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CUCUMBER RESPONSE TO TARGET BLOT AS A RESULT OF THE EFFECT OF PRODUCTS ON DISEASE CONTROL

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Abstract: Target spot, caused by Corynespora cassiicola, occurs in several cultivated species, being considered an important disease in cucumber. The objective was to evaluate the cucumber response to the target spot as a function of preventive management of the disease with fungicides and phosphites, associated or not with silicone adhesive spreaders. 'Soldier' cucumber plants were grown in 10 L pots in a greenhouse. Chlorothalonil and methiram + pyraclostrobin fungicides and potassium and zinc phosphites were evaluated, combined or not with Silwet L-77 Ag® and Break-Thru® adhesive spreaders, applied four days before pathogen inoculation. The severity of the disease was evaluated; the fresh and dry mass of the aerial part of the plants at 60 days after sowing; the number and fresh mass of fruits, and the number of leaves and plant height at intervals of 7 to 10 days from the inoculation of the pathogen. Fungicides were more efficient in controlling target spot, followed by zinc phosphite, while potassium phosphite did not differ from the inoculated control, which reached severity greater than 40%, 10 days after inoculation of the pathogen and more than 75% of dry leaves (2nd and 3rd true leaves), 25 days after inoculation. Greater fresh mass of the aerial part of the plants was observed with the fungicides, with no difference between the treatments for the other variables. Adhesive spreaders had no effect on the analyzed variables. Cucumber production was not affected by treatments up to 60 days of cultivation, despite the disease intensity being lower with fungicides and zinc phosphite.
Keywords: *Cucumis sativus*, *Corynespora cassiicola*, management.

INTRODUCTION

Cucumber (*Cucumis sativus*), belonging to the cucurbitaceae family, stands out among the main vegetables in Brazil. Several diseases can occur in the cucumber crop, such as target spot, caused by Corynespora cassiicola, which has been gaining importance, mainly due to the damage it can cause. Epidemics of the disease have been reported in protected crops in the north of the State of Paraná (Vida et al., 2004), reaching epidemic levels within a few days after the first symptoms are seen in the plants, with losses of up to 60% of cucumber production" Japanese type" and reducing fruit quality (Verzignassi et al., 2003). In the states of Amazonas, Goiás and São Paulo, this disease is also frequently found causing damage to producers, both in protected cultivation and in open field (Teramoto et al., 2011; Bezerra & Bentes, 2015; Fischer et al., 2022a). In 28 samplings of diseased leaves from cucumber growers in 10 cities in the Midwest of São Paulo, target spot was detected in 18 samples, being the main leaf disease in 11 of these samples (Fischer et al., 2022a).

The first symptoms of the disease appear in the form of small spots, like "flecks", light in color, which evolve into angular spots, with a straw-colored center and a small light yellow halo (Verzignassi et al., 2003). At this stage, the symptoms can be confused with those caused by zone spot (Leandria momordicae), downy mildew (Pseudoperonospora cubensis) or angular spot (Pseudomonas syringae pv. lachrymans). Subsequently, the spots grow, taking on a rounded shape, with a light brown center and soaked olive-colored edges, which can be confused with anthracnose (Colletotrichum orbiculare) and alternaria spot (Alternaria cucumerina). The coalescence of the spots causes drying of the leaf blade, with consequent defoliation of the plant (Pavan et al., 2016).

The recommended measures for managing cucumber target spot are crop rotation, adoption of more resistant genotypes and spraying with fungicides recommended for alternaria and cercospora spots (Pavan et al., 2016), since there are no products registered in the Ministry of Agriculture, Livestock and Supply (MAPA) for disease control in cucumber (Agrofit, 2022). The fungicides chlorothalonil, metyram + pyraclostrobin, boscalid + crezoxim-methyl and azoxystrobin + benzovindiflupyr controlled the disease in preventive treatment in a greenhouse (Fischer et al., 2022b).

