

Leaf spot and leaflet removal in day-neutral strawberry cultivars under different cultivation conditions, in organic management

Mancha de la hoja y eliminación de folíolos en cultivares de fresa de días neutros bajo diferentes condiciones de cultivo, en manejo orgánico

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ABSTRACT

The objective of this work was to evaluate day-neutral strawberry cultivars regarding leaf emission, intensity of leaf spot [*Mycosphaerella fragariae* (Tul.) Lindau] and the impact of the removal of diseased leaflets on the number of leaflet remaining, under plastic-covered and open cultivation. The cultivars Aromas, Monterey, Portola and San Andreas were evaluated in open field and in beds covered with white or transparent polyethylene sheets. Plants grown under open field condition showed greater area under the disease progress curve (AUDPC) of incidence. The AUDPC of severity was greater in Monterey and San Andreas when compared to Aromas, but without difference in AUDPC of incidence. San Andreas emitted a lower quantity of leaflets than Aromas, and had lower number of leaflets remaining after the removal of diseased leaflets. Monterey and Portola showed intermediate scores. As conclusion, the incidence of leaf spot is eased by cultivation in open field. The cultivars San Andreas and Monterey, compared to Aromas, favor *M. fragariae*. The impact of diseased leaflet removal in the quantity of leaflets in Aromas is lower than in San Andreas.

Key words: *Fragaria X ananassa*, *Mycosphaerella fragariae*, incidence, severity.

RESUMEN

*El objetivo de este trabajo fue evaluar cultivares de fresa de día neutro respecto a la emisión de folíolos, la intensidad de la mancha foliar [*Mycosphaerella fragariae* (Tul.) Lindau] y el impacto de la eliminación de los folíolos enfermos en el número de folíolos restantes, bajo cobertura de plástico y cultivo abierto. Los cultivares Aromas, Monterey, Portola y San Andreas se evaluaron en campo abierto y bajo coberturas de polietileno blanco o transparente. Las plantas cultivadas en campo abierto mostraron mayor área bajo la curva de progreso (ABCPE) de la incidencia de la enfermedad. El ABCPE de severidad fue mayor en Monterey y San Andreas en comparación con Aromas, pero sin diferencia en ABCPE de incidencia. San Andreas emitió menor cantidad de folíolos que Aromas y tuvo menor número de folíolos restantes después de la eliminación de los enfermos. Además, Monterey y Portola mostraron medias intermedias. Como conclusión, la incidencia de la mancha de la hoja es facilitada por el cultivo en campo abierto. Los cultivares San Andreas y Monterey, en comparación con Aromas, favorecen *M. fragariae*. El impacto de la eliminación de folíolos enfermos en la cantidad de folíolos restantes es menor en Aromas que en San Andreas.*

Palabras clave: *Fragaria X ananassa*, *Mycosphaerella fragariae*, incidencia, severidad.

Introduction

Leaf spot caused by *Mycosphaerella fragariae* (Tul.) Lindau is the most important foliar disease affecting strawberry (*Fragaria x ananassa* Duch.) crop in Brazil. Its symptoms occur mainly in leaves as necrotic lesions, although they can be found in other plant organs. Severe cases can result in leaf death and total loss of yield. The infection is eased

under air temperature about 25 °C and long periods of leaf wetting. Young leaves are more susceptible (Carisse *et al.*, 2000).

In organic strawberry cultivation controlling leaf spot is more difficult since fungicides are not allowed. In South Brazil the utilization of polyethylene sheets to cover strawberry fields, in order to protect leaves from rain and dew, is frequent. Genetic resistance is the most desired

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control strategy. However, available cultivars are in majority susceptible to *M. fragariae* (Nesi *et al.*, 2013). Furthermore there are several strains of *M. fragariae* occurring in different regions, what can modify the resistance/susceptibility response. Therefore, local evaluation of cultivars is necessary. Monterey, Portola e San Andreas are new cultivars released by the University of California (USA), and were introduced in Brazil in order to replace Aromas, Albion and Diamante, all day-neutral cultivars. However, there is no information available on their resistance to Brazilian *M. fragariae* strains.

