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Cultivation of *Agaricus blazei* in the environmental protection area of the Baturité region under three types of casing soils

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ABSTRACT. The outdoor cultivation (ditches) of *Agaricus blazei* was evaluated in the protected natural area (APA) of the mountainous region of Baturité on three types of casing soils (A, B and C). Casing soil A (horizon A) of the local soil was used (Alfisol). Casing B was obtained with a mixture of 30% of eucalyptus charcoal (1-2 cm of length) and 70% of horizon B of the local soil. Casing C was composed of 25% of vermiculite, 25% of coconut fiber and 50% of coarse sand. Temperature, relative humidity and pluviometric rates were monitored. The physical-chemical properties of the three casing soils were analyzed. The effect of the casing soil on the number and weight of the mushrooms, productivity, yield and biological efficiency of *A. blazei* were evaluated. The yield, productivity, biological efficiency and number of mushrooms were higher when using soil A. The highest productivity for soil A was attributed mainly to the physical characteristics, which were considered more appropriate for the cultivation, in addition to the high pluviometric rates and relative humidity. The productivity with soil A (9.62%) is comparable with the average productivity obtained in Brazil, meaning that the cultivation of *A. blazei* in this APA may have good perspectives for cultivation.

Key words: *Agaricus blazei*, outdoor cultivation, casing soil, medicinal mushroom.

RESUMO. Cultivo de *Agaricus blazei,* na área de proteção ambiental da região de Baturité, em três tipos de camada de cobertura. Foi avaliada a possibilidade de cultivo em ambiente desprotegido (campo), do cogumelo *Agaricus blazei,* na área de Proteção Ambiental (APA), da região montanhosa de Baturité (CE), com o uso de três tipos de camada de cobertura (A, B e C). A camada de cobertura A foi composta de horizonte A de um solo local (Alfisol). A camada de cobertura B foi obtida pela da mistura de 30% de carvão de eucalipto (fragmentos com 1-2 cm) com 70% de horizonte B do mesmo solo local. Já, a camada C foi composta de 25% de vermiculita, 25% de fibra de coco e 50% de areia de construção. A temperatura, umidade relativa do ar e índice pluviométrico foram monitorados e as propriedades físico-químicas das três camadas de coberturas foram analisadas, bem como os seus efeitos relacionados ao número e massa fresca de cogumelos, eficiência biológica, produtividade e produção de *A. blazei*. A produtividade, produção, eficência biológica e número de cogumelos foram mais elevadas na camada A, em relação às camadas B e C. Os valores mais elevados obtidos pela camada A foram atribuídos às suas características físico-químicas consideradas mais apropridadas ao cultivo, apesar das condições de elevados índices pluviométrico e umidade relativa do ar. A produtividade da camada A (9,62%) demonstrou-se compatível com a média de produtividade obtida no Brasil, tendo boas perspectivas de cultivo deste cogumelo nesta APA.

Palavras-chave: *Agaricus blazei*, cultivo desprotegido, camada de cobertura, cogumelo medicinal.

Introduction

The mushroom *Agaricus blazei* is found in Brazil. This species has been the subject of scientific research which has shown its important nutritional and medicinal properties. Therefore, there has been an increase in its demand from consumers and the pharmaceutical industry, mainly in developed nations. Commercialization prices, low investment costs, and fast return of invested capital make its cultivation financially attractive (Reichardt, 1990; Eira and Braga, 1997; Braga *et al.*, 1998; Minhoni *et al.*, 2005). The production of this mushroom has promising ecological aspects. Firstly, compost made of agricultural and agro-processing wastes is used as substrate (Quimio *et al.*, 1990; Kopytowski Filho, 2002). The differences as of mycelial growth amidst fungi strains already have been reported by a great many authors (Andrade and Graciolli, 2005; Andrade *et al.*, 2007). Otherwise, the spent substrate, chemically and physically enriched, can be used to protect the soil from erosion or as a fertilizer (Vedder, 1986).

In social terms, it creates jobs, settling families down to the land and, as it demands a small cultivation area, it is well adapted to the agricultural model of the area of Baturité (Ceará state), which is based on small farms.

All these factors, as well as the environmental characteristics of the mountainous region of Baturité, make *A. blazei* cultivation an alternative to promote the area socially, economically and ecologically according to the restrictions for land usage imposed by the protected natural area (APA). Regional alternatives utilized as casing soil constitute important factors for the crop success. Yet transportation of great amount of material makes them unfeasible.

The objective of this research was to evaluate the effects of three types of casing soils on the number, fresh weight, productivity, yield and biological efficiency of *A. blazei*.