Greater efficiency in spraying pesticides can be obtained with the addition of adjuvants, such as adhesive spreaders, which allow for improved foliar absorption, greater resistance to rain, aiding physiological performance, reducing phytotoxicity, as well as effects on the translocation of active ingredients. (Veronese, 2015). From the use of adhesive spreaders in the soybean crop, the control of powdery mildew (Erysiphe diffusa) with cyproconazole + azoxystrobin increased from 60.3 to 70.2% and of end-of-cycle diseases by 72.8% to 80.6%, as well as the grain yield was 10.0 to 16.5% higher with the spreaders (Güths, 2013).

In a study with 16 cucumber growers in the Midwest region of São Paulo, 87.5% use an adhesive spreader with a fungicidal spray, according to the growers' personal reports. However, in relation to open field cultivation, cucumber in protected cultivation commonly presents problems of toxicity with fertilizers and pesticides (Zambolim et al., 2000). According to Vida et al. (1991), symptoms of phytotoxicity result from the inappropriate use of defensives, mainly higher dosages and/or applications under high temperatures. Still according to Dias et al. (2015), cucurbits are very sensitive to several agrochemicals. Phytotoxicity symptoms were observed in cucumber and squash, in the initial stages of development, with the use of mineral oil (0.025 to 0.5% v/v) as an adhesive spreader (Raetano, 2000).

As a result of possible risks to human health and the environment, due to the incorrect use of pesticides, there is a growing interest in reducing or eliminating the use of pesticides in family vegetable production. Thus, the study of alternatives to be used in the integrated management of this disease is justified, such as alternative products to fungicides. Products based on phosphites originate from the neutralization of phosphorous acid by a base, and can be combined with elements such as potassium (K) or zinc (Zn). Classified as fertilizers, such compounds are characterized by stimulating plant growth and having considerable fungicidal action (Lovatt & Mikkelsen, 2006), causing death or inhibition of fungal growth or acting indirectly, through the activation of the defense systems of plants. plants. They have acropetal and basipetal systemic action and act to suppress foliar and root diseases (Guest & Grant, 1991). Preventive applications of K phosphites controlled the target spot in cucumber (FISCHER et al., 2021a) and acerola (Celoto, 2009) crops, with greater disease control in cucumber with Zn phosphite (FISCHER et al., 2021).

Research on cucumber target spot is scarce, making further studies necessary to define disease management strategies, important for the economic viability of the crop. In view of the above, the objective was to determine the cucumber response to the target spot as a result of preventive management of the disease with fungicides and phosphites, associated with adhesive spreaders.

MATERIAL AND METHODS

The experiments were carried out in greenhouse conditions with maximum temperature control of 30°C, from July to November 2021. Cucumber plants, cultivar Soldier (Japanese group), considered a pattern susceptible to target spot (Fischer et al., 2021), were grown in plastic pots (10 L) containing Carolina Soil Padrão® commercial substrate. Irrigation was manual and daily and fertilization was performed three times a week via fertigation, applying 1 g pot-1 of the formulation containing (%): 15 N, 5 P2O5, 10 K2O, 1 Ca, 1 Mg, 13 S, 0.2 Fe, 0.2 Zn, 0.06 B, 0.1 Mn, 0.05 Cu and 0.005 Mo.

The minimum and maximum temperatures inside the greenhouse were evaluated daily with a digital thermometer. The minimum, average and maximum temperatures obtained were 12.3°C, 20.6°C and 29.0°C, respectively, from July 10 to September 8, 2021 for the cucumber cultivation cycle in the first experiment, and 18.6°C, 24,6°C and 30.6°C, respectively, from September 13 to November 15, 2021 in the second experiment.

The C. cassiicola isolate used was obtained from a cucumber crop located in the municipality of Avaí-SP and selected among the most aggressive in a previous study (Fischer et al., 2022a), being preserved under the name MMBF 01/20, in the library "Mário Barreto Figueiredo" from APTA, Biological Institute of São Paulo. The multiplication of the pathogen inoculum was carried out in tomato juice medium (4.5 g of CaCO3, 15 g of agar, 200 mL of commercial tomato juice and 800 mL of distilled water), contained in Petri dishes, incubated for 15 days at 25 °C in B.O.D.-type climatized chambers, under continuous fluorescent light (Fischer et al., 2022a). The suspension of conidia in distilled water was adjusted to a concentration of 1x104 conidia/mL, with the aid of a Neubauer chamber.