Periodical removals of leaves with symptoms can reduce inoculum. Verona *et al.* (2007) reported that 21% of the leaves were removed because of symptoms of leaf spot in an organic experiment in South Brazil. The highest incidence was observed during the end of the autumn and beginning of the spring, when strawberry plants are supposed to have few leaves. Removing the leaves can reduce drastically the leaf area.

The objective of this work was to evaluate day-neutral strawberry cultivars regarding leaf emission, intensity of *M. fragariae* and impact of diseased leaflet removal on the number of leaflet remaining, under protected and open cultivation, in organic management.

Materials and Methods

The study was carried out in Xanxerê, Santa Catarina State, Brazil, 26°48' 17"S, 52°23' 50"W, 730 m high. The climate is Cfb (Koppen classification) and the soil is a Red Latosol. Beds mulched with black polyethylene sheet, 1.05 m wide, were utilized. Plant spacing was 30 cm with three longitudinal rows. Transplant was performed at June 28th, 2012 using cold stored transplants from Chilean Patagonia. Dripping irrigation pipes were placed under the mulching. The cultivars Aromas, Monterey, Portola and San Andreas were evaluated simultaneously with three cultivation conditions: open field and beds covered with transparent or white polyethylene sheet. The sheets were installed in August 7th forming plastic tunnels 70 cm upward soil surface in the center, while the edges were kept open 40 cm high during sunny days and completely closed at night and during rainy times. The experiment was arranged in a completely randomized design in double factorial scheme (cultivars and cultivation conditions), with three repetitions.

Leaflets with symptoms of leaf spot were pruned (removed) once a month, from September 11th until January 7th, and the plant leaflet number (LN) and the number of leaflets with leaf spot symptoms (NLS) were recorded. The incidence of leaf spot in leaflets (*I*) was calculated by: $I = NLS / LN$. The severity was scored in leaflets, based on a diagrammatic scale (Mazaro *et al.*, 2006), from September 11th until December 7th. Leaflets without symptoms were scored zero. The area under the disease progress curve (AUDPC), for incidence and severity, was calculated using the trapezoidal rule. The cumulated number of leaflets emitted was calculated for each date of evaluation, by summing the number of leaflets in the date and the NLS in previous dates (which had been removed). The number of leaflets remaining was calculated by deducting the NLS from the LN. The cumulated number of leaflets emitted, the number of leaflets remaining (both analyzed separately for each date) and the AUDPC were analyzed by ANOVA considering $p < 0.05$ as significant, and means were compared through the Tukey test.

Results and discussion

The highest scores of incidence of *M. fragariae* (80%) were found in the last evaluation (January) in the treatment open field, while covered plants were affected in less than 20%. Severity reached from zero to 9% of leaf area. The interaction effect between cultivars and cultivation conditions were not significant. However, isolated effects were found. The incidence AUDPC in the treatment open field was significantly highest than in white and transparent sheet (Figure 1), while the severity AUDPC showed no significant difference between cultivation conditions. Foliar wetness is probably the cause for the greater incidence in open field plants. In November 11th, cumulated leaflet emission in the treatment open field was greater than in the others, probably due to the highest light intensity (Awang & Atherton, 1995), but the difference did not persisted in the last evaluation (Table 1). In the same way, in November 11th more leaflets remained in plants grown in open field than under white sheet.

The severity AUDPC was significantly affected by cultivars (Figure 1). San Andreas and Monterey were more severely damaged than Aromas. Portola showed no difference in comparison with the others. The cultivars did not differ significantly in incidence

Table 1. Cumulated leaflet emission (CLE) and number of leaflets remaining (LR) after removals of leaflets with *M. fragariae* in strawberry as affected by cultivation conditions and cultivars in four dates.

