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Increasing tolerance to rust and drought of fig plants treated with dynamized high dilutions

Aumento da tolerância à ferrugem e à seca de figueiras tratadas com altas diluições dinamizadas

Aumento de la tolerancia a la roya y la sequía de las higueras tratadas con diluciones altamente dinamizadas

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Abstract

This work aimed to evaluate the impact of dynamized high dilutions on rust development and yield fig plants. Studies were conducted in the field. The experimental design was in split-plot, with five replications. The treatments were *Belladonna*, *Thuya occidentalis*, and nosode of fig-rusted leaves, all at 30 CH – centesimal Hahnemannian dilution order. Distilled water was used as the control. The cultivars used were Roxo de Valinhos and Branco Rosa Lages. Spray applications were performed every 15 days. The incidence and severity of rust *Cerotelium fici* were evaluated every seven days. The number of fruits per plant was counted. *Belladonna* reduced the severity of rust. *Thuya occidentalis* and nosode improved leave persistence. Dynamized high dilutions are a potential strategy to improve the tolerance of fig plants to drought and rust.

Keywords: *Ficus carica, Cerotelium fici,* Homeopathic preparations.

Resumo

O objetivo deste trabalho foi avaliar o impacto de altas diluições dinamizadas no desenvolvimento da ferrugem e na produção de plantas de figo. Estudos foram conduzidos em campo. O delineamento experimental foi feito em parcelas subdivididas com cinco repetições. Os tratamentos foram *Belladonna*, *Thuya occidentalis* e nosodio de folhas de figueira com ferrugem, todos em 30CH – escala centesimal Hahnemanniana. Água destilada foi usada como controle. As cultivares usadas foram Roxo de Valinhos e Branco Rosa Lages. Pulverizações foram realizadas a cada 15 dias. A incidência e severidade da ferrugem *Cerotelium fici* foram avaliadas a cada sete dias. O número de frutos por planta foi aferido. *Belladonna* reduziu a severidade de ferrugem. *Thuya occidentalis* e nosodio aumentaram a persistência das folhas. Altas diluições dinamizadas são potenciais estratégias para aumentar a tolerância de plantas de figo a seca e a ferrugem.

Palavras-chave: *Ficus carica, Cerotelium fici,* Preparados homeopáticos.

Resumen

El objetivo de este trabajo fue evaluar el impacto de diluciones altamente dinamizadas en el desarrollo de roya y producción de plantas de higo. Se realizaron estudios en el campo. El diseño experimental fue en parcelas divididas con cinco repeticiones. Los tratamientos fueron *Belladonna*, *Thuya occidentalis* y nosodium de hoja de higuera con roya, todos a 30CH – escala centesimal de Hahnemann. Como control se utilizó agua destilada. Los cultivares utilizados fueron Roxo de Valinhos y Branco Rosa Lages. Las aplicaciones de productos realizaron cada 15 días. La incidencia y severidad de la roya *Cerotelium fici* se evaluaron cada siete días. Se midió el número de frutos por planta. *Belladonna* redujo la gravedad del óxido. *Thuya occidentalis* y nosodium aumentaron la persistencia foliar. Las diluciones altamente energizadas son estrategias potenciales para aumentar la tolerancia de las plantas de higuera a la sequía y la roya.

Palabras-clave: *Ficus carica, Cerotelium fici*, Preparados homeopáticos.

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The fig plant (*Ficus carica* L.) is a species with high socioeconomic importance worldwide (Boliani *et al*., 2019). Fruits have high nutritional relevance, being a great source of minerals and vitamins (Rasool *et al*., 2023). The production of fig fruit in Brazil was 18,227 tons in 2022, with the highest quantity from orchards located in the Southern and Southeast regions (IBGE, 2022). Brazil is a prominent exporter of fresh fig fruits throughout the international off-season. In the year 2021, its annual earnings reached the sum of US$ 7.92 million (Faostat, 2023).

The fig production can be compromised by pests and diseases and abiotic factors such as high humidity or rainfall deficit. Water insufficiency that coincides with the growth stage instills a state of stress in plants, inducing physiological and morphological changes. Adequate rainfall distribution plays a relevant role in the growth period of plants (Moura *et al*., 2023), especially in figs because the fruits appear as the branches grow. The fig plants also manifest a sensitive response to the water deficit in the soil through foliar abscission, causing a direct reduction in fruit yield, as well. Even if the restoration of water conditions is established, the foliar abscission process may not be interrupted (Medeiros, 2002).

