NOTAS CIENTÍFICAS

Interaction between a biostimulant and cyazofamid in the control of clubroot of crucifers under conditions of high disease density

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ABSTRACT

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Clubroot of crucifers is a root disease caused by the fungus *Plasmodiophora brassicae*, responsible for causing more than 40% economic damage to brassica crops. This disease has led to a gradual decline in brassica production in several countries, including Brazil, where an approximate volume of 50 thousand tons are marketed every year. There are few studies involving the control of this disease, which led to the development of an experiment with four treatments: T1. negative control, T2. biostimulant (phosphorus + auxin + fulvic acid), T3. biostimulant + fungicide (phosphorus + auxin + fulvic acid + cyazofamid) and T4. fungicide (cyazofamid). The lowest incidence value obtained in the last evaluation was 21% (79% control) with the mixture of biostimulant and fungicide; the biostimulant alone did not significantly differ from the negative control, considering the condition of high inoculum density, which serves as a basis for future studies with a mixture of new compounds and biocontrol agents compatible with the fungicide.

Keywords: *Plasmodiophora brassicae*; auxin; fulvic acid

RESUMO

Irokawa, F.M.; Zambolim, L.; Parreira, D.F. Interação entre bioestimulantes e ciazofamida no controle de hernia de crucíferas em condições de alta densidade de doenças. ***Summa Phytopathologica,*** v.46, n.1, p.46-48, 2020.

A hérnia das crucíferas é uma doença radicular causada pelo fungo *Plasmodiophora brassicae*, responsável por danos econômicos no cultivo de brássicas que podem ultrapassar 40%. Devido a doença vem gradativamente ocorrendo declínio produtivo de brássicas em diversos países e no Brasil com volume aproximado de 50 mil toneladas comercializadas no país por ano. Existem poucos estudos envolvendo o controle desta doença, devido a isto foi elaborado um experimento com quatro tratamentos: T1.controle negativo , T2.bioestimulantes (fósforo + auxina + ácido fúlvico), T3.bioestimulante + fungicida (fósforo + auxina + ácido fúlvico + ciazofamida) e T4. fungicida (ciazofamida). A menor incidência obtida na última avaliação foi de 21% (79% de controle) com a mistura bioestimulante e fungicida; o bioestimulante sozinho não diferiu do controle negativo, considerando a condição de alta pressão de inóculo, servindo de base para trabalhos futuros com a mistura de novos compostos e agentes de biocontrole compatíveis com o fungicida.

Palavras-chave: *Plasmodiophora brassicae*; auxina, ácido fulvico.

Clubroot of crucifers is a root disease caused by *Plasmodiophora brassicae* Woronin (Plasmodiophoraceae), a fungus responsible for a considerable reduction in brassica crops in Brazil and worldwide (9). In Brazil, examples of brassicas cultivated especially in the south and southeast regions include kale (*Brassica oleracea* var. *acephala* DC), cauliflower (*Brassica oleracea* var. *botrytis* L.), broccoli (*Brassica oleracea* var. *italica* L.), arugula (*Eruca sativa* L.) and cabbage (*Brassica oleracea* var. *capitata* L.), representing approximately 50 thousand tons marketed in the country (4). There are reports of clubroot epidemics leading to yield reductions of up to 40% in Nepal and 60% in the United States (7; 8). Characteristic symptoms of this disease are plant wilt and gall formation on the roots due to abnormal root tissue growth, which thickens and shortens the root, resulting in a clubroot-like form; the shoot may appear normal but wilts during the hottest and driest periods of the day, recovering at night. If the infection is severe, there may be premature plant death (9). The inoculum may increase in the area with consecutive cultivation of susceptible species, which is aggravated by the fact that the pathogen can survive in the soil for up to 15 years (10). The disease intensity is greater in moist and sandy soils, which are mainly acidic and have low organic matter content (2;5). The most recommended method for its control is the use of resistant or tolerant cultivars. However, since the pathogen is highly adapted to adverse environments, some isolates have a high chance of overcoming the resistance of varieties in a relatively short time (3;9).

