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Number of pustules of garlic rust under different temperatures and leaf wetness

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Abstract

Puccinia porri is an etiological agent of garlic rust. The disease symptoms are characterized by leaf lesions that initially appear as whitish spots. With the disruption of the leaf cuticle, yellow-orange uredospores are exposed. These signs are commonly known as pustules. Bulb production is affected by the reduction of photosynthetically active leaf area. The decrease in production is most pronounced when the attack occurs before bulb formation. The objective of this work was to quantify the latency periods of garlic rust and the number of pustules formed under the influence of temperature (10, 15, 20 and 25ºC) and leaf wetness period (6, 12, 18 and 24h). The latent period for this pathosystem varied between 10 and 12 days when the plants were subjected to temperatures of 10, 15 and 20°C after inoculation. The number of rust pustules was higher in garlic plants subjected to a temperature of 15°C. However, there were also a significant number of lesions at temperatures of 10ºC, especially when the leaf wetness period was 24 hours. At temperatures above 20°C, the number of pustules was less expressive. The results are important to perform fungicide efficacy tests in optimal conditions for disease progression and epidemiological studies.

Keywords – epidemiology – *Puccinia porri* – uredospores

Introduction

Garlic (*Allium sativum* L.) is originated from Central Asia, being cultivated for centuries practically all over the world and considered of great social and economic importance (Moura et al. 2013). The usable part is the bulb, which is composed of bulbils. Rich in starch and aromatic substances, garlic also has great flavoring, nutritional and medicinal value (Moura et al. 2013).

The production is often limited by the occurrence of diseases such as garlic rust (*Puccinia porri* (Sowerby) G. Winter 1881 sin. *Puccinia allii* (DC.) F. Rudolphi). Rust is a disease of widespread occurrence in all regions of the world that, during the cultivation of susceptible plants, there are environmental conditions favorable to their progress. The disease occurs under conditions of high relative humidity and low rainfall. Moderate temperatures favour infection, which is

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inhibited when values above 24ºC and below 10ºC are recorded (Massola Jr et al. 2016).

Initially, numerous small, elliptical pustules appear on the leaves, covered by the leaf cuticle. Subsequently, the cuticle breaks and there is exposure of a powdery, yellow mass of uredospores of the fungus. The photosynthetic capacity is compromised at a more advanced stage of the disease, causing plant depletion and consequent reduction of the bulbs size (Massola Jr et al. 2016).

The amount of primary inoculum of *P. porri* present in a garlic crop and the density of uredospores on leaf surfaces influences the disease progress rate. Furthermore, the temperature also affects disease progress, as observations of rust in leek plants suggested that the rate of disease progress was reduced when temperatures were lower (Clarkson et al. 1997).

However, there are few studies in the literature related to favorable temperature and humidity for the onset of infection, as well as to the latency periods for the garlic rust pathosystem. The knowledge of these parameters behavior is important for the calibration of disease prediction models, especially for mechanistic mathematical models that enable the prediction of the amount of inoculum present in the crop. The objective of this work was to quantify the latency periods of garlic rust under the influence of different temperatures and leaves wetness during the infection phase and the number of pustules formed.

Materials & Methods

The work was carried out in a greenhouse at the Experimental Station of Caçador - Epagri, municipality of Caçador-SC, using the garlic cultivar San Valentim. The cultivar used in the experiment was planted at the density of two bulbils per pot, repeated five times. The pots with an 8 kg of soil capacity contained soil fertilized according to soil analysis. The pots were kept in the greenhouse until the day of inoculation under temperatures varying between 10-20ºC.

When the plants reached the bulbil differentiation stage, they were transferred to the watering chamber with intermittent mist jets and a 12-hour photoperiod, where inoculation was carried out with a manual sprayer directed to the leaves at a distance of approximately 20 cm.

