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Importance of Using Compost and Bacterial Biofuels in the Organic Production of Medicinal and Aromatic Plants

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Abstract

The areas under the organic production of medicinal and aromatic plants are constantly increasing, both domestically and globally. Since organic production does not allow the application of synthetic fertilizers, organic fertilizers like compost and bacterial biofuels have special importance. The aim of this paper is to point out the positive effects of the application of these fertilizers in the organic production of medicinal and aromatic plants. Microbiological fertilizers and compost not only have beneficial effects on the productivity of medicinal and aromatic plants by improving physical and biological properties of the soil, but also affect the quality and increase the content of essential oils and also improve the physiological status of a plant. Azotobacter produce anti-fungal compounds that protect against plant pathogens, while increasing germination and vitality of plants demonstrates the importance of their application in the organic production of medicinal and aromatic plants.

Key words: plant growth, yield, nutrition, soil characteristics, essential oil content

Introduction

Organic production conserves and improves biodiversity, protects the environment, increases soil fertility by applying the highest standards in order to protect plant and animal health (Veličković et al., 2016).

Over the past years, the world market for organic medicinal and aromatic herbs has seen a continuous growth trend, and an increasing number of producers have been identified for this type of production (Golijan, 2016). Organic production of medicinal and aromatic plants can be started immediately on a plot that has not been used (or has been used without the use of synthetic chemical preparations) in the period of the last two years (Rulebook, “RS Official Gazette”, issue 48/11). The organic production of medicinal and aromatic plants is extremely complex due to different biology of species (annual and perennial species), planting methods (vegetative propagation, from seedlings or seeds) and various cultural practices. Organic fertilizers have great importance in the organic production, as they are irreplaceable when it comes to improving physical, chemical and biological properties of the soil. The most commonly used organic fertilizers include manure, compost, peat, peat, fertilizer, wood ash, vegetable solutions and other organic matter waste produced as a by-product in food technology and industry (Mirecki et al., 2011). Compost is of key importance in organic farming. Composting is a biological, chemical and mechanical process that transforms rough organic material into a homogeneous, stable final product through aerobic degradation. Humus improves water retention, affects the binding and release of nutrients, improves soil structure, and in the case of warm compost rich in nutrients can also be used as a fertilizer (Veselý et al., 2016).

The application of compost in the organic growing technology of medicinal and aromatic herbs

When it comes to soil fertilization, in the organic production of medicinal and aromatic plants, one application of fertilizers of organic origin and natural mineral fertilizers is allowed (Aćimović, 2013). This is regulated by the "Law on Organic Production" (“RS Official Gazette”, issue 30/10), while the list of allowed organic fertilizers is in the "Rulebook on control and certification in the organic production and organic production methods" (“RS Official Gazette”, issue 48/11). Compost is an organic soil fertilizer produced during microbiological decomposition of various organic matter (plant and animal origin waste). It is used as an organic fertilizer in the amount of 0.5-6 kg/m² or for soil mulching (Mirecki et al., 2011). In fertilizers of organic origin and compost, the maximum allowed concentrations of heavy metals in mg/kg of dry matter are: cadmium: 0.7; copper: 70; nickel: 25; lead: 45; zinc: 200; live: 0.4; chrome (total): 70; chrome (VI): 0 (Rulebook, “RS Official Gazette”, issue 48/11).

When it comes to irrigation water, it needs to be classified as the first and second category (according to the provisions of the regulation on water categorization), and in accordance with that maximum allowed concentration of heavy metals it can contain: Cd <0.01; Pb<0.1; Hg <0.001; As <0.03; Cr <0.5; Ni <0.1; F <1.5; Cu <0.1; Zn <1.0; B <1.0 mg/l. (Rulebook, "RS Official Gazette", issue 23/94).

