

Evaluation of the antifungal potential of *Piper cf. fuligineum* Kunth leaf extract for the control of *Agroathelia rolfsii* (Sacc.)

Alexandre Ribeiro Alves dos Santos^{1,2}, Ana Beatriz Ferreira de Souza¹, Maria Eduarda Moura de Oliveira¹, Maria Eduarda Poczwadowski¹, Ingrid Barbosa da Costa^{1,2}, Emiliane dos Santos Belo¹, Milton Luiz da Paz Lima^{3,4}, Melina Korres Raimundi⁵ and Rejane Araujo Guimarães^{3,4}

¹ Instituto Federal Goiano Campus Posse, GO-453, Km 2,5, Fazenda Vereda do Canto, Distrito Agroindustrial, Posse, Goiás, Brazil

² Centro de Excelência em Bioinsumos, GO-453, Km 2,5, Fazenda Vereda do Canto, Distrito Agroindustrial, Posse, Goiás, Brazil

³ Instituto Federal Goiano Campus Urutaí, Laboratório de Fitopatologia, Rod. Geraldo Silva Nascimento, km 2,5, Zona Rural, Urutaí, Goiás, Brazil

⁴ Instituto Federal Goiano Campus Urutaí, Laboratório de Genética Molecular, Rod. Geraldo Silva Nascimento, km 2,5, Zona Rural, Urutaí, Goiás, Brazil

⁵ Universidade Estadual de Minas Gerais - UEMG unidade Divinópolis, Minas Gerais, Brazil

* Corresponding author. E-mail: alexandreriibeiro2711@gmail.com, rejane.guimaraes@ifgoiano.edu.br

ABSTRACT. This study evaluated the in vitro antifungal activity of *Piper cf. fuligineum* Kunth, a native shrub of the Brazilian Cerrado, obtained by ethyl acetate extraction, against *Agroathelia rolfsii*, a soilborne phytopathogen that infects several agricultural crops. The leaf extract of *Piper cf. fuligineum* was tested on potato dextrose agar (PDA) plates using a completely randomized design with seven replicates per treatment. Five treatments were evaluated: control, emulsifying agent control, and three extract concentrations: T3 (0.667 $\mu\text{L mL}^{-1}$ extract + 0.333 $\mu\text{L mL}^{-1}$ emulsifying agent); T4 (2.0 $\mu\text{L mL}^{-1}$ extract + 0.667 $\mu\text{L mL}^{-1}$ emulsifying agent); and T5 (4.0 $\mu\text{L mL}^{-1}$ extract + 1.333 $\mu\text{L mL}^{-1}$ emulsifying agent). Mycelial growth was monitored for 5 days through daily radial measurements and analyzed by analysis of variance (ANOVA) ($p < 0.05$). Mycelial growth inhibition was observed, with inhibition percentages of 10.7% (T3), 79.1% (T4), and 94.6% (T5). The mycelial growth rate index decreased from 3.15 cm day^{-1} in the control to 0.09 cm day^{-1} in T5, while the area under the mycelial growth progress curve decreased proportionally. The treatment containing only the emulsifying agent did not differ statistically from the absolute control. It was concluded that the extract of *P. cf. fuligineum* exhibits strong in vitro antifungal activity (94.6% inhibition) against *A. rolfsii*.

Key words: Ethyl acetate; biological control; mycelial growth; phytopathogen

DOI: <https://doi.org/10.33837/msj.v9i1.1763>

Received: November 4th, 2025

Accepted: September 25th, 2026

Published: October 15th, 2026

Associate editor: Érica Fernandes Leão Araújo

INTRODUCTION

Agroathelia rolfsii (Sacc.) is a soilborne phytopathogen with a wide geographical distribution and a broad host range, responsible for symptoms that include wilting, collar constriction, root, bulb, and fruit rot, as well as damping-off in seedlings, causing significant losses in agricultural crops (Konkel, 2021; Henning et al., 2014). Its pathogenic activity involves the production of oxalic acid and degradative enzymes, together with the

formation of resistant sclerotia, viable structures that can persist in the soil for several years, allowing the pathogen to survive between cropping seasons and making its management difficult (Halfeld-Vieira, Nechet, & Pereira, 2003).

Sclerotia are formed through the aggregation of hyphae associated with the accumulation of storage compounds, such as glycogen and lipids, in addition to melanin deposition in the outer layer, which provides structural resistance and makes pathogen control more difficult. Disease management largely relies on cultural practices and the use of chemical fungicides (Duarte, Tabaranã, Albuquerque, & Moraes, 2006). However, these control methods have practical and environmental limitations (Barathi, Sabapathi, Kandasamy, & Lee, 2024). The development of fungal resistance, environmental impacts, and economic costs

Copyright © The Author(s).

