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Spent mushroom substrate: a potential sustainable substrate for agriculture

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Abstract

Background/Objectives*: Mushroom cultivation is an eco-friendly activity as it exploits the wastes from agriculture, poultry, brewery, etc. and in turn produces fruit bodies with excellent and unique nutritional and medicinal attributes, but also produces Spent Mushroom Substrate (SMS) after crop harvest, which creates various environmental problems including groundwater contamination and other nuisance if mishandled. Due to this, there is an urgent need for a more suitable solution for disposing off SMS. The present study has been undertaken to evaluate the effect of Spent Mushroom Substrate (SMS) of different edible mushrooms as a biofertilizer on the growth of Vigna radiata.*
Methods/Statistical analysis: *The present pot experimental study focuses on the analysis of physicochemical properties of plant growth medium and also to evaluate the effect of SMS on the growth of Vigna radiata with pot experiments by considering morphological and biochemical parameters. Three experimental setups was carried with one being control where seeds were grown with soil and other two with 50% SMS + 50% Soil and 75% SMS + 25% soil respectively.*
Findings: *The study showed that the plant grown with 75% SMS had higher germination and faster growth than the plant grown in just soil, this can be due to available nutrients and minerals in SMS.*
Novelty/Applications: *All results showed that spent mushroom waste can be efficiently considered as a biofertilizer to replace the use of synthetic fertilizers and thus the utilization of SMS as a bio-fertilizer can reduce the wastes in the environment; which were generated during mushroom cultivation.*

Keywords: *Mushroom, Spent Mushroom Substrate, Physicochemical, Pot experiment, Vigna radiata*

1. Introduction

Mushroom cultivation is an environmental friendly activity as it exploits the wastes from agriculture, poultry, brewery, etc., and in turn, produces fruit bodies with admirable and unique nutritional and medicinal qualities. After mushroom cultivation, the partially degraded paddy or wheat straw and other agro-bio waste, which form as valuable by-products of edible mushroom cultivation, have been characterized as Spent Mushroom Substrate (SMS). Mushroom production results in SMS generation at the rate of 1-2 tons for every ton of mushroom harvested [1, 2]. Hence

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the production of SMS after crop harvest is a matter of great anxiety because it creates several environmental problems including groundwater contamination and a nuisance if not handled properly.

In current years, mushroom growers are facing the pressure of environmental legislation giving rise to the necessity for a more appropriate solution for disposing off SMS. Various disposal methods of SMS include direct application to the soil as a bioremediation agent, feed for animals and fish. Direct application of spent oyster mushroom substrate in the field has met with little success due to its high C: N ratio [3]. The expanded uses of SMS in managing environment, agriculture, and recycling energy have come in light recently and because of which its name has been changed from the spent mushroom substrate to "used mushroom substrate".

This SMS comprises of a simpler form of a protein-rich constituent, formed by a modification of agricultural resources by the fungus after few cycles of cultivation, can be used as a good source of soil conditioners for the cultivation of vegetables, fruits, flower, and foliage crops [4]. The rich organic matter, near-neutral pH, moderate nutrient load, and presence of beneficial microbial population makes SMS as an appropriate organic waste for its transformation into quality manure for crops [5, 6, 7]. The SMS has been found to be a good nutrient source for agriculture mainly because of its rich nutrients status, high cation exchange capacity, and slow mineralization rate; which retain its quality as an organic matter. Further SMS contains 45% water though bulky and is light in weight [8]. The recomposted spent mushroom substrate has been found to be a good growing medium for the majority of the vegetables and the field crops and has shown multifaceted utilities in improving the yield and quality of the crop, and management of the diseases, which is really encouraging for the mushroom industry. The other utilities of the spent mushroom substrate are like in vermicomposting, bioremediation, and as organic-mineral fertilizer [9, 10].

The present study has been undertaken to evaluate the effect of Spent Mushroom Substrate (SMS) of different edible mushrooms as a biofertilizer on the growth of *Vigna radiata.*

2. Materials and Methods

2.1. Evaluation of Physico-Chemical Properties of Plant Growth Media

The physico-chemical properties of SMS and plant growth media of control (100% soil), T1 (50% SMS + 50% Soil) and T2 (75% SMS + 25% soil) sets have been evaluated by considering various parameters such as pH, organic carbon, nitrogen, total phosphorus, potassium, sodium, calcium, magnesium, and iron content.

2.2. Experimental Design

Cultivation of *Vigna radiata* was done by using different proportions of Spent Mushroom Substrate (SMS). In this experiment, two treatments were done using the different proportions of soil and spent mushroom substrate and there was control without spent mushroom substrate. The spent mushroom substrate and the soil sample were dried completely under sunlight and used for the experiment. The treatments were: T1 (50% SMS + 50% Soil), T2 (75% SMS + 25% soil) and Control (100% soil). The experiment was designed in a complete randomized design; which was set up in 3 replicates. Pots were placed in open field conditions and no other organic or inorganic fertilizer used in the growing media. The plants were watered at regular intervals and the growth parameters were studied.

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Growth promotion was recorded in every 3 days intervals in terms of plant height. After 15 days of seeds sowing, the morphological and biochemical parameters of *Vigna radiata* were analyzed. The morphological parameters like seed germination rate, length of leaves, breadth of leaves, length of the plant, shoot length and root length were analyzed. The biochemical parameter such as total chlorophyll, total protein, and total carbohydrate content from the leaves of plants was analyzed.

3. Results and Discussion

The results of physico-chemical analysis of SMS and plant growth media of T1 (50% SMS + 50% Soil), T2 (75% SMS + 25% soil), and Control (100% soil) sets are shown in Table 1. It was revealed that the value of all the tested parameters was significantly higher in the T2 growth medium as compared to the T1 growth medium due to the presence of the maximum SMS proportion.