The place where the compost is to be prepared should be in shade, sheltered from wind, because direct exposure to the sun makes organic waste to dry too quickly, and the bacteria involved in composting die quickly while the organic matter remains unchanged for a long time. Herbal waste that is being put in compost should be healthy, because the disease present in plant tissue does not vanish by composting. Before composting, the surface layer of soil is removed from 8-10 cm, the drainage layer is laid out of twigs and then a layer of fresh and dry plant waste is alternately arranged to the desired height (15-20 cm; cutted nettle, stone flour or biological preparations based on chamomile, dandelion, valerian, silicon, cow bales, oak bark) and soil layer (5 cm). After a few days, a high temperature of 50-60 °C develops, and then the compost cools and the organic matter is mineralized. After 6-12 months the compost is prepared and then it is uniform, crumbly, light and dark brown (Mirecki et al., 2011). Composting at larger scale involves the formation of rotating bundles (for ventilation), or passive-ventilated piles arranged into long rows (with pipes that feed the air inside the crowd and spawn compost), static ventilated piles (which also have pipes and a ventilator that brings the air into the crowds), composting in bins, as well as various systems for ventilating the compost (Veselý et al., 2016). The process of composting on a farm level is done at the symbolic scale, and this is an area where there is a strong need for the development and improvement of the technological process and also innovative solutions related to the autochthonous starter culture of microorganisms (Berenji et al., 2013).

According to Zheljazkov and Warman (2004), the use of compost, as an organic fertilizer, offers extremely beneficial effects on the plant growth and yield by improving the physical and biological properties of the soil. Zhang et al. (1998) suggest the application of aqueous extracts of compost as a substitute for synthetic fungicides. The influence of compost on the soil structure and fertility as well as the impact on the productivity of medicinal and aromatic plants has been demonstrated by numerous scientific studies. For example, in the case of *Majorana hortensis* soil treatment with 15% and 30% aqueous compost extract significantly increases the percentage of essential oils by 39 and 52%, as well as the yield and biomass of the plant itself, while the chemical composition of ethylene oil has remained unchanged (Fatma et al., 2008).

Other authors obtained similar results (Table 1) in studying the impact of compost on *Majorana hortensis* and *Cymbopogon winterianus* (Edris et al., 2003; Adholeya and Prakash, 2004).

Table 1. The effect of aqueous extracts of compost and biofertilizers on essential oil percentage and yield of *Origanum majorana* plants
Утицај водених екстраката компоста и биођубрива на садржај есенцијалних уља и принос биљака Origanum majorana

Treatments	Oil%			Oil yield (ml plant^{-1})		
	1st	2nd	3rd cut	1st	2nd	3rd cut
Control (NPK)	0.374 i	0.582 h	0.679 i	0.154 i	0.139 h	0.118 h
Compost I (15%)	0.554 e	0.644 ef	0.795 f	0.261 f	0.171 fg	0.171 e
Compost II (30%)	0.496 g	0.614 g	0.775 g	0.205 h	0.154 g	0.147 g
Nitrogen fixer (N_2)	0.399 h	0.586 h	0.720 h	0.230 g	0.192 e	0.184 d
B.circulans (*B.C.*)	0.369 i	0.521 i	0.609 j	0.227 g	0.172 fg	0.156 fg
Nitrogen fixer+*B.C.*	0.630 b	0.741 b	0.826 c	0.406 c	0.264 c	0.215 c
Compost I+ N2	0.619 c	0.705 c	0.809 d	0.301 d	0.209 d	0.186 d
Compost II+N2	0.611 c	0.668 d	0.805 e	0.268 f	0.170 fg	0.160 ef
Compost I+*B.C.*	0.597 d	0.647 e	0.802 e	0.286 e	0.176 ef	0.184 d
Compost II+*B.C.*	0.528 f	0.635 f	0.776 g	0.230 g	0.159 fg	0.150 fg
Compost I+N2+*B.C.*	0.727 a	0.849 a	0.919 a	0.534 a	0.371 a	0.267 a
Compost II+N2+*B.C.*	0.644 b	0.743 b	0.887 b	0.420 b	0.295 b	0.241 b
L.S.D. at 5%	0.016	0.014	0.006	0.021	0.022	0.016

Means followed by different letters in the same column are statistically different according to the Duncan's multiple range tests P = 0.05. Source: Gharib et al. (2008).

In *Matricaria chamomilla* L. the effect of compost on productivity of the soil, in all treatments showed positive effect on the growth of floral heads (or fresh or dry weight of the flower heads and their diameter) has been increased, as well as the percentage and increase in the total content of essential oil per plant (Hendawy and Khalid, 2011).

Gharib et al. (2008) studied the impact of compost and bio-fertilizers on the growth, yield and oil constituents of *Majorana hortensis* L.

The oil percentage and yield per plant for three cuttings was almost twofold higher for fresh weight as a result of added aqueous extracts of compost at low level together with bio-fertilizers. The chemical composition of marjoram essential oil did not change due to the fertilization type but the relative percentages of certain constituents were affected.