This is an open-access paper published by the Instituto Federal Goiano, Urutaí - GO, Brazil. All rights reserved. It is distributed under the terms of the Creative Commons Attribution 4.0 International License.



have encouraged the search for sustainable and effective alternatives.

The genus *Piper* is native, non-endemic, and occurs throughout all regions of Brazil and its major phytogeographic domains (Guimarães et al., 2020). The extraction of metabolites present in this taxon demonstrates high potential for application and commercial viability on an industrial scale, reinforcing its economic value (Nguyen, Nguyen, & Mai, 2025). In addition to its commercial potential, plant extracts from species of this genus have shown promise in the control of phytopathogens, with demonstrated efficacy against fungi such as *Rhizoctonia solani* and *A. rolfsii*, reinforcing the potential of the genus as a sustainable alternative for disease management (Bastos et al., 2018).

Studies by Silva and Bastos (2007) demonstrated that *Piper callosum* extract can completely inhibit mycelial growth and basidiospore germination of *C. pernicioso*, even at low concentrations. This antifungal activity has been attributed to the presence of bioactive compounds, such as safrole, methyl eugenol, and highly oxygenated flavonoids, which act synergistically, providing both fungicidal and fungistatic effects.

However, the efficacy of leaf extracts of *Piper cf. fuligineum* Kunth, specifically against *A. rolfsii*, is not well documented in the literature. Previous studies with extracts of *P. fuligineum* have demonstrated antifungal activity against yeasts of the genus *Candida* and *Cryptococcus neoformans* (Mazzeu, 2014), but without evaluation against phytopathogens, highlighting a gap between the pharmacological evidence for the species and its practical application in plant disease control.

On the other hand, plant extracts from other genera have been shown to be effective specifically against *A. rolfsii*, as observed for species of *Capsicum* (Fonseca et al., 2020) and in recent evaluations of plant extracts against this pathogen (Díaz-Nájera et al., 2025), reinforcing the potential of plant-derived compounds as a management alternative. The study by Lee et al. (2024) demonstrated that ethyl acetate, due to its intermediate polarity, favors the extraction of bioactive compounds such as polyphenols, flavonoids, and terpenoids, metabolites associated with different biological activities. Maceration allows these compounds to be obtained under mild conditions, at room temperature and with low risk of thermal degradation (Sun et al., 2025).

Considering this gap and the need for low-environmental-impact alternatives for controlling soilborne pathogens, evaluating the *in vitro* antifungal activity of plant extracts represents an essential step in screening promising candidates. In this context, the present study evaluated the antifungal activity of the leaf extract of *P. cf. fuligineum* Kunth, obtained by ethyl acetate extraction, on the mycelial growth of *A. rolfsii* isolates under *in vitro* conditions.

MATERIAL AND METHODS

Well-developed branches of *P. cf. fuligineum* Kunth were collected from four distinct locations in Trombas, Posse, Goiás, Brazil (14° 7' 41.7" S, 46° 30' 42.4" W; 658 m altitude) in November 2024, during the morning. A voucher specimen was deposited at the Herbarium of the Brasília Botanical Garden, where the species was confirmed under registration number 38730 (Ramalho, 2025). At the Sample Preparation Laboratory of the Federal Institute of Goiás – Posse Campus, the plant material was washed under running water and subsequently with distilled water. The leaves were then dehydrated in a drying oven at 40 °C for 96 hours. After drying, the leaves were ground in a Wiley-type knife mill and subjected to the extraction process. The extract was obtained from 200 g of dried leaves placed in flat-bottomed flasks, to which 1,000 mL of 99.5% analytical-grade ethyl acetate was added. Contact between the solvent and plant material was maintained for four days at room temperature (26 °C), protected from light and with daily agitation at 90 rpm. The resulting mixture was filtered through filter paper and subjected to natural evaporation in an aluminum foil-covered beaker for 33 days, following the methodology adapted from Morais (2023). At the end of the process, a plant extract with a syrup-like consistency was obtained.

The *A. rolfsii* (Sacc.) isolates were provided by the Microbiology Laboratory of the Federal Institute of Goiás – Urutaí Campus and originated from the Mycological Collection. Sclerotium activation was performed by plating on potato dextrose agar (PDA) culture medium in a laminar flow cabinet, followed by incubation in a biochemical oxygen demand (BOD) incubator for 96 hours.