Material and methods

The experiment was carried out from January to March 2003, in Guaramiranga (CE), Brazil (4°16'55"S and 38°55'23"W). The area is 850 m above sea level and, according to Köeppen, the predominant climate is Aw (warm and wet), with annual precipitation varying from 1,000 to 1,500 mm.

Compost

The compost was supplied by the company Blazei Nordeste Ltda., with an initial C/N ratio of 25/1 and 63.8% moisture at spawning.

Spawning and Colonization

Strain BZ-04 (BRASMICEL/SP) was added to the compost (15 g kg^{-1} of fresh compost) and placed in plastic bags (11.5 kg of fresh compost). Spawn run (colonization) was carried out for 20 days at 26-28°C.

Casing Soils

Three types of casing soil were elaborated mainly with local materials.

Soil A: Horizon A (0 to 15 cm deep) of the local soil was used (Yellow-Red Argissoil). Calcium carbonate was added at the ratio of 13:0.1 v v^{-1}.

Soil B: Obtained from horizon B (100 cm deep). Fragments of charcoal (0.5 to 1.5 cm) and calcium carbonate at the ratio of 10:3:0.1 v v^{-1} v^{-1} were added.

Soil C: Coarse sand, coconut fiber, vermiculite, and calcium carbonate at a ratio of: 20:10:10:0.3 v v^{-1} v^{-1} v^{-1}. The fiber (mesocarp) was acquired from the coconut industry, rinsed and dried. Soil C was disinfected with formalin: 1 L for 9 L of water per cubic meter of casing soil.

Physical-chemical characterization of the casing soils

The analyses were carried out according to the methodology adopted by Embrapa (Ferreira, 1996). The analyses of the casing soils are presented in Table 1.

Table 1. Physical-chemical characterization of the casing soils.

Determination	Casing Soils		
	A*	B*	C*
Total Sand (g kg^{-1})	646	530	847
Silt (g kg^{-1})	167	250	86
Clay (g kg^{-1})	187	220	67
Water dispersed clay (g kg^{-1})	47	127	34
Textural Classification	sandy loam	sandy clay loam	loamy sand
Flocculation degree (g 100 g^{-1})	75	42	50
Global Density (g cm^{-3})	1.32	1.19	1.41
Moisture at 0.033 MPa	14.9	23.5	7.0
Moisture at 1.5 MPa	10.2	12.0	2.9
Useful Water (g 100 g^{-1})	4.7	11.5	4.1
pH - in Water (1: 2.5)	7.9	7.8	8.4
EC (dS m^{-1})	0.89	1.06	1.14
Ca^{2+} (cmol kg^{-1})	23.4	23.1	22.6
Mg^{2+} (cmol kg^{-1})	1.3	1.7	1.7
K^{+} (cmol kg^{-1})	0.24	0.46	0.27
Na^{+} (cmol kg^{-1})	0.23	0.37	0.35
Al^{+3} (cmol kg^{-1})	0.0	0.0	0.0
CEC (cmol kg^{-1})	25.2	25.6	24.8
C (g kg^{-1})	16.90	10.48	3.46
OM (g kg^{-1})	27.14	18.07	5.97
Assimilable P (mg kg^{-1})	1	3	1
Zn (mg kg^{-1})	6.2	0.3	0.2
Mn (mg kg^{-1})	1.9	1.0	1.0
Fe (mg kg^{-1})	24.3	0.6	0.7
Cu (mg kg^{-1})	0.5	0.1	0.2

*n = 3. EC = electrical conductivity, CEC = cationic exchange capacity and OM = organic matter.

Cultivation

Cultivation took place in a bordering area of native forest, measuring 6.8 x 5.1 m, at a 6.5% slope. Five parallel beds (4.8 m long, 0.40 m wide and 0.20 m deep) were installed along the slope. Each 1.6 lineal meter of bed constituted an experimental unit with 57.2 kg of compost and casing soil 5.5 cm in depth. Thirty centimeters of dried grass (*Melinus minutiflora*) were used to protect against dryness.

Harvesting

Harvesting was performed manually when the mushrooms reached 70% cap opening. Residues of soil and substrates were removed from the stipe with a knife (Reichardt, 1990).

Evaluated parameters

The following variables were appraised: number of mushrooms, yield, productivity and biological efficiency. Productivity (P) was expressed as fresh weight of mushrooms/fresh weight of compost x 100. Yield (Y) was expressed as fresh weight of mushrooms m^{-2}. Biological Efficiency (BE) was expressed as fresh weight of mushrooms/dry weight of compost x 100.

