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Evaluación de residuos agrícolas, como sustrato para la producción artesanal del Hongo Ostra (*Pleurotus Ostreatus*)

Evaluation of agricultural waste, as a substrate for the artisanal production of the Oyster Mushroom (Pleurotus Ostreatus)

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Resumen—*Pleurotus ostreatus* es uno de los hongos comestibles más consumidos a nivel mundial, en Ecuador, no existe mucha información sobre el uso de residuos agrícolas que sirvan como sustratos óptimos, ni adaptaciones agroclimáticas del cultivo artesanal de este hongo. El objetivo de este trabajo fue evaluar diferentes residuos agrícolas, como sustrato para la producción artesanal del hongo ostra (*Pleurotus ostreatus*) en la comunidad del Carmen, Loja, Ecuador. Para el desarrollo de este trabajo se evaluaron tres tratamientos con cinco repeticiones para cada tratamiento, los tratamientos fueron evaluados en residuos agricolas de: bagazo de caña (T1), cascarilla de café (T2) y tamo de arroz (T3), las variables que se midieron fueron: precocidad, eficiencia biológica y tasa de producción. El diseño estadástico utilizado fue un diseño completamente al azar evaluado estadísticamente mediante un ANOVA con el programa estadístico R. Los resultados indicaron que para el tratamiento con bagazo de caña (T1) la precocidad encontrada fue de entre 34 y 44 días, obteniendo una producción promedio de 25 % y una eficiencia biológica de 15 %. Para el cultivo del hongo en los residuos de cascarilla de cafe. (T2) se observaron problemas de crecimiento; en el tratamiento con tamo de arroz (T3) presentá una precocidad entre 52 y 81 días con una producción promedio de 3,2 % y una eficiencia biológica promedio de 2 %. Concluyendo que el bagazo de caña es el residuo agrícola más recomendado para el cultivo del hongo *Pleurotus ostreatus* en la comunidad del Carmen, Loja Ecuador.

Palabras clave—Bagazo de cana de azucar, Eficiencia biologica, Precocidad, Tamo de arroz, Tasa de produccion

Abstract—*Pleurotus ostreatus* is one of the most consumed edible mushrooms worldwide, in Ecuador, there is not much information on the use of agricultural residues that serve as optimal substrates, nor agroclimatic adaptations of the artisanal cultivation of this fungus. The objective of this work was to evaluate different agricultural residues, as a substrate for the artisanal production of the oyster mushroom (*Pleurotus ostreatus*) in the community of Carmen, Loja, Ecuador. For the development of this work, three treatments with five replicates for each treatment were evaluated, the treatments were evaluated on agricultural residues of: cane bagasse (T1), coffee husk (T2) and rice chaff (T3), the variables that were measured were: earliness, biological efficiency and production rate. The statistical design used was a completely randomized design statistically evaluated by means of an ANOVA with the statistical program R. The results indicated that for the treatment with sugar cane bagasse (T1) the earliness found was between 34 and 44 days, obtaining an average production of 25 % and biological efficiency 15 %. For the cultivation of the fungus in the coffee husk residues (T2), growth problems were observed; in the treatment with rice chaff (T3) it presented an earliness between 52 and 81 days with an average production rate of 3.2 % and an average biological efficiency of 2 %. Concluding that cane bagasse is the most recommended agricultural residue for the cultivation of the fungus *Pleurotus ostreatus* in the community of Carmen, Loja Ecuador.

Keywords—Sugarcane bagasse, Biological efficiency, Earliness, Rice chaff, Production rate

INTRODUCCIÓN

Pleurotus ostreatus is one of the most consumed foods worldwide (Grimm & Wösten, 2018), it ranks second among the most popular edible mushrooms in the western world, below Lentinula edodes (shiitake) and with a crop production between 18 % and 19 % (Puig-Fernández et al., 2020). In 2020, it is estimated that the cultivation of mushrooms represented a consumption of USD 16.7 billion (Sahagún, 2020). This market is represented by medicinal mushrooms (38 %), wild edible mushrooms (8 %) and edible cultivated mushrooms (54 %) (D. J. Royse et al., 2017). In China alone, 87% of the 35,000 million kg of edible mushrooms are produced for annual local consumption (Kapahi 2018). The consumption of mushrooms in European countries, especially in the Nordic countries is culturally accepted (Svanberg & Lindh, 2019). Latin America does not have a culture so developed by the consumption of mushrooms, but as time passes this trend is changing.