The experiment was conducted using a completely randomized design with five treatments and seven replicates. Each experimental unit consisted of a Petri dish containing 20 mL of culture medium, with a 5-mm-diameter mycelial disc placed at the center of the plate, with each Petri dish considered a replicate. The treatments were: T1 (control); T2 (0 $\mu\text{L mL}^{-1}$ extract + 0.667 $\mu\text{L mL}^{-1}$ emulsifying agent – EA); T3 (0.667 $\mu\text{L mL}^{-1}$ extract + 0.333 $\mu\text{L mL}^{-1}$ EA); T4 (2.0 $\mu\text{L mL}^{-1}$ extract + 0.667 $\mu\text{L mL}^{-1}$ EA); and T5 (4.0 $\mu\text{L mL}^{-1}$ extract + 1.333 $\mu\text{L mL}^{-1}$ EA).

The antifungal potential of the leaf extract was evaluated using the mycelial disc diffusion technique with *A. rolfsii*. The Petri dishes and culture medium were sterilized in an autoclave at 121 °C under a pressure of 1 atm for 20 minutes. While the culture medium was still warm and in the liquid phase, the emulsifying agent (EA) was added to homogenize the extract due to its nonpolar characteristics. After solidification of the medium containing the plant extract, 1-cm-diameter mycelial discs of *A. rolfsii* were placed at the center of the Petri dishes according to the respective treatments. The plates were then sealed and

incubated in a BOD incubator at 26 °C for subsequent evaluation.

Mycelial growth was evaluated over five days, with measurements taken at 24-hour intervals. Using a caliper, radial mycelial growth was measured along two orthogonal axes, and the means were subsequently calculated for each treatment. Based on the data obtained, the percentage inhibition of mycelial growth (PIMG) and the mycelial growth rate index (MGRI) were determined according to the equations described by Rezende et al. (2020). The data were subjected to analysis of variance (ANOVA), and the assumptions of the model were verified using the Shapiro–Wilk test to assess residual normality and Bartlett’s test to assess homogeneity of variances, both at a 5% significance level.

The analyses demonstrated that the assumptions required for the application of ANOVA were met, confirming the adequacy of the fitted models. The mycelial growth variables, including PIMG, MGRI, and the area under the mycelial growth progress curve (AUMGPC), were analyzed in an integrated manner. Mean comparisons using Dunnett’s test allowed significant differences between treatments and the control to be identified. This integrated approach consistently characterized the pathogen’s response to the different extract concentrations, demonstrating a gradual and concentration-dependent effect.

RESULTS AND DISCUSSION

The results obtained allowed a comprehensive assessment of the antifungal activity of the leaf extract of *P. cf. fuligineum* Kunth against the phytopathogen *A. rolfsii*. Dunnett’s test showed that the treatments containing *P. cf. fuligineum* Kunth leaf extract had a significant antifungal effect on *A. rolfsii* compared with the control ($P < 0.05$).

The extract concentrations of 0.667, 2.0, and 4.0 $\mu\text{L mL}^{-1}$ resulted in substantial reductions in the area under the mycelial growth progress curve (AUMGPC), with differences relative to the control of -130.49 , -168.51 , and $-170.44 \text{ cm}^2 \cdot \text{day}^{-1}$, respectively (Figure 1). The lowest concentration (0.667 $\mu\text{L mL}^{-1}$) showed an inhibitory effect, although of lower magnitude, whereas the concentrations of 2.0 and 4.0 $\mu\text{L mL}^{-1}$ resulted in marked inhibition of mycelial growth, demonstrating an increase in the inhibitory effect with increasing extract concentration. The highest concentration evaluated (4.0 $\mu\text{L mL}^{-1}$) resulted in 94.6% inhibition, approaching complete suppression of fungal growth.

On the other hand, the treatment containing the emulsifying agent alone (Emog) did not differ statistically from the control ($P > 0.05$), confirming that the reduction observed was exclusively associated with the action of the plant extract and not with interference from the emulsifying agent used in the preparation.

