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**PRELIMINARY INVESTIGATION ON EFFICIENCY OF MUCHES
AND OTHER MECHANICAL WEEDING METHODS
APPLIED IN *MENTHA PIPERITA* L. CULTIVATION**

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SUMMARY

Peppermint (*Mentha x piperita*) is a perennial, medicinal and aromatic, cultivated plant species belonging to *Lamiaceae* family. In this study, survey of 9 organic mulches (straw, chopped pieces of the pine bark, sawdust of acacia, cardboard, dry pine needles, chopped maize sedge, chopped pieces of the acacia bark, herbal composts 1 and 2), 1 biodegradable (black mulch film) and 4 plastic mulch films (silver-brown, perforated black, black, black “agrotexil”) were tested in *Mentha x piperita* experimental cultivation, located in Serbia. Three different models were used for application of mulches and films in the early spring of 2015. The plots were separated on two parts, one with hand weeding and the other one without weeding. Identical rows with peppermint were used as a double control, with no use of mulches/films; one control was kept free of weeds (C1 - weeds were manually removed), while the second one was kept intact (C2 - no weeds removal). Comparing to control treatment silver-brown polyethylene film (sPE), black agrotexil film (BA) and two organic mulches (sawdust of acacia and pine needles), showed very good effects on peppermint yield and reduction of weed biomass. Therefore, we selected them for further investigation.

The aim of this study was to evaluate and select the best application models of organic mulches and mulch films for further investigation which will lead to the achievement of the highest yield of good quality peppermint herbal drug.

Key words: *Mentha piperita*, peppermint, mulching, weed control, yield.

INTRODUCTION

Peppermint is cultivated plant species belonging to genus *Mentha*, of the *Lamiaceae* family [1]. Genus *Mentha* represent part of the wide flora with a large number of genera (240) and over 7200 species [2]. *Mentha x piperita* is a rhizomatous perennial plant [3], which is, in our agroecological conditions, cultivated mainly as an annual crop. Its rhizomes are wide-spreading, fleshy, and bare shallow fibrous roots. In autumn or spring, peppermint stolons use to be planted in the soil, at depth 10-15 cm. They continue to spread during all the vegetation period, so it is very important to choose the appropriate model for setting a kind of mulching material which is not going to damage fresh stolons.

In general, production of this plant species is oriented many towards its leaves and essential oil. The leaves are used for peppermint tea and the essential oil is used in pharmaceutical industry, aromatherapy and traditional medicine. One kilogram of dry peppermint leaves contains approximately 2 - 4% of essential oil, while the leaves and the stems together contain about half less [4]. The major volatile components of the oil are menthol and menthone [5]. Due to the wide use of its leaves and essential oil, peppermint is considered for a quite important medicinal and aromatic plant all over the world.

In cultivation of the most medicinal plants, including peppermint, the main problem is a weed control, as no or limited use of pesticides is advised. Weed infestation during the critical periods (between 30 and 75 days in the first harvest, and 15 and 45 days in the second one) in cultivation of *Mentha arvensis* L. caused significant reduction in plants height, herb and oil yields [6]. Therefore, principals of organic production [7] and application of acceptable alternative methods in weed control are highly recommended [8, 9]. Weeds suppression with application of physical method, such as mulching [9, 10] prove to have positive effects in so many ways [8, 11-16]; the main ones are reduction in weedness [14, 17, 18] with significantly lower weed biomass [19], and possibility to change weed composition in accordance to ecological conditions [20]. In addition, mulching positively influences the soil moisture, structure and temperature [21-23], providing better conditions for cultivated plant. Since, the peppermint needs enough water during summer periods and requires a special approach to weed control, mulching seems to be appropriate choice, able to provide both, to preserve loss of the soil water and to suppress weeds.

The aim of this study was to evaluate and select the best application models of organic mulches and mulch films for further investigation which will lead to the achievement of the highest yield of good quality peppermint (*Mentha x piperita*) herbal drug.

MATERIAL AND METHODS

Field experiment

Field studies were established in Pančevo, Serbia (44°52'20.0"N, 20°42'04.7"E). In order to compare the effects of physical weed control methods, following 9 organic mulches were investigated: straw, chopped pieces of the pine bark, sawdust of acacia, cardboard, dry pine needles, chopped maize sedge, chopped pieces of the acacia bark, herbal composts 1 and 2, biodegradable black mulch film, in addition to following 4 plastic mulch films: silver-brown polyethylene (PE) film (sPE), black biodegradable films (BB), black permeable polyethylene film (bPP), black polyethylene film (bPE) and black agrotexil film (BA).

Experimental cultivation of peppermint was set up in November, 2014. The stolons were planted in open rows, 0,7 m x 6 m. In the early spring, 2015., three different models were used for application of selected mulches and films; the soil surface between the peppermint rows (0,5 m) were covered with cardboard and sPE; the organic mulches layers ranged from 5 to 10 cm, and they were spread over the soil surface between the rows with peppermint; mulch films (BB, bPP, bPE, BA) were spread (0,7 m wide) over the soil surface, covering the peppermint rows; the central part of the films were manually perforated, in advance (10 cm in diameter with 10 cm space between holes). The plots were separated on two parts, one with applied hand weeding (ones in 10 days, from March till the first harvest), and the second one, with no weeding at all. Identical peppermint rows were used as control without the use of mulches or films.

