THE EFFECT OF WATERING FREQUENCY ON THE YIELD OF BUTTON MUSHROOM (*Agaricus bisporus*)

BY

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DICATION

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STRACT

study was conducted at the University of Zambia, School of Agricultural Sciences Field Station. wning was done on 12th July 2002, while casing was done on 17th August 2002. The objective of the y was to determine the effect of different watering frequencies on the yield and flushing intervals of on mushroom. The mean total yields obtained were 1089.7 g, 1113.9 g and 1530.4 g for the daily, 2- s interval and 3-days interval watering frequencies respectively. There was no significant difference in yields of button mushroom for the three watering frequencies. The treatments had no significant effect he number of days to the first, second and third flushes. The treatments also had little effect on the hing interval.

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1.0. INTRODUCTION

The white button mushroom resembles the shape of button, therefore mostly known as button mushroom. *Agaricus bisporus* is the Scientific name for button mushroom. In this genus *Agaricus,* mushrooms are of different colours. *Agaricus,* means gilled mushroom. In the early days of mycology, every gilled mushroom was placed in the genus *Agaricus.* Now *Agaricus* is restricted to saprophytic mushrooms with a chocolate brown or white spore print and usually an annulus (ring) around the stalk. The epithet "*bisporus*" refers to the two-spored basidia lining the gills (Thomas, 1999).

Many mushrooms are considered to be healthy food because they contain large amounts of qualitatively good protein, vitamins (B1, B2, C) and minerals and have a low fat content. The *Agaricus* spp are known to be rich in crude protein content on dry weight basis (De Jonghe, 1997). Protein is the most important component contributing to the nutritional value of a food. It was reported for instance that there was sufficient evidence to suggest and show that malnutrition in Zambia was widespread. In both urban and rural primary schools, between 50- 60% of children, showed signs of under- nutrition or mild malnutrition (National Commission for Development Planning, 1987). By 1980, it had been reported that nearly 7 percent of total admissions of children in hospitals were due to malnutrition and contributed 18 percent of total deaths of children in hospitals (GRZ, 1984).

For the farmers, mushrooms are a profitable crop because of the high price and potentially high yield. They have a short life circle and can be grown all year- round. With persistent droughts, floods and many other natural hazards, which have led to increased shortages of cereals and other essential foodstuffs, mushrooms, can contribute a lot to the country's food security.

Mushroom growing is a highly commercialized practice in the western world. It involves use of expensive equipment such as air conditioners, computers and many other things. Since mushroom growing is relatively new in Zambia, farmers will benefit from it if all the parameters involved in growing it are kept at the optimum.

The watering frequency is one of those parameters, which must be kept at the optimum.

1.1 Objective

To determine the effect of different watering frequencies on the yield and flushing intervals of Button mushroom

2.0 LITERATURE REVIEW

2.1. General overview

Mushroom is defined as a macro fungus with a distinctive fruiting body, which may be above ground (epigeous) or below ground (hypogenous). A macro fungus has a fruiting body of sufficient size to be seen by the naked eye and to be picked up by hand (Miles and Chang, 1997). All mushrooms belong to the kingdom MYCETAE, a group distinct from animals, plants and bacteria. As for the class, most mushrooms belong to either ASCOMYCETES or BASIDIOMYCETES. Like plants, fungi have a distinct cellular structure but they lack the most important feature of plants, the ability to use energy from the direct sunlight through chlorophyll (De Jonghe, 1997).

Mushrooms do not contain chlorophyll and therefore depend on other plant material (the "substrate") for their food. Commonly cultured mushrooms are saprophytic-organisms that feed on dead plant material. The part of the organism that we see and call a mushroom is really just the fruiting body. Unseen is the mycelium-tiny threads that grow throughout the substrate collecting nutrients by breaking down the organic material. For different species of mushrooms, the preferred growing medium varies. Some species can grow on a wide range of materials and others cannot. After the mycelium has grown throughout the substrate, and when its specific requirements are met, the mushroom will fruit.

2.2 Historical perspective

Mushrooms have been treated as a special kind of food since earliest times. Chinese and Japanese chronicles indicate that the shitake mushroom (*Lentinula edodes*) was collected in the wild and was given to the emperors as a tribute. The Romans ate mushrooms on special occasions, and Mexican Indians used hallucinogenic mushrooms in religious ceremonies (De Jonghe, 1997).