A mixture of *P. porri* isolates extracted from garlic leaves with a vacuum pump stored in a refrigerator was used. The spores were thawed and placed in a solution with distilled water to prepare the inoculum. The spore concentration was adjusted to 10^4 spores/ml, using an inoculum volume of 20 ml/plant to inoculate the leaves.

After inoculation, the plants were kept at temperatures of 10, 15, 20 or 25ºC and leaf wetness periods of 6, 12, 18 or 24 hours according to the treatment. Each wetness periods was stopped by using a blow dryer machine. After this period, the plants were transferred to the greenhouse under environmental conditions (10-20ºC). The evaluations of the number of lesions and the latency period were obtained from the sixth day after inoculation until the stabilization of the number of pustules performing one evaluation each two days. Simple linear regression analyses were used to characterize stimulus-response relationships between leaf wetness duration and temperature with treatment means for number of pustules. A three-dimensional graph was prepared for the rust variability and the interaction between temperature and leaf wetness. The maximum number of lesions was considered as favorability 1.

Results

The first symptoms (without sporulation of the pathogen) appeared on the surface of the leaves between seven to eight days after inoculation, depending on the temperature during the incubation period. The lower the incubation temperature, the fewer days it took for the first symptoms to appear.

The latent period for this pathosystem varied between 10 and 12 days, when the plants were subjected to temperatures of 10, 15 and 20°C after inoculation. The number of rust pustules was higher in plants subjected to a temperature of 15°C (Fig. 2), being more expressive when subjected to leaf wetness for 12, 18 and 24 hours (Fig. 3). However, there were also many lesions at temperatures of 10°C when the leaf wetness period was 24 hours. At temperatures above 20°C, the number of pustules was less expressive (Fig. 1).

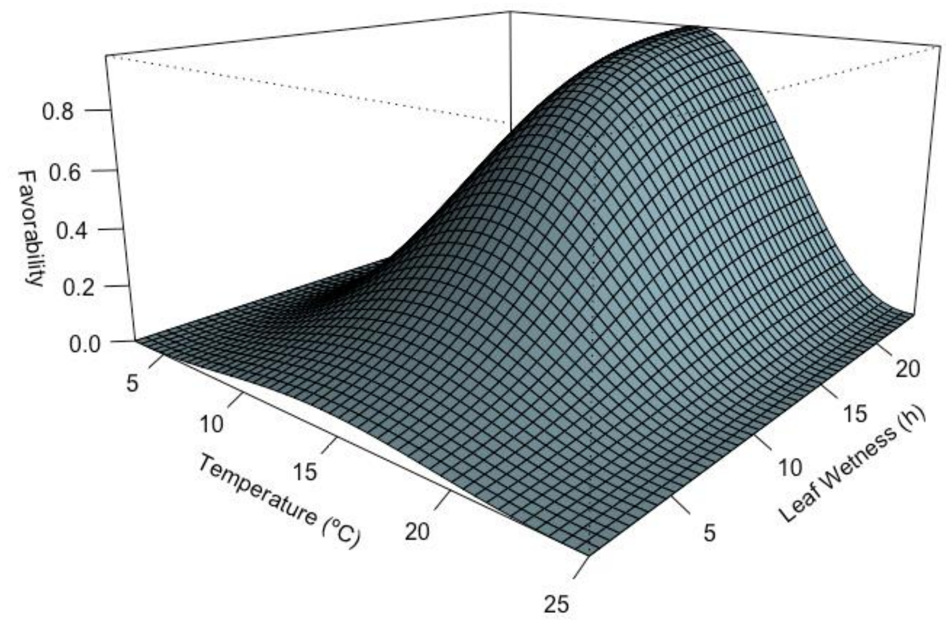

Fig. 1 – Favorability of garlic rust (*Puccinia porri*) in the cultivar San Valentim by the interaction of temperature and leaf wetness.