The pathogen inoculation was carried out by spraying the conidial suspension on all the leaves, on both sides, up to the point of runoff, in plants 35 days after sowing. Non-inoculated plants were sprayed with distilled water. Then, the plants were placed individually inside a transparent polyethylene plastic bag for 24 hours, aiming at the formation of a humid chamber.

The fungicides chlorothalonil (2 g/L) (Bravonil 500®) and metiram (1.1 g/L) + pyraclostrobin (0.1 g/L) (Cabrio® Top) and Zn phosphites (40% P2O5 + 10 % Zn, Phytogard Zn® at 1.0 mL/L) and K (40% P2O5 + 20% K2O, Phytofos K Plus® at 1.0 mL/L) were preventively sprayed on all leaves, to the point of run-off, four days before pathogen inoculation. In addition to inoculated and non-inoculated controls, two organosilicon adhesive spreaders were evaluated, organomodified polymethyl siloxane (Silwet L-77 Ag® at 0.25 mL/L) and polyether-polymethyl siloxane (Break-Thru® at 0.25 mL /L), applied alone and mixed with fungicides and phosphites. In a previous study, nonyl phenoxy poly(ethylenexy) ethanol adhesive spreader (Agral® 0.03%) and ethoxylated sorbitan monolaurate 20 EO (Tween 20® 0.01%), showed phytotoxicity in cucumber, being disregarded for the study.

The severity of the disease (% of the affected leaf area) was evaluated in digitalized photographs (36 cm2) of the middle region of the 2nd and 3rd fully expanded true leaf, using the ImageJ computer program, after five and ten days of pathogen inoculation, being visually evaluated at 11, 18 and 25 days after pathogen inoculation for total leaf dryness. The number of fruits and the fresh mass of fruits considered commercial (>20 cm in length) were evaluated (Carvalho et al., 2013); number of leaves and plant height at 35, 42, 49, 56 and 60 days after sowing; and the fresh mass and dry mass of the aerial part of the plants at 60 days.

The experimental design was in completely randomized blocks, in a factorial scheme of 6 (4 products and inoculated and non-inoculated controls) x 3 (two spreaders and water), with four replications and each plot represented by one plant, totaling 72 plants.

The results of the different parameters evaluated in the experiment were submitted to analysis of variance and compared by Tukey's test, at a 5% probability level. The experiment was repeated once.

RESULTS AND DISCUSSION

The average of the results of the two experiments was presented, since no differences were observed between experiments ($p>0.05$) for the variables analyzed in the joint analysis. No significant interactions were observed between treatments with fungicides/phosphites and adhesive spreaders, and no significant effect of adhesive spreaders was observed for the analyzed variables, with results expressed as the average of spreaders and water.

The treatments showed significant differences regarding the severity of the target spot, with the fungicides showing better results and equaling the non-inoculated control, with averages of less than 1% of the affected leaf area after five days of inoculation, and less than 4% after 10 days. days of pathogen inoculation. Treatment with Zn phosphite also controlled the disease, but with a lower result than fungicides, while K phosphite showed no difference for the inoculated control, which reached severity greater than 40% (Table 1). A similar result was observed when analyzing the drying of these leaves, with the K phosphite not differing from the inoculated control at 60 days, with more than 75% of dry leaves, and the other products delaying leaf death the same as the non-inoculated control (Figure 1). From 15 days after inoculation of the plants, the non-inoculated plants showed a progressive increase in the disease, resulting in 39.6% of dry leaves (2nd and 3rd true leaves) at 60 days of cultivation, a result of the natural inoculum of the pathogen produced by the inoculated plants, considering that the disease has a latent period of five days in the Soldier cultivar (Fischer et al., 2021b).