Prolonged periods of rainfall, on the other hand, especially during the summer season, can promote epidemics of fig pathogens. Fig rust caused by the biotrophic fungus *C. fici* (Cast.) Arth has been the main disease that affects fruit production, with significant losses and reduction in quality, due to premature leaf fall in a severe attack by this pathogen. The defoliation of fig plants caused by long rains in the crucial production of period of 30 days can cause fruit losses of up to 80% (Galleti; Rezende, 2016).

Studies demonstrate that this non-residual therapy has potential in the management of diseases and pests (Giesel; Boff; Boff, 2012; Oliveira *et al*., 2021). The use of dynamized high dilutions is a great strategy once it aims to reestablish the dynamic balance of crops with the surrounding environment (Boff; Verdi; Faedo, 2021). It may also act on the plant's primary metabolism such as photosynthesis and, consequently, on plant growth (Mioranza *et al*., 2018; Mazón-Suástegui *et al*., 2020). Since dynamized high dilutions are involved in morphological and metabolic changes in plants, they can be a great ally to provide ways of adapting these plants to adverse events.

The objective of this work was to evaluate the impact of dynamized high dilutions on fig rust *C. fici*, persistence of leaves, and production of fig fruits under field conditions.

The study was performed in a field trial from August/2021 to March/2022 in an experimental area at the Experimental Station of Epagri, Lages, SC (27°48'31"S 50°19'55"W). The experimental design was in split-plot, with five replications. The main plot was composed of the spraying treatments and the subplots were the fig cultivars. The dynamized high dilutions were *Belladonna*, *Thuya occidentalis*, and nosode of fig-rusted leaves with rust at 30 CH. Distilled water was used as a control. The fig plant cultivars were Roxo de Valinhos and Branco Rosa Lages.

The orchard area encompassed 400m² and it was previously prepared with mechanized harrowing and manual removal of rhizomes and stolons of *Pennisetum clandestinum*. Fig plants, cultivated in pots for 180 days, were transferred to the field by August 2021, with a spacing of 3m between plants and between rows. Throughout the crop cycle, no fertilization or irrigation was applied. After transplanting, white oats were sown in the inter-fig rows, as green manure. Sprays of the treatments started 30 days after fig transplanting. One hundred ml were sprayed in each plant and on the soil under canopy projection every 15 days, totaling ten applications.

The assessments of severity and incidence began after 47 days of transplantation when the first rust pustules appeared. For that, it was considered all the fully expanded leaves per plant. The severity evaluation was done with the aid of a diagrammatic scale according to Silva *et al*. (2019). The rust leaf incidence was estimated by registering the total number of leaves and the number of leaves with rust disease symptoms. Additionally, the number of fruits per plant was counted during disease evaluations.

Data from the evaluations of severity and incidence of fig rust were transformed to the area under the disease progress curve (AUDPC). Data were analyzed using the R software (RStudio Team, 2020), and means were compared using Tukey's test ($p \leq 0.05$).

The area under the disease progress curve (AUDPC) showed no interaction between the factor cultivar and dynamized high dilution preparation. A reduction of 41.78% in the severity was observed in plants treated with *Belladonna* in relation to the control distilled water (Figure 1a). *Belladonna* applied weekly and one week after the infection also showed an effect in reducing rust *Puccinia malvacearum* on *Malva sylvestris,* by 7% the AUDPC in relation to control, according to Oliveira *et al*. (2021). Maybe the preventive treatment, as performed in the present study, was important to induce the plant defense before the pathogen arrives, increasing the reduction of disease. It is important to apply these treatments before the climatic conditions become favorable to the development of rust. The highest germination of *C. fici* spores occurs in a temperature range of 22 and 28°C, with the higher number of pustules about 25ºC (Rogovski Czaja *et al*., 2021).

Roxo de Valinhos showed a 35.21% lower susceptibility to rust than the Branco Rosa Lages cultivar (Figure 1b). In contrast, according to Pastore *et al*. (2017), landrace cultivars from Lages, such as Branco Rosa, without treatments, were generally more tolerant to rust than Roxo de Valinhos. When comparing Lages to other regions, rust resistance was higher in fig landraces from Lages, probably due to their common genetic base. The atypical year, characterized by an extended period of drought, may have influenced to respond differently, according to climate conditions.