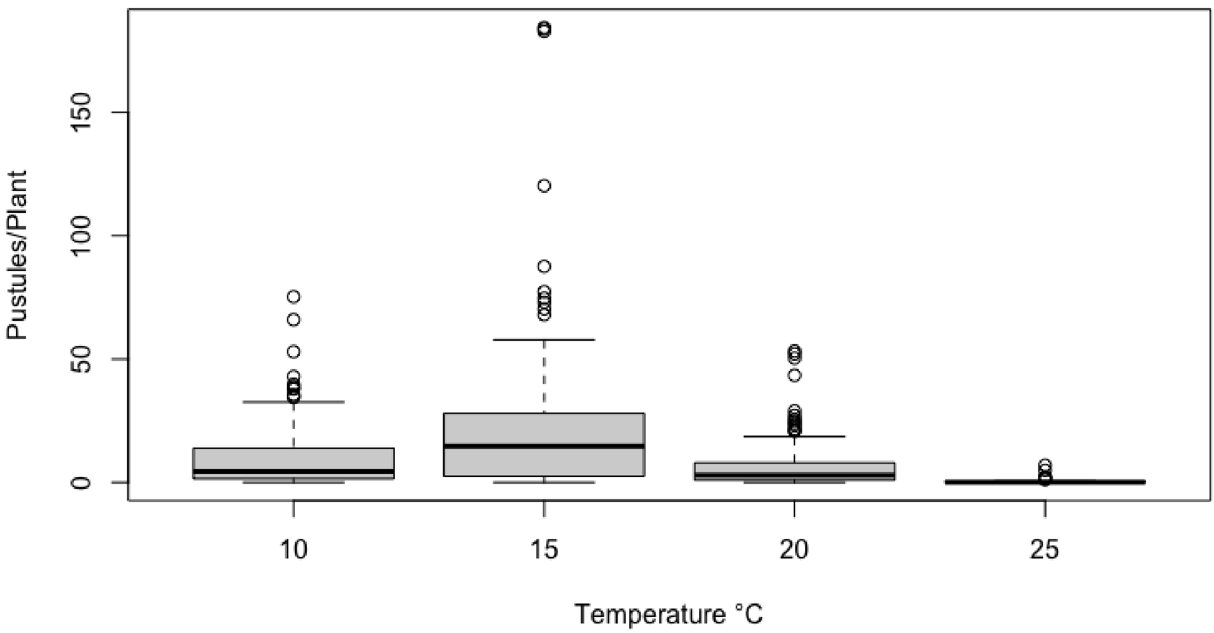

Fig. 2 – The number of pustules per leaf according to temperature.

