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ALTERNATIVE SUBSTRATE USE IN SAGE TRANSPLANTS PRODUCTION *(SALVIA OFFICINALIS* L.)

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ABSTRACT

Mushroom production has become more popular in our environment. The most common cultivated mushroom is *Agaricus bisporus.* After mushrooms are harvested a large amount of used compost remains. This compost is a good material and producers used it as alternative substrate in plant production. The benefits of this compost are numerous like high content of organic matter and the rich mineral composition. The aim of this study was to determine the effectiveness of the use of spent mushroom compost (as alternative substrate) on growth and development of roots and above-ground parts of sage transplants (*Salvia officinalis* L.). Measurements of morphological parameters of plants (plant height, number of leaves, number of branches and plant diameter) were performed, as well as determination of fresh and dry weight of roots and above-ground parts of transplants. Application of spent mushroom substrate in the production of sage *Salvia officinalis* L. positively influenced growth and development as well as fresh and dry weight of roots and above-ground parts of treated plants compared to non-treated plants during transplanting growing stage. Plant height (+104%), number of leaves (+65%), number of branches (+143%), plant diameter (89%), were significantly increased by the spent mushroom compost application compared to the control - commercial substrate.

Keywords: *spent mushroom compost, seedlings, sage.*

INTRODUCTION

The most important problem for growing transplants in the greenhouse is provision of adequate growing media. One option to approach this subject is the use of compost that is the most economical and sustainable for organic waste management (Nair *et al*., 2005). The mushroom industry is very increasing and it has been estimated that more than 10 million metric tons of spent mushroom compost, by-product of *Agaricus bisporus* mushroom, are produced worldwide (Philippoussis *et al*., 2004; Lau *et al*., 2003). After mushroom harvesting, storage or transportation of this spent material lead to environmental contamination and costs for mushroom growers. One solution for reducing spent mushroom compost is to utilize it for plant growing media in agriculture. The spent mushroom compost is more consistent and hygienic than other composted materials, but fresh spent mushroom compost has a high proportion of potassium (K), phosphorus (P), sodium (Na), and calcium (Ca) salts. High salinity is toxic to plants and has limited its wide application in agriculture. Spent mushroom substrates are often spread onto land and allowed to weather for several years. This allows salts and nitrates (NO3) to seep out of spent materials (Gonani *et al*., 2011). However, weathering is not enough to reduce salinity to a satisfactory level. Leaching is one of the possible options to more strongly reduce the salinity of spent mushroom compost (Riahi and Arab, 2004; Riahi and Azizi, 2006). Leached spent mushroom compost has less salinity, but nitrogen (N) and carbon (C) and most essential elements as well as microbial characteristics do not change significantly compared to non-leached spent mushroom compost (Riahi *et al.*, 1998). Spent mushroom compost is rich in organic matter and constitutes an important source of macro- and micronutrients for plants and microorganisms thereby increase the soil micro flora, soil biological activity and enhance soil enzyme activity (Debosz *et al.*, 2002; Crecchio *et al.*, 2001). It contains calcium carbonate ($CaCO_3$), which provides short term buffering of the acidic waters and elevates soil pH (Rupert, 1994). Combusted farm manure is the most commonly used fertilizer in order to enrich soil and better yield. Well combusted farm manure usually yield better crop production. However, high quality farm fertilizers increase the cost. This facts forces the farmers to emphasize alternative methods for development of an efficient and quality soil improvement approach (Özgüven, 1998). This experiment was conducted to determine the effects of spent mushroom compost on growth and development of sage transplants (*Salvia officinalis* L.). The effects of spent mushroom compost on plant hight, number of leaves, number of branches and plant diameter, as well as fresh and dry weight of roots and above-ground parts of transplants were studied.