For incidence analysis, the interaction was also not significant, and there was no difference among the applied treatments (data not shown). When comparing the cultivars, likewise, the Roxo de Valinhos cultivar presented 18,60% less incidence than Branco Rosa Lages (Figure 1c).

Plants of the Roxo de Valinhos cultivar treated with *Thuya occidentalis* and with nosode showed the highest numbers of attached leaves per plant per day in relation to *Belladonna* (Table 1). Nevertheless, *Thuya occidentalis* and nosode increased the remaining leaves of Roxo de Valinhos plants after the fifth application of treatments in comparison to the control (Figure 2a). *Thuya occidentalis* showed also excellent results in the Branco Rosa Lages cultivar after the fifth application concerning the remaining leaves of fig plants (Figure 2b).

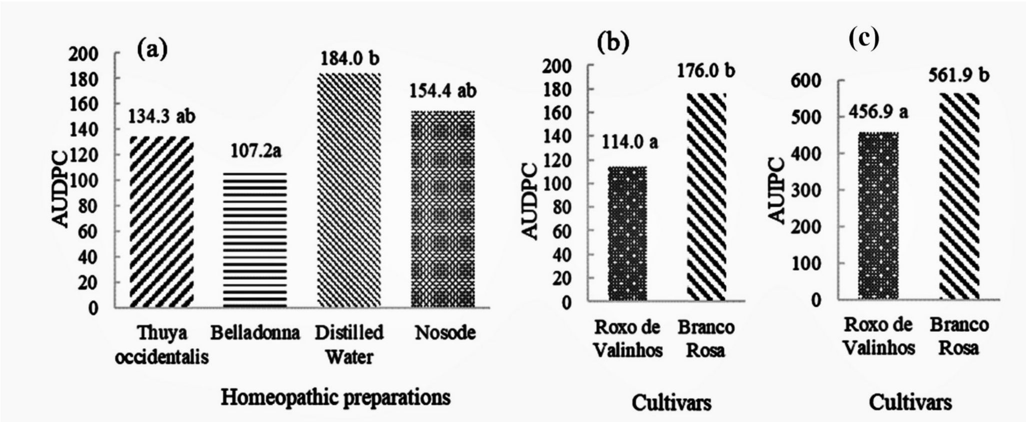

Figure 1. Severity for treatment (A) and cultivar (B) factors and incidence - AUIPC (C) in fig cultivars treated with dynamized high dilutions in the field. Lages, SC. CV subplot 28.32%; CV plot 35.97%; CV subplot 12.51%.
Source: Authors, 2023.

Cultivar Branco Rosa Lages did not respond to treatments in terms of the daily number of leaves.

Table 1. Number of attached leaves per day and fruits per plants of different fig cultivars treated with dynamized high dilutions in the field. Lages, SC.

Dynamized high dilutions	Leaves.day^{-1}		Fruits.plant^{-1}	
	Roxo de Valinhos	Branco Rosa Lages	Roxo de Va-linhos	Branco Rosa Lages
Thuya occidentalis	7.09 Aa	7.17 Aa	7.8 a	0.2^{ns}
Belladonna	3.30 Bb	6.04 Aa	3.2 b	0.0
Nosode	7.02 Aa	5.61 Ba	5.2 ab	0.2
Distilled water	5.29 Aab	5.07 Aa	3.8 ab	1.2

Leaves.day^{-1}: Means followed by the same lowercase in the column and uppercase letter in the row do not differ, according to Tukey's test ($p \leq 0.05$). CV subplot 24.38%; CV plot 22.45%.
Fruits.plant^{-1}: Means followed by the same letter in the column do not differ from each other, according to Tukey's test ($p \leq 0.05$). CV 23.04% and 37.15%. ns: not significant between treatments.
Source: Authors, 2023.

It was possible to observe a relation between the remaining leaves of plants and the climatic data. In the period of low average precipitation (mm) that occurred in the evaluation period, plants lost leaves in response to water stress. However, it was observed that plants treated with dynamized high dilutions showed rapid recovery and new leaf sprouting. Gholami *et al*. (2012) reported that fig plants stressed 7 days by drought had a decrease in leaf mass area, which did not recover after the test period.