| | September 11 | | October 11 | | November 12 | | December 7 | |
|------------------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|
| | CLE ¹ | LR ¹ | CLE | LR | CLE | LR | CLE | LR |
| Cultivation condition | | | | | | | | |
| White | 16.9 ^{ns} | 16.3 ^{ns} | 30.3 ^{ns} | 29.8 ^{ns} | 43.2 ^b | 40.7 ^b | 62.4 ^{ns} | 52.9 ^{ns} |
| Transparent | 15.8 | 14.5 | 31.4 | 30.0 | 51.2 ^{ab} | 46.0 ^{ab} | 60.2 | 54.7 |
| Open field | 19.0 | 16.9 | 30.9 | 29.5 | 62.3 ^a | 57.3 ^a | 67.7 | 61.7 |
| Cultivars | | | | | | | | |
| Aromas | 19.7 ^{ns} | 18.9 ^{ns} | 37.5 ^a | 35.7 ^a | 65.6 ^a | 62.6 ^a | 78.0 ^a | 73.1 ^a |
| Monterey | 18.2 | 15.5 | 30.6 ^{ab} | 29.7 ^{ab} | 52.7 ^{ab} | 46.3 ^{ab} | 69.5 ^{ab} | 58.2 ^{ab} |
| Portola | 17.2 | 16.0 | 30.5 ^{ab} | 31.0 ^{ab} | 53.0 ^{ab} | 50.4 ^{ab} | 62.8 ^{ab} | 55.8 ^{ab} |
| S. Andreas | 14.3 | 13.1 | 24.7 ^b | 22.6 ^b | 38.0 ^b | 32.6 ^b | 46.0 ^b | 38.3 ^b |

¹Means followed by the same letter in the columns and groups of treatments do not differ (Tukey, $\alpha = 0.05$). ^{ns} = difference is not significant.

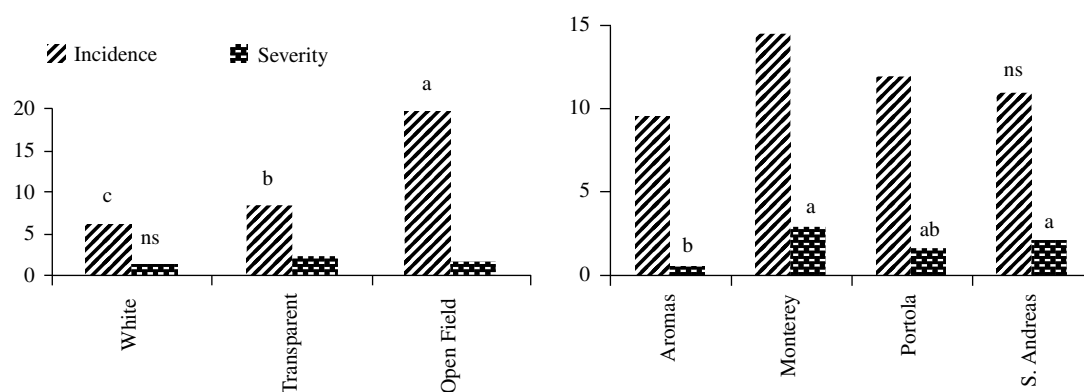


Figure 1. Area under the leaf spot incidence and severity progress curve in strawberry as affected by cultivation conditions (left chart) and cultivars (right chart). Columns with the same label do not differ (Tukey, $\alpha = 0.05$). “ns” = not significant.

AUDPC (Figure 1). Nesi *et al.* (2013) reported differences in incidence and severity of leaf spot in eight strawberry cultivars, none evaluated in this work. The less susceptible cultivars delayed the beginning of the epidemic due to the lower effective initial inoculum. Delhomez *et al.* (1995) considered that cultivars showing less than 25% of leaf area diseased are probably possible to be grown without fungicide sprays for leaf spot control in Canada. The severity observed here is lower, indicating that Aromas, Monterey, Portola and San Andreas, regarding leaf spot intensity, are adequate to organic production.

The cumulated number of leaflets emitted by Aromas was greater than the observed in San Andreas (Table 1), excepting in September 11th. Aromas had more leaflets remaining after the removal probably due to its greater emission, since incidence was the

same. This trait should be considered when choosing cultivars to organic production.

Conclusion

In conclusion, the incidence of leaf spot is eased by cultivation in open field. Using the cultivars San Andreas and Monterey, compared to Aromas, favor the leaf spot. This trait should be considered when choosing cultivars to organic production, since removing diseased leaflets can help delaying the epidemics.

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