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Impact of physico-chemical properties of casing on yield of *Agaricus bisporus* (Lange) Imbach

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ABSTRACT: Six casing mixtures viz. FYM + Spent compost (1:1, 2:1, 1:3 v/v), FYM + Garden soil (3:1 v/v), FYM alone and spent compost alone were formulated and analyzed for their physico-chemical properties and evaluated further for their effect on production and productivity *of Agaricus bisporus.*
Minimum (0.60 g/cm^3) and maximum (0.88 mg/cm^3) bulk density were recorded from FYM and spent compost, respectively. The bulk density increased with the increase in ratio of spent compost with FYM. In FYM alone porosity was highest (92 per cent) followed by FYM and spent compost (2:1) where it was 88 per cent. Water holding capacity was highest (191.55 per cent) in FYM alone and the minimum (91.70 per cent) in spent compost. The pH of the mixtures did not differ substantially from each other. In mixture, where FYM dominated, electrical conductivity and organic matter was higher and significantly low where spent compost was the major material.
Macro and micro-nutrients estimation included nitrogen, phosphorus, potassium, iron, copper, manganese and zinc. The levels of all these nutrients were significantly different in the casing mixtures studied.
The casing mixtures when evaluated in terms of yield kg/quintal compost, the results have been interesting. The yields recorded in all the six treatments were significantly different from each other. In the first as well as second crop, casing mixture prepared using FYM + Spent compost (2:1) performed best giving a yield of 18.83 kg and 17.21 kg/qtl compost. Casing mixture formulation developed from FYM and garden soil (3:1) was the next best in both the crops. Thus, it has been observed that the formulations having higher amount of FYM and lower quantity of spent compost or soil performed better and looked more suitable for developing casing mixtures.

1 INTRODUCTION

Casing mixtures are developed by using different organic matters of plant origin and soil. Once they are mixed together in different proportions, the resultant mixture will have physico-chemical properties such as water holding capacity, bulk density, electrical conductivity, macro- and micro nutrients etc. different from the individual original components. This modification in physico-chemical properties is most likely to affect biological characteristics of the casing mixtures which in turn affect the production and productivity *of Agaricus bisporus.* In the present investigations six casing mixtures were analyzed for their physico-chemical properties and correlated with the yield *of Agaricus bisporus.*

2 MATERIALS AND METHODS

Casing mixtures were developed using FYM (one year old) and spent compost (two years old) alone and also mixed in the ratio of 1:1, 2:1 and 1:3 v/v. In another mixture FYM and garden soil were mixed in the ratio of 3:1. The casing mixtures developed were treated by formalin (2%) before use. Physico-chemical properties were determined using methods suggested by various workers: Bulk Density (Blake, 1965), Porosity (Allen, 1974), Water holding capacity (Peters, 1965), pH (Jackson, 1967), Electrical conductivity (Jackson, 1967), Organic matter (Walkley & Blake, 1934), Available Nitrogen (Subbiah & Asija, 1956), Available Phosphorus (Olsen, 1954), Available micro-nutrients, Zn, Fe, Cu and Mn *a* .indsav * Novell 19781

3 RESULTS

3.7 *Physico-chemical properties of Casing Mixtures*

The results of major physico-chemical properties of different casing mixtures and their impact on yield of *A. bisporus* are presented in Table 1, 2 and 3.
FYM alone had the minimum bulk density (BD) (0.60 g/cm^3) while the spent compost alone had the highest (0.88 g/cm^3). The remaining four mixtures developed from spent compost, FYM or garden soil did not differ from each other and had bulk density ranged from 0.64 - 0.78 g/cm3. It is significant to note that bulk density increased with the increase in the ratio of spent compost with FYM. Another important physical property estimated was porosity. In FYM alone it was highest (92%) followed by FYM and spent compost (2:1) where it was 88 per cent. In case of spent compost alone, it was minimum and significantly less (66 per cent) as compared to other five mixtures.
Water holding capacity appears directly related to porosity and bulk density. These factors are directly affecting microbial build up and yield of *A. bisporus.* It was highest in 191.19 per cent in FYM alone and minimum (91.70%) in spent compost. The pH of the mixtures developed did not differ substantially from each other. pH of the casing mixtures varied from 6.82-7.61.
Significantly increased electrical conductivity (EC) was recorded from the FYM (570.33 deci siemen"^{1}. In contrast, spent compost alone had the minimum 305.00 deci siemen"^{1}. In mixtures where FYM dominated it was significantly higher and significantly lower where spent compost was the major material.
Organic matter content of the mixtures were also different from each other. Mixtures developed from spent compost and FYM or FYM alone had an organic matter content of appr. 24 to 25%. Significantly lower percentages of 20.59 and 20.34 were recorded in spent compost alone and in FYM + garden soil (3:1), respectively (Table 1.)

