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Use of humic substance and GA3 in *Agaricus bisporus* cultivation

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Agaricus bisporus yetiştiriciliğinde humik madde ve GA3 kullanımı

Abstract: In this study, the effects of commercially used gibberellic acid and humic acid, known as plant growth regulators, on mushroom yield were investigated. At the end, the positive effect of both humic substance and gibberellic acid (GA3) which were added to the irrigation water was determined. The highest efficiency was obtained from the trials in which 0.75% and 1% solutions of both substances were used, on average. According to these results, humic substance or gibberellic acid addition to the post-harvest maintenance water in *Agaricus bisporus* cultivation positively affects the harvest amount.

Key words: *Agaricus bisporus*, cultivated mushrooms, humic, GA3

Özet: Bu çalışmada bitki gelişim düzenleyicisi olarak bilinen ve ticari olarak kullanılan Giberelik asit(GA3) ve humik asitin mantar verimine etkisi araştırılmıştır. Çalışma sonunda sulama suyuna ilave edilen hem humik madde hem de giberelik asit ilavelerinin olumlu etkisi tespit edilmiştir. En yüksek verim her iki maddenin %0.75 ve %1'lik çözeltilerinin kullanıldığı denemelerden elde edilmiştir. Bu sonuçlara göre *Agaricus bisporus* yetiştiriciliğinde hasat sonrası bakım suyuna humik madde veya giberelik asit ilave edilmesi hasat miktarını olumlu yönde etkilemektedir.

Anahtar Kelimeler: *Agaricus bisporus*, kültür mantarları, humik, GA3

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1. Introduction

Mushroom cultivation around the world has developed very rapidly with the use of advanced technologies. Especially *Agaricus bisporus* (J.E. Lange) Imbach, and among *Pleurotus* species *P. ostreatus* (Jacq.) P. Kumm., and including the other mushroom species production rates have increased significantly. As humanity's nutritional needs increase, it is expected result that cultivated mushroom species will also increase due to the search for various foods due to the increase in population. From this perspective, serious progress has been made in the production studies of many macrofungi around the world. It has recently been known that more than 20 macrofungi have been cultured at different levels. Today, the most produced mushroom in the world is the *Agaricus bisporus* species, known as the button mushroom. Parallel to this, the situation is in the same direction in our country. Therefore, some studies have been carried out on champion mushrooms in terms of different substrates, earliness, and yield. Some of these have been reduced to the application field by manufacturers, while others remain in the article lines.

Significant developments have been observed in cultivated mushroom production in Türkiye in recent years, and the production amount reached 65.000 tons as of the end of 2018 (Eren and Pekşen, 2019). There are regional development differences in terms of cultivated mushrooms in Türkiye. This difference is evident between some regions. The Mediterranean Region leads in production (61.5%) and the Marmara Region leads in consumption (40%) (Eren and Pekşen, 2016). However, it is also known that natural mushrooms are used for export rather than cultivated mushrooms in economic terms and are an important source of foreign exchange income (Öztürk et al., 2019).

Different studies have been carried out related to the compost structure (Kaşık and Öztürk, 2000; Baysal, 2004) and the cover material in the cultivation of *Agaricus bisporus* species (Duran et al. 2023; Eren and Boztok, 2013; Çetin and Eren, 2017; Gülser and Pekşen, 2003; Pekşen and Günay, 2009).

The effects of plant growth regulators on plants are evident. Both humic substances and gibberellic acid are used in different periods in plant production and are reported to be effective (Shunkla et al., 1987; Chen and Aviad, 1990; Madrap et al., 1992; Bohme and Thi Lua, 1997; Adani et al., 1998; Nardi et al., 1998; Sharif et al. 2002; Eyheraguibel et al., 2008; Aşık et al., 2009; Saruhan et al., 2011; Engin and Cöcen, 2013).

No study has been found in the literature regarding the administration of plant growth regulators with irrigation water in the cultivation of *Agaricus bisporus*, also known as Champion Mushroom (Sesli et al. 2020). The effects of applying these substances to the cover soil with irrigation water in different solution rates on mushroom culture were examined.

