IHC2022, 15-17 August 2022
XII International symposium on banana: celebrating banana organic production

Can edible mushroom boost soil health in banana organic systems?

Walter Ocimati, Evans Were, Geofrey Ogwal, Miguel Dita, Anthony F. Tazuba, Si-Jun Zheng, G. Blomme

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Introduction

- The increasing global demand for safe and healthy foods produced using environmentally sound approaches has propelled the importance of organic farming.
- Soil health is an integral component of this.
- Healthy soils provide regulating and supporting ecosystem functions that impact crop productivity.

- Soil health management in organic systems requires the elimination the current heavy reliance on agrochemicals for managing biotic (weeds, pests, and diseases) and abiotic constraints.
- Addition organic amendments (OA) is one of the compatible soil health management practices.
- OA use is constrained by access, availability, and the tedious and often complex preparation process.

Mushroom wastes as a manure source

- Edible mushroom production has gained importance over the past two decades
- Global annual consumption fresh mushroom increased from 1kg in 1993 to 4.7 kg in 2013 per person.
- Global mushroom production exceeded **40 m tons** in 2021 translating into to **200 m tons** of spent mushroom wastes (SMW).
- SMW contain large amounts of mineral nutrients, lignocellulolytic enzymes and microbial biomass, making them suitable for agricultural use.

