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Evaluation of spent biogas silage as casing soil in mushroom cultivation

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Abstract

Various combinations of spent biogas plant silage, DAP, super phosphate, FYM, spent compost and garden soil were evaluated as casing soil for mushroom cultivation. Among the various combinations tried, a mixture of spent biogas silage (50%) + FYM (25%) +spent compost (25%)+ DAP (1%) + super phosphate (1%) was found superior. It not only resulted best productivity and reduced the cropping schedule and induced better quality solid mushrooms with hard texture and could be kept for about 6 days more without opening or softening.

Key words: Mushroom, casing soil, spent biogas plant silage, DAP, super phosphate, FYM, quality

Introduction

White button mushroom is grown on compost based on various agricultural wastes and animal manures. The composting process is a high temperature self-sustained fermentation, which results in partial break down of lignin and cellulose. It fixes unstable forms of nitrogen into stable complexes, and favours rapid increase in microbial population (fungi, bacteria, and actinomycetes). This process results in formation of highly selective substrate compost for the growth of mushroom mycelium. Researches have been conducted on various sterile and semi sterile substrates as casing for mushroom cultivation.There are certain limitations to carry out complete process indoor as composting process is not only biological but chemical process also (Tiwari, 1993). In the present investigation, main stress has been directed towards the use of biogas plant silage as a major constituent of casing soil after modifying it with various additives; and to assess the applicability and usefulness of such modified silage for use in mushroom farms.

Materials and methods

Preparation of compost: Straw-based compost was used in the study and the ingredients in the compost were as per following formula:

Wheat straw (500 kg), horse manure (1000 kg), poultry manure (300 kg), Brewer's grain (60 kg), urea (20 kg), super phosphate (10 kg), Murate of potash (12 kg) and gypsum (30 kg).

The compost was readied by adopting short method as suggested by Vijai (1993):

Wetting of the straw: The straw was spread on the concrete floor and was watered thoroughly. It was mixed vigorously so that the straw was completely wet. This was left as such for 3 days with occasional sprinkling of water. The straw thus absorbed water/ moisture up to 75%. On the third day horse dung manure was also mixed thoroughly into the straw and was sprinkled with water. This stage was -2 day stage.

Zero Day: The above mixture was thoroughly spread and all the activators like brewers grain, chicken manure and other fertilizers (urea, super phosphate, murate of potash) were spread uniformly over the horse dung - straw mixture. These were then thoroughly mixed and sprinkled with water whenever these were felt as dry so as to maintain the moisture level of 75%. When the mixture was ready, it was stacked into a heap of 1.75 x 1.75 x 1.75m. The heap was pressed from the top as well as sides and was allowed to stand for 6 days so that thermophiles and other microbes could develop.

6th day: First turning was given to the heap. It was broken and remade after proper aeration. Dry patches, if present, were sprinkled with water.

10th day: The second turning was given. The heap was processed, vigorously, mixed and remade after light sprinkling of water as was done earlier.

13th day: The heap was broken, the compost was allowed to aerate properly. The gypsum was added to the heap and was thoroughly mixed so that gypsum was evenly distributed. After about 4 hrs of standing, water was sprinkled and the heap was remade and pressed.

15th day: The compost was loaded into pasteurization tunnel. The doors of the tunnel were closed and sealed along with closure of the dampers/vents. The entire compost mass was brought to a uniform temperature of 45^{o}C by introducing steam. When the temperature reached 45^{o}C, the stem was cut off and the compost was left for fermentation at this temperature for about 18hrs.

16th day: The temperature of the compost was raised to 65^{o}C (@ 2^{o}C/ hour) by introducing the steam. This temperature was maintained for about 10 hrs (for peak heating of the compost) after which the steam was cut off. Fresh air was introduced into the compost with the help of blowers with simultaneous opening of the vent upto 15-20%. This resulted in drop of the temperature of the compost.

Day 17-20: The temperature of the compost was maintained at this temperature by recirculating air alongwith 10% fresh air as well as steam as and when required. This resulted in aerobic fermentation and conditioning of the compost.

Day 20-22: The compost was further cooled by introducing fresh micro-filtered air upto 37°C (for one day) and 25°C (for another one day).

The compost by this time was completely free of ammonia, instead had a sweet smell, was dark brown in colour and had a moisture content of about 65%. The pH of the compost thus prepared was 7.4-7.6 and had good texture free of greesiness.