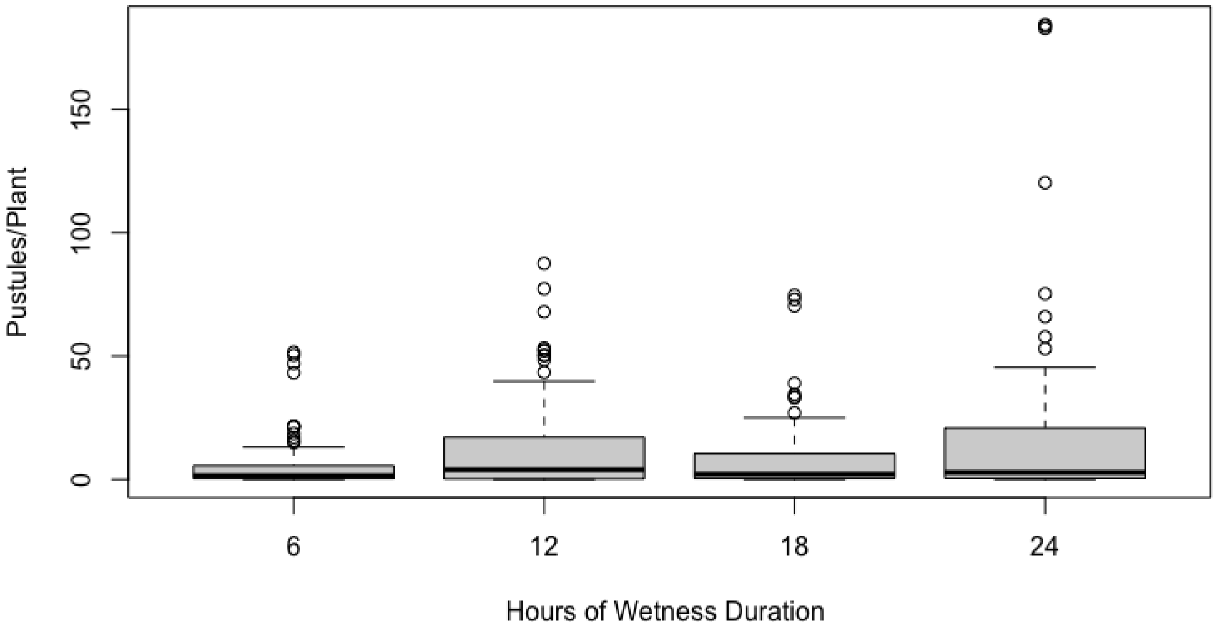

Fig. 3 – The number of pustules per leaf according to leaf wetness.

Discussion

Optimal conditions for the garlic rust progress are mild temperatures (15 to 20ºC) and high relative humidity (Lucini 2004). Marcuzzo & Duarte (2021) also declare that temperatures between 15-20ºC combined with leaf wetness higher than 10 hours sharp increase in disease severity. In our work, the optimal conditions for the disease progress were temperatures between 10 to 15ºC and leaf wetness for 24 h during the spores germination and infection phase. Reis & Casa (2016) state that for wheat rust, favourable environmental conditions for the disease progress are temperature of 20ºC and more than six hours of continuous leaf wetness. In the oat leaf rust pathosystem, the temperature range for the germination of uredospores vary from 2 to 33ºC, optimal between 18 and 22ºC and a relative humidity of 100% (Forcelini & Reis 2016).

According to Lucini (2004) the garlic rust cycle vary between 9 and 14 days depending on the weather and garlic cultivar. The latent period in our study using San Valentim was 10-12 days. Wiese (1998) states that for wheat rust temperature between 15 to 25ºC and wetness for 4 to 8 hours are key elements for the infection. Infection occurs in 6 to 8 hours through the plant stomata and secondary uredospores occur in 7 to 10 days.

Gilles & Kennedy (2003) verified that at high spore densities, the production of garlic rust pustules was higher between 9 and 11ºC and the number of pustules decreased at higher temperatures. Massola et al. (2016) state that the disease occurs more frequently in conditions of high relative humidity and low rainfall. Moderate temperatures favour infection, which is inhibited when values above 24ºC and below 10ºC are recorded. In the present work the optimal temperature for uredospore infection was 15°C, and with the increase in temperature to 20ºC or higher, there is a marked decrease in the number of pustules. Based on the results, temperature and leaf wetness during the spore germination and infection is crucial to the disease intensity (incidence/severity), regardless of the environmental conditions after that 24 h from the inoculation.

In alfafa leaf rust, Webb & Nutter (1997) observed that the infection efficiency increased as leaf wetness duration increased from 4 h (60 pustules/leaf) to 24 h (183.4 pustules/leaf), and then declined to 121.3 pustules/leaf at 32 h of wetness. As temperature increased from 17.5 to 28ºC, infection efficiency decreased in a linear fashion, and temperature during the initial 24h leaf wetness period explained 97.3% of the variation in the change in infection efficiency.

With regard to studies for disease control, it is noteworthy that the experiments must always be conducted under environmental conditions favourable to the occurrence of the disease, which for garlic rust is temperature of 15ºC and leaf wetness for more than twenty hours during infection, as shown in present work, so that there is a high severity of the disease, allowing a better comparison between the tested active ingredients. Because, in adverse environmental conditions to the attack of the pathogen, the environment itself will control the progress of the disease and may mask the result of the products tested.

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