Source: Ocimati et al. 2019

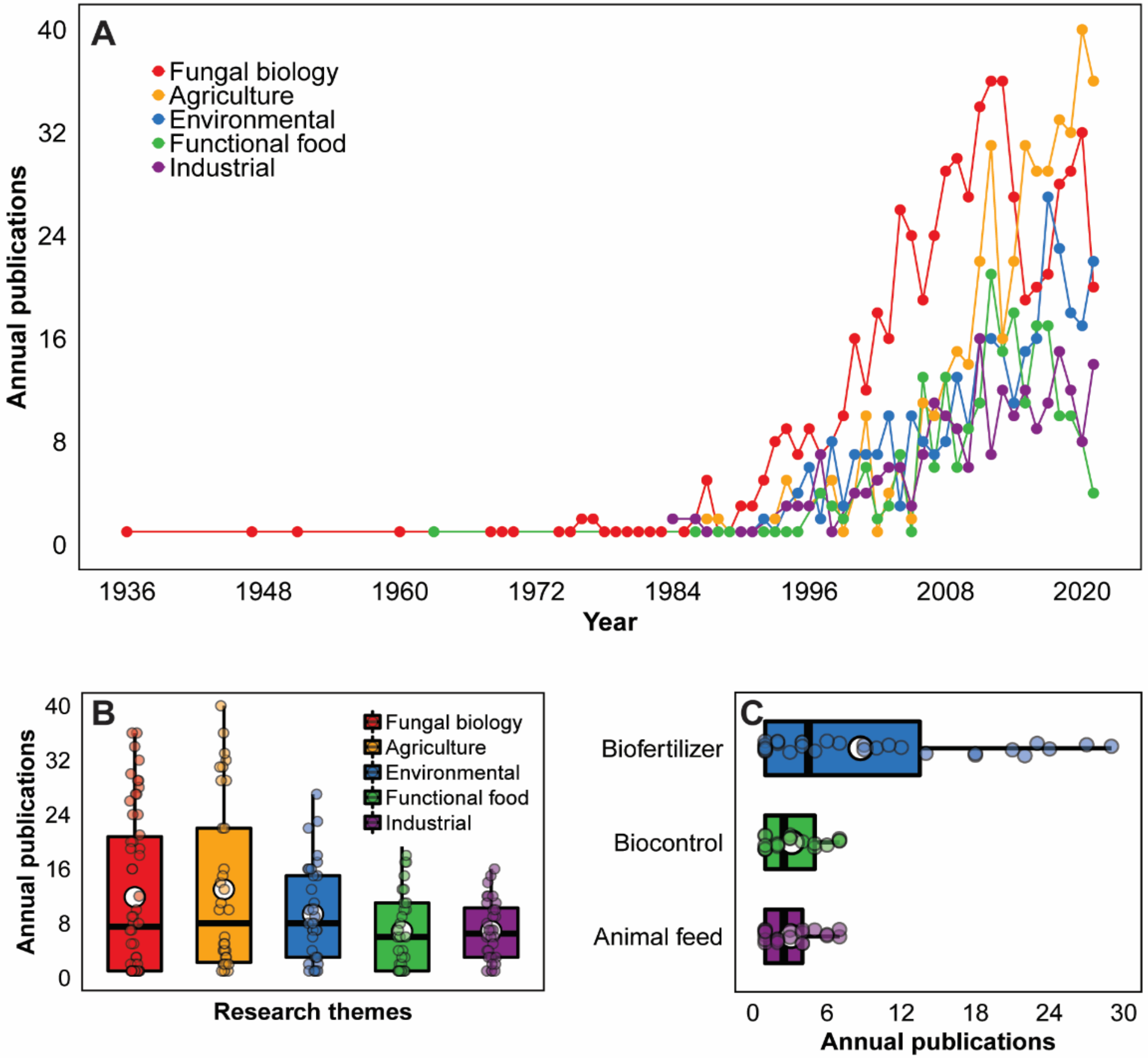
Mushroom wastes as a manure source

- SMW have been reported to improve soil physical, biological and chemical parameters; and to suppress soil borne pests and diseases
- SMW could be an important source of soil organic amendments for organic banana systems.

- In this review we conduct a meta-analysis of publications to determine the major trends on the use of SMW to benefit crop rhizosphere.
- We conclude by providing an outlook on potential benefits of SMW to management of key soil health challenges of organic banana systems.

Source: Ocimati et al. 2021

Publications on edible mushrooms and their wastes



- A total of 1,851 publications between 1936 and 2022, with limited publications between 1936 and 1996.
- Increase in publications between 1996 and 2022 (Fig. A)
- **Fungal biology and genetics** (35%), and SMW **use in agriculture** (24%) dominate the publications (Fig B).
- Out of 427 publications on **agricultural use** of SMW, **69%**, 16% and **15%**, respectively, focused use as **biofertilizers**, animal feed and **biocontrol agents** (Fig C).

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Edible mushroom waste use for suppressing plant pathogens

- Diverse genus of edible mushrooms have been shown to suppress plant pathogens (Fig. A)
- SMW use in the management of fungal pathogens (58%) dominated the publications (Fig. B).
- Others - bacterial pathogens (16%), nematodes (12%), and mycotoxin degradation (9%)
- Mechanisms of pest/pathogen suppression (Fig. C):
  - ✓secondary metabolites or enzymes (33%),
  - ✓modulation of plant defense responses (16%),
  - ✓promotion of secondary metabolites (13%) and
  - ✓plant growth promotion