Spawn and spawning: The spawn used in the present investigation was procured from Mandeep Mushroom Farms at Gurgaon. The variety of the mushroom spawn was UM3-002 which is a hybrid variety with most of its characters like that of *Agaricus bitorquis* and production characters like that of *A. bisporous*.

The spawn was procured at least 10 days before the spawning and was kept in lower shelves of refrigerator where temperature of about 15°C is present.

The compost was dispensed either into the plastic bags 22" wide x 32" height and filled upto a 1.5' or onto the beds of 2.5' width upto a thickness of 8". The spawning was done by mixing it with the compost (in bags) or by broadcasting (in the beds and mixing). About 10% of the spawn was layered on the top of the compost after spawning. When spawning was complete, the compost was lightly pressed and covered with newspapers.

The rate of spawning was 0.75% of the compost. The bags were arranged in rows and covered with newspapers. The beds were also covered with newspapers. The top of papers was lightly sprinkled with water to maintain the moisture.

These all activities were carried out in growth rooms where the temperature of 24°C 10°C was maintained for spawn run. The spawn run was complete on 12th day when a layer of mycelium appeared on the surface. The mycelium by this time thoroughly impregnated into the compost.

Casing soil: For preparation of casing soil, the biogas plant silage was collected (dried) and crushed into powder. The amendments and the composition of the casing soils prepared were as follows:

a. Garden soil (loam) 50% + 2 year old FYM (Control) (Set-1)

b. Spent Biogas plant Silage + DAP (0.5%) + super phosphate (0.5%) (Set-2)

c. Spent Biogas plant Silage 50% + FYM 50% (Set-3)

d. Spent Biogas plant Silage 50% + FYM 25% + 25% spent compost (2 year old) + DAP (1%) + Super phosphate (1%) (Set-4)

e. Spent Biogas plant Silage 50% + 50% spent compost + DAP 0.5% + Super phosphate (0.5%) (Set-5)

f. Spent Biogas plant silage 50% + FYM 25% + 25% garden loam soil. (Set-6)

The casing soils so prepared were based on logics derived from the analysis of silage and spent compost. The two components were observed to be deficient in nitrogen and phosphorous.

After thoroughly mixing the individual set of casing soil these were placed in bags and sterilized with formaline. The sterilization was carried out for 5 days after which the bags with casing soils were opened and the soil was used for casing.

The casing soil was layered over the compost after spawn run to a thickness of about 1.5" either in bags or in beds. The moisture content in the casing soil also was brought to 60% before casing. When the casing was complete, it was slightly pressed and light sprinkle of water in the form of mist was applied. The temperature of the chamber was maintained at 24°C ± 1°C. The water was sprayed on the casing soil almost daily to the extent that casing soil looked wet. The growth room was kept closed because of which CO_2 concentration in the chamber was increased.

The mycelium of the mushroom took about 8 to 10 days to impregnate into the casing soil. The variability of mycelium to spread into the casing soil appears to depend upon composition and density of the soil. For example in case where casing soil consisted of garden soil and farm yard manure, the mycelium took 10 days to spread but when it is silage + FYM or silage + FYM + spent compost, it took about 8 days. In case of casing soil being silage and spent compost only, it took even little lesser time.

Cropping: When the casing soil became fully impregnated with the mycelium the temperature of the growing chamber was lowered to 18°C± 1°C. At this stage fresh air was introduced into the chamber with simultaneous opening of the vents as well as exhaust fans. The fresh air replaced the CO_2 rich air of the chamber and O_2 concentration increased in comparison to CO_2 concentration in the chamber.

In about 7 days the pin heads of mushroom started showing up on the casing soil and by 11th to 12th day the crop was ready for the harvest.

The crop was hand picked, the stripe was cut, and the mushrooms were washed in cool fresh water to remove the soil particles. The crop from individual bags was harvested separately treatment-wise and the weight of mushrooms along with weight of trimmed parts was taken separately. At least 10 bags of each treatment were grouped together for mushroom production. Each treatment was performed in triplicate.

The time of 2nd flush of mushrooms and thereafter was noted and at least 8 flushes of mushrooms were harvested and weighed to reach legitimate conclusions about the total production of mushrooms against total amount of compost and also the time taken for completion of cropping period (8 flushes). The data were analysed statistically and have been presented in the table in observations.

Results and discussion

The spent silage from biogas plants is waste by- product and is usually thrown out in the fields or drains. It has been a common experience that the silage contains good amount of fibre and nitrogen. It is lightweight soil, which may have good amount of unicelled population of methanolgenic bacteria. Phosphorous and other micronutrients, which are of immense need by the methanogens, are utilized during gas production by methanogens so that the silage is poor in many of these micronutrients.