In Ecuador, *Pleurotus ostreatus* is an introduced species cultivated especially by many mycology enthusiasts, and only for personal consumption since there is not yet a culture of mushroom consumption as widespread as in other regions of the world. In addition to this, there is almost no research on regional agroclimatic adaptation and substrate use, which is available in the country to cultivate this type of edible mushrooms, being a relatively new activity in the Ecuadorian market, which could be developed in populations with limited economic resources (Cruz et al., 2021). However, it is known that some native communities in Ecuador consume mushrooms collected from the forest as part of their diet (Gamboa et al., 2019).

The lack of information of the adaptations needed to cultivate the *Pleurotus ostreatus* mushroom in different agroclimatic regions, as well as the lack of incentives for rural communities. This has affected the production and commercialization of this mushorrom, despite its great importance in the circular economy and in the production of edible and/or medicinal (Grimm & Wösteb, 2018). A possible solution to improve production and yield is use of local agricultural residues, as these are easy to obtain and low cost, allowing for artisanal production. In addition, by using agricultural residues, it contributes to the circular economy and takes advantage of resource that was previously considered waste.

That is why, the objective of this work was to evaluate different agricultural residues of the main local industries, as a substrate for the artisanal production of the oyster mushroom (*Pleurotus ostreatus*). This work is important because it will allow us to understand how the cultivation behavior of the *Pleurotus ostreatus* fungus is on an artisanal scale in different agricultural substrates with the agroclimatic conditions of Loja where environmental temperatures range from 9 ºC to 21 ºC. In addition to starting to answer questions about the adaptation of cultivation in these cold sites and with high humidity, delivering valuable knowledge about mushroom cultivation to the most vulnerable populations in the sector.

Materiales y Métodos

The research was conducted in the community of Carmen in the city of Loja, between the months of September through December 2021, a community located between the geographical coordinates of 4° 1’ 42.063” South latitude and 79° 10’ 56.654"West longitude, at an altitude of 2060 m.s.n.m. with an average temperature of 23 °C.

A completely randomized design (DCA) was used, with 3 treatments T1) in cane bagasse; T2) coffee husk and T3) rice straw. With a total of 20 gr of mycelium per experimental unit in quintuplicate. The genetic material used to conduct this research was *Pleurotus ostreatus* mycelium acquired from .Edible Fungi DIKARYA". The substrate obtained was sterilized by means of two processes: 1) Exposing the substrate in water at 70 ºC for 30 minutes; 2) In an electric pressure cooker brand INSIGNIA, for 15 minutes and 15 pounds 15 pounds of pressureof pressureusing the programming "Vegetable Steem", after this, calcium carbonate (agricultural lime) was placed in the amount 10 g per bag.

In this study, 2 kg polyphane bags were used for the cultivation of *Pleurotus ostreatus* fungus. Each bag contained 10 g of mycelium and 800 g of dry subtrate composed of local agricultural residues selected from sugarcane bagasse, coffee husks and rice straw. Subsequently, a wet weight was carried out with approximately 65 to 75% humidity (hand test = crush the substrate in the hand and just a few drops of waterfall), (Cruz et al., 2021).

Once the bags of each substrate had been inoculated with the mycelium, the bags were closed with a YONG TELI brand bag sealer, model PFS 300, after this, the contents were mixed homogeneously leaving two small holes in the bags to remove the air and compact the substrate together with the mycelium. The cultivation of *Pleurotus ostreatus* was carried out in greenhouse conditions.