Table I. Physico-chemical properties of casing mixtures

SI. No.	Treatment/casing soil	Properties					
		Bulk density (g/cm^3)	Porosity (%)	Wnter holding capacirv (%)	pH	Electrical condirc-tivitv deci-sinien"'	Organic matter (%)
1.	FYM + Spent compost (1:1)	0.70	79.33	141.48	6.97	358.00	25.92
2.	FYM + Spent compost (2:1)	0.64	88.00	129.35	6.84	404.00	24.43
3.	FYM + Spent compost (1:3)	0.78	72.00	101.19	6.86	325.00	24.97
4.	Spent compost alone	0.88	66.00	91.70	6.82	305.00	20.59
5.	FYM alone	0.60	92.00	191.19	7.61	570.33	25.58
6.	FYM + Garden soil (3:1)	0.68	82.00	95.97	7.07	396.00	20.34
	CD at 5%	0.04	12.14	7.22	0.06	41.92	1.08

Table II. Macro and micro nutrients of casing mixtures

Sl. No.	Treatment/ casing soil	Nutrients Nitrogen (%)	Phosphorus (%)	Potassium (%)	Iron (ppm)	Copper (ppm)	Manganese (ppm)	Zinc (ppm)
1.	FYM + Spent compost U: 1)	0.076	0.338	1.80	0.018	2.44 x 10"3	0.093	0.020
22	FYM + Spent compost (2:1)	0.098	0.175	1.90	0.034	2.30 x 10"5	0.104	0.021
3.	FYM + Spent compost (1:3)	0.069	0.213	1.60	0.019	1 68 x 10J	0.114	0.021
4.	Spent compost aione	0.072	0.388	1.20	0.017	1.58x 10"3	0.098	0.020
5.	FYM alone	0.140	0.460	1.60	0.055	2.44 x 10"3	0.086	0.042
6.	FYM + Garden soil (3:1)	0.054	0.188	0.80	0.028	8.8 x 10"4	0.111	0.018
	CD at 5%	0.0058	0.031	0.39	0.0047	0.00045	0.014	0.011

Table III Yield of *A. blsporus* in relation to physico-chemical properties of casing mixtures

Sl. No.	Treatment/ casing soil	Average yield kg/qtl compost: Crop I Number	Crop I Weight	Crop 11 Number	Crop 11 Weight
1.	FYM-Spent compost (1 : 1)	1206.67	15.27	1313.33	16.63
2.	FYMH-Spent compost (2 : 1)	1413.33	18.83	1346.67	17.21
3.	FYM T Spent compost (1 :3)	1213.33	14.67	1166.67	15.52
4.	Spent compost aione	1413.33	14.10	1199.99	14.84
5.	FYM alone	1222.00	16.38	1266.67	16.19
6.	FYM * Garden soil (3 : 1)	1346.67	17.43	1260.00	16.65
	CD at 5% (For fruity body)	14.32	0.13	11.63	0.16