To control this disease in Brazil, cyazofamid (4-chloro-2-cyano-N,N-dimethyl-5-p-tolylimidazole-1-sulfonamide) belonging to the imidazole chemical group, is the only active principle registered by MAPA (Brazilian Ministry of Agriculture, Livestock and Food Supply) that can be used in some brassica species (broccoli, Chinese cabbage, cauliflower and cabbage). Therefore, management techniques for the cultivation of brassicas must be adopted to significantly reduce the development of this disease and the consequent economic losses

Table 1. Effect of treatments on clubroot incidence (%) throughout the days after transplanting, area under the disease progress curve and control.

Treatments	DAT [1]						AUDPC[2]	Control%[3]
	0	28	35	49	77	96		
T1[4]	0.0	26.0 c	63.0 c	100.0 c	100.0 c	100.0 c	8558.00	0
T2[5]	0.0	11.0 c	60.0 c	100.0 c	100.0 c	100.0 c	8243.00	0
T3[6]	0.0	0.0 a	0.0 a	0.0 a	21.0 a	21.0 a	1162.00	79
T4[7]	0.0	7.0 ab	14.0 b	27.0 b	44.0 b	74.0 b	3392.00	26
CV[8] (%)	0.0	18.5	13.6	6.3	6.7	5.6		

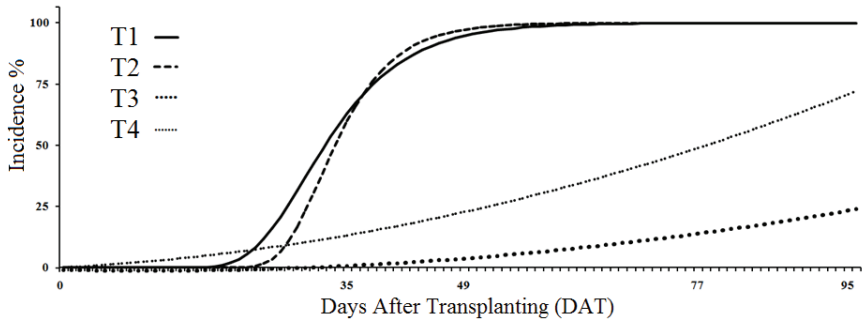
[1]Days after transplanting (DAT); [2]Area under the disease progress curve (AUDPC); [3]Control; [4]Negative control (T1); [5]Bioestimulant (T2); [6]Bioestimulant + fungicide Cyazofamid (T3); [7]Fungicide Cyazofamid (T4); [8]Coefficient of variation (CV). Means followed by the same lowercase letters in the column do not differ significantly according to SNK test (p-value < 0.05)

(7;8;9;10).

The objective of this study was to evaluate the effect of a biostimulant and the fungicide cyazofamid, alone and in mixture, on the management of *P. brassicae* in cabbage (*Brassica oleracea* var. *capitata*) under conditions of high inoculum density.

