South African Journal of Botany 146 (2022) 101–102

Contents lists available at ScienceDirect

South African Journal of Botany

journal homepage: www.elsevier.com/locate/sajb

Technical Note

Nematicidal activity of the *Lentinula edodes*' spent mushroom compost

Juliana Marques Ferreira[a], Fabio Ribeiro Braga[c], Filippe Elias de Freitas Soares[a,b,*]

[a] Institute of Tropical Pathology and Health, Universidade Federal de Goiás, Brasil
[b] Department of Chemistry, Universidade Federal de Lavras, Minas Gerais, Brazil
[c] Laboratory of Experimental Parasitology and Biological Control, Universidade Vila Velha

ARTICLE INFO

Article History:
Received 29 June 2021
Revised 31 August 2021
Accepted 6 October 2021
Available online 21 October 2021

Edited by Prof. J. van Staden

Keywords:
Biological control
Waste recovery
Shiitake

ABSTRACT

The mushroom *Lentinula edodes*, known as shiitake, has the potential to control plant diseases. However, there is no work that mentions the nematicidal activity of the SMC from shiitake. The aim of the present study is to evaluate the nematicidal potential of *L. edodes* spent mushroom compost (SMC) on *Panagrellus* spp. SMC action on *Panagrellus* spp. larvae was evaluated in Petri dishes containing 2% water-agar (WA2%). In comparison to the control group, the number of intact larvae in the group treated with SMC of *L. edodes* was significantly ($p<0,01$) reduced by 77, 73, 71% after 24, 48 and 72 exposure period respectively. The current study presents the possibility of using an agroindustrial residue (SMC) of low cost to control nematodes. SMC has nematicidal activity and may in the future be beneficially used in other sustainable approaches.

© 2021 SAAB. Published by Elsevier B.V. All rights reserved.

1. Introduction

The judicious use of pesticides, as well as the reuse of industrial waste, can jointly play a key role for the environment. Noteworthy is the reuse of spent mushroom compost (SMC), a residue generated in the production of edible mushrooms, in the production of animal feed, organic fertilizer, soil conditioner, vegetable substrate and in bioremediation and cleaning processes of contaminated soil and water (Phan and Sabaratnam, 2012, Grujić et al., 2015). In a recent study, Soares et al. (2019) reported that SMC originated from a mushroom (*Hypsizygus marmoreus*) demonstrated nematicidal activity on ruminant nematode infecting larvae, leading to advances in biological control and the need for further research.

The mushroom *Lentinula edodes*, known as shiitake, has the potential to control plant diseases such as tomato bacterial wilt, fungal diseases of sorghum and passion fruit bacteriosis (Phan and Sabaratnam, 2012; Mamiya et al., 2005 a,b). However, there is no study that mentions the nematicidal activity of the SMC from shiitake.

Thus, the aim of the present study was to evaluate the nematicidal activity of *L. edodes* SMC on *Panagrellus* spp.

2. Material and Methods

SMC from the production of *L. edodes* used in the present study was obtained from the Urakami Group, Mogi das Cruzes, São Paulo-Brazil (latitude 23°31′29″ and longitude 46°11′14″).

Model nematodes of the genus *Panagrellus* were used. These free-living nematodes are being maintained in Petri dishes in an oatmeal-based culture medium, in the Laboratory of Pathology of Invertebrates, Institute of Tropical Pathology and Public Health (IPTSP) of the Federal University of Goiás, Brazil (latitude 16°67'49" and longitude 49°24'52").

The experimental assay was performed as described by Ferreira et al. (2019). Two groups were formed: one treated group (with SMC) and one control group (without SMC). Experimental assays were performed in Petri dishes (4,5 cm in diameter) containing 2% water-agar (WA2%). For treated group, approximately 0,1g of SMC of L. edodes was inoculated in the center of Petri dishes and incubated for 5 days (12h photoperiod, 27°C) After this period 1000 larvae of *Panagrellus* sp. larvae were inoculated onto the center of Petri dishes. For control group 1000 larvae were inoculated onto Petri dishes. For three days, at intervals of 24, 48 and 72 hours, 10 random fields in each plate both groups were observed under an optical microscope at 10x objective, counting the number of intact larvae. Plates were incubated in the dark at 28°C. The experiment was performed with 10 replicates for each group.

Data obtained at the three-time intervals were interpreted by ANOVA and Tukey's posttest at 5% using the software BioEstat 5.0. After this, the percentage reduction was calculated as

* Corresponding author:
E-mail address: filippe.soares@ufla.br (F.E.d.F. Soares).

https://doi.org/10.1016/j.sajb.2021.10.008
0254-6299/© 2021 SAAB. Published by Elsevier B.V. All rights reserved.

Table 1
Daily average, standard deviation and percentage reduction of *Panagrellus* spp. larvae in water-agar (2% WA) during the period of 72 hours in the treatments with the spent mushroom compost (SMC) from *Lentinula edodes* and the control group without fungi.

Intervals (hours)	SMC (*Lentinula edodes*)	Control	% Reduction
24	21.7 ± 11.4^a	94.7 ± 19.9^b	77
48	13.0 ± 3.89^a	48.4 ± 11.6^b	73
72	15.3 ± 3.62^a	53.5 ± 10.4^b	71

Averages followed by the same lowercase letter in the lines do not differ statistically of ($p>0.01$).

follows:

$$\%\text{Reduction} = \frac{(\text{average of live in the control group} - \text{average live larvae in the treated group}) \times 100}{\text{average of live larvae in the control group}}$$

3. Results

The results of this study showed that there was a significant difference ($p < 0.01$) in the recovery of the larvae from the groups treated with SMC in relation to the control group (Table 1). The percentages of reduction, in comparison to the control group, were: 77, 73 and 71% for 24, 48 and 72 hours, respectively.

