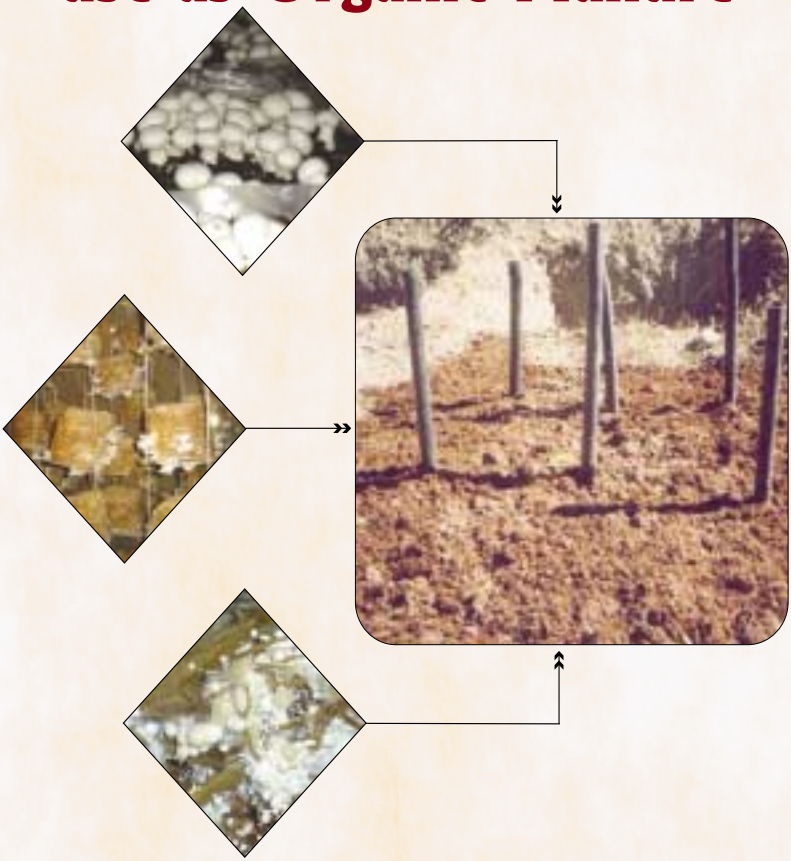
Recycling of Spent Mushroom Substrate to use as Organic Manure



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INTRODUCTION

Mushroom growing is an eco-friendly activity as it utilizes the wastes from agriculture, poultry, brewery etc. and in turn produces fruit bodies with excellent and unique nutritional and medicinal attributes. The production of spent mushroom substrate after crop harvest is a matter of concern because it creates various environmental problems including ground water contamination and nuisance if not handled properly. Compost is considered "spent" when one full crop of mushroom, has been taken or when further extension of cropping becomes unremunerative. The diversified uses of spent mushroom substrate in managing agriculture, environment and recycling energy have came in light recently and because of which its name has been changed from spent mushroom substrate to "used mushroom substrate".

TRAITS OF SPENT MUSHROOM SUBSTRATE

SMS contains 1.9-0.4-2.4% (N-P-K) before weathering and 1.9-0.6-1.0 (N-P-K) after weathering for 8-16 months. SMS contains much less heavy metals than sewerage sludge, which precludes its classification as a hazardous substance. SMS obtained from various sources usually have conductance in the range of 1.9 to 8.3 memos/cm. Chloride used to be one of the major inorganic anions in SMS and it varies from 1.5 to 7.5kg/1000 kg in fresh SMS, while 0.3kg/1000kg in well rotten SMS. SMS has an initial pH of 7.28 which increases during weathering. The volume of SMS also decreases (shrinkage) over the time. The fresh SMS obtained from various sources varies in its density: 0.198 g/cm^3 with a range of 0.15 to 0.24 g/cm^3 in U.K., 0.475 g/cm^3 in Ireland and 0.24 to 0.62 g/cm^3 in USA.

USES

The material has been found to be good nutrient sources for agriculture because of its nutrient-status. It has a high cation exchange capacity, a measure of the amount of nutrients a medium can hold and a slow mineralization rate retains its quality as an organic matter.

A. Spent mushroom substrate for organic-farming:

The addition of spent mushroom substrate in the nutrient poor soil leads to an improvement in soil texture, water holding capacity and nutrient status. Spent mushroom substrate incorporation in soil does not have any adverse effect on its alkalinity while, its amendment in soil leads to an increase in both pH as well as the organic carbon content. The phosphorus and potassium requirements of the crop plants can be fulfilled by incorporating 5% of SMS by volume, while nitrogen requirement can be fully met by 25% of SMS by volume. The actinomycetes, bacteria and fungi inhabiting the compost not only play role in its further decomposition but also exert some antagonism to the normal pathogens surviving and multiplying in the soil eco-system.

i) Horticulture

Suitable treatments like rapid salt leaching and weathering in open for two to three years make SMS more suitable for either complete or partial substitution of growing media for growing flowers, vegetables, fruit, saplings, ornamental shrubs and other horticulture plants of economic importance. The spent mushroom substrate being rich in N, P and K acts as a good growing medium for vegetables like cucumber, tomato, broccoli, tulip, cauliflower, peppers, spinach etc. but the response of the plants varies at different levels of SMS incorporation. The performance of the species does not vary with respect to the source of SMS; initial or subsequent salt concentration in the media; chemical or physical characteristics of the media. The findings given below are the outcome of the AP-Cess funded scheme concluded at National Research Centre for Mushroom, Solan (HP) recently.

