Integration of fertility management, cultivar selection and alternative spray treatments to optimize control of foliar diseases of greenhouse grown tomatoes

N.G. Dafermos[1], A.M Kasselaki, [2] N.E. Malathrakis[2], C. Leifert[1]

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Abstract

Powdery mildew caused by Leveillula taurica (Lev.) Arn. is one of the most serious foliar diseases of greenhouse and open field tomato. The disease is currently controlled with the use of organic fungicides and sulphur, the latter being the only product permitted in organic crops. The aim of this study was to investigate the potential of controlling the disease by integrating: a) hybrids of low susceptibility to the disease, b) organic fertilisers (chitin) and c) alternative spray treatments. Some of the combinations of the above factors were highly effective in decreasing the percentage of disease severity. Specifically the combination of the hybrid of low susceptibility with the addition of chitin in the substrate and the spray treatment Milsana®+chitosan, was equally effective to sulphur. These results indicate that the combination of the above factors could probably be used as an alternative to sulphur for control of L. taurica in the greenhouse.

Introduction

One of the most serious diseases of greenhouse tomato is powdery mildew. In conventional farming systems the disease is mainly controlled by sulphur and other fungicides while under organic farming standards only sulphur products are permitted. However sulphur can affect the efficacy of insect predators negatively and can be phytotoxic in the greenhouse at temperatures above 30°C (Belanger and Labbe, 2002). It may also contribute to the faster degradation of greenhouse plastic covers (Malathrakis, personal communication).

Previous studies indicated that soil amendment with chitin in combination with the use of resistant hybrids and the foliar spraying with chitosan or plant extracts, may increase the resistance of crops (e.g. cucumber) to foliar diseases (Giotis, 2006). However, the integrated use of these strategies against powdery mildew has not yet been studied. Therefore, the objective of this study was to assess the efficacy of integrating compost amendment, hybrid selection and application of alternative foliar spray treatments against the powdery mildew of tomato (*Leveillula taurica*) under greenhouse conditions in Greece.

[1] Nafferton Ecological Farming group, Newcastle University, Stocksfield NE43 7XD, UK, E-mail: nikolaos.dafermos@ncl.ac.uk

[2] Technological Educational Institute of Crete, Stavromenos 71004, Heraklio-Crete, Greece

Materials and methods

Two experiments were performed: the 1st between September 2005 and January 2006 and the 2nd between May 2006 and July 2006. The hybrids 'Elpida' F1 (Enza Zaden-The Netherlands), 'less susceptible' to powdery mildew (*Leveillula taurica*), and 'Bison' F1 (Golden West-U.S.A), relatively susceptible to *L. taurica,* were used. Tomato seedlings were transplanted into 15L plastic pots in a polythene greenhouse (10x40x4m), at the 3rd true leaf stage. Pots (28x23cm) contained a mixture of compost and soil (50:50). The compost was prepared according to the standard method for biological composts (windrow composted for 3 months, regularly turned) and contained sea algae, olive tree leaves and sheep manure at a ratio (v/v/v) of (1:1:1). Total organic matter was 22% and the pH 7.8. The soil was a sandy clay loam, medium heavy in drainage and alkaline. In half of the pots, 150ml/ pot of chitin powder (>98%), 'France Chitine' (France) were added to the growth substrate. The experimental design was a split–split plot with six replicates and three factors: (a) hybrid (main plot), (b) foliar spray treatment (subplot) and (c) addition of chitin in the substrate (sub-subplot). The following foliar spray treatments were tested: (a) Milsana® (plant extract of *Reynoutria sacchalinensis*, Biofa-Germany) at the rate of 3ml/L, (b) chitosan (Chitoplant®, 99.9%WP, ChiProGmbH-Germany) at the rate of 0.5g/L, (c) sulphur (Sulfex, 80%WP, Hellafarm S.A.-Greece) at the rate of 2.5g/L, (d) Milsana + chitosan at full rates and (e) tap water (untreated control). Plants were sprayed at 7 day intervals starting 5 days after transplanting (20 days for exp.2). Plants were infected by naturally developing epidemics of *L. taurica* in the greenhouse. Plants were checked daily for disease appearance and severity (% infected area per leaf) was assessed weekly starting when first symptoms were detected. The percentage of infected area was calculated per plant and at the end of the experimental period, Area Under the Disease Progress Curve (AUDPC) values were calculated and subjected to ANOVA. Yield per plant was also recorded, by harvesting fruits at regular intervals, in terms of number, weight and diameter of fruits (data not presented).