MATERIAL AND METHODS

This study was conducted in a greenhouse at Faculty of Agriculture, University of Banja Luka, Republic of Srpska/BiH. In the experiment were used already rooted sage cuttings which are growing on family farm Šušak in Prnjavor (photo 1.). For rooting cuttings were used a commercial substrate suitable for sowing seeds and cuttings Fruhstorfer Erde type: *Aussaat und Stecklingserde* from Hawita EU manufacturer. The substrate contains perlite for better aeration and friability. Other substrate characteristics are: pH 5.9; N mg/l=80; P_2O_5 mg/l=60; K_2O mg/l=90; EC 50 ms l; retention capacity 700 ml/l. Sage plantlings were transplanted into 9 cm diameter plastic pots. Experiment was set up as a split-plot design with four replications and two treatments - a commercial substrate (A1) and a mixture of commercial substrate and spent mushroom compost (button mushroom) at a ratio of 70:30 (A2). The trial consisted of a total of 80 plants, which are divided into two groups with 40 plants in each group and 10 plants per replication (photo 2.).

Commercial substrate: Klasmann-Deilmann substrate - *Potground H*, pH 6.0, very fine structure, with a mixture of white and black sphagnum peat was used as a control for sage transplants. Spent mushroom compost was previously mixed with garden soil and composted for six months and was used as a treatment . Pots were placed in greenhouse condition and slow-acting fertilizer was used only in control plants. Control plants had a slight increased and 0,3% concentration of *Yara* red cristalone 12+12+36+micro was applied. Growth promotion was recorded in every 7 days intervals during the experiment. The following morphological parameters were recorded: plant height (cm), number of leaves, number of branches, plant diameter (cm). At the end of experiment, the root was cleaned from the substrate, washed with water, and after that was measured fresh weight of above ground part and root. The plant material was placed in chamber dryer. After drying to a constant mass weighting of the dry root and above ground part was perfomed. The obtained data were statistically analyzed and the differences between specific substrate were calculated using analysis of variance with computer program VVSTAT (Vukadinović, 1994).

Photo 1. Rooted sage cuttings

Photo 2. Experiment after one month

RESULT AND DISCUSSION

Effects of spent mushroom compost on plant height (cm), number of leaves, plant diameter (cm) and number of branches are shown in Table 1. As seen in the table the effects of spent mushroom compost were statistically highly significant during transplants growth on all investigated morphological parameters. Results showed the amendment commercial substrate with 30% spent mushroom compost increased plant height highly significant (p=0.01). The largest height was observed in A2 - tretament with spent mushroom compost (11.8 cm), and the lowest in A1 - control (5.8 cm). Number of leaves were more in A2 (25.5) and less in A1 (15.5). It is the same with plant diameter - the largest in A2 with 10.6 cm, and the lowest in A1 with 5.6 cm; and with number of branches - more in A2 (4.4) and less in A1 (1.5).

Table 1. Effects of spent mushroom compost (SMC) on morphological parameters of sage transplants - *Salvia officinalis* L. (A1- control - commercial substrate - Potground H; A2- treatment - spent mushroom compost+Potground H)

Treatment (A)	Plant height (cm)	No. of leaves	Plant diameter (cm)	No. of branches
Control (A1)	5.8	15.5	5.6	1.5
Treatment (A2) SMC+Potground H	11.8	25.5	10.6	4.4
Average	8.8	20.5	8.1	3.0
Analysis of variance - F	*427.94***	*15.61***	*263.43***	*255.68***
LSD	Plant height (cm)	No.of leaves	Plant diameter (cm)	No. of branches
0,05	***0.71***	***6.22***	***0.75***	***0.45***
0,01	***1.08***	***9.43***	***1.13***	***0.69***

After analyzing the morphological parameters of growth and development of sage transplants (*Salvia officinalis* L.) measurement of fresh and dry weight of plants were carried out and the obtained results are shown in Table 2.