The variables analyzed in this work were: precocity of the fungus where it took as reference the number of days that it takes for the fungus to grow, from inoculation to the appearance of the first primordia subsequently, we performed the calculations proposed by Vega & Frank, (2013), for measuring the rate of production (TP) and the biological efficiency (BE) of the fungus to each of the treatments.

$$EB(\%) = \frac{\text{Weight of fresh mushrooms (g)}}{\text{Weight of fresh substrate (g)}} \times 100 \quad (1)$$

$$P = \frac{EB}{\text{Number of days of the process (harvest)}} \quad (2)$$

The results expressed in percentage were transformed for their statistical processing by the formula $\sin -1\sqrt{\%}$, which guaranteed that they complied with a normal distribution and with homogeneity so that in this way, ANOVA parametric statistics was used. All the results were analyzed by analysis of variance and the means of the treatments were compared by means of Tukey’s Multiple Range Tests; These analyzes were performed with 95% confidence (0.05). The statistical software used was the R studio (Rstudio Team, 2020).

Resultados y Discusión

The precosity of the *Pleurotus ostreatus* fungus cultivated by hand on different substrates was obtained that, the treatment based on cane bagasse (T1) was the most effective relative to the other treatments obtaining development values between 34 and 44 days statistically significant results (P=0.02161). Our results are similar to those reported by Cruz et al., (2021) who observed that in combined substrates of coffee husk, rice husk and sawdust the primordia of P. ostreatus grew between 35 and 45 days. Cardenas (2017), showed that the time to develop the mycelium in cane bagasse substrate was 35 days and Cuervo & Garzon, (2008) found that in cane bagasse the *Pleurotus ostreatus* fungus took 39 days to develop primordia.

Treatment 2 (T2), using coffee husks did not have good results in this research, this is consistent with what was reported by Fan et al (2006) who found that substances in cof-

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fee husks such as tannins and caffeine can have a toxic effect on fungus cultures. Such as *P. ostreatus*, significantly affecting its growth, biological efficiency and production rate. This may be caused by the ability of tannin to act as enzyme inhibitors, preventing the fungus from synthesizing enzymes necessary to degrade the substrate and develop. Mateus et al. (2017) also reports that boiled coffee substrates may be more susceptible to contamination by green fungi such as Trichoderma, which compete for space and nutrients, causing Pleurotus growth inhibition.

Which hindered the growth of P. ostratus within this substrate. This result is possibly due to what was reported by Fan et al., (2006) who reports that in coffee husk substrates there are substances such as tannins and caffeine that can exert a toxic effect on fungal crops, mainly P. ostratus reason why, it can significantly affect the growth of the fungus. Mateus et al., (2017) reports that coffee substrates that are boiled present greater contamination by green fungi. It should be mentioned that, the treatment with rice tamo (T3), presented a precosity between 52 and 81 days (Fig 1). Regarding

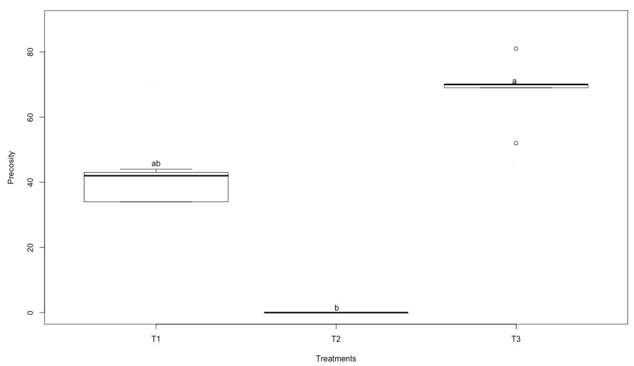

Fig. 1: Precosity of the *Pleurotus ostreatus* mushroom cultivation in different agricultural residues where: T1) in cane bagasse; T2) coffee husk and T3) rice straw.