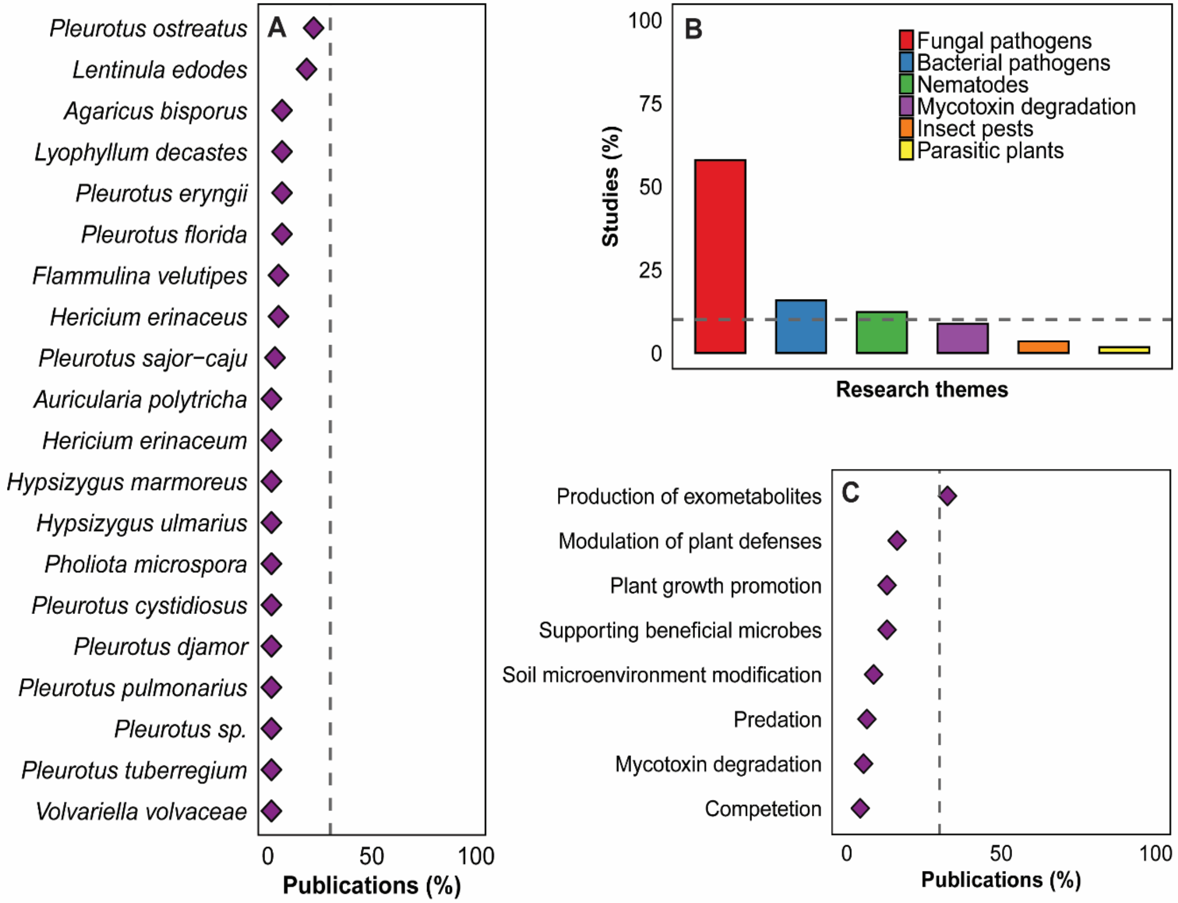

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Table 1. Sample publications showing different mechanisms of pest and pathogen suppression by mushroom wastes

Mushroom sp.	Mechanism(s)	Target pathogen or pest and effect	Citation
Pleurotus pulmonarius	-**Nematicidal** metabolites (S-coriolic acid, linoleic acid, p-anisaldehyde, p-anisyl alcohol, 1-(4-methoxyphenyl)-1,2-propanediol, and 2-hydroxy-(4'-methoxy)-propiophenone) - **Predation**	- Nematodes (*C. elegans*) - Immobilization and shrinking of nematode head prior to infection and digestion	Stadler et al., 1994.
Hericium erinaceus	- **Antibacterial activity** of Water, n-butanol, and ethyl acetate extracts of SMS. - **Induced expressions of plant defense genes** encoding β-1,3-glucanase (GluA) and pathogenesis-related protein-1a (PR-1a) -associated with systemic acquired resistance - **Plant growth promotion** - 85% suppression of *R. solanacearum*, improved growth	- **Phytopathogenic bacteria**: *Pectobacterium carotovorum* subsp. *carotovorum*, *Agrobacterium tumefaciens*, *Ralstonia solanacearum*, *Xanthomonas oryzae* pv. *oryzae*, *X. campestris* pv. *campestris*, *X. axonopodis* pv. *vesicatoria*, *X. a*. pv. *citiri*, and *X. a.* pv. *glycine*.	Kwak et al., 2015
Lactarius rufus	- **Antifungal sesquiterpene** - **Growth inhibiting** Rufuslactone	- *Alternaria alternata*, *A. brassicae*, *Botrytis cinerea* and *F. graminearum*.	Luo et al., 2005;
SMS compost and extracts, *P. ostreatus*	- Effect on **diverse mesophilic bacteria and actinobacteria** - **Increased soil carbon and organic matter** - Pleurostrin - Peptides with **antifungal activity**	- *Fusarium oxysporum* f. sp. *melonis*, *F. oxysporum*, *Mycosphaerella arachidicola* and *Physalospora piricola* - Upto100% suppression of mycelia	Suárez-Estrella et al., 2012, Chu et al., 2005

Journal of *Fungi*

MDPI

Article

Spent *Pleurotus ostreatus* Substrate Has Potential for Managing Fusarium Wilt of Banana

Walter Ocimati [1,*], Evans Were [2], Anthony Fredrick Tazuba [1], Miguel Dita [3], Si-Jun Zheng [4] and Guy Blomme [5]