3.2 *Nutritional Status of Casing Mixtures*

In order to assess the nutritional status of all the six casing mixtures, macro- and micro-nutrients were analyzed and results are given in Table 2. FYM alone had the highest nitrogen percentage (0.140 %) followed by FYM + Spent compost (2:1), where it was 0.098 per cent. It was significantly lowest, 0.054 per cent in spent compost alone. In the remaining formulations it ranged from 0.069 per cent to 0.076 per cent. Similarly the levels of two immobile nutrients, phosphorus and potassium also differed significantly in different casing formulations. Phosphorus was highest (0.46 per cent) in FYM alone, followed by FYM + Spent compost (2:1), and FYM + Garden soil (3:1). In spent compost alone and FYM + Spent compost (1:1), the level of phosphorus was minimum and varied from 0.175 to 0.180 per cent. Potassium was lowest (0.80 per cent) in spent compost alone, followed by FYM + Spent compost where it was 1.20 per cent. In the remaining formulations, it ranged from 1.60 to 1.90 per cent.

Micro-nutrients estimation included iron, copper, manganese and zinc (Table 2). The levels of these four micro-nutrients were almost significantly different in the casing mixtures studied, where FYM was richest for three elements iron, copper and zinc and spent compost was the poorest one except for manganese. The level of iron was 0.055 ppm in FYM; its level in the others ranged from 0.017 to 0.034 ppm. The concentration of copper in spent compost alone was significantly less. FYM + Spent compost (1: 1) contained 1.68 x 10-3 ppm. In the remaining mixtures it varied from 1.58 x 10-3 to 2.44 x 10-3 ppm. With respect to manganese, it was maximum 0.114 ppm in spent compost alone and lowest 0.086 ppm in FYM alone, however, zinc was maximum 0.042 ppm in FYM alone. In the remaining five formulations it varied from 0.018 to 0.021 ppm.

3.3 *Yield ofAgaricus bisporus in Relation to Physico-chemical Properties*

All the six casing mixtures that were formulated and analyzed for their physico- chemical properties were further evaluated for their effects on production and productivity of strain 512-H of *A. bisporus.* The yield data recorded for a period of 35 days in g/kg compost are finally presented in kg/qtl. compost. Data of two crops in succession are presented in Table 3.

It is clear (1 crop) that FYM + Spent compost (2:1) and spent compost alone favored development of a significantly higher number of sporophores. The second in order, was the formulation FYM + Garden soil (3:1) where the total number of sporophores was 1346. The remaining three formulations, FYM + Spent compost (1:1), FYM + Spent compost (1:3) and FYM alone were almost similar in their effectivity. In the second crop as well FYM + Spent compost (2:1) performed best. Highest number(1340) of sporophores were recorded. Second in performance was FYM + Spent compost (1:1). In the remaining formulation, the numbers recorded were significantly less.

All the six treatments were significantly different from each other in terms of yield. In the first as well as second crop, casing mixture prepared using FYM + Spent compost (2:1) performed best. In the first crop, a yield of 18.83 kg/qtl compost and in the second crop 17.21 kg/qtl compost were recorded. Casing mixture made from FYM and garden soil (3:1) was the next best in the crops: 17.43 kg and 16.65 kg/qtl compost yield were harvested in first and second crop respectively. Following the FYM alone were FYM + Spent compost (1:1), FYM + Spent compost (1:3) and spent compost alone. Thus, it has been observed that the formulations having a higher amount of FYM and lower amount of spent compost or soil or FYM alone performed better and looked more suitable for developing casing mixtures.

4 DISCUSSION

It is an established fact that the bulk density of soil affects porosity and that porosity proportionally affects the water holding capacity, pH, electrical conductivity and organic matter of casing soil. All these factors together determine the quality and utility of casing soils. Results of physico-chemical properties given in Table 1 and 2 amply demonstrate that the higher the bulk density of casing materials made from FYM and spent compost (1:3 v/v) the lower the porosity. The FYM which had higher WHC, when added to spent compost in the ratio of 1:1 or 2:1 v/v improved the WHC while reduction in ratio of FYM content in spent compost, reduced the WHC of casing material. Similar observations have been recorded in case of pH. It decreased when the ratio of spent compost was increased. In contrast, higher EC and OM of FYM decreased when supplemented with spent compost and soil.