Table 1. Physico-chemical properties of SMS and plant growth media

Parameters	SMS	Control	Treatment 1 (T1)	Treatment 2 (T2)
pH	7.23	6.82	6.89	6.91
Organic carbon (%)	21.153	0.975	4.642	9.367
Nitrogen (%)	1.637	0.081	0.331	0.588
Total phosphorus (%)	0.364	0.023	0.112	0.196
Potassium (%)	2.016	0.103	0.547	0.710
Sodium (%)	0.368	0.016	0.052	0.098
Calcium (%)	4.281	0.215	1.059	1.75
Magnesium (%)	0.730	0.029	0.137	0.224
Iron (%)	0.651	0.011	0.035	0.083

For the pot experimental study, 20 seeds were sown in each experimental pot and it was revealed that the average seed germination percentage for T2, T1, and Control set was found to be 90 %, 85%, and 65% respectively. It was also revealed that the SMS treatment influences the growth of the plants as compared to the control plants as shown in Figure 1. After 12 days of seeds sowing, the average plant height for T2, T1, and Control set was found to be 22.4 cm, 21.3 cm, and 16.1 cm respectively.

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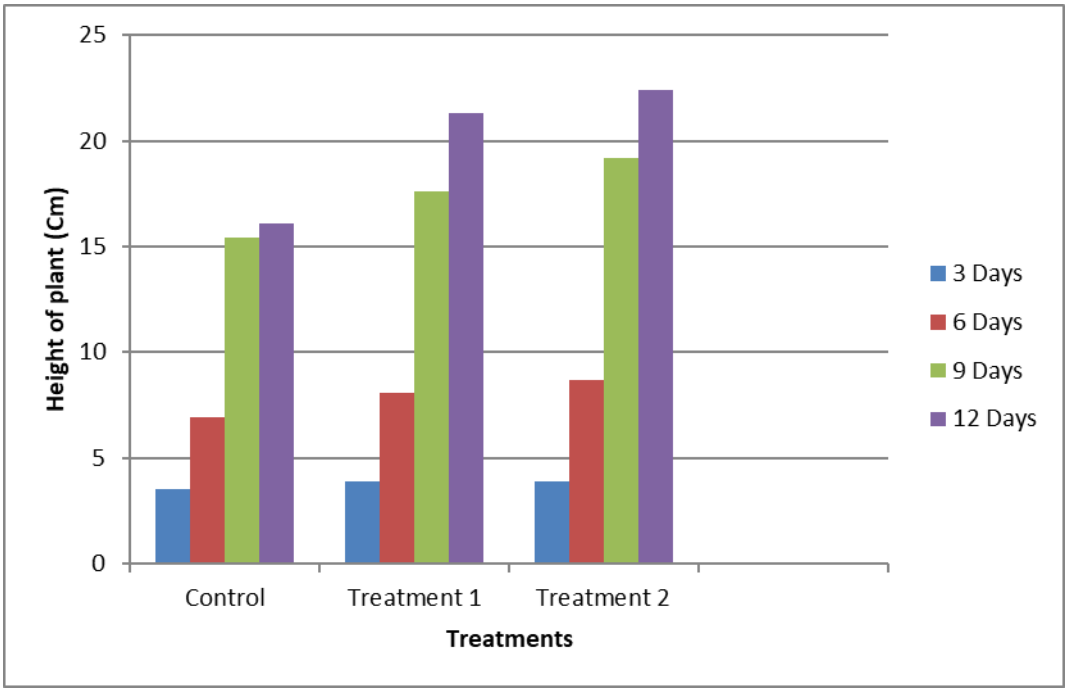

Figure 1. Effect of SMS treatment on the height of Vigna radiata plant.

The plants from T2 and T1 set showed significant improvement in the studied morphological parameters and biochemical parameters as compared to the control set as shown in Table 2 and Table 3 respectively.

Table 2: Effect of SMS on morphological parameters of *Vigna radiata* plant

Treatment	Length of leaves (cm)	Breadth of leaves (cm)	Shoot length (cm)	Root length (cm)
Control	2.3	1.1	16.1	2.6
Treatment 1 (T1)	2.5	1.2	21.3	2.7
Treatment 2 (T2)	2.5	1.4	22.4	3.1

Table 3: Effect of SMS on biochemical parameters of *Vigna radiata* plant

Treatment	Total Chlorophyll (mg/g)	Total Protein (µg/mg)	Total Carbohydrate (µg/mg)

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Control	5.13	0.93	1.05
Treatment 1 (T1)	5.20	1.35	1.16
Treatment 2 (T2)	7.43	1.94	1.22

4. Conclusion

The experiment was carried out to investigate the suitability of spent mushroom substrate (SMS) as a biofertilizer for the growth of *Vigna radiata*. The present investigation reveals that *Vigna radiata* grow much faster in the presence of spent mushroom substrate treated soil than the control soil. Seed germination percentages, length of leaves, breadth of leaves, shoot length and root length seems to be promoted in *Vigna radiata* during the growth period in presence of spent mushroom substrate. Control plants had minimum growth in all experimental setups during all the stages of growth. The results also suggest that the spent mushroom substrate treated plants had higher chlorophyll, protein, and total carbohydrate content when compared to the control experimental samples. Hence, it can be concluded that the soil alone was not able to provide all the nutrients to the plants but when the soil was mixed with the SMS in the proportion of 75% SMS + 25% soil, then the plants can grow much better; as SMS contains many different types of nutrients and makes these essential nutrients available to the plants for their growth. The utilization of SMS as a bio-fertilizer can reduce the wastes in the environment; which were generated during mushroom cultivation. Thus, it is feasible to use spent mushroom waste as a biofertilizer to replace the use of synthetic fertilizers.

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