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Role of supplementation in mushroom cultivation: A Review

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Abstract
Mushroom cultivation needs a special kind of process called the agronomical process which consist of the cultivation of mushroom using different substrate which is rich in carbon and nitrogen source for growing mushroom with higher nutrition content. Different supplements of carbohydrate, protein, vitamins and protein are used with the substrate to increase the yield and quality of mushroom. However, there is still many controversies on the nutrition which is required by the mushroom for its proper growth and development, and also on the development of new commercial additives. It is also seen that addition of external additives increases the yield and quality of some low-yielding mushroom that is why it is a useful tool foe the industry to introduce some new commercial verities of mushroom. One important thing which is beneficial for environment in mushroom cultivation is mushroom usually grow on the waste of agriculture and after the crop is harvested again its substrate is used as the compost in the field. So, it is very beneficial for the mushroom cultivation and also for the crop production. On the other hand, it also provides the very great area of research. Some supplements used for the cultivation of mushroom and their agronomic potential in terms of yield and quality are reviewed in this paper which not even help in recycling the agriculture waste but also helps to produce a high cost product from the, low cost substrate.

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I. INTRODUCTION

A most of the cultivated mushroom belongs from the species of basidomycitoes. Some species from the ascomycetes from the genera Morchella or Tuber have also been cultivated successfully. (Rubini et al. 2014; Liu et al. 2017). Mushroom are also heterotrophic organisms. Heterotrophic are those organism which also require nutritrion from outside for there development. The mycelium which is vegetative provide nutrition for the growth of basidomes(reproductive stage) (Taylor and Ellison 2010). Mushroom is a rich source of many enzymes such as (laccases, lignin peroxidases, manganese peroxidases, arylalcohol oxidase, aryl-alcohol dehydrogenases or quinone reductases), and hemicellulose and cellulose-degrading enzymes (xylanase, cellulases or cellobiose dehydrogenase), to facilitate the degradation of lignocellulosic substrates (Sánchez 2009; Kabel et al. 2017; Vos et al. 2017). Like any other organism mushroom also requires the optimum condition for its growth. Carbon and nitrogen are the two main micronutrition for any fungi for its structure . other essential micronutrition for the mushroom are P, K and Mg. other important trace elements for mushroom cultivation are Fe, Se, Zn, Mn, Cu and Mo. (Chang and Miles 2004).

The first step in mushroom cultivation starts from the solid fermentation process. In spawning step of mushroom cultivation the mycelium grown under the optimum and aseptic environment. (Zervakis and Koutrotsios 2017). There are basically two methods for the formation of substrate used in mushroom cultivation, and both the methods can be optimized according to the species of mushroom which are going to be cultivated. One common thing between both method is both the methods are based on the agriculture by product such as plant fibre/husk, manure or sawdust: materials used in compost preparation are prepared by pasteurization and sterilization. (Pardo et al. 2017; Kabel et al. 2017; Vos et al. 2017). Agaricus bisporus (Lange) Imbach (AB) or A. subrufescens Peck (Pardo-Giménez et al. 2014; Pardo et al. 2017), Pleurotus ostreatus (Jacq: Fries) (PO), P. sajor-caju (Fr.) Singer or P. cistidiosus O.K. Mill. (Chang and Miles 2004; Sánchez 2010).

The non composte materials of by product from agriculture is prepared by steam sterilization before the inoculum of mycelium is added into it. Certain commercial species are produced employing this kind of substrate, including Lentinula edodes (Berk.) Pegler (LE), Auricularia sp., Flammulina velutipes (Curtis) Singer, Pleurotus eryngii (DC.: Fr.) Quel., Agrocybe aegerita (V. Brig.) Singer, Volvariella volvacea (Bull. Ex Fr.) or Hypsizygus marmoreus (Peck) Bigel (Chang and Miles 2004; Estrada et al. 2009; Liang et al. 2016; Xie et al. 2017; Kleofas et al. 2014; Yamanaka 2017).

Different mushroom species required different optimum condition for its growth. Such as the white button mushroom which is the most cultivated mushroom requires the casing overlay to cover the colonized substarte in order for the mushroom fructification (Pardo-Giménez et al. 2017a).

Providing mushroom supplement is the method of physical farming in which supplemets are mixed with the substrate during composting , spawning or casing. (Estrada et al. 2009; Pardo-Giménez et al. 2012a, 2016). This idea of adding supplementes at the time of composting or casing was first time used in the 1960s. (Schisler and Sinden 1962; Sinden and Schisler 1962; Lemke 1963). And this technique is worldwide used and fully accepting.