the production rate (PT), it was obtained that the treatment based on cane bagasse (T1) had higher average values in the production rate of 25 %, statistically significant results ($P \leq 0{,}008082$) (Fig 2). Our results are similar to those found by Cuervo & Garzon, (2008) who found that, in cane bagasse, the TP was 32 %, just as those reported by Cardenas, (2017) indicated a low TP of 15 % in cane bagasse substrate. On the contrary, Cuervo & Garzon, (2008) expresses that by mixing coffee leftovers with sugarcane bagasse, the best results in productivity are obtained. hey express that in their research, however, they do not indicate the percentage of it. Other studies express that combined substrates may be better than individual substrates but do not say exactly which substrates For the biological efficacy (EB), the treatment based on cane bagasse (T1) demonstrated the best results, obtaining a biological efficacy between 5 % and 15 % with statistically significant data ($P \leq 0{,}005678$) (Fig 3). Our results are lower than those reported by Vetayasuporn (2006), who notes in his study that under controlled laboratory conditions, it is possible to achieve a biological efficacy of 103.56 %. However, he reported a biological efficacy of 36 %, which is much higher than what was found in this work.

In order for the process to be economically feasible, as es-

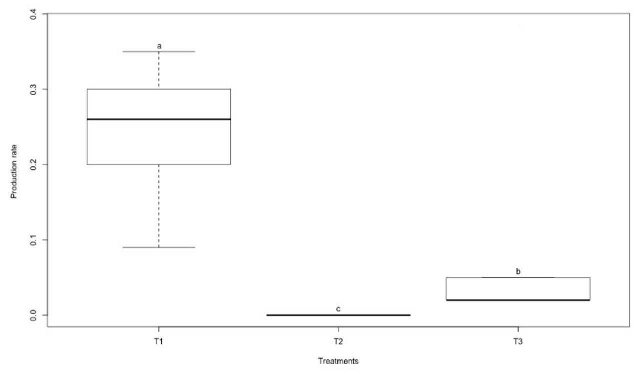

Fig. 2: Production rate (TP %) of the *Pleurotus ostreatus* mushroom culture in different agricultural residues where: T1) in cane bagasse; T2) coffee husk and T3) rice straw.

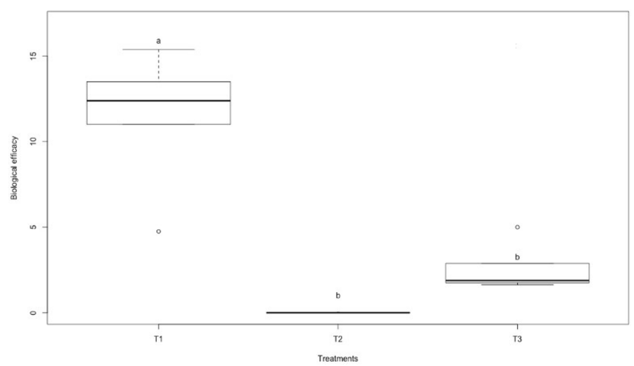

Fig. 3: Biological efficacy (EB %) of the *Pleurotus ostreatus* mushroom culture in different agricultural residues where: T1) in cane bagasse; T2) coffee husk and T3) rice straw.

tablished by the applied technology, the yields must be greater than 10 % and the biological efficiency must reach values of at least 40 % (Puig et al., 2020), therefore, the results of biological efficiency and yield in cane bagasse found in this study would not be satisfactory for biological efficiency, so in EB they were perceived as lower than those found with other authors, however Ríos et al., (2010), express that the low percentages mainly of Biological Efficiency, they are caused by variations in time mainly to the variability of temperature and humidity conditions, causing stress on the development of the fungus, decreasing its metabolism. The treatment with rice straw (T3) did not obtain good yields in terms of the three variables of precosity, biological efficiency and production rate that was measured in this study in addition to this, Cueva & Monzón, (2014) conclude that rice straw is not a good substrate for the cultivation of the fungus, due to its low moisture retention. It is recommended to revise the translation from Spanish to English, and to use technical terms for a good understanding in the English language.

Conclusiones

Although our results are not as expected, we can conclude that the sugar cane bagasse is a good base substrate for the cultivation of *Pleurotus ostreatus*, showing good results in terms of the variables of precosidad and production Rate, but a low activity in the variable Biological Efficiency that can be explained by the climatic conditions of the place where the study was conducted, giving us more information about the behavior of this crop is mainly in conditions of low temperature and high humidity.

Contribuciones de los Autores

RAN): field work, manuscript writing; (ARAS): research, translator, data analysis; (JJRP): article editing, statistical analysis.

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