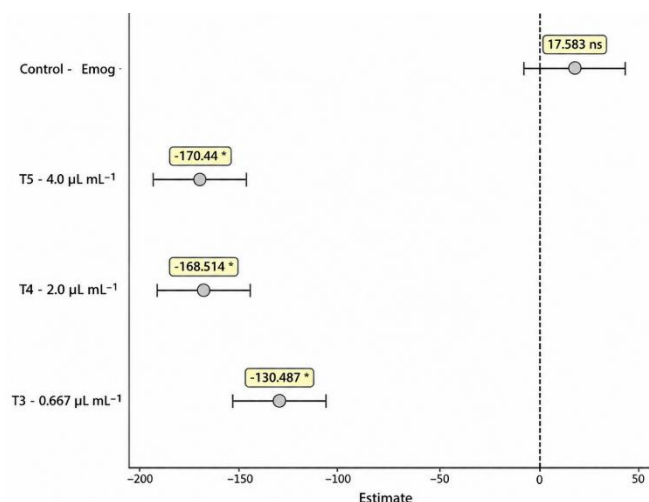


Figure 1. Estimated differences in the area under the mycelial growth progress curve (AUMGPC) between each concentration of *P. cf. fuligineum* Kunth leaf extract ($\mu\text{L mL}^{-1}$) and the control, according to Dunnett’s test ($P < 0.05$).

The analysis of the area under the mycelial growth progress curve (AUMGPC) revealed a strong dose-dependent effect of the extract on fungal growth. The control and emulsifying agent treatments showed the highest mean values (171.38 and 188.97 $\text{cm}^2 \cdot \text{day}^{-1}$, respectively), confirming the absence of an effect of the emulsifying agent. The treatment with 0.667 $\mu\text{L mL}^{-1}$ of extract significantly reduced the AUMGPC, with a value of 40.89 $\text{cm}^2 \cdot \text{day}^{-1}$. At concentrations of 2.0 and 4.0 $\mu\text{L mL}^{-1}$, the lowest AUMGPC values were observed, at 2.87 and 0.94 $\text{cm}^2 \cdot \text{day}^{-1}$, respectively, indicating a strong reduction in mycelial growth and an inhibitory effect approaching complete suppression at the highest concentrations (Figure 2).

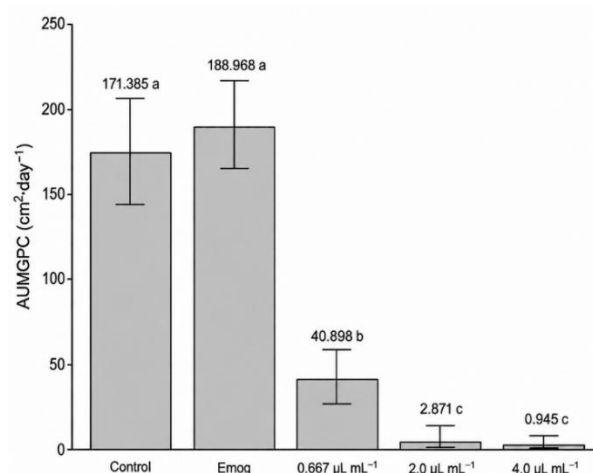


Figure 2. Area under the mycelial growth progress curve of *A. rolfsii* under different concentrations of *P. cf. fuligineum* Kunth leaf extract. Means $\pm$ standard error followed by the same letter do not differ significantly according to Dunnett’s test ($P < 0.05$).

The results regarding the percentage inhibition of mycelial growth (PIMG) clearly demonstrated the response of the leaf extract of *P. cf. fuligineum* Kunth against *A. rolfsii*. While the control and emulsifying agent (Emog) treatments showed no antifungal activity,

remaining at values close to 0%, the treatment with $0.667 \mu\text{L mL}^{-1}$ of extract promoted partial inhibition of mycelial growth, corresponding to 10.7%, which was not sufficient to effectively restrict the growth of the phytopathogen.

In contrast, the concentrations of 2.0 and $4.0 \mu\text{L mL}^{-1}$ showed markedly higher inhibition rates, reaching 79.1% and 94.6%, respectively. These results demonstrate a pronounced reduction in mycelial growth at the higher concentrations, with the $4.0 \mu\text{L mL}^{-1}$ concentration promoting inhibition close to complete suppression of fungal growth (Figure 3).

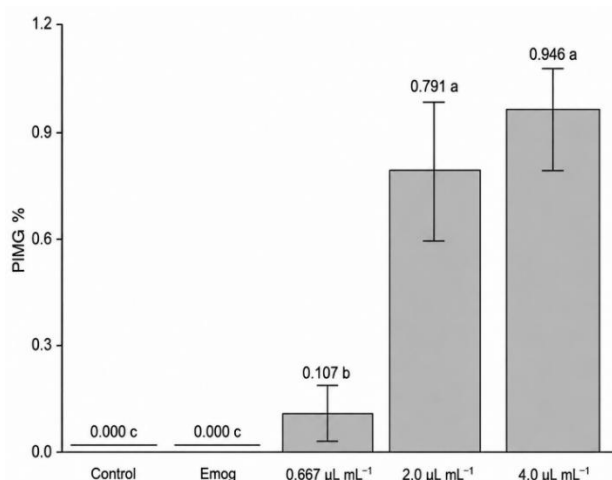


Figure 3. Percentage inhibition of mycelial growth of *A. rolfsii* at different concentrations of *P. cf. fuligineum* Kunth leaf extract. Different letters indicate significant differences among treatments ($p < 0.05$).