The present mini-review gives or provide the information about the different supplements used in the mushroom cultivation and there uses and advantages. (Zhang et al. 2014).

Formulation of nutritional additives for mushroom cultivation

Every micro organism requires an optimum condition for its proper growth and function, and mushroom is a fungus which also requires an optimum condition for its growth and development (Zied et al. 2011). Mushroom basically requires the optimum concentration of carbon to nitrogen ration for its proper growth. defatted vegetable meal, which includes soya bean, and other organic proteins sources and are commonly used as the supplements. Among all the defatted vegetable meal creal bran is the most enriched source of minerals and vitamins, and is ferequently used in the cultivation of mushroom mainly Agaricus and Pleurotus species (Zied et al. 2011; Burton et al. 2015. There are various other suppliments which are also used in the cultivation of mushroom among them most of were designed to supplement in the stage of phase II (at spawning) and phase III (at casing). The commercial products mostly designed are produce by amycel, champfood, lambart, havens, and everris. In addition with these supplements a new approach of low cost by products are also increasing day by day. Other by products such as cereal meals and brans, chicken manure, cottonseed meal, urea, superphosphate, ammonium sulphate, grape pomace, feather flour or defatted meals from dry nuts are also used in the mushroom cultivation in Brazil and Europe (Zied et al. 2011; Pardo-Giménez et al. 2016, 2018).

Experiment on cultivation of mushroom reveals that 20% to 40% of compost and 20% raw two-phase olive mill waste gives the best result for Pleurotus spp. and Agrocybe cylindracea. Every species of mushroom requires different substrates and supplements for its growth , Flammulina velutipes species of mushroom require high amount of concentration of alperujo which is a great potential for the cultivation of species like Pleurotus spp. and Agrocybe cylindracea. In Spain A. bisporus and P. Ostreatus need some commercial additives such as grapeseed meal, defatted pistachio meal or defatted almond meal for cultivation (Pardo-Giménez et al. 2012a, 2016, 2018). Supplements consisting of 25% ration of soybean, black bean, wheat bran and chia is used for the cultivation of mushroom usually A. bisporus (Colmenares-Cruz et al. 2017). .

On trials it is also reported that corn husk, oat husk, soy bean nuggets and peanut shell, along with soya as a nutritional supplement are used for the cultivation of oyster mushroom in straw-based substrates at spawning and it is noted that it produce a mushroom with high protein content (Jeyanthi Rebecca et al. 2015). Other supplements are also used in the cultivation of oyster mushroom in different parts of the word, for example in Iran wood chips, boll, sugar beet pellet pulp and palm fibre along with wheat bran, rice bran, soya cake powder, soya cake powder and rice bran and carrot pulpare used as the supplements in the substrate for the better growth and development (Jafarpour et al. 2010).

Application of mushroom supplements

There are number of applications of mushroom and supplements also. There are several other factors also which directly affect the growth of mushroom cultivation. Correct timing and techniques for the mushroom cultivation is very important for the best expected result in mushroom cultivation (Desrumaux et al. 1999). Another very important factor in the mushroom cultivation is the control of temperature for mycelia growth before and after the casing. also, the choice of supplements used for the cultivation play a important role in proper development of mushroom.

It is very important to achieve the successful formulation of supplements for the proper growth of mushroom cultivation. It is necessaires to develop a supplement which retards the availability of nutrition in mushroom cultivation. This concept of delayed nutrition during spawning was first time noticed or reported by Carrol and Schisler (1976) by the treatment with formaldehyde. According to the author the formaldehyde limited the solubility and also it denatures the protein present in the supplements along with this it also inhibited the growth of competitive moulds which allow the mushroom mycelium to grow properly and get the adequate nutrition for its growth, this also gives the mushroom the whole control over the mass of compost. Another very important point to kept in mind is to control the temperature after adding the supplements to the compost. Immediately increasing in temperature after adding the supplements may not give the proper result, although now a days a well-equipped machine are used for the control temperature control, a well air condition, growing rooms are made for the mushroom cultivation. Therefore, all the optimum condition are maintained and are able to controlled so, there are less chances of development of any unwanted mould in the compost.

