Influence of environmental factors in mushroom yield

Introduction: Mushrooms are like plants when it comes to environment conditions to grow. Despite few similarities mushroom yield depends on the quality of the substrate it grows on, humidity and temperature variability depending on what stage of life the mushroom is in. It is also important the substrate has good moisture content (minimum of 50-70%) and minerals (N2 1-2%,Mg,K,Ca, S, P) composition [1]. Mushroom bodies are made up of 70-90% water and this water comes from compost or substrate while humidity prevents the mushroom from drying out in growing stage. Compost needs to be slightly acidic with pH between 5 and 6.5. Even though mushrooms grow in a warm, humid climate but the temperature and humidity level ideal for them highly depends on its growth stage mushroom type. Here, button mushrooms are taken under consideration in major. Another factor that contributes to mushroom fruiting is CO2 concentration. high con2 level (1,000-2,000 ppm) induces pin sets while low concentration (1000 ppm) is required during growth or harvest[6]. Temperature is a vital factor both while spawning and growing. Low temperature with high humidity favours mushroom yield in general [5]. A good compost is what has good moisture and mineral content. Together good compost and environment (temperature, humidity) is the key to good mushroom yield.   
  
Observation: Environmental factors are necessary to be monitored all the way round the life cycle of mushrooms. Some factors does need alternation depending on the phase of mushrooms while some stay constant and even cannot be changed for example compost composition.

Mushroom growth can be divided into two phases:-

Pinning stage: when mushrooms heads are appeared out of casing of the compost. It is the earliest stage when mushroom caps are under construction and just started to grow. Spawning is another name of this phase.

Growing phase: Growing phase is when mushrooms are little developed, stalk and caps are distinguishable and proceeding towards harvesting period. This phase is longer than pinning.

Both, these two phases are equally important towards mushroom production. Pinning stage is subtle though and depending on this stage the number of mushrooms per bed can be visualised.

Compost interaction with mushrooms-

Compost is a key ingredient in mushroom cultivation. As mentioned earlier mushrooms grow on and take food from compost. Therefore, without proper compost mushroom production can be difficult, if not impossible. There exist three main types: animal –based, plant-based and synthetic compost. It seems synthetic compost is much expensive, and mushrooms grow more in comparison with other types. Compost must have high weight per volume to fill in the case where mushroom are supposed to cultivate and it is proven that mushroom yield is not tied to decomposition of compost but cultivation area with high amount of substrate[3]. [8] suggests, with white mushrooms having specific nutrient requirements, for good yield, high nitrogen, phosphorus and potassium are essential. Concurrently, micronutrients like calcium, zinc and magnesium promotes mushroom growth. Mycelium interacts with the compost and it needs high humidity and warm weather condition. It is vital to maintain the environment suitable for the mushroom alongside humidity and temperature. Therefore, compost needs to be monitored in regular basis. Loss of dry matter, loss of water are two main factors bound to mushroom yield [3].

Factors interlinked with compost and mushroom yield-

|  |  |  |  |
| --- | --- | --- | --- |
| Ingredients | Relevant Factors | Other Factors | Best type of Compost |
| Micro-nutrients: K,Ca,Mg,Zn  Macro-nutrients: N2, P, Na | Regular monitoring, Stable required condition | Humidity and temperature | Synthetic/ mixed compost with organic |

How temperature and humidity influence mushroom growth-  
**A.** High temperature with High humidity mushrooms may develop small in size with light colored caps.   
**B.** High temperature Low humidity causes the caps be thin, umbrella shaped and brittle with thick stripe  
**C.** Low temperature High humidity causes strong color and fruiting bodies but reduced in number   
**D.** Low temperature Low humidity causes dark color caps , thick stripes and few fruiting bodies  
  
The higher the temperature, the faster the growth of mycelium or pins is [4]. This is why in LMF, temperature is set higher during spawn phase in comparison to that during growing phase. During harvesting period temperature was set around 16\*C with relative humidity of 70-80%.

CO2 level needs to be altered accordingly-   
CO2 level must be tightly controlled during mushroom growth in order to achieve high-quality, large sizes and overall yield. A concentration higher than 1000 ppm during growth phase and or harvest phase will turn the yield down. Preferably, 500-800 pmm marks as standard during harvesting period. Leggy mushrooms are cause of high level of CO2 during spawning/pinning as the developing body pushes higher in the air to search for oxygen[6]. Conversely if stems are too short, it is an indication that the pin set was introduced to low level of CO2.

