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STATISTICAL ANALYSIS OF COMMON MUSHROOM YIELDING FROM CULTIVATION INTEGRATED WITH PREPARATIONS CONTAINING BENEFICIAL MICROORGANISMS

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ABSTRACT

The development of the common mushroom production sector in Poland and worldwide is accompanied by growing problems of mushroom producers. Production intensification, a constant increase of market expectations, and changing legal regulations, as well as consumers, lead to the situation that producers of common mushrooms have increasing problems associated with the cultivation technology. This situation, therefore, forces producers to look for new solutions. One of such solutions is integrated cultivation of the common mushroom with microbiological preparations. The effect of these preparations on mushroom yielding was investigated in this study.

Introduction

An increase in purchase prices on the domestic market, a large part of which was exported, contributed to the growth and development of mushroom production in the last decade (Parret et. al., 2005). It should be noted that production costs (mainly labour costs) remained competitive, especially in relation to other European countries (Sahin, 2005). The dynamic development of mushroom production in Poland results from the fact that the costs of manual harvesting of mushrooms in Poland are much lower than in Western Europe, and access to the main markets is unlimited (Niżewski et. al., 2006)). In 2002, producers on the domestic market received PLN 3.14 per kilogram of the common mushroom, and in 2010 – PLN 4.09, i.e. almost by one third more (Olewnicki et.al, 2012).

The pro-export importance of the Polish common mushroom, well-established in the past decades, has been particularly evident in the recent years (Roys, 2014). This was due, among other things, to the fact that at the end of the 1990s the European Union guaranteed high limits of preferential import for the export of these products, which were not even fully utilised (Kubiak, 1999).

Mushroom producers, along with the dynamic development of the mushroom industry, are looking for new solutions that will allow them to meet the expectations of the market, while at the same time searching for technologies that will enable them to reduce production costs and minimize the problems they face. One of the most important problems is to

reduce the incidence of diseases during production cycles and increase the yield obtained (Romaine et. al., 2005, 2007).

Therefore, the effect of preparations containing beneficial microorganisms on the yield of mushrooms was investigated in this study.

Objective and methods

The aim of the study was to evaluate the impact of using preparations containing beneficial microorganisms on the yields of the common mushroom.

The research was conducted in production conditions in halls used for mushroom cultivation, located in Opolskie Voivodeship in Poland, approximately 6 km of the city of Opole. The selected mushroom-growing plant produces about 1200 tons of fresh common mushrooms per year – in 30-day-long cycles. The mushroom-growing plant consists of 15 cultivating halls of the same size and area with the total surface area of 5.250 square metres. The halls have the same layout and computer control system. There are two rows of racks in each hall. Each rack consists of five production shelves. Ten complete production cycles were carried out simultaneously in four cultivation halls. The traditional production of mushrooms took place in one of the cultivation halls, while a new innovative production technology was applied at the same time in three other halls, using preparations containing beneficial microorganisms. In three cultivation halls, individual doses of the preparations containing beneficial microorganisms were studied (doses were marked A, B, C), and the fourth cultivation hall (marked D) was a control hall where no new integrated technology was used. EmFarma and Ema5 preparations, which were applied in combination, were used in the study. Dose A – starting dose with the concentration of 1.6%, dose B – solution with the concentration of 3.3%, dose C – solution with the concentration of 4.9%. These doses were applied on the day of loading the substrate and cover on the shelves and on the 23rd day of the production cycle during the last watering process. Dose D was a control sample where the preparations with beneficial microorganisms were not used (Szwedziak et. al., 2014).

The EmFarma preparation contains key substances such as: lactic acid bacteria, photosynthetic bacteria, fermenting fungi, yeasts, ecological sugar cane molasses, revitalized water, salt, and mineral complex. The composition of the mother culture is as follows: *Bifidobacterium Animals, Bifidobacterium bifidum, Bifidobacterium longum, Lactobacillus acidophilus, Lactobacillus bulgaricus, Lactobacillus casei, Lactobacillus delbrueckii, Lactobacillus plantarum, Lactococcus diacetylactis, Lactococcus lactis, Streptococcus thermophilus, Bacillus subtilis var. natto., Saccharomyces cerevisiae, Rhodopseudomonas palustris.*