In the present study, Roxo de Valinhos plants treated with *Belladonna* reacted to the sprays with the appearance of necrotic spots on some leaves. This could be the pathogenesis symptoms as described in the literature (Rossi *et al*., 2004). However, by the conclusion of the applications, the plants had recovered and the necrosis was no longer observed.

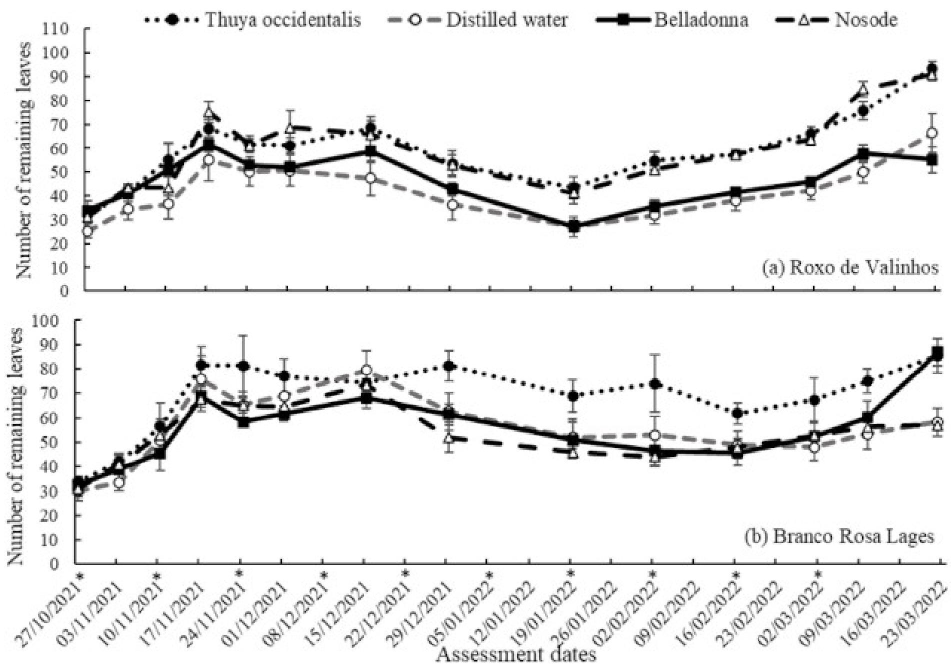

Figure 2. Remaining leaves of fig plants in the field submitted to dynamized high dilutions during the evaluation period, from Oct/2021 to Mar/2022. Lages, SC. Bars represent standard error. Comparison between means of each assessment day was performed using Tukey's test ($p<0.05$). *Days of treatment application.
Source: Authors, 2023.

A higher number of fruits were recorded in the Roxo de Valinhos cultivar treated with *Thuya occidentalis* than with *Belladonna*. *Belladonna* may have caused pathogenesis, which influenced fruit productivity. Pathogenesis is caused when a homeopathic medicine is applied too much or incorrectly. In this case, the six applications of this specific treatment may have externalized symptoms and these specific symptoms indirectly caused a decrease in productivity by reducing the number of leaves. When the application stopped, the plant recovered itself in the number of leaves.

The cultivar Branco Rosa did not present differences among the treatments. This is probably because Branco Rosa Lages had low fruit production during the evaluation period. Perhaps in that cultivar, the plants need greater time of maturity after transplanting in comparison to Roxo de Valinhos. Breeds show frequently younger production than landraces. Nevertheless, those characteristics can also shorten the productive period of years (Maranna *et al*., 2021).

The highest production was 7.8 fruits per plant, which is a low value if compared with 55.87 fruits per plant found by Norberto *et al*. (2018). Plants used by these authors are about 3 years of age, with spacings ranging from 1m. The plants used in the present study had just 230 days of life until production. The plants need time to establish themself in the field. Following Moniruzzaman *et al*. (2020), fig plants generally take 161.5 to 200.3 days after planting to start producing fruits. These same authors demonstrated that different cultivars could start production on different days after planting. Roxo de Valinhos plants started fruit production 50 days after transplanting, while Branco Rosa plants took 15 days more time (data not shown).

In conclusion, *Belladonna* has the potential to reduce the severity of *C. fici* in fig plants. The dynamized high dilutions may improve the recuperation of plants in relation to the number of leaves after periods of stress.

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