The highest level of *cis*-sabinene hydrate (18.47%) and terpinene-4-ol (24.24%) was obtained with aqueous extracts of compost at 30% with *Bacillus circulans* and aqueous extracts of compost at 30% with *Azospirillum brasiliense, Azotobacter chroococcum and Bacillus polymyxa.*

The influence of bacterial biofuels on the content of essential oils and the yield of medicinal and aromatic plants in the organic production system

Some bacteria dissolve phosphate in the soil having a positive effect on the plant growth. Application of biofertilizers in the soil made from a bacterial mixture leads to balanced nutrition of plants, and in addition, improved absorption of nitrogen and phosphorus by the root (Sharma, 2002). The largest number of studies related to the symbiosis of bacteria and plants were carried out on cereals, and only a few on medicinal and aromatic plants.

The most important growth is stimulated by the *Pseudomonas*, *Azospirillum* and *Azotobacter* bacteria, which, in addition to the biological fixation of nitrogen and phosphate dissolution from the soil, have significant influence on the growth regulators giberelin, auksin and cytokinin, through which they influence the complete physiological status of a plant. In addition, *Azotobacter* not only enhances germination and plant life, it also produces antifungal compounds involved in the control of plant pathogens (Chen, 2006). In addition to azotofixation, *Azospirillum* also increases plant root growth (Tilak et al., 2005). The application of biofertilizer *Azospirillum* and *Azotobacter* in cultivation of *Salvia officinalis* increases the plant height (Vande-Broek, 1999). Ratti et al. (2001) found that, in relation to the control treatment, the height and biomass of the lemon balm were significantly increased by the use of bacterial fertilizers that dissolve phosphorus.

The use of biofertilizers increases the total growth of *Thymus vulgaris*. Microscopic inoculation of *Scutellaria integrifolia* has shown an increase in the total growth of the plant, as well as the root length in low-phosphorous soil (Joshee et al., 2007). The biomass of the *Cymbopogon maritinii* species increases with simultaneous inoculation of the *Azospirillum* and *Bacillus* mycosis.

It has been shown that the increase in the growth of medicinal and aromatic plants lies in the fact that bacterias that dissolve phosphates, inoculated in these plants, can absorb the nutrients from the soil more rapidly, resulting in an increase in the content of N, P and K in leaves (Saharan and Nehra, 2011). Also the application of biofertilizers in the species *Hibiscus sabdariffa, Nigella sativa, Ammi visnaga* and *Salvia officinalis* enhanced all the characteristics of their growth (Abo-Baker and Mostafa, 2011).

Conclusion

The organic production of medicinal and aromatic herbs is regulated by law, and to obtain the raw materials of the most optimal quality in every sector of production and processing, it is necessary to comply with the prescribed organic principles.

The application of bacterial biofertilizers and compost leads not only to the increase in the quality and fertility of the soil, but also in all the characteristics of plant growth. Despite all the benefits of using compost, composting on farms is still carried out at a minimum level, showing the need for developing a composting model and improving the technological process, as well as innovative solutions related to the autochthonous starter culture of microorganisms.

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Примена компоста и бактеријских биођубрива у органском систему производње лековитог и ароматичног биља

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Сажетак

Површине под органском производњом лековитог и ароматичног биља повећавају се како на домаћем, тако и на глобалном нивоу. С обзиром да у органској производњи ових врста биљака није дозвољена употреба синтетичкин ђубрива, посебан значај имају органска ђубрива, а нарочито цомпост и микробиолошка ђубрива. Циљ овог рада је да укаже на позитивне ефекте примене ових ђубрива у производњи лековитог и ароматичног биља по методама органске пољопривреде. Бактеријска биођубрива и компост не само што имају повољне ефекте на продуктивност лековитог и ароматичног биља побољшањем физичких и биолошких особина земљишта, утичу и на квалитет и повећање садржаја етеричног уља и повећање комплетне "кондиције" биљке. *Azotobacter* лучи антифунгална једињења која учествују у борби против биљних патогена, а при томе и повећава клијање и животну способност биљака, тако да је његова примена у органској производњи лековитог и ароматичног биља је неизоставна.

Кључне ријечи: раст биљке, принос, исхрана, карактеристике земљишта, садржај етеричног уља

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