The nutrition content in the mushroom by using the supplements

Mushroom is a source of many nutrition content and proteins. The mushroom which are grown on Agro industrial waste, agricultural waste and biological waste have more content of nutrition available in them. It is also reported that the oyster mushroom which were grown on 100% sugar bagasse and 100% corncob have higher content of protein and fibres in them, then the mushroom which were grown on the 100% sawdust. Furthermore, mushroom grown on the supplements also possess the presence of trace elements, and this can complete the concentration of trace elements deficiency which is generally present in human diet. As we know that mushroom need a substrate for its growth, so, every species of mushroom needs a different substrate with different optimum condition, and these substrates along with the supplements used for cultivation play a very important role in the quality and quantity of mushrooms. Compost with supplements such as defatted pistachio meal and defatted almond meal significantly increases the quality and quantity of white button mushroom like this different concentration of saw dust along with wheat bran, rice bran or maize powder effect the quality and quantity of Lentinula edodes. Among all the techniques and all the supplements used in compost the best result is shown by Pleurotus species which was produced on the substrate which contains grape marc or olive mill wastes.

Apart from all the application of mushroom one very important application is , for mushroom cultivation biological and Agro-agriculture waste is used which not only convert the convert a low cost product into a high cost valuable product but also it helps to recycle the waste. According to the survey in 2013 around 170_204 billion waste is used for mushroom cultivation. This waste from agriculture and biological waste is a rich source of protein and nitrogen content.

New varieties of cultivated mushrooms to diversify the industry: *Agaricus subrufescens*

Five different species of mushroom consists of whole 85% of the whole edible mushroom. Those five are Lentinula edodes (shiitake), Agaricus (mainly Agaricus bisporus), Pleurotus spp. (5 or 6 species), Auricularia and Flammulina (Royse et al. 2017). It is reported that supplements have a good impact on the quality and quantity of mushrooms. Although many species of mushrooms are cultivated worldwide but many species of mushroom are not cultivates due to their commercial limitation. Along with this it is also reported that cultivation of mushroom on supplements of medicinal mushrooms improve its quality such as Agaricus subrufescens. It is also known as sun mushroom. Ellis & Everh (Zied et al. 2018). Some good effects of soybean meal and other by-products from soybean is also seen in the sun mushroom. Zied et al. (2011), Wang et al. (2010), Zhou et al. (2010). In addition with this agro-industrial waste (provided by peanut and acerola juice) and noble grains, a mix with bran of soybean, corn, and cotton have a role in effective increase in the yield of the sun mushroom. Some trace elements like S, CU, Mn are also an ideal supplements for some species of mushroom.

Bioinoculants as an alternative or addition to traditional supplementation

Like different nutrition is required by mushroom for its growth at different stages like that bioinoculants also develop at different stages to support the mycelium growth. Certain microbiota like Azotobacterial, Bacillus, Penicilliums and Pseudomonas helps in the increasing the mycelium growth. while some antagonism against competitive moulds, have also been reported as candidates for the design of alternative nutritional supplements/biofertilizers (Payapanon et al. 2011; Jadhav et al. 2014; Pratiksha et al. 2017). Bacteria from the genera Bacillus, Pseudomonas or Bradyrhizobium recosded to be beneficial for the mycelium growth. Of some cultivated species like (A. bisporus, A. bitorquis, A. subrufescens, P. ostreatus or P. eryngii) and some genera Pseudomonas also help in mushroom fructification in casing. (Kertesz and Thai 2018). With the changing word there are lots of biofertilizer are available based on bacterial and fungal, which promote plant growth. (Goswami et al. 2016), but till now there is no particular supplements based on the mushroom promoting microorganisms. Next generation sequencing is the advance technology by which we can collect the information about the micro-organism which inhabits the substrates used in mushroom cultivation (McGee et al. 2017a, b; Kertesz and Thai 2018; Vieira and Pecchia 2018; our unpublished results). Other technologies such as omics, metagenomics, met transcriptomics, metabolomics, sets the basis for the bioinoculants.

Overview and Perspectives

The technique of using the agriculture waste as the supplements for the mushroom cultivation is not only eco friendly but also cost effective but however some technical and economical issue is still limits it to used globally.

Majority of the supplements used in the mushroom cultivation are rich in nitrogen source which enhance the mushroom growth but it is unclear that supplements which are rich in carbon source such as cellulose and hemicellulose can also enhance the mushroom growth or not. In comparison to protein rich content some supplements which are rich in carbohydrate such as agriculture and commercial waste are much cheaper and readily available (Pardo-Giménez et al. 2016). However, it is noticeably recorded that supplements with protein based is the profitable investment because mushroom growth on protein rich supplements have better quality and quantity. Along with the nutritional additives it is also a useful tool in SMS in new cycle. It is also a good source of waste management of agriculture waste. Although the interaction between the mushroom and the environment have a very good niche interaction which is barely described. Microorganism play a very vital role in mushroom cultivation at different stages of mushroom cultivation therefore future prospective of improving in mushroom yield would be benefited if we have the deeply information of various microbiota.

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