4. Discussion

Nematophagous activity of mushrooms has been known for some time, since these fungi use toxins and special attack devices to prey on nematodes (Soares et al., 2018). The shiitake mushroom is widely recognized for its important nutritional properties and production of biomolecules (Gaitán-Hernández et al., 2019; Ishihara et al., 2018). On the other hand, in relation to generation of huge amounts of waste, there is a need for a more sustainable destination. In Brazil, SMC production is around 200 tons per year. Worldwide, SMC residue generates approximately 210,000 tons, making clear the need for reuse measures (Soares et al., 2019).

Pacumbaba et al. (1999), in addition to highlighting the properties of the shiitake, also draw attention to the scarcity of studies in the agricultural area. The action of *L. edodes* on nematodes has already been described by Mamiya et al. (2005 a,b). In those papers, the authors demonstrated the activity of *L. edodes* on the nematode *Bursaphelenchus xylophilus*. However, the present study is the first report of the nematicidal activity of its SMC. It is still worth noting that the experimental model used (*Panagrellus* spp.) may also be used as a methodological tool for future research in this field.

Experimental models using *Panagrellus* spp. may be a good strategy for the preliminary knowledge of some biological properties of edible fungi. Corroborating this fact, Ferreira et al. (2019), using the *Flammulina velutipes* SMC on *Panagrellus* spp, first recorded the nematicidal activity of this fungus. However, in that paper, the authors stressed the importance of further clarifying the role of nematicidal metabolites produced by this edible mushroom and its SMC. Similarly, in the present study, the SMC of *L. edodes* showed nematicidal activity on *Panagrellus* spp.

Despite the increase of world mushroom consumption, their nematicidal action is still scarce in scientific literature. Actually, world production and consumption are centered on shiitake mushrooms (*L. edodes*), button mushrooms (*Agaricus bisporus*), and oyster mushrooms (*Pleurotus* spp.) (Boin and Nunes, 2018). Thus, the present study highlights a poorly studied property of residues from the production of one of the most consumed mushrooms in the world (*L. edodes*). Moreover, this study presents the possibility of using an agroindustrial residue (SMC) of low cost to control nematodes.

5. Conclusions

The results showed that the SMC residue has nematicidal activity and may in the future be beneficially used in other sustainable approaches. In addition, we highlight the need of more studies that may prove its enzymatic activity on phytonematodes.

Declaration of Competing Interest

The authors declare that they have no conflict of interest.

Acknowledgements

This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES) - Finance Code 001. The authors also thank the National Council for Scientific and Technological Development (CNPq) and Foundation for Research and Innovation Support of the Espírito Santo (FAPES) for financial support.

References

Boin, E., Nunes, J., 2018. Mushroom consumption behavior and influencing factors in a sample of the portuguese population. J. Int. Food Agribus. Mark. 30, 35–48.
Ferreira, J.M., Carreira, D.N., Braga, F.R., Soares, F.E.F., 2019. First report of the nematicidal activity of Flammulina velutipes, its spent mushroom compost and metabolites. Biotech 3 (9), 410.
Gaitán-Hernández, R., López-Peña, D., Esqueda, M., Gutiérrez, A., 2019. Review of bioactive molecules production, biomass, and basidiomata of shiitake culinary-medicinal mushrooms, Lentinus edodes (Agaricomycetes). Int. J. Med. Mushrooms. 21 (9).
Grujić, M., Dojnov, B., Potočnik, I., Duduk, B., Vujčić, Z., 2015. Spent mushroom compost as substrate for the production of industrially important hydrolytic enzymes by fungi Trichoderma spp. and Aspergillus niger in solid state fermentation. Int. Biodeterior. Biodegrad. 104, 290–298.
Ishihara, A., Goto, N., Kikkawa, M., Ube, N., Ushijima, S., Ueno, M., Ueno, K., Osaki-Oka, K., 2018. Identification of antifungal compounds in the spent mushroom substrate of Lentinula edodes. J. Pestic. Sci. 43 (2), 108–113.
Mamiya, Y., Hiratsuka, M., Murata, M., 2005. Ability of wood-decay fungi to prey on the pinewood nematode. Bursaphelenchus xylophilus (Steiner and Buhrer) Nickle. JJN. 35 (1), 21–30.
Mamiya, Y., Hiratsuka, M., Murata, M., 2005. Effects of wood-decay fungi on the population of the pinewood nematode in wood of pine trees. JJN 35, 63–70.
Pacumbaba, R., Beyl, C.A., Pacumbaba, Jr., R., 1999. Shiitake mycelial leachate suppresses growth of some bacterial species and symptoms of bacterial wilt of tomato and lima bean in vitro. Plant Dis 83, 20–23.
Phan, C.W., Sabaratnam, V., 2012. Potential uses of spent mushroom substrate and its associated lignocellulosic enzymes. Appl. Microbiol. Biotechnol. 96, 863–873.
Soares, F.E.F., Sufiate, B.L., Queiroz, J.H., 2018. Nematophagous fungi: far beyond the endoparasite, predator and ovicidal groups. ANRES 52, 1–8.
Soares, F.E.F., Nakajima, V.M., Sufiate, B.L., Satiro, L.A.S., Gomes, E.H., Fróes, F.V., Sena, F.P., Braga, F.R., Queiroz, J.H., 2019. Proteolytic and nematicidal potential of the compost colonized by Hypsizygus marmoreus. Exp. Parasitol. 197, 16–19.