B.V.). The dimensions (length and width) of 300 conidia and a number of asci and ascospores were measured by using the software Motic Images 2.0 (Motic China Group Co., Ltd).

RESULTS AND DISCUSSION

During spring of 2015 (April-May), typical symptoms and signs of powdery mildew were observed on camelina and wild mustard plants. The regional weather conditions especially during April and May were favorable for the development of the disease. The precipitation during the period of April-May was 71.6 mm, while the mean temperatures were 13 and 19.4°C, for April and May, respectively. In particular, in April average maximum, and minimum temperatures of 18.3 and 8.8°C were recorded. Regarding the relative humidity, the mean maximum and minimum values were 78.3% and 41.6%, respectively (Fig. 1). As shown in another study, high temperatures of 24-30°C were positively correlated to powdery mildew severity on Indian mustard (*Brassica juncea*) (Desai et al., 2004).

Domokos is a plateau in Central Greece with distinct weather conditions. The region is also quite isolated from the neighbour plains and camelina was cultivated for the first time in the area. Although cruciferous vegetables (i.e. cabbage, broccoli and cauliflower) are widely cultivated for more than twenty years, powdery mildew is a rare disease of these plants. However, powdery mildew is a common disease of wild mustard plants in the area.

The signs on camelina and wild mustard plants appeared as circular to irregular whitish colonies on leaves, stems and fruits (Fig. 2). At initial stage the individual colonies were small and distinct (middle of April), but later on they expanded resulting in covering the whole leaf surface. The whitish colonies consisted of mycelium, conidiophores and conidia. Conidiophores were cylindrical and comprised of 3 cells, producing single one-celled hyaline conidia (Fig. 3). Their shape was oblong to cylindrical and measured 21.8 to 40.5 × 9.4 to 18.4 µm (average 32.1 × 13.9 µm) with a length/width ratio of 1.6 to 3.5. These characteristics were consistent with previous records of *Erysiphe cruciferarum* Opiz ex L. Junell (Purnell and Sivanesan, 1970; Kim et al., 2013; Zhao et al., 2014; Alkooranee et al., 2015).

Chasmothecia were also observed on the upper surface of camelina leaves and on wild mustard siliques (Fig. 4). Immature chasmothecia were globose, yellow and turned dark brown as reached maturity. Each chasmothecium contained six asci that were measured 47.6 to 74.5 × 29.8 to 44.7 µm (mean 56.1 × 35.5 µm). These characteristics were consistent with previous record of *Erysiphe cruciferarum* Opiz ex L. Junell (Garibaldi et al., 2009). Each ascus contained four ellipsoid ascospores, 13.6 to 20.4 × 8.4 to 14.8 µm

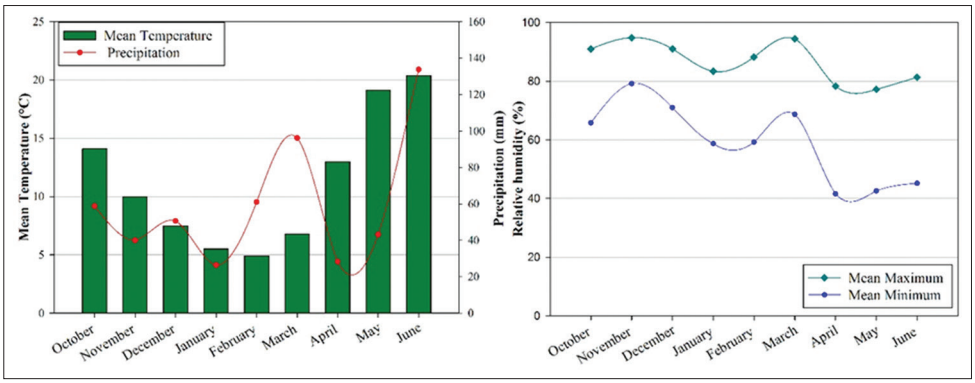

Fig 1. Meteorological data of Domokos region during the growing season (October 2014-June 2015).