The fungicides chlorothalonil and metiram + pyraclostrobin, as well as boscalid + crezoxim-methyl and azoxystrobin + benzovindiflupyr, controlled the cucumber target spot in a previous study, when applied three or seven days before inoculation or one day after inoculation of the pathogen, being recommended preventive management as it results in greater disease control (Fischer et al., 2022b). According to the same authors, the efficiency of fungicides containing a strobilurin in their formulation, in controlling the target spot, is mainly due to the other active principle, since the concentration of strobilurin in the mixture was lower than the inhibitory concentration of 50% (IC50) corresponding. While chlorothalonil and metyram were highly efficient (IC50 < 1 mg/L) in inhibiting pathogen germination, pyraclostrobin was ineffective (IC50 > 100 mg/L) in vitro (Fischer et al., 2022b). Satisfactory control of the disease was also obtained under field conditions, with six applications of chlorothalonil (1,800 mg/L), at intervals of ten days (Blazquez, 1967). Tomato target spot control had already been observed with the metiram + pyraclostrobin mixture in preventive treatment (Barbosa, 2016).

Contrary to the present study, where adhesive spreaders did not influence the effectiveness of fungicides, greater control of powdery mildew and late-season diseases in soybeans and corn rust were observed when the fungicide coproconazole + azoxystrobin was associated with the polyether-adhesive spreader. polymethyl siloxane (Güths, 2013).

Three preventive applications using K and Zn phosphites carried out at weekly intervals controlled the target spot in the cucumber crop (FISCHER et al., 2021a), showing that control efficiency tends to increase with the frequency of application. An alternative to

Treatments	Severity at 5 days	Severity at 10 days
Clorotalonil	0,33 c	0,94 c [1]
Metiram + piraclostrobina	0,61 c	3,35 c
zinc phosphite	2,93 b	15,87 b
potassium phosphite	6,26 ab	31,54 ab
witness inoculated	7,84 a	40,73 a
Witness not inoculated	0,23 c	0,57 c
CV (%)	35,4	49,8

1. Mean data followed by the same letter in the column do not differ by Tukey's test, at 5% probability. Statistical analysis with the data transformed into root x+1.

Table 1. Severity (%) of target spot on cucumber plants preventively submitted to treatments with fungicides and phosphites, five and ten days after inoculation of *Corynespora cassiicola*, under greenhouse conditions.

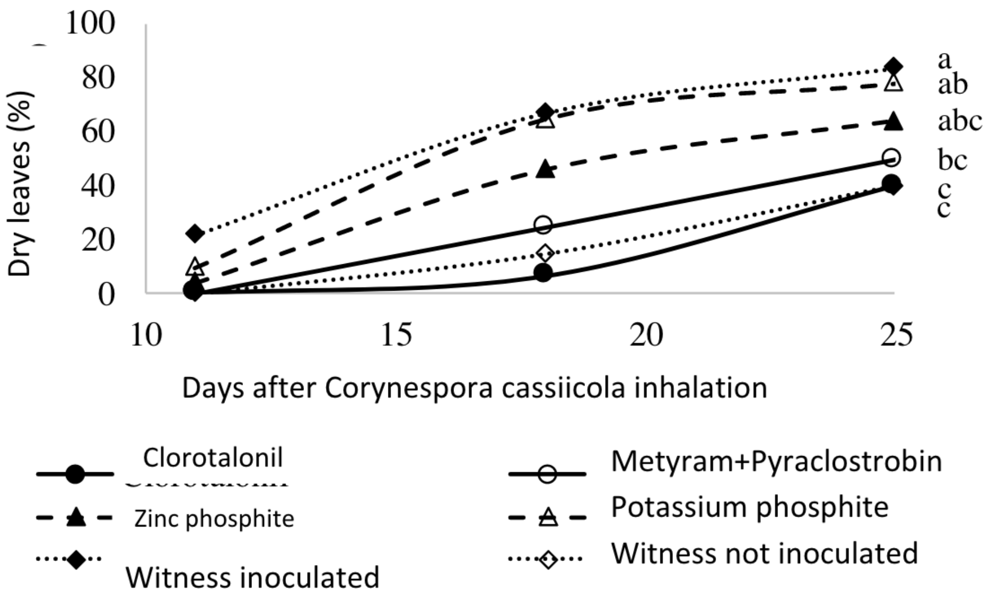

Figure 1. Dry leaves (%) of cucumber plants submitted to preventive treatments to control target leaf spot, after inoculation of *Corynespora cassiicola* under greenhouse conditions. Data followed by the same letter at 25 days after inoculation do not differ by Tukey's test, at 5% probability, CV (%) = 26.2.

be explored is the use of phosphites mixed with fungicides, as recommended by Boneti & Katsurayama (2012) for the control of apple scab under conditions favorable to the disease, such as in rainy years when the level of scab control in fruits it is low. Tomato late blight control was more effective when K phosphite and fungicides were applied in a mixture, compared to isolated products (TÖFOLI et al., 2012).