The analysis of the mycelial growth rate index (MGRI) complements the findings for PIMG, demonstrating the impact of the extract on the temporal dynamics of fungal development. The control ($3.15 \text{ cm} \cdot \text{day}^{-1}$) and emulsifying agent ($3.39 \text{ cm} \cdot \text{day}^{-1}$) treatments showed the highest growth rates. The treatment with $0.667 \mu\text{L mL}^{-1}$ of extract significantly reduced the mycelial growth rate, with an MGRI of $1.40 \text{ cm} \cdot \text{day}^{-1}$. The concentrations of 2.0 and $4.0 \mu\text{L mL}^{-1}$ promoted more pronounced reductions, with MGRI values of 0.33 and $0.09 \text{ cm} \cdot \text{day}^{-1}$, respectively. These results demonstrate a progressive reduction in mycelial growth rate with increasing extract concentration, with the lowest MGRI observed at the concentration of $4.0 \mu\text{L mL}^{-1}$ (Figure 4).

Visually, *A. rolfsii* colonies grown on media containing the extract exhibited less dense mycelia and irregular margins, in contrast to the dense and uniform mycelium observed on the control plates (Figure 5). These morphological characteristics indicate interference with fungal physiology and morphogenesis. In the control (T1) and the treatment containing the emulsifying agent alone, Emog (T2), the mycelium developed fully, occupying nearly the entire surface of the plates.

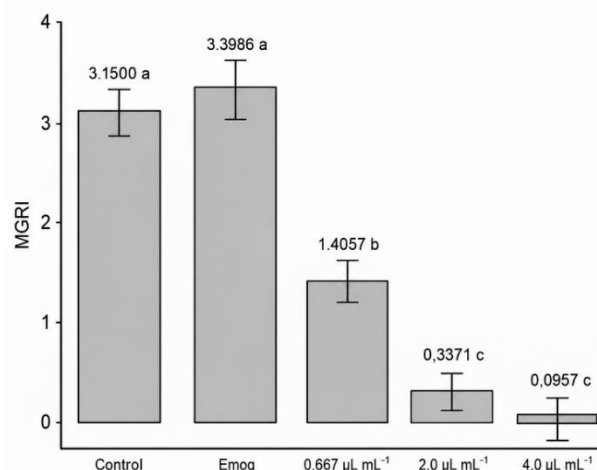


Figure 4. Mycelial growth rate index of *A. rolfsii* under different concentrations of *P. cf. fuligineum* Kunth leaf extract. Different letters indicate significant differences among treatments ($p < 0.05$).

At the concentration of $0.667 \mu\text{L mL}^{-1}$ (T3), a moderate reduction in radial growth was observed, with a visibly smaller colony compared with the control. At concentrations of $2.0 \mu\text{L mL}^{-1}$ (T4) and $4.0 \mu\text{L mL}^{-1}$ (T5), mycelial growth was markedly reduced, being restricted to small initial foci or showing an almost complete absence of mycelial expansion (Figure 5). This visual pattern corroborates the quantitative results obtained for the percentage inhibition of mycelial growth (PIMG) and the mycelial growth rate index (MGRI), demonstrating the increase in inhibitory activity with increasing extract concentration.

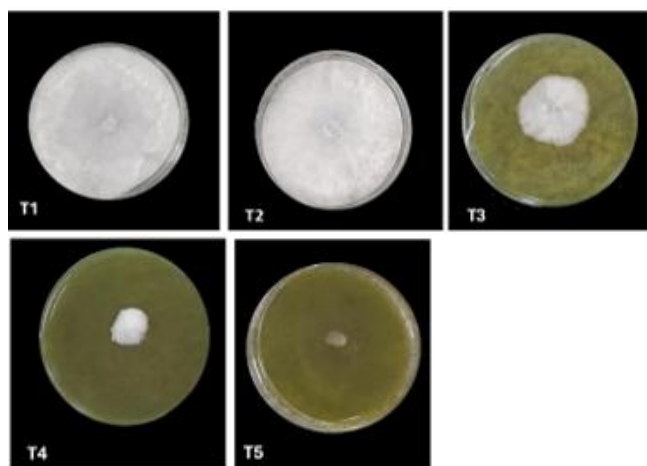


Figure 5. Macroscopic appearance of plates inoculated with *A. rolfsii* on the last day of evaluation (5th day) after inoculation. T1: control; T2: emulsifying agent (Emog); T3: $0.667 \mu\text{L mL}^{-1}$ of extract; T4: $2.0 \mu\text{L mL}^{-1}$ of extract; T5: $4.0 \mu\text{L mL}^{-1}$ of extract.