The Ema5 preparation contains key substances such as: lactic acid bacteria, photosynthetic bacteria, fermenting fungi, yeasts, ecological sugar cane molasses, wine vinegar, ethyl alcohol, and revitalized non-chlorinated water. The composition of the mother culture is as follows: *Bifidobacterium Animals, Bifidobacterium bifidum, Bifidobacterium longum, Lactobacillus acidophilus, Lactobacillus bulgaricus, Lactobacillus casei, Lactobacillus delbrueckii, Lactobacillus plantarum, Lactococcus diacetylactis, Lactococcus lactis, Streptococcus thermophilus, Bacillus subtilis var. natto., Saccharomyces cerevisiae, Rhodopseudomonas palustris.*

Due to the fact that the application of the above-mentioned preparations should be performed in a specific way with the use of devices enabling their application, a conveyor belt was used for this purpose. Additional elements of the conveyor belt, in the form of a sprinkler system with appropriately selected nozzles, were installed. Due to the fact that the pressure in the liquid distribution nozzles may adversely affect the application efficiency of the preparations causing damage to the cell structures of microorganisms, long 0.3 size ejector nozzles were selected and installed, operating at a working pressure of 4 bars. Additionally, the same nozzles were installed on the irrigation system, which was used during the second stage of applying the preparations containing beneficial microorganisms in the cultivation of the common mushroom. The use of long ejector nozzles does not cause any damage to the cell structures of the microorganisms contained in the preparations, which affects the effectiveness of the proposed cultivation technology. Long 0.3 size ejector nozzles, operating at a working pressure of 4 bars, cause slow distribution of the liquid with the preparation containing beneficial microorganisms owing to appropriately large droplets of the liquid (Tsukamoto et. al., 2002).

Analysis of results and discussion

The obtained results were subjected to a detailed statistical analysis using the PQStat v.1.6.6 software. Table 1 presents descriptive statistics.

Table 1.
Descriptive statistics of the dependence of doses of the preparation containing beneficial microorganisms on crop yield (own source)

Descriptive statistics	Dose A	Dose B	Dose C	Dose D – control
Statistical significance	0.05	0.05	0.05	0.05
Size	3	3	3	3
Arithmetic mean	8.40	8.54	8.20	7.43
Median	5.87	6.03	5.84	4.60
Variance	45.08	47.06	48.13	38.35
Standard deviation	6.71	6.86	6.57	6.19
Coefficient of variability	0.79	0.80	0.80	0.83
Standard error of the mean	3.87	3.96	3.79	3.57

On the basis of the descriptive statistics obtained, normality tests were carried out for each variant considered.

For the variant where the doses of the preparation were compared to the cultivated mushroom yield on the basis of the values observed, the results are shown in Figure 1. The following hypotheses were assumed:

H_0 – distribution differs significantly from normal distribution

H_A – distribution is normal

On the basis of the obtained descriptive statistics of the normality test, H_A was assumed, which indicates that distribution of data is normal distribution. The obtained statistics p for each variant are within the range of 0.06. On the basis of the performed analysis, we have obtained dependency totalling $p<0.05$, therefore there are grounds to reject H_0.

