FTA-Kunming Scientific Conference 2021

Mushroom cultivation for soil amendment and bioremediation

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ABSTRACT

Intensive crop production, use of pesticides, and unsustainable farming practices are known to cause land degradation and soil contamination. Both lead to a decline in biodiversity and changes in the functional groups of soil microorganisms. In this study, we list the edible mushroom species suitable for growing in fields and summarize the important role that mushroom field cultivation can play in soil erosion control, nutrient cycling, and the bioremediation of contaminants. Decomposition, symbiosis, assimilation, degradation, bioweathering, oxidation, biosorption, and bioconversion are all critical components of mushroom field cultivation. Research has shown that field mushroom cultivation contributes to nutritional bioavailability while also promoting the degradation of pollutants and formation of soil aggregates. Through soil amendment practices, a portion of agricultural waste can be converted into high-quality food and nutraceutical sources, and the remaining organic matter improves soil quality via fungal mycelial networks and the re-use of spent mushroom substrates. Only a small number of mushroom species have been used in the application of soil amendments in field conditions. This study shows the need for further research into specific mushroom species for achieving different soil amendment goals in order to balance agricultural development with sustainable land management.

Key words: sustainable agriculture; compost; fungi; mushrooms; nutrien cycles; soil health

INTRODUCTION

Agricultural production degrades soil quality due to the depletion of nutrients, contamination with pesticides and agrichemicals, soil erosion, and a decline in soil microbial diversity. Soil erosion presents a serious threat to soil health, exacerbating existing agricultural problems, such as limited land for food production. Contamination of agricultural soils not only negatively impact soil ecosystems, they are also a threat to human health and water systems. Given these challenges, sustainable solutions are required in order to maintain agricultural productivity over the long-term. In-field mushroom cultivation process includes culture preparation, spawn production, composting of agricultural waste, inoculation, incubation, and harvest (Figure 1). A range of mushroom species have been cultivated in fields with close connections to soils (Figure 2). Previous studies have focused on the effects of spent mushroom substrates and additives on soil amendments as well as the removal of soil pollutants. However, the effects of field mushroom cultivation on soil improvement have received little attention, and no research has been reported on the benefits of growing mushrooms in agricultural fields. The aim of this review is to share the current state of knowledge regarding the field cultivation of mushrooms, which species are best suited for this style of cultivation, and the positive impacts that field cultivation of mushrooms can have on soil systems.

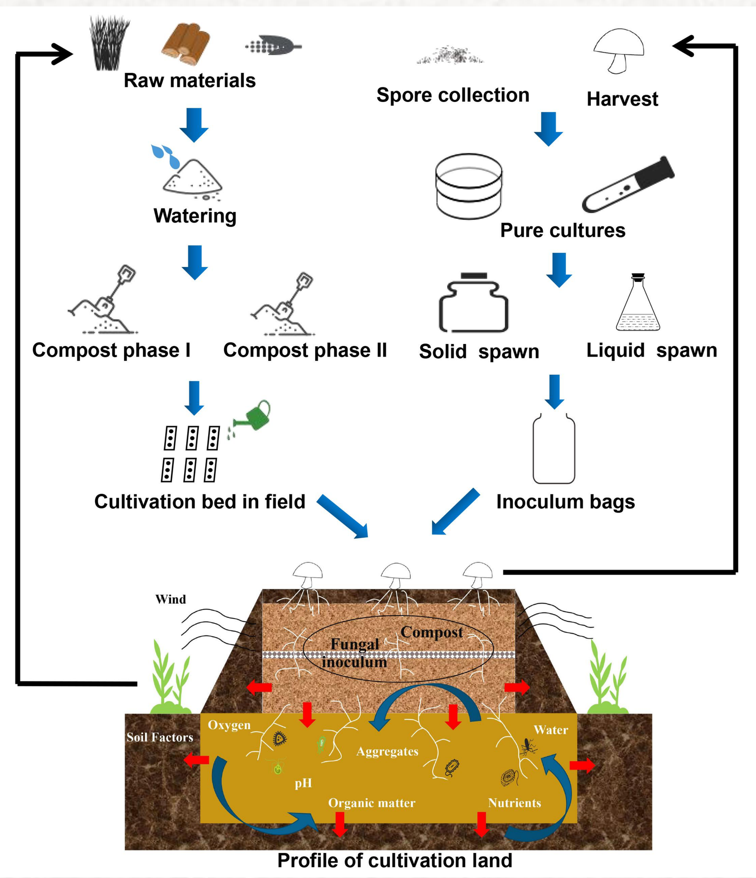

Figure 1. Field mushroom cultivation process.

Figure 2. Compost-based field cultivation of edible mushroom species, a, *Phallus impudicus* L; b, *Coprinopsis cinerea* (Schaeff.) Redhead, Vilgalys & Moncalvo; c, *Pleurotus flabellatus* Sacc; d, *Volvariella volvacea* (Bull.) Singer; e, *Stropharia rugosoannulata* Farl. ex Murrill; f, *Lepista sordida* (Schumach.) Singer; g, *Agaricus bisporus* (J.E. Lange) Imbach; h, *Agaricus subrufescens* Peck.