Statistical design

The treatments were randomly disposed in five repetitions. Analyses of variance were performed and mean separation carried out by Tukey test (5%) (Flegg *et al*., 1985).

Results and discussion

Climatic Monitoring

A precipitation of 969 mm was observed during the cropping period. The values of temperature (°C) and relative humidity (%) are observed in Figures 1 and 2.

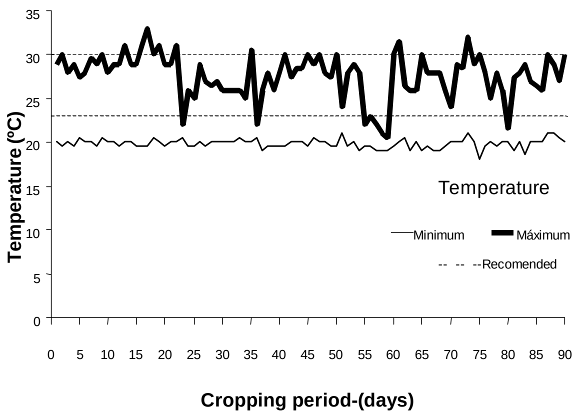

Figure 1. Maximum and minimum temperatures at cropping.

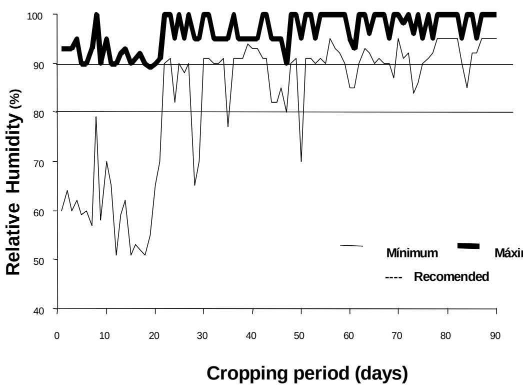

Figure 2. Maximum relative air humidity at cropping.

Evaluation of the casing soils in mushroom number, fresh weight, yield, productivity and biological efficiency of *Agaricus blazei*

The results of the Tukey test evidenced that the averages of all the variables of soil A were significantly higher. This was also observed in Soil C for the number of mushrooms, and in soil B for the average weight of the mushrooms, as it can be observed in Table 2.

Physical properties

Bononi *et al*. (2001) describe the desirable granulometric composition with contents from 27 to 43% of total sand, 11 to 22% of silt and 49 to 55% of clay. According to the data presented in Table 1, Soil A has 64.7, 16.7 and 18.7% of total sand, silt and clay respectively. Soil B has 53, 25 and 22%, and Soil C shows 84.7, 8.7 and 6.7%. In relation to the total sand, all the investigated soils surpassed the values mentioned by Bononi *et al*. (2001), mainly Soil C. For silt contents, only soil A matched the recommendation. For clay contents, none matched the recommended minimum values. For soils A and B, the textural classification was sandy loam and sandy clay loam, respectively, closer to the condition of a desirable medium texture (Embrapa, 1997). The clay values found in A and B, still taking into account the data of Table 1, were higher than the ones found in soil C, reinforcing the possible superiority of the first two soils, for better potential in water retention. However, the granulometric composition, in spite of some indications, does not allow us to trace a qualitative profile of the three investigated soils for *A. blazei* cultivation.

In relation to the contents of natural clay, there is a superior condition for soil A before B, because, although relatively close, soil A shows a presence of natural clay almost three times lower than B. In soil C, the lowest amount of clay in its granulometric constitution explains the proportionality and the low contents of natural clay. The flocculation degree presents direct relationship with the stability and, as it takes into account the total clay for its calculation, supplies an idea about the stability of the soils investigated than the contents of natural clay previously analyzed. Therefore, the values 75, 42 and 50%, respecttively for soils A, B and C, do confirm the superiorrity of soil A in terms of stability in relation to the other two. As for the pluviometric data in the cultivation period, this characteristic was certainly important for soil A not suffering serious structural damages, a desirable condition (Gier, 2000; Bononi *et al*., 2001) which had higher production and productivity possible.

The condition of similar stability in the other two soils is consistent with the results of the averages of the analyzed variables (Table 2), indicating proximity in the values, though only fresh weight of mushrooms is differing statistically.

It is known that the density of the soil affects the porosity and this porosity proportionally influences the capacity of water retention, pH, electric conductivity and organic matter of the casing soil. All these factors together determine the quality and the usefulness of the casing soils. The analyses of the physical-chemical properties (Table 1) show that soils A, B and C presented densities of 1.32, 1.19 and 1.41 g cm^{-3}, respectively.