A significant correlation between the number of sporophores that were produced and the free pore space in the casing mixture was documented earlier (Flegg, 1953). Similarly, space in casing facilitates better air exchange has a relation to moisture and also affects microbial buildup particularly that of pseudomonads (Nair & Hayes, 1974; Raincy et al, 1986; Stainer et al, 1986 andKurtzman, 1995).

It was suggested that casing material must have a high water holding capacity (Flegg, 1953b). In the present investigation the casing material FYM alone and in combination had a better WHC, which resulted in good crop yield.

The acidity and alkalinity of the casing also affect the production. In this study pH ranged from 6.8-7.16. A pH range between 7-8 has also been reported by several workers (Howker, 1966; Atkins, 1972; Edwards, 1978). It is clear that a slight alkaline pH of FYM had a positive impact in enhancing the yield of mushrooms in both Crops.

Decrease in number of pinheads is almost proportional to increase in conductivity (Shandilya & Hayes, 1987). Data from the present investigation on EC (Table 1) and mushroom yield (Table 3) demonstrated that the lower the EC FYM + Spent compost (2:1), the higher the yield as compared to the yield from FYM alone. However, the same did not apply in case of FYM + Spent compost (1:3) of which the EC was measured lower than that of FYM + Spent compost (2:1) but it did not result in a higher yield. These results indicate that the EC plays an important role in the production of *A. bisporus* but is not the sole controlling factor. Productivity of *A. bisporus* is determined by the additive effects of various factors.

There is no evidence of the relationship between the total organic matter and yield. However, in the present study we found in general a significantly lower yield with low organic matter in the casing mixtures.

The physico-chemical properties of casing-mixtures and the average weight of mushrooms have a significant relationship. With higher porosity and WHC as observed in FYM, FYM + Spent compost (2:1) and FYM + Spent compost (1:1), the number and weight of fruit bodies was higher. In contrast, when porosity and BD were reduced as observed in spent compost alone, a higher number of fruit bodies with lower weight was recorded. These findings are in agreement with the findings of various workers (Bels-Koning, 1950; Tschierpe & Sinden, 1972; Nair & Hayes, 1981 and Rainey et al, 1986) who have reported the importance of air pores in the casing layer. They have also suggested that the number of mushrooms is larger with higher pore spaces and that this has a positive effect in both, the yield and mean mushroom weight.

The nutritional requirement of *A. bisporus* has been studied and reviewed (Stoller, 1941; Treschow, 1944; Sarazin, 1955; Bohus, 1959) but for the requirement of micro-elements for *A. bisporus,* not sufficient information is available on the presence of macro- and micro-nutrients in casing and their effects on the mushroom yield. It was interesting to record that the FYM alone and spent compost alone with highest and lowest concentrations of macro- and micro-nutrients respectively, did not perform as anticipated in terms of mushroom yield during the first or second crop but in combination, when the levels of macro- and micro-nutrients were in between FYM and spent compost, there was a significant increase in the mushroom yield. Even in one of the formulations, FYM + Garden soil (3:1), the yield was higher as compared to spent compost and FYM alone though the micro- and macro-nutritional make-up of the former was much lower compared to the latter. In a study, Watson (1973) found that a large proportion of nitrogen in liquid culture could be taken up by mycelium as long as phosphorus was not limiting but where the phosphorus level was low, an increase in nitrogen did not lead to an increase in growth of N2 uptake. He suggested that the optimum requirement for phosphorus is $10\sim^{3}$ Mol.

A level below this reduces mycelial growth while higher levels were inhibitory under certain conditions (Treschow, 1944). This may explain why the higher phosphorus content in FYM and spent compost might be the limiting factor for a higher yield. In addition to iron other micronutrients such as zinc, copper and manganese also play a significant role in destroying the quinone that is a metabolite of *A. bisporus* which is released by its mycelium and inhibits its fructification (Stoller, 1979). The presence of iron, copper, manganese and zinc in FYM alone and in the combination with spent compost may be one of the reasons for a better crop with them (Garchaetal. 1987a).

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