ROLES OF FIELD MUSHROOM CULTIVATION

1. Soil erosion control

1.1 Cord-forming mycelial networks (Figure 3)

1.2 Soil organic matter increased (Figure 4)

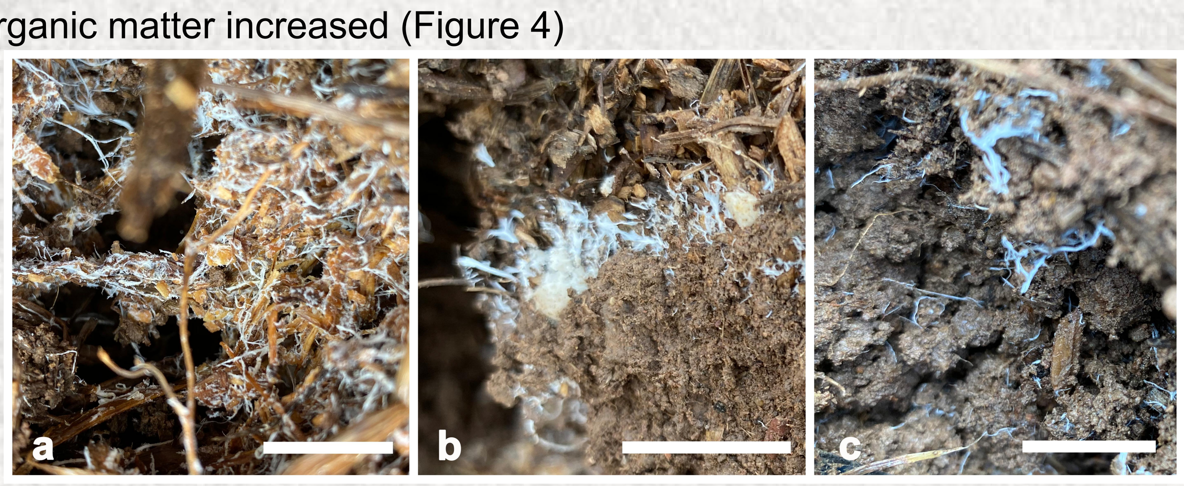

Figure 3. Cord-forming mycelial network observed during field cultivation of Stropharia rugosoannulata in Honghe, China. (a) Mycelium colonized on substrate. (b) Mycelium invade to soil from growing substrate. (c) Mycelium transmission in soil. Scale bars: 1 cm.

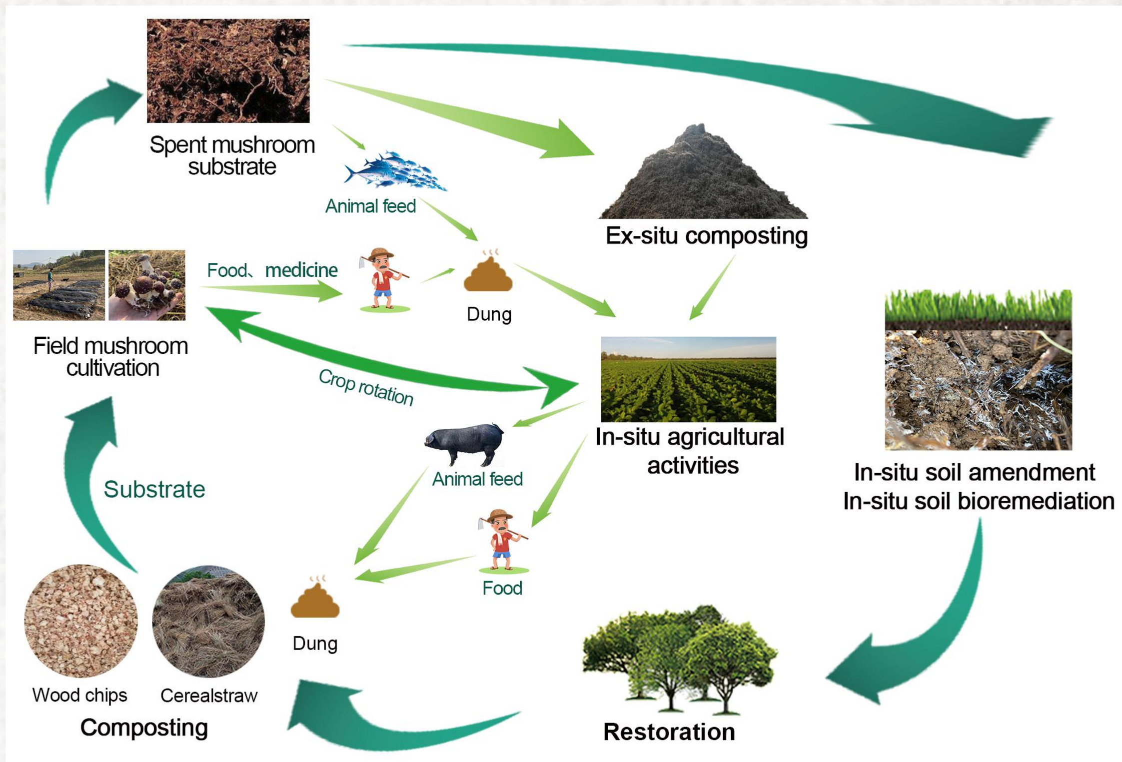

Figure 4. Roles of field cultivation of mushrooms in soil organic matter increase and nutrition cycling