Table 2. Averages of the variables in function of the casing soils (A, B and C).

	Averages				
Casing Soil	Number of Mushrooms	Fresh Weight (g)	Yield kg m^{-2}	Productivity (%)	Biological Efficiency (%)
A	75.4 A	72.28 A	8.51 A	9.62 A	25.97 A
B	56.6 B	67.14 A	5.94 B	6.65 B	18.11 B
C	65.2 AB	57.01 B	5.82 B	6.51 B	17.73 B

*Means followed by the same lower case letter within a column do not differ significantly (Tukey test, 5%).

Reichardt (1990) determined densities of sandy soils ranging between 1.4 to 1.8 g cm^{-3}; however, the texture of loamier, fine soils have arrangement possibilities of much larger particles, with their porous space constituted essentially of a large volume of micropores and, according to this author, presenting a little larger density interval ranging from 0.9 to 1.6 g cm^{-3}. This means that soil B, followed by A, presents a larger capacity of water retention when compared with soil C.

The capacity of water retention, a requirement for a good casing soil, is directly related to the weight of the mushrooms. This can explain why the averages of soils A and B have differed significantly from the average of soil C, for the weight averages of the mushrooms.

The values found in the three treatments (Table 2) demonstrate the superiority of soil B over the other treatments in relation to the capacity of water retention, confirming the analysis of the previous item and in agreement with Gier (2000) and Singh *et al.* (2000). On the other hand, the high pluviometric rates observed, as well as the capacity of water retention of the coal and the larger amounts of clay present in soil B, favored an excess of water retention, occurring constant soaking and committing the permeability and damaging the flow of gases, fundamental to the induction of primordium (Gier, 2000) and, consequently, to form the mushrooms. This fact did not happen with the soils A and C, as they had better drainage and did not present significant differences between their mean numbers.

Chemical properties

The pH of the three soils ranged from 7.8 to 8.4. The pH recommendation for casing soil *A. blazei* is 7.0 and 7.5 (Bononi *et al.*, 2001). In case of a higher dose of limestone added, it does not cause negative influences, because of soil buffering. Therefore, while being within the acceptable pH range parameters or relatively close to them, one cannot credit a significant influence in the averages of the analyzed variables.

There is an inversely proportional relation between the number of primordium and electric conductivity. Electric conductivity over 7 dS m^{-1} has a negative influence in the quality and, especially, in the amount of produced mushrooms; some negative symptoms can be noticed starting from 3 dS m^{-1}. The values of electric conductivity for the treatments A, B and C, were lower than the limiting values described by Gier (2000). As the values were relatively close, such as for pH, it is unlikely that they had any influence in the averages of the analyzed variables.

The presence of organic matter in the casing soil increases undesirable microorganisms in the composition, while the impacts of physical-chemical properties of the casing soil in the production of *A. bisporus*, verified have in general, low levels of organic matter were related with low productions. This is justified if the positive influences that the organic matter exercises on the physical properties of the soil are taken into account, in reference to density, structures, consistence, water retention, aeration and drainage.

For the treatments A, B and C, the values for the organic matter were 27.14, 18.07 and 5.97 g kg^{-1}, respectively. They can explain the superiority of soil A over the others, and also of soil B over C, regarding the physical properties previously analyzed, justifying the best averages of production and productivity in the same order of the presence of organic matter.

Usually, there is not enough information about the presence of macro and micronutrients in the casing soil, neither about their effects in the production of mushrooms. Casing soil should have reduced contents of nutrients, as they might increase the population of undesirable microorganisms.

In the results referring to macronutrients, no remarkable difference of content was verified between the treatments. Considering magnesium seen as a toxicant element by most authors (Gier, 2000), its levels were slightly lower in soil A comparative to B and C, this could be a positive factor for the best yield.

Iron, in its reduced form (Fe^{2+}), is known for its negative effect in fructification, however, when oxidated (Fe^{3+}), the opposite is observed (Singh *et al*., 2000). Iron, without distinction among the valance, as well as zinc, copper and manganese, are stimulants to fructification, as they have a significant role in the elimination of quinone, which is a metabolite released by the mycelium of *A. bisporus* that inhibits its fructification.

Biological properties

Only soil C was treated with formalin and, taken into consideration the composition and the disinfection condition of these materials, it is very probable that soil A was richer in biodiversity, followed by B and C.