The earliest known description of how to grow mushrooms was written by a Frenchman, de Tournefort, and published in Paris in 1707. About 1800, the French started growing mushrooms underground, in the quarries around Paris (Atkins, 1972). In 1894, Costan and Matruchot succeeded in making pure spawn in a laboratory from mushroom spores. But it was Duggar in America who succeeded in making pure spawn from mushroom in 1905 (Atikins, 1972).

2.3 Importance and utilization

There are various extremely important roles that mushroom play in the world. Their usefulness to man as food, as tonics and medicinals and also in the bioconversion of waste organic materials to forms that can enter the major nutrient cycles are all of great benefit to both man and nature.

In nature, the mycelial growth utilizes lignocellulosic materials, such as the polysaccharides of straw and wood, for nutrient materials. Since such substrates are commonly insoluble in water, they are broken down to smaller, soluble units through the activity of enzymes excreted by fungal cells. This bioconversion of insoluble materials results in the production of products rich in protein content (Miles and Chang, 1997).

As tonics and medicines, modern Chinese medicines have succeeded in isolating and identifying compounds from many mushrooms which have been proven to be beneficial in the treatment of certain ailments (Miles and Chang, 1997).

As food for man, many mushrooms presently under cultivation are quite nutritious. They contain large amounts of qualitatively good protein, vitamins (B1, B2, C) and minerals and have a low fat content.

2.4 Growth requirements of *A. bisporus*

A. bisporus is grown on fermented substrate (compost). The purpose of composting is to create physically and chemically homogenous substrate, to create a selective substrate in which the mushroom mycelium thrives better than competitor microorganisms, to concentrate nutrients for use by the mushrooms and exhaust the heat generating capabilities of the substrate.

Compost supports the vegetative phase of *A. bisporus* growth but the establishment of the reproductive stage in the commercial system of culture is influenced by the microorganisms colonizing the casing layer (Stamets and Chilton, 1983).

Among the physical growth factors, temperature, moisture, light, aeration and pH are important.

2.4.1 Temperature

Temperature is the most widely studied because of its effect upon the growth of *A. bisporus.* The role of temperature is correlated with enzyme activity, which generally increases with an increase in temperature. Vegetative growth is markedly retarded at temperatures outside the range of 20-28 degrees Celsius. Growth is rapid when temperatures are maintained at the optimum of 24 degrees Celsius (Treschow, 1944).

2.4.2 Light

A. bisporus is grown in the caves or mushroom houses in the dark, because light is actually inhibitory to the development of primordia and affects stipe elongation and expansion (Miles and Chang, 1997).

2.4.3 PH

There are variations in pH involving different strains and species, which may affect the range and optimum values (Deacons, 1984). PH values must be in the range of between six and eight.

2.4.4 Moisture

In considering moisture requirements for the cultivation of mushrooms, there are two important considerations;

1. The moisture content of the substrate and
2. The relative humidity of the atmosphere in which the mushrooms are grown.

Management of both is important. Species may differ in values of humidity, which may also vary at different stages of growth (Miles and Chang, 1997). The water content influences strand formation. In the compost, if moisture content is 40-50%, growth is filamentous with little or no strand formation. in wetter compost (55-56%), strands predominate with little filamentous growth whereas water content exceeding 75% reduces strand formation and the growth of mycelium may stop (Chang and Hayes, 1978). For most mushroom species a relative humidity of 95-100% provides for maximum growth with little loss of moisture content of the substrate by evaporation.

Atmospheric moisture must be carefully managed to allow mushroom development but not to the advantage of competitors. While relative humidity approaches 100% during primordia formation, it should be lowered to levels whereby a constant rate of evaporation is drawn from the fruit bodies. The crop should be sprayed several times a day, as long as the mushrooms, the substrate, or the air soon reabsorbs the excess water. This dynamic process of replenishment and loss encourages the best crops of mushrooms. The humidity in the growing room is often reduced several hours prior to picking, extending the shelf life of the crop. This is where the "art" of cultivation plays a critical role in affecting quality (Stamets, 2000).

According to Rama (2000), in the first stage of mushroom cultivation, the spawn is mixed with compost so that it can successfully compete with other microorganisms for nutrients. The mixing of spawn in compost is called spawning. After spawning, the compost surface is covered with old newspaper sheets, and is sprinkled with water to provide humidity (no water is added directly to the compost during spawn run).

Atkins, (1972), observed that as mushrooms exceed half an inch in diameter, watering should be reduced to a minimum. This is because the caps will tend to stain unless they are dried quickly.