In the evaluation of cucumber production, the evaluated fungicides and phosphites did not affect the number and production of fruits (g) (Table 2), although the target spot severity was lower in treatments with fungicides and Zn phosphite (Table 1). In tomato, control of the target spot with methiram + pyraclostrobin also did not result in an increase in production (JUZIELE, 2016). Similarly, Mesquini (2012) reported for soybeans, where no correlation between severity and production was observed, presenting as a hypothesis the fact that the disease occurs with greater intensity in the lower leaves, which fall naturally from the plants before they can be a detrimental factor in production. Another factor mentioned by Mesquini (2012) that may justify the lack of influence on production is the photosynthetic capacity, which may not be altered by the disease, since it settles in the leaves of the lower third of the plant, and photosynthesis is carried out more intensity by the upper leaves, as they receive direct solar radiation. The intensity of the disease in the plants at 60 days, with a reduction of less than 10% in the dry mass of the inoculated control in relation to the other treatments with fungicides and phosphites (Table 3), did not result in severe defoliation to the point of compromising production, since that cucumber supports up to 25% defoliation without decreasing production (NOMURA; CARDOSO, 2000).

The vegetative development and the initial production of cucumber up to 40 days of cultivation were not affected with three sprays of K and Zn phosphites (FISCHER et al., 2021a), in agreement with the results obtained in the present work. Although some works indicate positive effects of phosphite on productivity and quality of crops (RICKARD, 2000; LOVATT & MIKKELSEN, 2006), most research carried out both in the field and under controlled conditions, has shown null or negative effects of phosphite on the plants compared to phosphate when applied via root (LEE & TSAI, 2005; SCHROETTER et al., 2006; THAO et al., 2008; JUÁREZ et al., 2012). McDonald et al. (2001) point out that there is no concrete evidence that plants use phosphite as a direct source of phosphorus (P). Furthermore, it would be very costly if we provided this source to supply the desirable amounts of P for the crops. However, according to Castro et al. (2009), the effect of phosphite in reducing the occurrence of diseases may be sufficient to increase crop productivity and quality.

In the variables plant height and number of leaves, there were no significant differences for the effect of fungicides and phosphites (Table 2) (Figure 2), with 211.7 cm in height and 96.9 leaves, in the average of treatments. In an experiment carried out with the cucumber crop, defoliation treatments, removing 25% to 75% of the plant's leaves, did not differ in terms of plant height (NOMURA; CARDOSO, 2000).

For fresh mass, the treatments showed significant differences, with the chlorothalonil treatment presenting the highest mass (615.8 g), followed by metiram + pyraclostrobin (583.4 g), not differing from the treatment with non-inoculated plants (585.0 g) and differing from the inoculated control (496.0 g) (Table 3). The treatments based on phosphites did not differ among

Treatments	Number of fruits	Production (g)	Height (cm)	Number of leaves
chlorothalonil	7,3 ns	1267,6 ns	201,6 ns	95,3 ns
Metyram+Pyraclostrobin	7,6	1302,9	215,5	93,5
Zinc phosphite	7,8	1344,5	212,9	102,7
Potassium phosphite	7,0	1375,8	214,8	95,8
Witness inoculated	7,4	1312,5	209,6	96,5
Witness not inoculated	8,1	1378,0	215,5	97,9
CV (%)	21,3	18,6	12,5	16,2

Data submitted to the Tukey test at 5% probability. ns= not significant.

Table 2. Number of fruits and production of cucumber plants during 60 days of cultivation and plant height and number of leaves 60 days after sowing as a function of inoculation of Corynespora cassiicola and preventive treatment with fungicides and phosphites, under greenhouse conditions.