The experiments were performed in a greenhouse in Itapetininga County, São Paulo State, at the following geographical coordinates: 23º35'06"S; 48º04'20"W; 680 m a.s.l. The regional climate is classified as Cwaby, according to the international system of Koppen, showing humid and dry winter, average annual rainfall of 1,800 mm and average annual temperature of 19.3º C. The variety Fenix (Sakata®) of green cabbage was selected for seedling production in a greenhouse, where ten 200-cell plastic trays containing commercial substrate received one seed per cell. Subsequently, ten seven-day-old seedlings were transplanted into trays, 40 cm x 20 cm x 12 cm, containing pathogen-free planting soil. The inoculation process was adapted from Cruz et al. (1) and consisted in grinding in a blender a mixture of 500 mL pathogen inoculum, originated from 1000g roots presenting clubroot in field crops, with the planting soil from each tray. This amount of inoculum in preliminary tests resulted in all infected plants. The seedlings in the trays remained in a growth chamber at 22ºC and 75% RU until reaching the ideal point for transplanting to the field, when the plants had four to five leaves and were between 12 and 15 cm tall. The first application of treatments was performed in the growth chamber after seedling transplanting, as follows: T1. Negative control; T2. Biostimulant ((Raizal: Phosphorus + auxin 2.5g/tray) + (Kaionic: fulvic acid 3.0 g/tray)); T3. Biostimulant + fungicide (Raizal + Kaionic + Ranman 400 SC (Cyazofamid 2.5g/tray)); T4. fungicide (Ranman 400 SC). The second and third applications were done at 7 and 14 DAT (Days After Transplanting). Experimental design was in randomized blocks with four treatments and seven replicates. Each plot had ten cabbage seedlings and the pre-inoculated substrate. Liming and fertilization requirements to meet the plants' needs were determined based on soil analysis, according to the recommendations of the manual for using correctives and fertilizers in Minas Gerais - 5th approximation (6). A micronutrient solution (boron, zinc and molybdenum) was applied three times, at seven-day intervals, over the experiment.

Treatment efficiency was assessed by considering the disease incidence (number of cabbage plants that showed clubroot and were withered) at 0, 28, 35, 49, 77 and 96 DAT. These data underwent statistical analysis, and regression models were based on OriginPro® program; clubroot control was assessed by considering the last



Treament	Model	Equation	$R^{2(1)}$
T1(2)	Gompertz	y = 100*exp(-exp(-0.15286*(x-29.94902)))	0.9951
T2(3)	Gompertz	y = 100*exp(-exp(-0.20907*(x-31.78706)))	0.9989
T3(4)	Polinomial	$y = 0.0035x^2 - 0.0782x - 0.838$	0.8729
T4(5)	Polinomial	$y = 0.0061x^2 + 0.1663x - 0.0398$	0.9863

Figure 1. Regression of clubroot disease incidence in *Brassica oleracea* var. *capitata* caused by *Plasmodiophor*a *brassicae* using different treatments. [1]Coefficient of determination; [2]Negative control (T1); [3]Bioestimulant (T2); [4]Bioestimulant + fungicide (T3); [5]Fungicide (T4).

evaluation (96 DAT). The first symptomatic cabbage plants were identified at 28 DAT, showing wilting as a result of clubroot infection in their vascular system. The lowest incidence during evaluations and the smallest AUCPD (**1162) (Table 1)** were found for T3 (biostimulant + fungicide), which showed 21% disease incidence at 96 DAT and 76% control. The treatment T4 (Cyazofamid) had 74% disease incidence at 96 DAT, 3392 AUDPC and 24% control, supporting the importance of chemical control. Treatments T1 (control) and T2 (biostimulant) reached 100% incidence at 49 DAT and 8558 and 8243 AUDPC, respectively; the effect of the biostimulant alone was similar to that of control, leading to a high disease intensity. No phytotoxicity was observed for any treatment. The root system of treatment T3 developed better than the others probably due to a reduced attack to the roots (data not shown). All regression models (Figure 1) were acceptable (R^2> 85%). For treatments T1 and T2, the disease spread faster, leading to losses before plants were good for harvesting; on the contrary, treatments with the fungicide (T3 and T4) caused less disease development, allowing harvest even under conditions of high disease density.

Evaluation of new biostimulants in an environment of high inoculum density is also desirable to improve the efficiency of fungicides recommended for disease control. The treatment T3 (biostimulant + fungicide) can be considered an important tool for the integrated management of this disease and should be explored in the production of brassicas, considering that cyazofamid is the only product registered in Brazil. This strategy, together with soil pH correction to 6.3 - 7.4, solarization when possible and rotation with trap plants, may result in cultivars that remain resistant for longer periods, allowing the reutilization of areas that had the cultivation of brassicas abandoned due to the high incidence of clubroot. The obtained results, especially under high inoculum density, serve as basis for future studies of new biostimulants mixed with biocontrol agents compatible with the fungicide.

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