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Short communication

Weather-based decision support reduces the fungicide spraying to control onion downy mildew

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ABSTRACT

Onion downy mildew is a major production constraint. Weather-based decision support has been an important tool for the rational use of fungicides. The present study established a chemical management strategy of the disease based on temperature and relative humidity. We defined daily severity values (DSV) according to temperature range (08–13.9 °C; 14–21.9 °C; 22–29 °C) and relative humidity ≥90% to carry out the spraying. The treatments mancozeb/copper oxychloride or metalaxyl-M/chlorothalonil were applied when the summations of the DSV reached the 6–11 range, or 12–17 range, or ≥18, besides weekly sprays using these fungicides or water. The area under disease progress curve (AUDPC) and yield of commercial bulbs were calculated. In both years evaluated (2014, 2015), we managed to reduce the number of metalaxyl-M/chlorothalonil sprays without compromising commercial yield. In 2014, the yield values for all treatments using metalaxyl-M/chlorothalonil were significantly higher than those which used mancozeb/copper oxychloride and control. In fact, with one spray less the routine weekly application, yield was 48.203 tons per hectare, while following the routine weekly application it was 42.411 tons per hectare. In 2015, we have reduced the number of metalaxyl-M/chlorothalonil sprays by 20%, while maintaining the same levels of AUDPC and yield. For both years, treatments with mancozeb/copper oxychloride did not differ from the control (water weekly). The rational use of fungicides is a key element for establishing an integrated production system of onion.

1. Introduction

Onion (*Allium cepa* L.) ranks as one of the most important worldwide vegetable crops grown. In Brazil, it is the third vegetable most economically important and produced. The Brazilian estimated planting area is about 58,000 ha, while production is close to 1.6 million tons (IBGE, 2015). Onion downy mildew, caused by *Peronospora destructor* (Berkeley) Caspary ex Berkeley, has widespread occurrence and can affect onion leaf area severely, leading to reduction in the bulbs growth (Scholten et al., 2007).

Optimal conditions for sporulation and germination of *P. destructor* have been established. According to Hildebrand and Sutton (1982), the pathogen sporulation was drastically reduced under temperatures exceeding 24 °C and/or relative humidity less than 95%. Bulovienė and Survilienė (2006) found that alternating the temperature (15 °C for eight days, followed by five days at 22 °C) under high humidity have favoured sporulation. The onion production season in South of Brazil (winter) has climatic conditions favourable for downy mildew. Considering that the disease is influenced by the specific climatic conditions, a management based on weather variables, such as temperature and relative humidity, could indicate the best time for fungicide sprays.

Weather-based decision support systems have shown satisfactory results regarding the reduction of fungicide application, when compared to the conventional calendar (Hardwick, 2006). The first decision support system reported for onion downy mildew was DOWNCAST (Jesperson and Sutton, 1987). This model used the variables temperature, relative humidity and precipitation, and provided ideal conditions for sporulation of the pathogen. However, the system did not calculate sporulation, and presented limitations (positive predictions of sporulation is only 11 out of 24 nights when sporulation was observed). Adjustments in DOWNCAST system were made by Visser (Visser, 1998), improving it for positive predictions to 17 out of 24 nights when sporulation had occurred. Battilani et al. (1996) developed ONIMIL (also based on DOWNCAST). However, the ONIMIL model has not been tested for its accuracy with independent observations of sporulation.

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ZWIPERO was a forecasting model proposed for onion downy mildew (Friedrich et al., 2003). Developed in Germany, ZWIPERO aims to predict future sporulations based on climatic conditions that have not yet occurred. The latest model proposed, MILIONCAST (Gilles et al., 2004), using only temperature and relative humidity as parameters showed good sporulation prediction when compared to previous models, but tests in the field have not been performed. The use of variables not easily calculated such as leaf wetness associated with mathematical and empirical models with relative complexity hinders the understanding and adoption of systems by the farmers. In this sense, a decision support system based on temperature and relative humidity and its relationship with the occurrence of the disease in the field may have a broader acceptance and implementation.

Thus, this study aimed to carry out the chemical management of onion downy mildew based on temperature and relative humidity, which resulted in reducing the number of systemic fungicide sprays, without compromising plant health and yield.

2. Materials and methods

The experiments were conducted in 2014 and 2015, from July to November (winter-spring). Onion seedlings were grown on site system during April and approximately 70 days after sowing, the seedlings were transplanted to the field (during July). All cultural practices were performed as recommended by the production system for onion: Santa Catarina (soil pH ~ 6; 100 kg de N/ha, 80 kg de P/ha, and 60 Kg de K/ha) (Epagri, 2013). For both experiments, we have used the cultivar 'EMPASC 352—Bola Precoce', which does not have the resistance gene *Pd* (Kofoet et al., 1990), showing susceptibility in previous assays. The experimental plot consisted of 140 plants (seven rows with 20 plants) arranged in a spacing of 0.35 m (between rows) × 0.10 m (between plants), simulating a plant density of approximately 300,000 plants per hectare. In both years, downy mildew epidemics started by natural infection. Symptomatology and presence of structures (sporangia and sporangiophores) observed under a stereoscopic loupe (50 and 80 days after transplanting) were used in order to confirm the disease occurrence. An automatic mobile weather station (ISIS, S1220-M, Squitter do Brasil®), installed at experimental field was used to measure temperature and relative humidity every ten minutes.