Presence of microorganisms in the casing soil is related to the formation of primordium and, in axenic conditions, they may be substituted by activated coal (Braga *et al.*, 1998). Therefore, a larger presence of microorganisms in soil A would justify its largest number of obtained mushrooms. In relation to soil B, it was expected that the coal, although not activated, would induce primordiums, providing a better position of that soil before the others for number of mushrooms. The physical attributes of soil B probably contributed to a reduced number of mushrooms in relation to the soils A and C. Considering the important role of microorganisms in the induction of primordium (Eira and Braga, 1997) it was expected that the average of mushrooms in soil C to have been the smallest of the three. However, other factors, such as the absence of pollutants or the physical condition of the soil, must have acted isolated or interactively for not having reached the expected results.

The fact that soil A has stood out can be attributed, in addition to its superior physical and chemical condition (micronutrients), to its greatest biodiversity, which might have created a less favorable environment for the development of pests. It is interesting that this factor is not excluding, i. e., macro, meso and micro biodiversity, acting together and in balance might have favored the good structure of the soil and homeostasis in that compost, providing the due protection for the mycelium, strengthening it against pathogens, or even creating an inadequate medium for the growth of those natural enemies.

Conclusion

Soil A was significantly more productive than B and C, except for the number of mushrooms, as soil C presented the same performance as soils A and B, and fresh weight of mushrooms, when soil B had similar behavior to soil A.

Outdoor cultivation in the city of Guaramiranga and its environmental conditions made it possible to induce *A. blazei* primordium, with productivity around 6.51% (soil C) and 9.62% (soil A). Therefore, its cultivation is viable in the region.

References

ANDRADE, M.C.N. *et al*. Avaliação do crescimento micelial de linhagens de shiitake, da produção em toras de eucalipto e de alterações físicas da madeira. *Acta Sci. Agron.*, Maringá, v. 29, n. 1, p. 23-27, 2007.

ANDRADE, M.C.N.; GRACIOLLI, L.A. Controle de fungos contaminantes no cultivo do cogumelo comestível shiitake em toros de eucalipto. *Acta Sci. Agron.*, Maringá, v. 27, n. 2, p. 293-299, 2005.

BONONI, V.L.R. *et al*. *Cultivo de Agaricus blazei Murrill*: o cogumelo do sol. São Paulo: Instituto de Botânica, 2001.

BRAGA, G.C. *et al*. *Manual do cultivo de Agaricus blazei Murrill cogumelo do sol*. Botucatu: Fundação de Estudos e Pesquisas Agrícolas e Florestais, 1998.

EIRA, A.F.; BRAGA, G.C. *Manual de cultivo do "champignon" (Agaricus spp.)*. Botucatu: Fundação de Estudos e Pesquisas Agrícolas e Florestais, 1997.

EMBRAPA-Empresa Brasileira de Pesquisa Agropecuária. *Manual de métodos de análises do solo*. Rio de Janeiro, 1997.

FERREIRA, P.V. *Estatística experimental aplicada à Agronomia*. Maceió: Edufal, 1996.

FLEGG, P.B. *et al*. *The biology and technology of the cultivated mushroom*. Chichester: John Wiley & Sons, 1985.

GIER, J.F. A different perspective on casing soil. *In:* GRIENSVEN, L.J.L.D. (Ed.). *Science and cultivation of edible fungi*. Rotterdam: Balkema, 2000. cap. 3, p. 931-934.

KOPYTOWSKI FILHO, J. *Relação C/N e proporção de fontes nitrogenadas na produtividade de Agaricus blazei Murrill e poder calorífico do composto*. 2002. Dissertação (Mestrado em Agronomia)-Universidade Estadual Paulista, Botucatu, 2002.

MINHONI, M.T.A. *et al*. *Cultivo de Agaricus blazei Murrill ss. Heinemann*. 3. ed. Botucatu: Fundação de Estudos e Pesquisas Agrícolas e Florestais, 2005.

QUIMIO, T.H. *et al*. *Technical guidelines for mushroom growing in the tropics*. Rome: FAO, 1990.

REICHARDT, K. *A água em sistemas agrícolas*. São Paulo: Manole, 1990.

SINGH, M. *et al*. Impact of physico-chemical properties of casing on yield of *Agaricus bisporus* (Lange) Imbach. *In:* GRIENSVEN, L.J.L.D. (Ed.). *Science and cultivation of edible fungi*. Rotterdam: Balkema, 2000. cap. 4, p. 441-446.

VEDDER, P.J.C. *Cultivo moderno del champiñon*. Madrid: Mundi-Prensa, 1986.

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