As is the practice among the village folk, most of the cowdung is either used for burning purposes or is used in preparation of farmyard manure. On an average about only 7.3% of total waste is utilized in biogas production as estimated on total yield from farm animals. The amount of silage that is put out from this kind of use in biogas is about 4.7%. It means that only 2.6% of organic matter are converted into biogas while rest is thrown as waste. Only few farmers, especially those with good land holdings, use the spent silage in the fields as supplement to mannures.

On the other hand the mushroom growers, especially those who do not have much economic support or those who do not have animals, face a crisis of non-availability of casing soil. With this view in mind it was thought to work out the feasibility of using the silage, as such or with modification, as base material to be used in casing soil for mushroom production so that something concrete and useful could be suggested to mushroom growers if silage gives good results.

Table 1. Productivity of mushroom with different casing soils derived from spent biogas silage (compost conditions are uniform)

Treatment	Compost used (kg)	Total cropping period (8 flushes)	No. of normal + secondary flushes	Total crop yield (kg)	Production (per cent of total compost)
Set 1	360	64	8	37.25	10.35
Set 2	370	55	7+1	30.39	8.21
Set 3	373	58	8	44.29	11.87
Set 4	370	58	8	48.16	13.01
Set 5	380	56	8	46.89	12.33
Set 6	375	56	8	42.46	11.32

Set 1= Control

The premise that silage could be used as casing soil was conceived from the fact that in a number of mushroom growing plants 'biomanure' is being prepared through wormiculture and used. This biomanure is prepared by culturing the earthworms in cattle dung. The earthworms feed upon this dung and excrete the spent part, which is then used as casing soil. As the earthworms feed upon the cattle dung, the excreted material by these worms is expected to be deficient in materials, which are required by biological systems. Similarly cow dung when used in biogas plant supports the growth of methonogenic bacteria and other biological forms. When it is no more in a condition to support the biological systems, it is taken out and thrown as silage. It is thus obvious that this silage will be in most of its parameters equivalent or only slightly different from the earthworm excreta or biomanure. Therefore, like the earthworm excreta (biomanure), the silage can also be used as casing soil in mushroom industry.

As is apparent from the table the productivity in case of set 2 where only spent silage was used as casing soil went down to the extent of about 79% of the controls (21% reduction). When the spent silage was mixed with 25% FYM and 25% garden loam soil, the productivity of mushroom approached to the productivity in control plants (set 6). In rest of the combinations the productivity was observed to be more than that recorded in the control plants.

The best production of mushroom was obtained when the spent silage was used with 25% FYM and 25% spent (2 year old) compost with addition of 1.0% DAP and 1.0% super phosphate. The enhancement over controls in total productivity observed was to the extent of about 25.7%, which is a significant enhancement (set 4). Similarly in case of set 3 and in case of set 5 the enhancement was to the extent of 14.5-18.5% over the controls.

Another feature of the interest is the time schedule, where 8 flushes (good flushes) are taken for full productivity. It is showing some change. In controls the productivity period is about 64 days, it is reduced to 56 to 58 days in case the casing soil, based on spent silage. This reduction in time schedule of full cropping of mushroom is very important for big as well as small farm houses where one crop per year can be taken extra from the farm house thus giving an edge over the use of conventional type of casing soil.

Although the cropping period is smallest in case of set-2 where only modified spent silage is used but in this case only 7 flushes have been obtained with a weak 8^{th} flush. Further the total productivity is much lower than the controls and hence is of no economic value. Simultaneously it has been observed that the density of the casing soil is lowest and this probably results in very soft soggy type of mushroom head unsuitable for market or canning etc. These mushrooms open up and their gills are exposed within 3 days of storage. This type of combination for the casing soil as used in set 2 is therefore, of no use.

On the basis of the above observations, it is therefore obviously concludable that spent silage can be profitably used (after proper modification) in place of conventional casing soils. Among the combinations tried, the best combination that can be advised to the growers is the one used in set 4, *i.e.,* spent silage (50%) + FYM (25%) + spent compost (25%) + 1 % DAP + 1 % superphosphate.This combination not only gives best productivity but also is helpful in reducing the cropping schedule and has good density to give a crop of mushrooms that have hard texture and are sufficiently solid. These mushrooms can stay for about 6 days without opening or sogging.

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