We used the table developed by Wallin (Wallin, 1962), adapted as shown in Table 1, for the calculation of the daily severity values (DSV), which determined the moments of fungicide spraying. For the two-year experiment, the DSV counting started 25 days after transplanting. The DSV were calculated every 24 h according to the combination of temperature and relative humidity described in Table 1. Applications occurred when the summation of DSV were in the range of 6–11 (never reaching 12); 12 to 17 (never reaching 18); and when equal to or more than 18. Thus, weekends or rainy days did not become a limiting element for implementing the decision system. After fungicide spray, the accumulated DSV were reset and restarted up the summation. Nine treatments were compared: (1) mancozeb/copper oxychloride weekly; (2) mancozeb/copper oxychloride DSV between 6 and 11; (3) mancozeb/oxychloride copper DSV 12–17; (4) mancozeb/copper oxychloride DSV ≥ 18; (5) metalaxyl-M/chlorothalonil weekly; (6) metalaxyl-M/chlorothalonil DSV between 6 and 11; (7) metalaxyl-M/chlorothalonil DSV 12–17; (8) metalaxyl-M/chlorothalonil DSV ≥18; (9) water weekly as control. The amount of active ingredients per hectare of mancozeb, copper oxychloride, metalaxyl-M, and chlorothalonil for all treatments were 0.93 kg a.i./ha, 1.05 kg a.i./ha, 0.05 kg a.i./ha, and 0.5 kg a.i./ha, respectively. The applications were performed with manual pressure sprayers (SeeSa®, 2-litre capacity, manufactured in China and imported by Wipek Import®, Rio do Sul, SC, Brazil) and the spray volume corresponded to 500 L per hectare. Disease severity was measured weekly, according to Horsfall-Barratt scale (Horsfall and Barratt, 1945), with the following relationship between note/percentage of diseased area: 1/0%; 2/1–3%; 3/3–6%; 4/6–12%; 5/12–25%; 6/25–50%; 7/50–75%; 8/75–87%; 9/87–93%; 10/93–96%; 11/96–99%; 12/100%. Five predefined plants from the plot central part were evaluated. Twelve weekly assessments were carried out in 2014, and nine in 2015. The harvesting was carried out 123 days after transplanting in 2014, and 103 days after transplanting in 2015. Onion bulbs were harvested from the central rows of each plot, discarding single border rows.

The average from scale notes of the five predefined plants was used to calculate the area under disease progress curve - AUDPC (Shaner and Finney, 1977). The experiments were randomised in blocks designed with three replications. We considered only the commercial bulbs (bulbs with less than 35 mm in diameter, and rotten bulbs were not considered) for yield calculation. For each year/experiment, the values of AUDPC and commercial yield were analysed using ANOVA and, whenever necessary, means were grouped with Scott-Knott cluster analysis ($p = 0,05$). The GENES® (Cruz, 2013) software was used for all analyses.

Table 1
Combinations of temperature ranges and relative humidity to estimate the daily severity values used in this study.

Temperature range (°C)	Daily Severity Values (DSV)[a]				
	0	**1**	**2**	**3**	**4**
Hours with relative humidity ≥90%					
08-13,9	12	13–15	16–18	19–21	22–24
14–21,9	9	10–12	13–15	16–18	19–24
22–29	15	16–18	19–21	22–23	24

[a] After the fungicides spraying, daily severity values were reset and counting was restarted.
Table adapted from Wallin (1962).

3. Results

There was a reduction of the number of metalaxyl-M/chlorothalonil sprays without compromising commercial yield in the two-year experiment. Considering only the weather data, 2015 was more favourable to the occurrence of the disease due to greater hours accumulation with humidity higher than 90% (Fig. 1). In the 2014 experiment, the plots treated according to the DSV 6–11 had higher yield than the plots treated according to DSV 12–17 and DSV ≥18. However, in the 2015 experiment, AUDPC values and commercial yield of the plots treated according to the DSV 6–11 and DSV 12–17 were similar. In the 2014 experiment, the values of the commercial yield for all treatments using metalaxyl-M/chlorothalonil, based on DSV, differed significantly from the control (water weekly). Besides, there was an increase in the yield of commercial bulbs, even with one application less the routine weekly application (Table 2). Moreover, treatments with lower number of metalaxyl-M/chlorothalonil applications (DSV 12–17, and DSV ≥18) were significantly more productive than the treatments using mancozeb/copper oxychloride and control, despite having less yield than the routine weekly application. In 2015, we reduced the number of sprays of metalaxyl-M/chlorothalonil by 20%, while maintaining the same levels of yield and AUDPC. However, unlike 2014, treatment with higher accumulation of DSV (≥18) and consequently less sprays (five) did not differ from control regarding yield and AUDPC. In both years, all treatments using mancozeb/copper oxychloride showed yield and AUDPC values similar to control.