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Melon yield response to the control of powdery mildew by environmentally friendly substances

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ABSTRACT

A two-year research study was conducted at Metaponto (40°24′ N; 16°48′ E; 10 m a.s.l.; Southern Italy) in 2008 and 2009 to evaluate on melon, the efficiency of two substances with low environmental impacts against powdery mildew. Three melon (*Cucumis melo* L. var. *inodorus* Naud.) cultivars ('Amarillo oro', 'Fonzy' and 'Gialletto Napoletano') were treated by two new natural liquid formulations containing *Brassicaceae* meal ('TREXP001') or rock flour products (chabazite, 'Chab'). The above substances, with low environmental impact, were compared with a conventional control treatment ('Conv') that used conventional active substances (penconazole, myclobutanil, azoxystrobin and sulfur) and an untreated control. Laboratory analyses conducted on leaves infected by powdery mildew showed that *Golovinomyces cichoracearum* was responsible for the disease. The conventional treatment was the most effective for containing powdery mildew, if compared to the untreated control, and it positively influenced the yield and fruit quality of all tested melon cultivars. Between the two natural products, 'TREXP001' was more effective; even if its efficiency, more evident in the first year, was significantly lower than 'Conv' treatment.

The type of melon cultivar was an important factor for limiting the spread of the pathogen, especially in the early stages of cultivation. The 'Fonzy' cultivar, due to its shorter crop cycle, was attacked later in the season and sustained lower damages than the other two cultivars. The 'Amarillo oro' cultivar was more susceptible to powdery mildew in both trial years.

1. Introduction

Powdery mildews are some of world's most widespread diseases caused by plant pathogenic fungi and infect nearly 10,000 species of angiosperms (Glawe, 2008). Furthermore, powdery mildew disease commonly impacts melon and other cucurbits (Braun, 1995) and nearly always requires specific chemical treatment for its control. Although powdery mildew is not destructive, it can cause serious damage in open fields and in protected cultivation (Alvarez et al., 2000; Brunelli, 2007) and can strongly decrease the quantity and quality of crop yields. This disease is very common in Italy, where melon (*Cucumis melo* L.) is a widely cultivated vegetable crop. Melon is cultivated on 24,434 ha of open fields and on 3250 ha of greenhouse space, which results in a total production of 683,729 t (ISTAT, 2010). The crop is mostly grown in Southern Italy and accounts for 68% of the total national melon surface. The *inodorus* cultivars are used exclusively in open field cultivation. These cultivars are also called 'winter melons'. In contrast, the *reticulatus* and *cantalupensis* cultivars are mainly grown in greenhouses (Incalcaterra and Vetrano, 2007). The main aetiological agents of powdery mildew of cucurbits in the world are *Golovinomyces cichoracearum* (D.C.) Huleta (syn. *Erysiphe cichoracearum* D.C.), also reported in Italy on orange coneflower (Garibaldi et al., 2008) and *Podosphaera xanthii* (Castag.) U. Braun *et* N. Shish. [syn. *Sphaerotheca fuliginea* Schlect. ex Fr. (Poll.)] (Křísková et al., 2009). Generally, *P. xanthii* is more widespread in the Mediterranean basin (Branzanti and Brunelli, 1992; Tores Montosa, 1987; Pérez-Garcia et al., 2009), whereas *G. cichoracearum* seems to be more widespread in Central Europe (Křísková et al., 2009). These powdery mildews cause

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indistinguishable infection symptoms in melon. The two micromycetes can be distinguished by microscopic observation of their propagative and conservative structures. In melon, powdery mildew mainly affects the vegetative structures (leaves, stalks, stems), which are covered by white powder-like spots. Symptoms rarely occur on the fruits, and the resulting damage decreases the weight-based productivity and reduces fruit quality (*i.e.*, loss of aroma and sugar content). Chemical defense means depend on a wide range of active substances that are applied at pre-harvest intervals from 3 to 14 days. However, the use of these substances can lead to resistance, which can occur with benzimidazoles, sterol biosynthesis inhibitors (SBI) and strobilurines (QoI). Both cucurbit powdery mildew species have high evolutionary potential (McDonald and Linde, 2002) and are highly variable in their pathogenicity and virulence by the existence of a large number of different pathotypes and races (Lebeda and Sedláková, 2006; Miazzi et al., 2011) which likely develop fungicide resistance.

Reduced fungicidal efficacy has been reported for all of these substances (Heaney et al., 2000; McGrath and Shishkoff, 2003; Brunelli et al., 2006; Collina et al., 2006; Fernandez-Ortuno et al., 2006). Therefore, it would be useful to enrich the current defense means by formulations that have innovative action mechanisms and have presumptive low impact on the agroecosystem during the short pre-harvest intervals (Gilardi et al., 2011).

In addition, these formulations should not harm agroecosystems, should have minimum shortage time (Camele et al., 2009; Konstantinidou-Doltsinis et al., 2006; Liu et al., 2010; Rongai et al., 2009) and should be used as biofungicides (Kavková and Čurn, 2005; Gilardi et al., 2011) for the biological control of cucurbit powdery mildew. Regarding the use of plant extracts, Camele et al. (2009), determined that Stifenia, a substance extracted from *Trigonella foenum-graecum* L. seeds, did not prevent *E. cichoracearum* attacks in melon despite conventional chemical control. Chabazite is a natural substance that controls some fungal diseases (Romanazzi, 2008), including powdery mildew (Passaglia, 2006).