Discussion: Temperature and Humidity play an important role in making sure mushroom cultivation is successful. If pinning phase is compared to harvesting phase, it is more crucial to have balance in Temperature, Relative humidity and CO2 level than that in harvesting phase[4][6]. Pinning decides the number of mushroom when growing period decides how heavy the mushrooms would be. Therefore, pinning stage and growing phase contributions go hands-in-hand in total yield.  
  
Tables

During spawning

|  |  |  |  |
| --- | --- | --- | --- |
| Temperature | Humidity | Yield | Pin Number |
| High | High | Normal | High |
| High | Low | Down(weight) | Not good |
| Low | High | Down(less pin) | Low |
| Low | Low | Down(weight and count) | Restrained |

During Growth

|  |  |  |  |
| --- | --- | --- | --- |
| Temperature | Humidity | Yield | Size |
| High | High | <normal | Small cap, light color, number ok |
| High | Low | <normal | Thin caps, long stalk, number ok |
| Low | High | Good | Strong cap, color |
| Low | Low | <normal | Thick stalk, less number |

CO2 level requisite Comparision

|  |  |  |
| --- | --- | --- |
| Mushroom phase | CO2 level | Result |
| Pinning | 1000-2000ppm | Induces number and faster growth |
| Growing/Harvesting | <1000ppm | Avoids mushrooms be leggy |

Relative Humidity (RH) comparison

|  |  |  |
| --- | --- | --- |
| Mushroom phase | RH level | Result |
| Pinning | In average 80-92% | To avoid mushrooms, dry out while they are in their most metabolic stage |
| Growing/Harvesting | ~80% | To avoid mould and micro-organismic disease |

Conclusion: Three major environmental factors that can be inferred as vital key in mushroom growth are ambience temperature, compost composition and reaction (moisture content), Relative humidity. CO2 level contributes the most at the beginning of both phases: pinning and growing. For pinning CO2 level needs to be higher being roughly 1000-2000 ppm in comparison to that during growing phase[6]

1. Temperature dependency-

It seems mushrooms grow more in number when it the ambience is little warm ¬ 17/19\*C during pinning while in growth phase(harvest phase) ambience temperature is set a little lower but not less than 15\*. [4] concurred with this statement concluding relatively mild warm fixed temperature(16\*C) is suitable for mushroom growth in normal occasions.

1. Compost composition, moisture and reaction dependency-

Compost or substrate is the foundation of mushroom growth and production. It needs to be high in quality: N2 level 2-2.14%, C:N=13:1 [1][7], organic matter=25%, wet in state with moisture level of 50-70%. As mushrooms are made up of nearly 80% water and consumes food from the compost starting from pinning to be picked up, it is crucial to maintain these conditions to have good production of mushrooms. [7] suggests less moisture and organic content causes reduction in yield.It also recommends having compost stable in condition where these elements do not change abruptly, resulting in hight mushroom yield.

1. Relative Humidity dependency-

Relative humidity is adjusted depending on the phase of mushroom likewise CO2 level. It is evident that during pinning stage RH level needs to be 80-92%[2] while the same goes down to more or less 80% when the mushrooms are in growing phase. It also depends on flush as well, like for3rd flush humidity is set to 80% or even less while for the 1st flush it is set to 80-90%[LMF provided data].

1. CO2 dependency-

Mushrooms grow faster with higher CO2 concentration(1000-2000ppm) given when it is in pinning stage in search of oxygen at higher level than the compost. Adversely, co2 level needs to be <1000ppm when mushrooms are in growing stage or harvesting mode, otherwise, mushrooms will end up being leggy, with reduced cap size and weight.

As a side hustle, air circulation needs to be taken care of either making sure air can flow through the mushroom caps easily without causing any trapping, that is why farm uses fan for ease circulation when mushroom separation facilitates this. To conclude, compost composition (type of manure or straw, N2 content) and water content (wet-roughly 60%) alongside right temperature and CO2 level (different for pinning and growing as mentioned above) decides yield to go good or bad.

Reference:

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