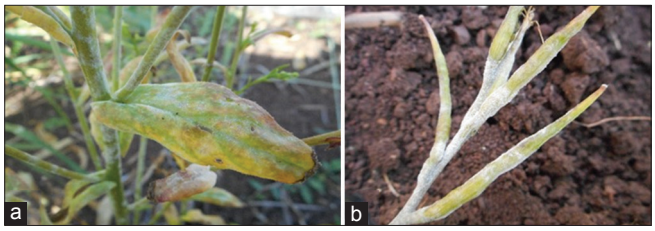

Fig 2. Symptoms of powdery mildew on *Camelina sativa* leaves (a) and *Sinapis arvensis* siliques (b).

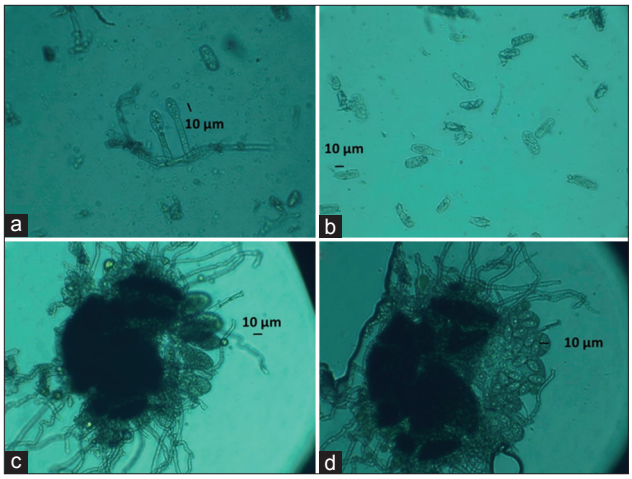

Fig 3. *Erysiphe cruciferarum* causing powdery mildew on camelina and wild mustard. a: Conidiophore with conidium, b: Conidia, c-d: Mature chasmothechia with appendages and asci with ascospores.

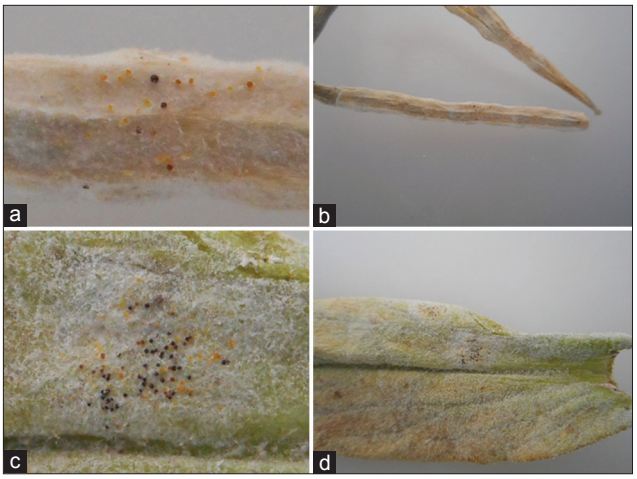

Fig 4. Chasmothecia on wild mustard siliques (a, b) and camelina leaves (c, d).

(mean 17.6 × 11.5 µm) with a length/width ratio of 1.2 to 2. However, ascospores were generally smaller than that reported on spider flower (*Cleome hassleriana* Chod.) in Italy (Garibaldi et al., 2009).

Based on the symptoms and morphological characteristics, this fungus was identified as *E. cruciferarum*. In recent years, several hosts of *E. cruciferarum* had been reported such as *Brassica napus* and *Brassica rapa* ssp. *pekinensis* in China (Zhao et al., 2014; Alkooranee et al., 2015), *Cleome hassleriana* in Italy (Garibaldi et al., 2009), and *Brassica juncea* in Korea (Kim et al., 2013), while our study indicate that wild mustard could be also an alternative host of the powdery mildew (*E. cruciferarum*) pathogen which infect camelina plants. In several studies, the importance of weeds as reservoir hosts for plant pathogens have been demonstrated (Shah et al., 2010; Karkanis et al., 2012). Wild mustard apart from powdery mildew is also a host of a number of diseases, including *Peronospora brassicae* Gäum, *Plasmodiophora brassicae* Woron. and *Albugo candida* (Pers. ex Chev.) Kuntze (Mulligan and Bailey, 1975). To our knowledge, this is the first report of *E. cruciferarum* causing powdery mildew on camelina in Greece.

Author's contribution

Authors have contributed equally.

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