2. Materials and Method

In this study ready-planted compost, purchased from Mega Tesnim company, was used as material. Compost packages were placed in the incubation chamber and incubated at 22-

24 °C and 70-80% humidity to allow mycelia to develop in the compost. Mycelial development was monitored. Following the completion of wrapping the mycelia in compost, the disinfected cover soil prepared using peat was covered on the bags with a thickness of 3-4 cm, and the bags were placed in the production rooms.

The climatic conditions of the production rooms were adjusted to 16-18 °C and 80-90% humidity.

Plant growth regulators were applied in pulverized form to the mycelia that developed in the cover soil and reached the soil surface. Trial solutions were used to maintain soil moisture during primordium development (Fig. 1).

Figure 1. Developing primordiums and young basidiocarps

Gibberellic acid (GA3), known under the trade name Berelex, and humic acid, known under the trade name Humat 75, were used as plant growth regulators. A solution of 0.5, 0.75, and 1 g of plant growth regulators was prepared in 10 L of water. The prepared solution was applied to the mycelia visible on the soil surface and on the bag to prevent soil moisture loss. This solution was used as maintenance water during the harvest period. The amount of solution used was 5lt for each bag. The study was carried out with three replications and four bags were used in each trial. Conditions other than irrigation water were prepared in accordance with the methods applied within the scope of the standard mushroom cultivation process. Temperature, ambient humidity, and ventilation were controlled by automatic systems. The amount of product obtained from each bag during the harvest period was determined separately, and the total amount of product obtained from a bag during the harvest period was determined. The average values of each application were obtained by evaluating the amount of product obtained from the bags followed in each application. The harvest period was determined as 30 days in the trials.

The results obtained were evaluated statistically.

3. Results

In this study, the effects of humic acid and GA3, two plant growth regulators, were investigated and their effects on the harvest amount were examined by giving them as a solution in certain proportions to the maintenance water and cover soil in mushroom cultivation, and the results given in Table 1 were obtained. The results obtained from the experiments were evaluated statistically.

One-way ANOVA was performed to determine the statistical significance of the difference between the groups' averages. Since the p-value of the analysis was 0.859>0.05, the difference between the groups was found to be statistically insignificant. Large measurement variances and small sample sizes reduce the power of the ANOVA test. Considering this situation, the fact that the difference is statistically insignificant does not mean that there is no difference in efficiency. For example, the difference between the average yield of the control group and the average yield of humic acid and gibberellic acid at 0.75 and 1% rates is noteworthy. Although it was not statistically significant, it was observed that there was an increase in efficiency compared to the control group in all trial averages.

The change graphs of the yield amount obtained per bag in the control group and trials in the study are given in Figure 2.

4. Discussions

In this study, the effect of aqueous solutions of humic acid and gibberellic acid, two plant regulators, applied during mycelium development and primordium formation after soil cover, on the yield in the culture of *Agaricus bisporus* species, was examined. During the first appearence of the fungal hypha on the surface of the cover soil, pulverized irrigation was applied according to the moisture of the soil in the bags. Five liters of aqueous solution prepared with plant regulators was used for each bag. After the mushrooms reached to harvest size, the mushrooms were harvested from the bags and weighed. The data obtained data of the trials were evaluated and the yield amounts per bag were determined.

Table 1. Yield averages (g) and standard deviation values obtained in the study

Bags in trials	Control	Humic acid			Giberellic acid		
		0.5	0.75	1	0.5	0.75	1
1	4633.33	5221.25	5191.25	4607.50	4151.25	4928.75	5480.00
2	2586.66	2896.25	3661.25	3317.50	3236.25	3840.00	3365.00
3	3490.50	3612.50	3857.50	3851.25	2570.00	3642.50	3866.50
4	1815.55	2670.00	2718.75	3601.25	4306.25	3687.50	3103.25
General Average	3131.51	3600.00	3857.50	3844.38	3565.94	4024.69	3953.69
Standard deviation	1212.84	1153.07	1018.84	553.50	814.70	608.60	1065.68
Standard error	606.42	576.53	509.42	276.75	407.35	304.30	532.84