Tomato (*Lycopersicon esculentum*)

SMS Dose: 18.5 ton/ha

Superior Yield: 6-24 months old naturally weathered SMS and 12 months old anaerobically recomposted SMS

Superior Quality: Superior fruit weight, ascorbic acid content, dry matter, total soluble solids (TSS) & acidity in anaerobically recomposted SMS.

Diseases management: Lower incidence of Blossom end rot, Buck eye rot, Leaf curl in anaerobically recomposted SMS, while Fruit borer in FYM.

Shimla Mirch (*Capsicum annuum*)

SMS Dose: 25 ton/ha

Superior Yield: 6-18 months old naturally weathered and 12 months old aerobically recomposted SMS

Superior Quality: Superior fruit length, fruit width, dry matter, total soluble solids & ascorbic acid content in 12 months old naturally weathered and aerobically recomposted SMS.

Diseases management: Lower incidence of Fruit rot, Chilli veinal mottle virus, Grasshopper attack in 24 months old naturally weathered and aerobically recomposted SMS.

Pea (*Pisum sativum*)

SMS Dose: 20 ton/ha

Superior Yield: 12 months old anaerobically recomposted SMS

Superior Quality: Higher contents of protein, ascorbic acid, dry matter & total soluble solids in 18 months aerobically/anaerobically recomposted SMS.

Diseases management: Lower incidence of *Fusarium* wilt and Powdery mildew score in SMS.

Cauliflower *(Brassica oleracea var botrytis)*

SMS Dose: 25 ton/ha

Superior Yield: 12 months old anaerobically recomposted SMS

Superior Quality: Superior stalk length, curd length, curd dia, dry matter, ascorbic acid content, curd appearance in 12 months old anaerobically/aerobically recomposted SMS.

Diseases management: lower incidence of black rot and Caterpillar in SMS.

Ginger (*Zingiber officinale*)

SMS Dose: 30-32 ton/ha

Vegetative growth and Yield: 18 months old aerobically recomposted SMS + basal dose of chemical fertilizers.

Superior Quality: Superior rhizome length, breadth, thickness, dry matter, total soluble solids, fibre & NSS in 18 months old aerobically/anaerobically recomposted SMS + chemical fertilizers.

Diseases management: Lower rotting incidence in SMS

Onion (*Allium cepa* L.)

SMS Dose: 25 ton/ha

Vegetative growth and yield: 12 months old anaerobically recomposted SMS + basal dose of chemical fertilizers.

Superior Quality: Superior length and diameter of bulb, total soluble solids, dry matter, pyruvic acid and ascorbic acid contents in 12 months old anaerobically recomposted SMS + fertilizer

Brinjal (*Solanum melongena*)

SMS Dose: 25 ton/ha

Superior Yield: 12 and 24 months old anaerobically recomposted SMS

No. of fruits: Highest in 24 months old aerobically recomposted SMS followed by control and 12 months old aerobically recomposted SMS.

Fruit Quality: Best in standard followed by SMS treatments.

ii) Cereals

The SMS incorporation @ 100,200 and 400 tons (fresh weight)/acre in nutrient poor soil like silty dry loam shows positive effect on the silage and grain yield of cash crops. The grain and silage also contain significantly higher level of nitrogen and it did not affect the water quality.

Wheat (*Triticum aestivum*)

Vegetative Growth & Yield: 12 months old anaerobically recomposted SMS + basal dose of chemical fertilizers.

Ear quality: Superior in 12 months old anaerobically recomposted SMS + chemical fertilizers.

iii) Mushrooms

The use of anaerobically fermented spent mushroom substrate as casing material gave mushroom yield at par with that of the peat based casing material with additional advantage of less bacterial blotch infection.

In cultivation trials at NRC for Mushroom, Solan, casing of button mushroom bags with one year old aerobically recomposted SMS supported about 2-3 days early crop of button mushroom along with mushroom yield at par with coir pith and superior than 2 year old left over SMS and 2 year old FYM with no significant difference in fruiting body weight.

B. Bioremediation of contaminated soil

The uncontrolled release of industrial wastes in the open and poor availability of pretreatment facilities contributes towards the increased levels of contaminants on the soil. The degradation of these contaminants mainly depends upon the physical and chemical conditions prevailing in the soil and the nature of microorganisms thrive in the soil. SMS adsorbs the organic and inorganic pollutants and harbors diverse category of microbes having capabilities of biological break down of the organic xenobiotic compounds. The microbes, especially actinomycetes (*Streptomyces* sp. and *Thermomonospora* sp.) present in spent mushroom substrate also have strong pollutants catabolizing capabilities which results in decreased level of pollutants in contaminated soil after incubation with SMS.

Study conducted at the Centre showed that application of button mushroom SMS @ 20% v/v resulted in maximum disappearance of Mancozeb, Melathion, Decis and Bavistin from soil and negligible level of these fungicides was recorded in tomato and peas fruits. Amendment of soil with 10 & 20 % SMS (v/v) resulted in maximum bio-elimination of cadmium and lead from soil, respectively.

C. Vermicomposting

The spent substrate from paddy straw and oyster mushroom was observed as better substrate in comparison to SMS of button mushroom for their use as substrate for vermicomposting. The fresh button mushroom substrate alone or with FYM in 1:1 ratio or semi rotten (15-20 days) button mushroom SMS alone can be used for effective vermicomposting.

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