The chemical literature available for *P. cf. fuligineum* Kunth reports that its essential oils contain a diversity of constituents, with monoterpenes and sesquiterpenes such as limonene, β -pinene, nerolidol, β -caryophyllene, and eupatoriocromene standing out, in addition to secondary metabolites such as kavalactones, chromanones, and prenylated benzoic acid derivatives, which are frequently associated with

antifungal, antiviral, and trypanocidal activities (Mazzeu, 2014; Vieira et al., 2025). These classes of compounds have been associated in different studies with antifungal activity and toxic effects against fungi and insects, providing a plausible basis for interpreting the activity observed in the *in vitro* assays.

Biological assays have demonstrated that the essential oil from the fruits of the species exhibits strong insecticidal activity against *Tribolium castaneum*, with a feeding deterrent effect of 55% and an LC_{50} of $56.4 \mu\text{g mL}^{-1}$, without significant hemolytic toxicity (Vieira et al., 2025). In addition, studies have indicated a pronounced ovicidal effect, with up to 90% of *Spodoptera frugiperda* eggs being rendered nonviable at concentrations of 1% (Pinheiro, et al., 2022). Prenylated benzoic acid derivatives found in several *Piper* species and in essential oils by Leite (2023), as well as in the leaves of *P. fuliginum* Kunth by Mazzeu et al. (2018) also exhibit marked antifungal activity. Studies isolating prenylated benzoates and analogues have documented mechanisms ranging from the inhibition of fungal biosynthetic enzymes to membrane disruption, as well as measurable fungicidal effects at micromolar concentrations (Malami, 2012). Thus, the presence of these prenylated compounds in *P. cf. fuliginum* Kunth constitutes a strong candidate for explaining part of the antifungal activity observed.

The choice of ethyl acetate as the extraction solvent proved methodologically appropriate, since this solvent has intermediate polarity, favoring the recovery of semipolar secondary metabolites such as kavalactones, chromanones, and prenylated benzoic acid derivatives, compounds frequently associated with antifungal activity in species of the genus *Piper* (Mazzeu, 2014; Pinheiro et al., 2022). Thus, the use of ethyl acetate provided a balance between selectivity and extraction yield, enhancing the recovery of constituents most likely to be responsible for the inhibition of mycelial growth of *A. rolfsii*.

Although this study did not include a treatment containing ethyl acetate alone, results published by Oliveira et al. (2026), using a similar methodology to evaluate the growth of *A. rolfsii*, demonstrated that treatments containing only the solvent did not differ statistically from the control. The authors therefore indicated that ethyl acetate did not exert a significant effect on fungal mycelial growth, reinforcing that the inhibition observed is mainly associated with the bioactive compounds present in the plant extract.

CONCLUSION

The leaf extract of *P.cf. fuliginum* Kunth, obtained using ethyl acetate, exhibited *in vitro* antifungal activity against *A. rolfsii*. The inhibitory effect increased with increasing extract concentration, with mycelial growth inhibition of 10.7%, 79.1%, and 94.6% at concentrations of 0.667, 2.0, and $4.0 \mu\text{L mL}^{-1}$, respectively. The highest

concentrations also reduced the mycelial growth rate and the area under the mycelial growth progress curve (AUMGPC), indicating greater restriction of phytopathogen development. Therefore, under the conditions evaluated, the leaf extract of *P. cf. fuliginum* Kunth demonstrated antifungal potential against *A. rolfsii*, with the greatest effect observed at a concentration of $4.0 \mu\text{L mL}^{-1}$.

CONFLICT OF INTEREST

None to declare.

ACKNOWLEDGEMENTS

The authors thank the scholarship recipients affiliated with CEBIO – Center of Reference in Bioinputs of the Instituto Federal Goiano - Campus Urutaí, the Goiás State Research Support Foundation (Fapeg), and the Research Support Foundation (FUNAPE) for their collaboration in conducting the experiments and laboratory activities that contributed to the development of this study. They also thank Instituto Federal Goiano - Campus Urutaí for the institutional support, laboratory infrastructure, and academic support provided for this research.