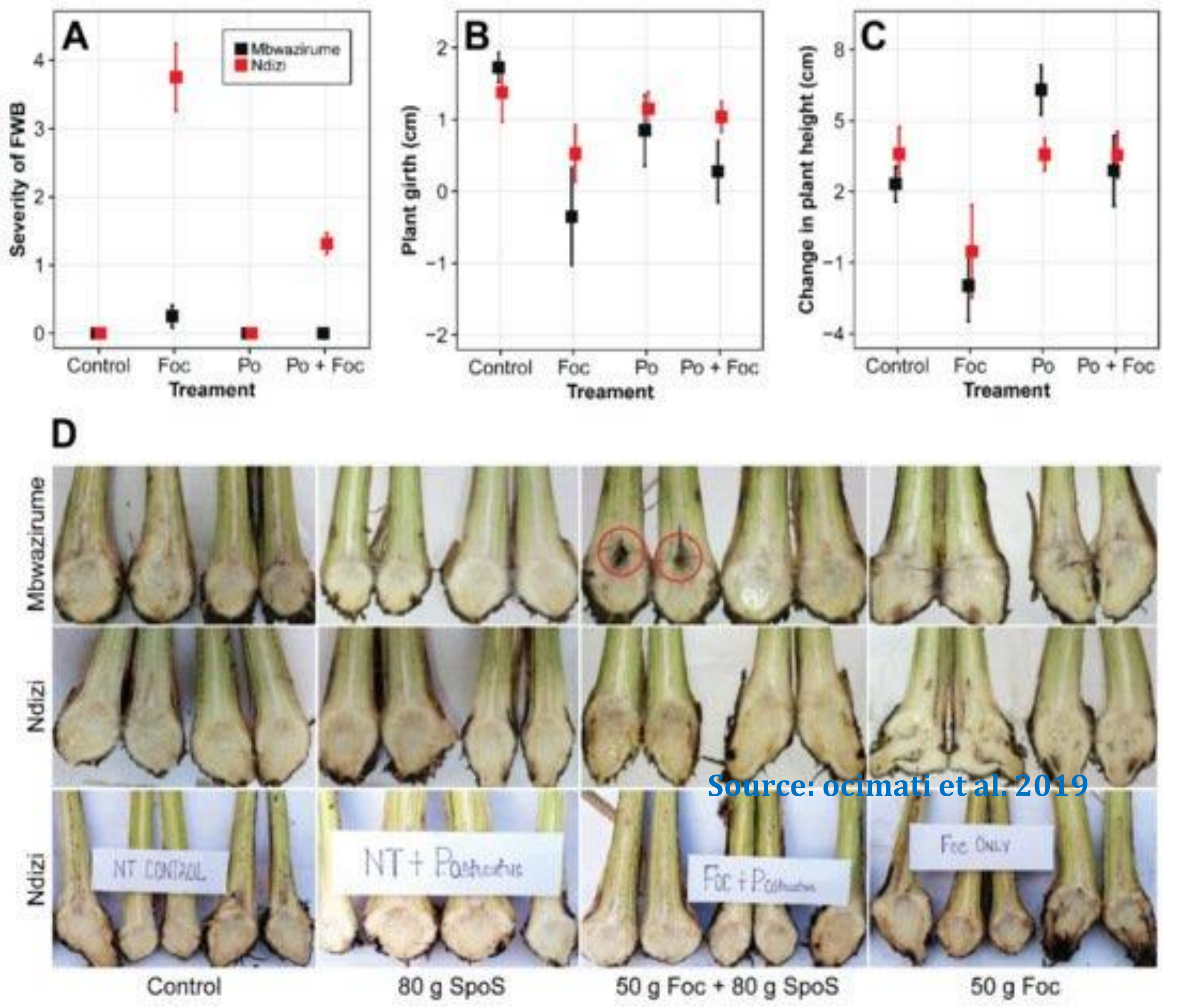
- In-vitro suppression of Foc race 1– anti-fungal compounds

- Promotion of diverse beneficial microbes

- Screenhouse

✓ Plant growth promotion

✓ reduced corm damage in plantlets of a susceptible banana cultivar - in both sterile and naturally infested soils.



Source: ocimati et al. 2019

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Edible mushroom waste use as biofertilizer