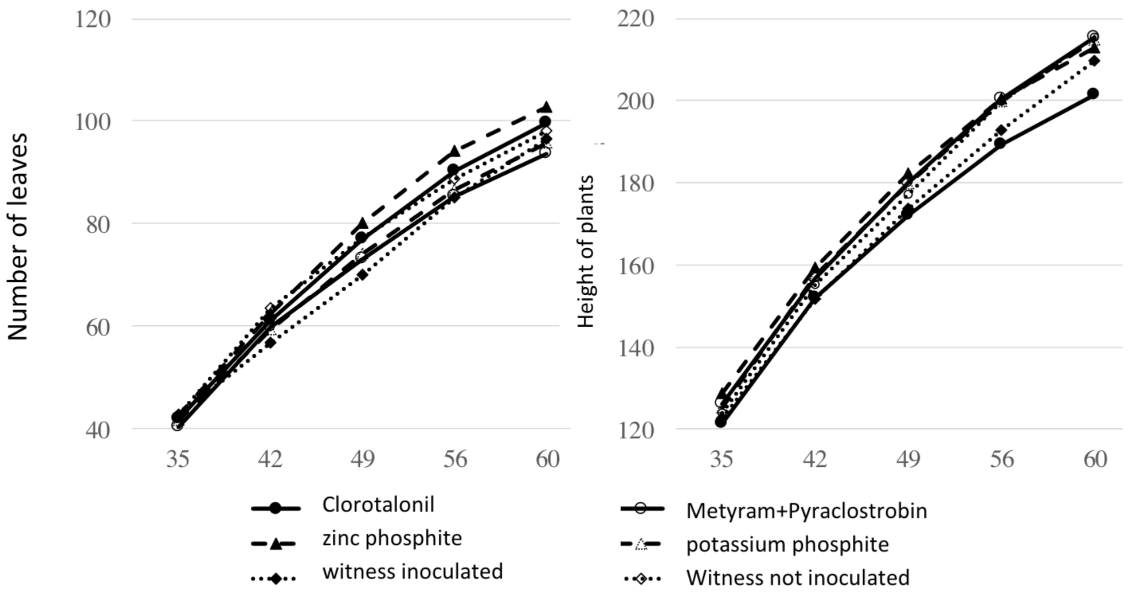

Figure 2. Number of leaves and height of cucumber plants submitted to preventive treatments applied 4 days before inoculation of *Corynespora cassiicola*, during 60 days of cultivation in greenhouse conditions.

Treatments	Fresh pasta (g)	Dry mass (g)
Clorotalonil	615,8 a	69,1 ns
Metiram + piraclostrobina	583,4 ab	70,5
Zinc phosphite	533,0 bc	67,6
Potassium phosphite	529,4 bc	67,0
Witness inoculated	496,0 c	64,6
Witness not inoculated	585,0 ab	67,9
CV (%)	14,3	12,5

1. Average data submitted to Tukey's test, being ns= not significant at 5% probability.

Table 3. Fresh mass of cucumbers after 60 days of sowing with inoculation of *Corynespora cassiicola*, in inoculated and non-inoculated plants, which received different preventive treatments (4 days before inoculation) and use of spreaders, under greenhouse conditions.

themselves and between the inoculated and non-inoculated controls. The fungicides were more efficient in controlling the disease, delaying leaf drying (<50% of dry leaves at 60 days) (Figure 1) and, consequently, contributing to this higher fresh mass of the aerial part of the plants, however, they did not result in in significant differences in dry mass, with no effect of treatments up to 60 days of cultivation (Table 3).

CONCLUSIONS

The fungicides and Zn phosphite were efficient in the preventive control of the target spot, with no effect of the use of silicone adhesive spreaders, however, the reduction in the severity of the disease did not influence the initial fruit set. In the fresh mass variable, the treatments based on chlorothalonil and metram + pyraclostrobin showed the best results. In the other variables, number and production of fruits, height, number of leaves and dry mass of plants, there were no significant differences between treatments, as well as the use of spreaders.

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