REFERENCES

- Barathi, S., Sabapathi, N., Kandasamy, S. and Lee, J. (2024). Present status of insecticide impacts and eco-friendly approaches for remediation—a review. *Environmental Research*. 240, 117432. DOI: <https://doi.org/10.1016/j.envres.2023.117432>
- Bastos, J. S. F., Fernandes, C. F., Vieira Junior, J. R., Fonseca, A. S., Freire, T. C., Sangi, S. C. and Barbieri, F. S. (2018). Potencial de controle de espécies de *Piper* sobre fungos fitopatogênicos. *Revista Ibero-Americana de Ciências Ambientais*. 9, 260–272. DOI: <https://doi.org/10.6008/CBPC2179-6858.2018.008.0023>
- Díaz Nájera, J. F., Terrones Salgado, J., Ayvar Serna, S., Vargas Hernández, M., Apáez Barrios, M., Arispe Vázquez, J. L. and Adame Bores, J. F. (2025). Sensibilidad de *Sclerotium rolfsii*, agente causal del tizón sureño del chile, a *Trichoderma* spp., extractos vegetales y fungicidas. *Revista Mexicana de Fitopatología*. 43, 1–11. DOI: <https://doi.org/10.18781/R.MEX.FIT.2209-1>
- Duarte, M. de L. R., Tabaranã, M. G. F., Albuquerque, F. A. B. de and Moraes, A. J. G. de. (2006). Controle químico da podridão-das-estacas (*Sclerotium rolfsii*) da pimenteira-do-reino. Comunicado Técnico, 157. Belém, PA: Embrapa Amazônia Oriental.
- Fonseca, A. S. da, Fernandes, C. de F., Vieira Júnior, J. R., Rocha, R. B., Freire, T. C., Sangi, S. C. and Alves, R. de C. (2020). Extratos vegetais do gênero *Capsicum* com potencial atividade antifúngica contra *Rhizoctonia solani* e *Sclerotium rolfsii*. *Revista Ibero-Americana de Ciências Ambientais*. 11, 89–98. DOI: <https://doi.org/10.6008/CBPC2179-6858.2020.001.0010>
- Guimarães, E. F., Medeiros, E. V. S. S. and Queiroz, G. A. (2020). *Piper in Flora do Brasil 2020*. Jardim Botânico do Rio de Janeiro. Available at: <http://floradobrasil2020.jbrj.gov.br/reflora/floradobrasil/FB12735>. Accessed August 22, 2026.
- Halfeld-Vieira, B. de A., Nechet, K. de L. and Pereira, P. R. V. da S. (2003). Ocorrência de *Sclerotium rolfsii* em condições de cultivo protegido na cidade de Boa Vista, Roraima e recomendações de controle. Comunicado Técnico, 4. Boa Vista, RR: Embrapa Roraima.
- Henning, A. A., Almeida, A. M. R., Godoy, C. V., Seixas, C. D. S., Yorinori, J. T., Costamilan, L. M. and Dias, W. P. (2014). *Manual*