According to Thomas (1999), most mushroom farmers in the United States of America, crop their mushrooms for 30 - 40 days. During cropping, the casing layer (usually peat) is watered 2 to 3 times per week and air temperatures are maintained between 15-18°C. This temperature range favors mushroom growth and lengthens the life cycles of both disease pathogens and pests. Water is applied intermittently to raise the moisture level of the casing layer to field capacity.

In one experiment by Flegg (1999), It was observed that applying 10, 20, 30 and 40 litres of water per square metre to mushroom beds from casing until the casing layer was ruffled (about one week) had no significant effect on crop yields. Measurements of the water content of the compost showed that the upper layer of the compost loses water and the bottom layer becomes wetter. The higher levels of watering hardly affected the water contents of the upper and middle layers of compost but the bottom layer became increasingly wetter with the heavier watering. It was concluded that much of excess water applied drained through to the bottom layer. Even though the bottom compost layer reached water content of 80% yields of mushrooms were not affected. Adding a water-absorbent polymer to the upper layer (5 cm) of compost to increase its moisture content did not affect yield.

2.4.5 Aeration

Mushroom species are aerobic organisms and adequate oxygen is necessary for mycelial running. This vegetative growth may be increased when the level of Carbon dioxide is increased slightly. Carbon dioxide concentration of 0.3 to 0.5% will affect the formation of fruiting body primordia of *A. bisporus* and development of the fruiting bodies that are forming may be modified (Miles and Chang, 1997).

3.0 MATERIALS AND METHODS

3.1 spawning

Spawning was carried out on the 12th July 2002. D 649 commercial spawn was planted to a central height of the compost, by sprinkling the surface of the compost. Compost was turned inside- out to bury the spawn to a depth of 3- 5cm from the surface of the compost. Boxes were later covered with newspapers and watered with a sprayer, in order to keep the surface of the compost moist.

3.2 Casing

The casing material used was pine bark and black soil mixed in the ratio of 1:1 by volume. The area where the black soil came from was a seasonally flooded, and at the time of collection, the soil was dry.

The surface of the casing material was kept moist by watering in the growing room, and the relative humidity was kept as high as possible by keeping the floor wet and frequent water spraying of the growing room.

3.3 Treatments

Three treatments were made and each treatment was replicated three times bringing a total of nine experimental units. The amount of water per treatment was one litre per box per watering. The boxes measured 100 x75 x 20 cm each.

In the first treatment, watering was done every day. To each box, an amount of one litre of water was added everyday from spawning up to the first, second and third flushes.

In the second treatment, a 2-days interval of watering was used. Each box in thi treatment was watered every other day with one litre of water up to the end of th experiment

In the third treatment, a 3-days interval was used between watering.

3.4 Characteristics measured

1. Days to the first, second and third flush

   The number of days, from the time of casing up to the first, second and thir flush were carefully recorded for each treatment, respectively.
2. Weight of mushroom per flush

   For the first, second and third flush, the weight of mushroom was recorded.
3. Total yield of mushroom per treatment

   The total yield of mushroom per treatment was recorded after the end of the third flush for the all treatments.

3.5 Statistical analysis

The boxes were arranged in a Completely Randomized Design with one factor Watering frequency since the environment in the was uniform. The results were analyzed using the F- Test by the MSTATC computer programme. The Null hypothesis was that there was no significant difference in the yields among the three treatments.

4.0 RESULTS AND DISCUSSION

4.1 Flushing Intervals

Casing was done approximately after five weeks. Full colonization of the compost was delayed probably due to fluctuations in temperature, which may have affected the growth of the growth of the mycelium.

Three distinct flushes were observed. The daily watering frequency had longer flushing intervals (12 days between first and second flush). The watering frequency of 2-days had a flushing interval 9 days while that of 3-days had a flushing interval of 7 days. The first flush came earlier in the daily watering frequency (13days). Between the second and third flushes, there was no significant difference in the flushing intervals. Results are as shown in table 1

4.2 Days to the first, second and third flush

The mean numbers of days, taken to the first flush were 13 days, 15 days and 16 days for the daily, 2-days interval and 3-days interval watering frequencies respectively. For the second flush, the number of days taken were 24 days, 22 days and 23 days for the daily, 2-days interval and 3-days interval day watering regimes respectively. For the third flush, it took mean days of 37, 37 and 35 for the three watering frequencies respectively. There was no significant difference on the days to first, second and third flushes at $p = 0.05$ (Table1), meaning, the three watering frequencies used had no effect on the number of days to the first, second and third flushes.