Results and Discussion

Disease severity: Analysis of variance showed significant differences for all 3 main factors (hybrid, foliar spray treatment and chitin soil amendment). In both experiments, 'Elpida' (less susceptible) gave lower AUDPC values than Bison (susceptible) and the addition of chitin to the soil reduced disease, regardless of hybrid. Furthermore, there were significant two and three-way interactions between the 3 main factors (individual results not shown).

Comparison between foliar spray treatments was done by Tukey's Honest Significant Difference (HSD) test and results are presented below, separately for the 2 different experiments.

Experiment 1 (Autumn 2005-2006): Sulphur was consistently the most effective treatment while the Milsana treatment was significantly better than chitosan and water control, regardless of hybrid or addition of chitin in the soil. The chitosan treatment controlled disease significantly only when chitin was not simultaneously used as a soil amendment but even then it was not proved adequately effective. Only for the less susceptible hybrid Elpida grown in soil amended with chitin the Milsana + chitosan treatment was significantly more effective than the Milsana treatment and equally effective to sulphur (table 1).

Table1: Effect of different foliar spray treatments in controlling severity (AUDPCs, % days) of powdery mildew (*Leveillula taurica*) on greenhouse tomato (exp. 1).

	Bison (susceptible hybrid)		Elpida (less susceptible hybrid)	
Treatment	**No chitin**	**Chitin**	**No chitin**	**Chitin**
Sulphur	2326.9 a	2224.3 a	1843.2 a	1773.1 a
Mils.+Chit.	2678.0 b	2543.6 b	2315.3 b	1883.9 a
Milsana	2788.5 b	2570.3 b	2315.7 b	2188.1 b
Chitosan	3157.8 c	3214.7 c	2795.5 c	2689.1 c
Control (Water)	3504.4 d	3427.5 c	3035.9 d	2838.9 c

Means with the same letter within columns are not significantly different between them according to Tukey's HSD test ($p \leq 0.05$)

Experiment 2 (Spring 2006): During the period of the second experiment, the mildew epidemic was not as severe as in experiment 1 (tables 1 and 2). This probably explains why the Milsana spray treatment gave similar levels of control with the fungicide sulphur on both the susceptible and the less susceptible hybrid and irrespectively of the chitin addition in the soil. Furthermore it was shown that during a less aggressive epidemic, adding of chitosan in the spray did not improve Milsana's efficacy since the mixture was not significantly better than the Milsana treatment itself. The chitosan spray treatment reduced the disease severity significantly on both the susceptible and the less susceptible hybrid. In contrast to the first experiment, spraying with chitosan was significantly effective even when chitin was simultaneously used as a soil amendment. However, this was only observed for the susceptible hybrid Bison (table 2).

Table 2: Effect of different foliar spray treatments in controlling severity (AUDPCs, % days) of powdery mildew (Leveillula taurica) on greenhouse tomato (exp. 2).

	Bison (susceptible hybrid)		Elpida (less susceptible hybrid)	
Treatment	**No chitin**	**Chitin**	**No chitin**	**Chitin**
Sulphur	430.7 a	368.6 a	329.7 a	252.9 a
Mils.+Chit.	431.6 a	375.4 a	354.3 a	271.0 a
Milsana	432.0 a	347.6 a	358.0 ab	337.3 a
Chitosan	656.3 b	594.3 b	490.5 b	508.2 b
Control (Water)	1186.3 c	876.8 c	644.0 c	487.4 b

Means with the same letter within columns are not significantly different between them according to Tukey's HSD test ($p \leq 0.05$)

Yield

Data of weight/plant, number of fruits/plant and diameter/fruit were analyzed separately for the two experiments by ANOVA. According to Tukey's Honest Significant Difference (HSD) test, there were no significant differences between foliar sprays for any of the above parameters in any of the experiments.

Conclusions

Based on the above results it is concluded that the integrated use of the 3 different strategies tested (hybrid, soil amendment and foliar spray treatment) can be highly effective against powdery mildew development. It was clearly shown that the effects are greater during a more severe epidemic (exp1). In this case, leaf spraying with the Milsana+chitosan treatment in combination with the chitin soil amendment on a 'less susceptible' hybrid, was equally effective to the chemical control sulphur. In order to further clarify the effects of the integrated strategy against tomato powdery mildew in relation to disease pressure, experiments continue. Additional analyses remain to be carried out. These include quantification of effects of treatments on the nutritional composition and sensory quality of tomatoes. These characteristics are very important in the organic food market. In addition, correlation analyses between nitrogen content, leaf greenness and disease severity are planned. Finally, the mode of action of chitin will be studied in the laboratory with the use of biochemical and molecular techniques.

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