- de identificação de doenças de soja. 5th ed. Londrina, PR: Embrapa Soja.
- Konkel, R. V. (2021). *Influência de óleos essenciais na germinação dos escleródios de Sclerotinia sclerotiorum (Lib.) de Bary e Sclerotium rolfsii Sacc.* Trabalho de Conclusão de Curso. Universidade Federal de Santa Catarina, Curitiba, SC, Brasil.
- Lee, J.-E., Jayakody, J. T. M., Kim, J.-I., Jeong, J.-W., Choi, K.-M., Kim, T.-S. and Ryu, B.-M. (2024). The influence of solvent choice on the extraction of bioactive compounds from Asteraceae: A comparative review. *Foods* 13, 1–21. DOI: <https://doi.org/10.3390/foods13193151>
- Leite, J. P. D. P. (2023). Análise química e avaliação da atividade antioxidante de extratos de *Piper fuligineum* (galhos) e *Piper macedoi* (galhos e frutos). Trabalho de Conclusão de Curso, Universidade Federal de Uberlândia. Instituto de Química, Uberlândia, MG, Brasil.
- Malami, I. (2012). Prenylated benzoic acid derivatives from *Piper* species as source of anti-infective agents. *International Journal of Pharmaceutical Sciences and Research*. 3, 1554–1559. DOI: [https://doi.org/10.13040/IJPSR.0975-8232.3\(6\).1554-59](https://doi.org/10.13040/IJPSR.0975-8232.3(6).1554-59)
- Mazzeu, B. F. (2014). *Estudo de aspectos químicos, biológicos e biossintéticos em Piper fuligineum Kunth (Piperaceae)*. Dissertação de Mestrado, Universidade Estadual Paulista. Instituto de Química, Araraquara, SP, Brasil.
- Mazzeu, B. F., Felipe, L. G., Cotinguiba, F., Kato, M. J. and Furlan, M. (2018). Kavalactones and benzoic acid derivatives from leaves of *Piper fuligineum* Kunth (Piperaceae). *Journal of the Brazilian Chemical Society*. 29, 1286–1290. DOI: <https://doi.org/10.21577/0103-5053.20170225>
- Morais, V. P. (2019). *Extratos ativos de Piper aduncum L., sobre os fungos Sclerotinia sclerotiorum, Colletotrichum gloeosporioides e Rhizopus stolonifer: teste in vitro e in vivo em soja*. Dissertação de Mestrado. Instituto Federal de Educação, Ciência e Tecnologia Goiano, Campus Rio Verde, Goiás, Brasil.
- Nguyen, T. N. P., Nguyen, P. T. and Mai, C. H. (2025). Extraction of bioactive compounds from pepper (*Piper nigrum*) in Vietnam using response surface methodology and the piperine purification process. *Oriental Journal of Chemistry*. 41, 317–329. DOI: <https://doi.org/10.13005/ojc/410201>
- Oliveira, M. E. M., Santos, A. R. A., Souza, A. B. F., Poczwadowski, M. E., Costa, I. B., Belo, E. dos S. and Guimarães, R. A. (2026). Evaluation of the potential of the ethyl acetate extract of *cupira* in the *in vitro* control of *Agroathelia rolfsii*. *Multi-Science Journal* 9, 18–23. DOI: <https://doi.org/10.33837/msj.v9i1.1767>
- Pinheiro, K. D., Rezende, K. F. and Krinski, D. (2022). Efeito ovicida de óleo essencial de folhas e frutos de *Piper fuligineum* (Piperaceae) sobre ovos de *Spodoptera frugiperda* (Lepidoptera). *Journal of Education, Science and Health*. 2, 1–10. DOI: <https://doi.org/10.52832/jesh.v2i3.147>
- Ramallo Romão. (2025). HEPH – *Herbário Ezechias Paulo Heringer*. Version 1.123. Jardim Botânico de Brasília. Available at: <https://www.gbif.org/occurrence/529495631>.
- Rezende, J. L., Alves, C. C. F., Costa, A. O. M., Santos, L. S., Vicente Neto, F., Sperandio, E. M. and Miranda, M. L. D. (2020). Antifungal potential of essential oils from two varieties of *Citrus sinensis* (lima orange and bahia navel orange) in postharvest control of *Rhizopus stolonifer* (Ehrenb.: Fr.) Vuill. *Food Science and Technology*. 40, 405–409. DOI: <https://doi.org/10.1590/fst.30519>
- Silva, D. M. H. and Bastos, C. N. (2007). Atividade antifúngica de óleos essenciais de espécies de *Piper* sobre *Crinipellis pernicioso*, *Phytophthora palmivora* e *Phytophthora capsici*. *Fitopatologia Brasileira*. 32, 143–145. DOI: <https://doi.org/10.1590/S0100-41582007000200008>
- Sun, S., Yu, Y., Jo, Y., Han, J. H., Xue, Y., Cho, M. and Zhuang, S. (2025). Impact of extraction techniques on phytochemical composition and bioactivity of natural product mixtures. *Front Pharmacol*. 16, 1–14. DOI: <https://doi.org/10.3389/fphar.2025.1615338>
- Vieira, T. E. S., Romano, C. A., Carvalho, A. L. S., Paz, A. T. S., Oliveira Neto, J. R. de, Cunha, L. C. and Paula, J. R. de. (2025). Potencial inseticida do óleo essencial de *Piper fuligineum* Kunth (Piperaceae) contra o besouro vermelho da farinha *Tribolium castaneum* (Herbst, 1797) (Coleoptera: Tenebrionidae). *Revista Virtual de Química*. 17, 256–264. DOI: <https://doi.org/10.21577/1984-6835.20240071>

To cite this paper, use:

Santos, A.R.A., Souza, A.B.F., Oliveira, M.E.M., Poczwadowski, M.E., Costa, I.B., Belo, E.S., Lima, M.L.P., Raimundi, M.K. and Guimarães, R.A. (2026). Evaluation of the antifungal potential of *Piper cf. fuligineum* Kunth leaf extract for the control of *Agroathelia rolfsii* (Sacc.). *Multi-Science Journal*, 9(1): 70-75. DOI: <http://doi.org/10.33837/msj.v9i1.1763>