Another natural substance that could be used to control powdery mildew is 'TREXP001', a new water vegetable oil emulsion containing *Brassicaceae* defatted seed meals. 'TREXP001' was used for some insects (mealybugs and aphids) (Rongai et al., 2008a; Cicciarello et al., 2012) and for powdery mildew control (Rongai et al., 2009). 'TREXP001' plays a suffocating effect that was similar to that of refined mineral oils, that is added to a biofumigant activity of the glucosinolate degradation products, mainly allylisothiocyanate (AITC), released at good levels from the defatted seed meals. The time of glucosinolate hydrolysis, and consequently of AITC rate, in the trials was planned following a patented formulation and was set to two hours after meal addition to the water-oil emulsion. More recently, this time was reduced to 30 min to make more practical its application for the farmer.

The future definition of new sustainable alternatives in agriculture is pending in the Europe Union on an answer to the legislative context that is defined by the following: (i) EC Regulation No. 1907/2006 concerning the registration, evaluation, authorization and restriction of chemical substances (REACH), (ii) EU Regulation (EC) No. 1107/2009, which defines new rules for placing plant protection products on the market, inserting new controls and limiting the authorization of many chemicals and (iii) recent EC Directive 2009/128/EC, on the sustainable use of chemicals that strongly encourages non-chemical methods of pest control.

The aim of this study was to evaluate the effectiveness against powdery mildew and yield response on three *inodorus* melon cultivars of two commercial products based on natural substances.

2. Materials and methods

The research was conducted in open field conditions in the years 2008 and 2009 at the "Pantanello" Experimental Farm (40°24′ N; 16°48′ E; 10 m a.s.l.) in Metaponto, Basilicata region – Southern Italy. Each year, the medium textured soil was ploughed to a depth of 30 cm prior of harrowing and fertilizing with 80, 80 and 150 kg ha^{-1} of N, P_2O_5 and K_2O, respectively. Plastic mulching was laid down by covering 80-cm-wide bands of the soil with black LDPE (50 μm thick). Melon seedlings at the 3rd–4th true leaf stage were transplanted on June 4th 2008 and on June 6th 2009. The seedlings were spaced at 1 m on the rows that were 2 m apart to obtain a density of 0.5 plants m^{-2}. Throughout the crop cycle, irrigation was conducted by a drip irrigation system placed under the plastic mulch with drip holes (2.5 l h^{-1} water flow rate) spaced 20 cm from each other. Post-transplantation fertilization provided 40 kg ha^{-1} of N, 70 kg ha^{-1} of P_2O_5 and 50 kg ha^{-1} of K_2O.

The three following *inodorus* melon (*C. melo* var. *inodorus* Naud.) cultivars were used: 'Fonzy F_1' and 'Amarillo oro' from "Seminis Italia" and 'Gialletto Napoletano', which had been selected from the CRA-ORA research Center. None of these cultivars had been classified as resistant to powdery mildew.

Phytosanitary control was performed by chemical treatments against phytopathogenic fungi or, when needed, against insects.

For powdery mildew protection, 3 treatments were compared to an untreated control ('Control'). The first treatment was the conventional one ('Conv'), which used different substances to avoid the occurrence of resistant strains. The active substances used in this study included penconazole (Topas® 5WP, Syngenta Crop Protection), myclobutanil (SYSTHANE®, 4,5 PLUS, Dow AgroSciences), azoxystrobin (ORTIVA®, Syngenta Crop Protection) and sulfur (TIOVIT JET®, Syngenta Crop Protection), commonly used against powdery mildew in the Metaponto area. All substances were applied according to the manufacturer's instructions. The second treatment was chabazite ('Chab'), a product-based on rock hydrophilic powder (allumo silicate of K, Ca, Mg, Fe, chabazite content 60 + 5% p/p, made by Verdi Co. SpA, Castelnovo di Sotto – Reggio Emilia, Italy). A rate of 1000 g h l^{-1} water was applied for a total of 10 kg ha^{-1}. The third treatment was named 'TREXP001', which is a three-phase patented formulation (Rongai et al., 2008b) based on an oil-water emulsion containing *Brassicaceae* defatted seed meals of *Brassica carinata* A. Braun. In particular, the composition is an emulsion of carinata oil at 1.5% in water with addition of defatted carinata seed meals (2 g for liter of emulsion) modified by a patented procedure (Rongai et al., 2008b). It was applied at a dose of 1500 ml of oil + 200 g h l^{-1} of formulated meals diluted in water (1 h l). The emulsion amount that permitted a good plant wetting ranged between 272 and 429 l ha^{-1}. The formulation was sprayed 5 times during the entire crop cycle, starting from the beginning of blossom stage and repeated every two weeks. The same scheduling was followed for 'Chab' applications.

All anti-oidium treatments were applied by a sprayer powered by a 2-cycle engine. A spray pressure of 5–6 bar was used, and the volume of water varied between 400 and 800 l ha^{-1} according to the degree of crop growth.

In both years, a total of 12 experimental treatments were obtained. These treatments were arranged in a split-plot complete block design with 3 replicates of 4 anti-oidium treatments in the main plots and 3 cultivars in the sub-plots, which had a surface area of 42 m^2 (6.0 m × 7.0 m). The sub-plots, consisting of 3 rows, were spaced 2 m apart in both directions (length and width).

To assess the diffusion of powdery mildew and the severity of its damage, the central row (7 plants) of each plot was visually inspected. Every week, following transplanting, five leaves were inspected on each plant and were assigned a score between 0 and 4 (Lebeda, 1984). These levels corresponded to the following