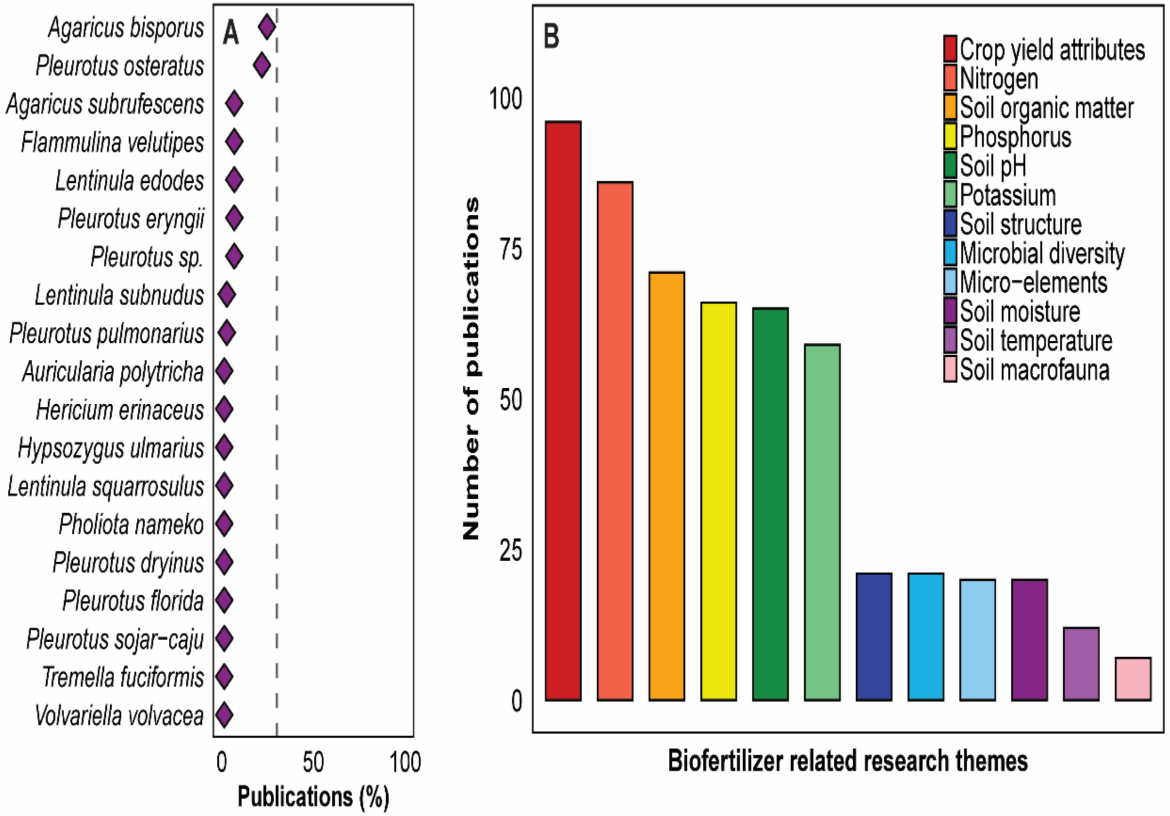

Table 2. Sample publications on spent mushroom waste use as biofertilizers

Benefits in the soil rhizosphere	Citation
Crop vigor and yield Improvement	Kadiri and Mustapha, 2010
Improves soil organic carbon and matter	Li et al., 2020, Becher et al., 2021
Enhances soil macro (nitrogen, phosphorus, and potassium)- and micro (iron, zinc)-nutrients	Lou et al., 2017, Ma et al., 2021, Jonathan et al., 2011
Regulates and maintains soil pH in range of agricultural production	Abreu et al., 2020, Lipiec et al., 2021
Helps improve soil structure, thus a higher and balanced air porosity	Courtney et al., 2009, Lipiec et al., 2021
Improves soil microbial biomass and functional diversity within the soil	Li et al., 2020, Frac et al., 2021
Regulates soil moisture and temperature	Ma et al., 2021

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Spent mushroom waste (SMW) use for managing soil health problems of organic banana systems

- **Key biotic soil health challenges of banana systems:**

✓ Diverse nematode species (*Radopholus similis, Pratylenchus* spp., *Meloidogyne* spp., and *Helicotylenchus multicinctus)*.

✓ Fusarium wilt caused by *Fusarium oxysporum* f. sp. *cubense* (Foc) - a major soil borne threat to banana production.

✓ Bacterial pathogens (*Xanthomonas vasicola* pv. *musacearum* and *Ralstonia* spp)

- Current review shows multiple studies (invitro, screenhouse and field) in which multiple species of nematodes, in genera of Fusarium, Xanthomonas and Ralstonia to suppressed by SMW.

- Findings of Ocimati et al. (2021) further support the potential use of SMW in management of Foc in banana systems

- **Key abiotic constraints:**

✓ Low soil moisture content and nutrient deficiency are major yield limiting factors for the banana.

✓ Studies above show SMW to improve soil structure, soil pH, levels of macro and micro elements, soil organic matter and water retention-function that could improve performance of the banana crop in organic systems.

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Study recommendations

- Assessing the potential of SMW on a wider range of edible mushroom species to:
  - ✓ suppress biotic constraints (especially, *Foc,* including Foc TR4) and
  - ✓ Improve highlighted chemical, biological and physical properties of soils in organic banana production systems is recommended.

Acknowledgement

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Thank you for listening

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