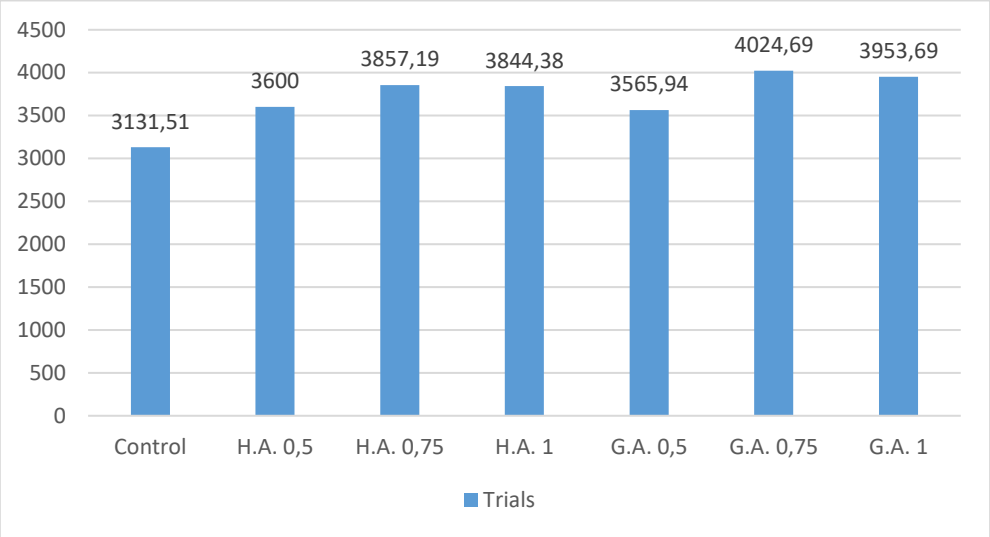

Figure 2. Yield averages (gr.) obtained in the trials

There is no data in the literature regarding the use of humic acid and gibberellic acid as irrigation water in mushroom cultivation. However, there are some studies on additives added to compost. In the study conducted by Kaşık and Öztürk (2000), the effects of some nutrients added to wheat straw synthetic compost on mycelial development, yield, and earliness of *Agaricus bisporus* were investigated. Corn meal, wheat feed meal, soybean meal, sunflower seed meal, and laying hen feed were used as additional nutrients. The highest yield was determined as 2900-2715 grams in the bags to which 250 grams and 350 grams of laying hen feed were added. As a result of the experiments, they stated that not only earliness was achieved in terms of mycelial development, but also an increase in yield was detected. In the study by Padem et al. (2003) on humic acid in *Agaricus bisporus* culture conducted, it was reported that the addition of humic acid to the cover soil consisting of organic wastes had a negative effect on the yield. The reason was shown to be the presence of humic substance as a natural decomposition material in organic wastes, which were investigated for the possibility of being used as cover soil and kept for about a year, and they concluded that no additional humic substance was required. It has been understood that the presence of a humic substance, which increases with the addition of humic acid, has a negative effect on fungal growth. In the study reported by Özdemir (2007), it was reported that the highest yield was obtained in the experiment in which *Agaricus bisporus* culture was added to the compost at the rate of 0.72 liters/ton, and low yield was observed at higher doses (Önay et al., 2018). Taş et al. (2021) stated in their cultural study that as a result of the processing of pistachios (*Pistacia vera* L.) grown in the Southeastern Anatolia region of our country, approximately 20.000 tons of outer shell (exocarp) emerge as agricultural industrial waste every year and that these wastes are an important source of environmental pollution. Since these wastes have various organic compounds, cultivated mushroom compost can be obtained by fermenting the waste shells, and they produce cultivated mushrooms by mixing different proportions of peanut shells into the compost. As a result of the study, the mushrooms grown were analyzed and evaluated. As a result of the evaluation, they determined that the application containing 25% fermented pistachio shells could be used in mushroom cultivation.

The evaluation of the findings of addition of HA and GA3 to irrigation water revealed that that the highest efficiency averages were obtained from the trials in which 0.75% and 1% aqueous solutions of both substances were applied. It can be concluded that the addition of humic matter and GA3 to irrigation water at certain rates during the primordium formation stage in the cover soil give positive results in terms of productivity in *Agaricus bisporus* cultivation. When applying humic acid and GA3, it should be taken into consideration that the structural composition of the cover soil may be important.

Conflict of Interest

Authors have declared no conflict of interest.

Authors' Contributions

The authors contributed equally.

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