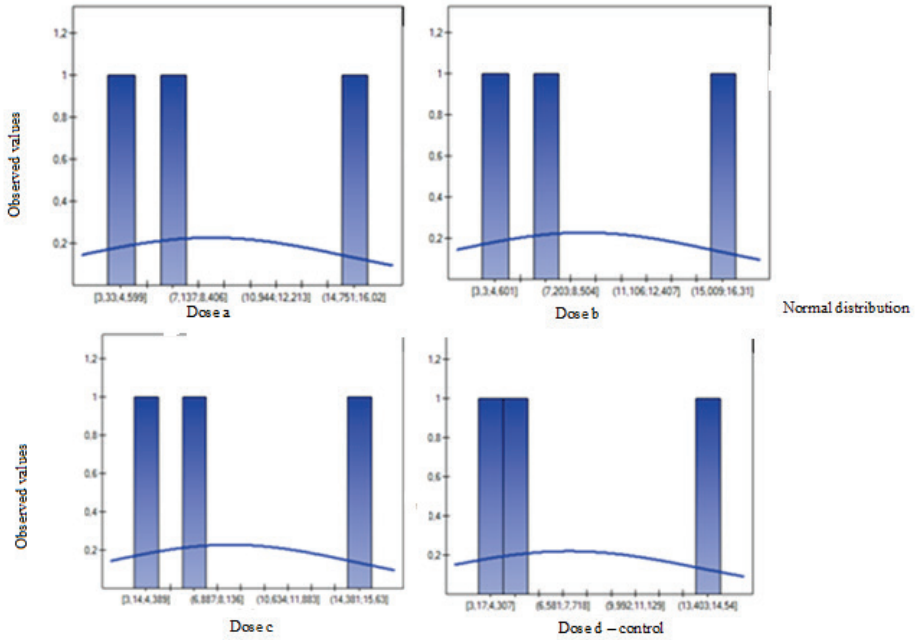

Figure 1. Normal distribution test for individual doses of the preparation in relation to yield

Due to the fact that data distribution is normal distribution, the one-way analysis of variance for dependent groups was used in further analysis.

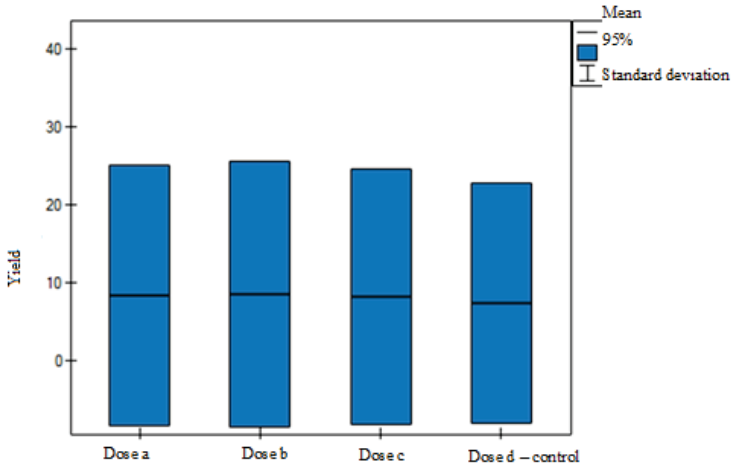

Figure 2. Dependence of doses of the preparation containing beneficial microorganisms on crop yield. Analysis of variance

The obtained coefficient $p = 0.051$, thus $p>0.05$**.** On this basis, we can say that there is a correlation between the size of doses of the preparation containing beneficial microorganisms and the yield of cultivated common mushrooms. By analysing the correlation graph, it is possible to say that the lowest yield was obtained for control dose D, while the highest yield was obtained using dose B.

Conclusions

During cultivation of the common mushroom integrated with preparations containing beneficial microorganisms, there is a correlation between the amount of the preparation used and the crop yield obtained. On the basis of the experiment, it was found that the highest yield of the common mushroom was obtained by applying the dose with the concentration of 3.3%. The yield obtained was 13% higher than in traditional cultivation. This was confirmed by means of using a one-way analysis of variance for dependent groups. The coefficient $p = 0.051$ was obtained, therefore $p>0.05$.

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ANALIZA STATYSTYCZNA PLONOWANIA PIECZARKI Z ZASTOSOWANIEM PREPARATÓW ZAWIERAJĄCYCH POŻYTECZNE MIKROORGANIZMY

Streszczenie. Rozwój sektora produkcji pieczarki w Polsce, jak i na świecie, wiąże się z występowaniem coraz to większych problemów producentów tego grzyba. Intensyfikacja produkcji i ciągły wzrost oczekiwań rynku zbytu, zmieniających się przepisów prawnych, jak i konsumentów, sprawia, że producenci pieczarki mają coraz więcej problemów związanych z technologią uprawy. Sytuacja ta zmusza więc producentów do poszukiwania nowych rozwiązań. Jednym z takich rozwiązań jest zintegrowana uprawa pieczarki z preparatami mikrobiologicznymi. W pracy tej zbadano wpływ tych preparatów na plonowanie pieczarki.

Słowa kluczowe: pieczarka, plon, analiza statystyczna, preparaty, pożyteczne mikroorganizmy