Table 2. Effects of spent mushroom compost (SMC) on fresh weight (FW) and dry weight (DW) of root and above ground part of sage transplants - *Salvia officinalis* L. (A1- control - commercial substrate - Potground H; A2- treatment - spent mushroom compost+Potground H)

Treatment (A)	Above-ground part FW (g)	Above-ground part DW (g)	Root FW (g)	Root DW (g)
Control (A1)	1.7	0.2	0.7	0.1
Treatment (A2) SMC+Potground H	6.9	1.3	3.0	0.5
Average	4.3	0.8	1.8	0.3
Analysis of variance - F	*480.81***	*391.42***	*52.56***	*266.37***
LSD	Above-ground part FW (g)	Above-ground part DW (g)	Root FW (g)	Root DW (g)
0,05	***0.59***	***0.13***	***0.79***	***0.06***
0,01	***0.89***	***0.20***	***1.19***	***0.09***

In the table 2. it is visible that additional of 30% of spent mushroom compost increased fresh and dry weight of root and above-ground part of sage transplants and it is also statisticaly highly significant (p=0.01). The largest fresh above-ground part and root weight were recorded in A2 - treatment with spent mushroom compost (6.9 g and 3.0 g), and the lowest in A1 - control (1.7 g and 0.7 g). As well, dry above-ground part and root weight were more in A2 (1.3 g and 0.5 g) and less in A1 (0.2 g and 0.1 g). All of the recorded parameters of growth and development were influenced by treatment, with greater plant height, plant diameter, number of branches, fresh and dry above-ground and root weight of the plants growing in alternative substrates (photo 3. and photo 4.)

Photo 3. Treatment and control sage transplants

Photo 4. Treatment and control sage transplants at the end of experiment

Numerous researchers confirm that disused mushroom compost can be used as substrate for successful cultivation of many crops (Dubsky and Sramek 2009; Vukobratović, 2008; Polat *et al.,* 2009; Gonani *et al.,* 2011). Lemaire *et al.* (1985) reported that the used mushroom compost can not be used alone due to weak water permeability, high salinity and neutral pH which is not suitable for all horticultural plants. Çelikel and Çağlar (1997) reported that higher yield and earliness for tomato and cucumber growth were found in mixtures of peat and spent mushroom compost (1:1) than for the plants that were grown in a garden soil. In the cultivation of marigold (*Tagetes patula* L.) does not recommend the use of spent mushroom compost in an amount greater than 50% relative to the amount of commercial substrates, due to the impossibility of controlling the substrate and the low salinity water capacity (Young *et al.* 2002). Spent mushroom substrate of oyster mushroom and button mushroom compost are good sources of biofertilizer as they influence the growth of *Capsicum annuum* positively. These not only affect the growth but also affect the physiochemical properties (Roy *et al.*, 2015). According to Zeljković *et al.* (2015) the application of spent mushroom compost can be used in the production of anise *Pimpinella anisum* L. as a supplement to commercial substrate caused an increase number of leaves and plant hight more than 50% compared with control. Also, spent mushroom compost can be used in the production of *Pelargonium peltatum* L. and *Petunia hybrida* Juss. transplants because of a positive impact on the growth and development of roots and above-ground parts (Zeljković *et al*., 2015a). Ahlawat *et al*. (2010) confirmed that the spent mushroom compost and its associated microflora can be used in bioremediation of fungicides. Application of spent mushroom compost in the production of geraniums *Pelargonium peltatum* L. und *Pelargonium zonale* L. positively influenced growth and development of morphological parameters and the fresh and dry weight of roots and above-ground parts of treated plants compared to non-tretated plants during two growing seasons (Parađiković *et al.*, 2017).

CONCLUSION

This study confirmed that the spent mushroom compost can be used in the production of *Sage officinalis* L. transplants as a supplement to commercial substrate in the amount of 30%. Efficient use of spent mushroom compost is reflected in an increase in the average measured value of morphological parameters of growth and development and the increase in fresh and dry weight of above ground parts or root relative to the average value of control plants. In some measured parameters values of treatments are bigger two or three times then a values obtained in control which is more then 100% increased by spent mushroom application. From the above results, it can be concluded that spent mushroom compost of button mushroom (*Agaricus bisporus*) are good sources in the preparation of alternative substrates in the production of sage transplants. Reducing the mushroom waste and re-using the spent mushroom compost as a component of growing media was the main objective of many studies. The use of spent mushroom compost as an additive to growing media not only would be economically advantageous but also, field inventories of the waste byproduct and minimize the contamination of ground-water (Gonani *et al.*, 2011).

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