Table 1: Effect of watering frequency on the days to flushes and flushing interval

Frequency Watering	Number of flushes	Mean days to First flush	Interval between 1st and 2nd flush	Mean days to Second flush	Interval between 2nd and 3rd flush	Mean days to Third flush
Daily	3	13	12	25	14	37
2-days interval	3	15	9	23	12	37
3-days interval	3	16	7	23	12	35
LSD		2.40	3.21	2.66	5.67	9.69
C.V (%)		2.40	32.60	9.80	19.70	14.71

LSD: Least Significant Difference at P=0.05

C.V-Coefficient Variation (%)

4.3 Total mushroom yield

The mean yields obtained in the first, second and third flushes were non significant at p=0.05 for the treatments concerned. The mean yields per flush were higher in the second flush compared to the other two flushes. The total mean yields per treatment were 1089.7 g, 1113.9 g and 1530.5 g for the daily, 2-days interval and 3-days interval watering frequencies (Table 2).

The results showed that yields of button mushroom were the same for the three watering frequencies used. Though yields seemed to increase with an increase in the number days skipped during the watering regime, statistically there was no significant difference.

Table 2: Effect of the watering frequency on the yield of button mushroom

Watering Frequency	Number of flushes	Mean Yield 1st flush	Mean yield 2nd flush	Mean yield 3rd flush	Mean Total yield (g)
Daily	3	209.6	478.7	401.5	1089.7
2-days intervals	3	309.4	484.7	319.7	1113.9
3-days intervals	3	447.7	731.6	351.7	1530.4
LSD		136.75	356.75	96.92	599.52
C.V (%)		10.07	36.60	49.72	37.99

LSD- Least significant Difference at $p = 0.05$

C.V-Coefficient of Variation (%)

The yields obtained in general were very low as compared to a similar experiment carried out in Belgium by Flegg. The only difference in experimental procedure was that he observed the effect of water volume on the yield of button mushroom rather than the effect of watering frequency. The results were not significant at $p = 0.05$. He obtained yields of 31. 4, 31. 9, 32. 2 and 31.8 kg/m² mushrooms for the 10, 20, 30 and 40-l/m² water. In this study, the low yields could be attributed to the following reasons:

a) The conditions in which the experiment was carried out did not offer the ideal requirements of button mushroom. The temperatures in the growing room were more than 24 ^{O} C, which is the optimum temperature for mushroom mycelium growth. Mycelial growth is markedly retarded at temperatures outside the range of 20 –28^{O} C (Treschow, 1944). Fruiting is best at 16-20 °C

b) Since casing was done after full colonization of the compost, the yields may have been affected. According to Atkins 1972, early casers aim at minimizing three risks:

– Spoiling the surface of the compost due to direct watering

- Infection of the compost by air borne spores of disease or competitive moulds and

-Arrival of pests such as mushroomflies that burrow into the compost and lay their eggs.

The above reasons are in line with what was observed during the course of the study. The watering frequency of every day affected spawn running "stroma" also called "over lay" or "sheeting".

The growing room was heavily infested by the mushroom flies, which may have interfered with the mycelium in the compost, causing mushrooms above to die (Atkins, 1972).

c) Humidity levels in the growing room were very low. The reason for this is that room humidification was done manually with the Knapsack sprayer. According to Chang and Hayes (1978), for most mushroom species a Relative Humidity of 95-100% provides for maximum growth with little loss of moisture content of the substrate by evaporation.

The other problem encountered though it did not affect the yield was the brown staining of the mushrooms, especially in the every day and to some extent in the after one-day watering frequencies. This gave unpleasant color to the mushroom fruits.

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

Watering frequency of a 3-days interval was found to give higher yields as compared to the watering régimes of daily and 2-dys intervals. However, the yields were non significant for the three watering frequencies meaning that the treatments were the same. The watering frequencies had no effect on the days to the first, second and third flushes.

5.2 Recommendations

Based on this study, other areas of research could include:

- Varying the amount of water added to growing boxes whilst keeping the watering frequency constant.
- Applying different amounts of water in relation to the growth (vegetative and fruiting) stages since mushrooms require less moisture at primordial formation
- Doing a similar study in different seasons to determine the effect the watering frequency on the yield of button mushroom

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