2. Contribution of field-based mushroom cultivation to soil nutrition

2.1 Spent mushroom substrate as fertilizer and soil amender (Figure 4)

2.2 Nutrient cycling in soil systems (Figure 5)

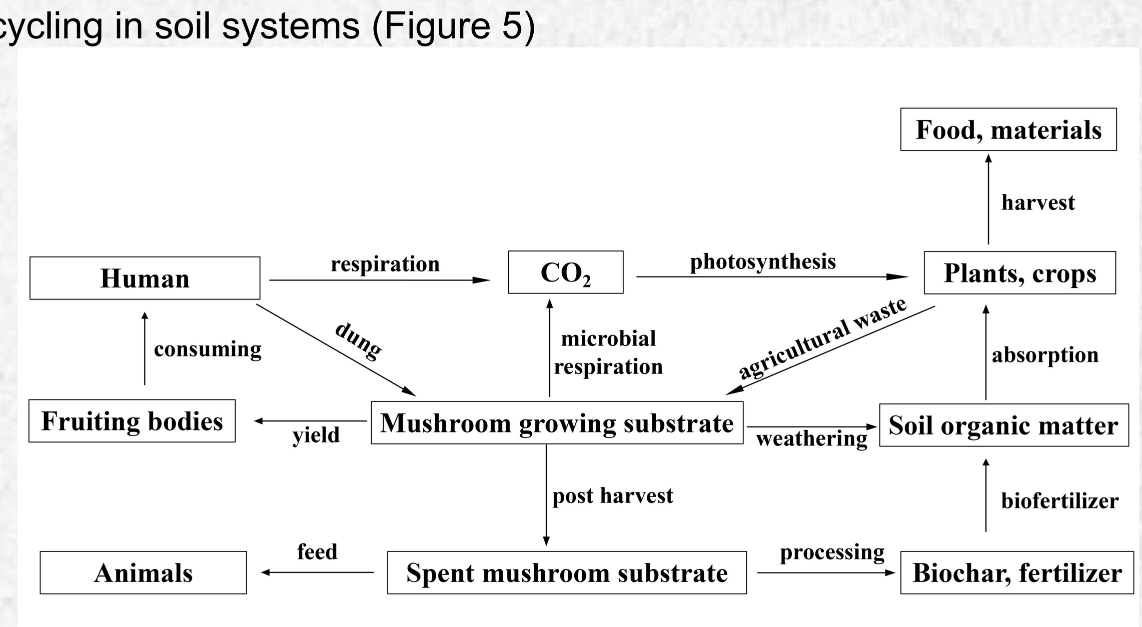

Figure 5. Carbon cycling in soil during field mushroom cultivation

3. Mushrooms and spent substrate compost for soil bioremediation

The main soil pollutants include polycyclic aromatic hydrocarbons, chlorinated hydrocarbons, petroleum and related products, pesticides, and heavy metals.

The inoculum type includes fungal culture, spawn, substrate with mycelium, and spent mushroom compost. The three main roles of mycoremediation in field based mushroom cultivation are biodegradation, bioconversion and biosorption, and numerous research projects provide proof of concept and the potential for application.

The mushroom species include *Agaricus bisporus, Agaricus subrufescens, Flammulina velutipes, Coprinus comatus, Ganoderma lucidum, Irpex lacteus, Lentinula edodes, Lentinus sajor-caju, Pleurotus ostreatoroseus, Lentinus squarrosulus, Pleurotus eryngii, Pleurotus ostreatus, Pleurotus pulmonarius, Pleurotus tuber-regium, Stropharia coronilla, Stropharia rugosoannulata, Trametes versicolor, Bjerkandera adusta*.

CONCLUSION AND PERSPECTIVES

There is abundant evidence showing the potential of fungi to improve soil health in agricultural systems by increasing carbon and nutrient levels, preventing soil erosion, and breaking down pollutants. However, much of this evidence is indirect or has not been tested at scale. Thus this field of study remains wide open, with opportunity for field practitioners and scientists to provide scaled research investigating which fungal species have the greatest impact on soil health, which species degrade, bind, or accumulate toxins and heavy metals, and ultimately which fungal species still provide a harvest of mushrooms considered safe for human consumption.

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