One control was without weeds (C1), where weeds were hand removed, the same way as it was conducted in the plots, while the second control (C2) was left intact (no weeds removal). In the treatments, the crop was kept free of weeds, manually, after both peppermint harvests.

Harvest

The peppermint samples were collected, separately, every meter in a row, i.e. from each treatment in 3 replicates, the same for all plots. The dry biomass was separately measured for each sample (repetition). Positive effects of applied mulches were estimated based on applied mulching model, and depending on weed biomass and total dry peppermint yield (the first and the second harvest, together). The weed samples were collected from plots, where weeds grew intact, together with peppermint. Samples of weeds (0,2 m wide and 1 m of row) were collected from each treatment in 3 replicates, and the entire dry biomass per treatment was separately measured.

Soil and meteorological conditions

Mineral fertilizer NPK 16:16:16, in a dose of 600 kg/ha, was applied by the

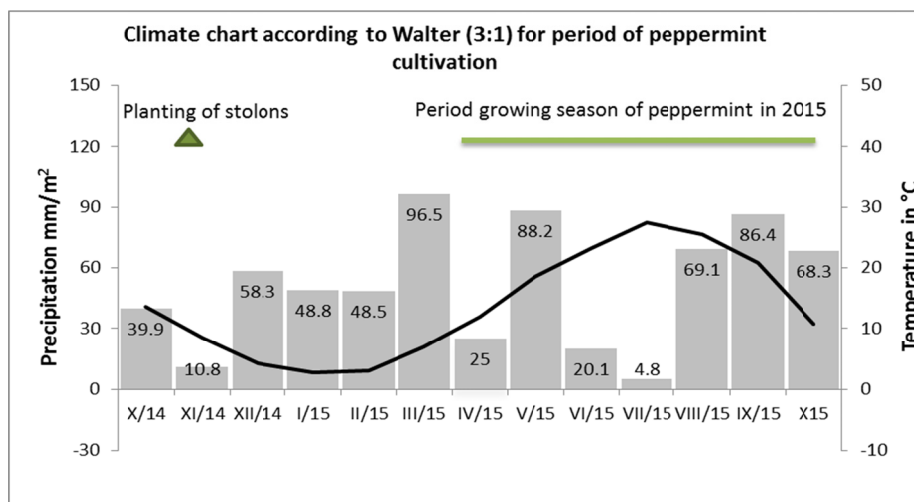
soil tilling, right before plantation of peppermint stolons. The soil was humogley type, with the moderate acidic reaction, and in the topsoil layer it was low in humus supplies and phosphorus content, but high in potassium supply (Table 1).

Table 1. Chemical properties of the soil (0-30 cm) in Pančevo locality, in the 2014.

Tabela 1. Hemijska svojstva zemljišta (0-30 cm) za lokalitet Pančevo, u 2014. godini.

Soil type	pH		Humus %	N %	Al –method mg/100g	
	in H ₂ O	in KCl			P ₂ O ₅	K ₂ O
Loam	6,42	5,39	2,31	0,183	3,6	36,2

Meteorological data for peppermint vegetation in the study are provided by the Meteorological station of the Institute "Tamiš", Pančevo (Climatic diagram 1).



Climatic diagram 1. Climadiagram for vegetation period 2014-2015., for locality Pančevo.
Klimadijagram 1. Klimadijagram za vegetacioni period 2014-2015., za lokalitet Pančevo.

RESULTS AND DISCUSSION

The first harvest yields of the peppermint produced under different mulches were presented in Figures 1a, 2a and 3a, while the second harvest yield was presented in Figures 1b, 2b and 3b. Every Figure presents results of peppermint production in conditions in which they compete with weeds, as well as in those where weeds were manually removed, thus allowing peppermint to grow spontaneously, without weed interference.

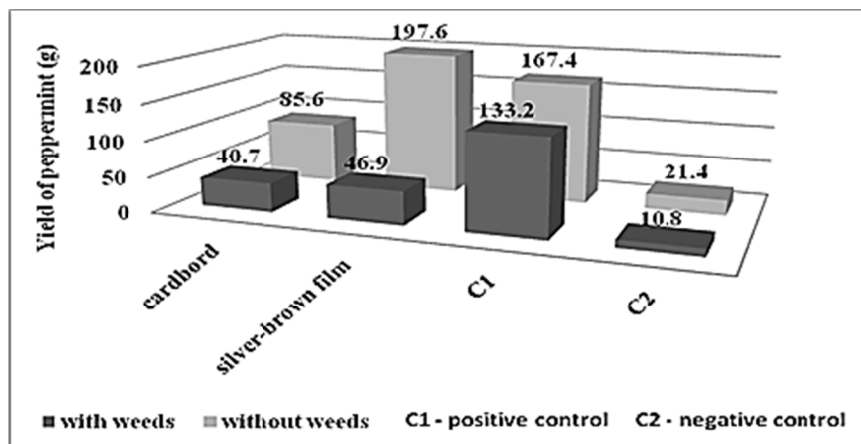


Figure 1a. First harvest yields of peppermint (g) with mulches applied between the crop rows; the cardboard and the silver-brown polyethylene film (sPE).

Figura 1a. Prinosi prve žetve pitome nane (g) sa primenom malča u međurednom prostoru; karton i srebrno-braon film folija (sPE).

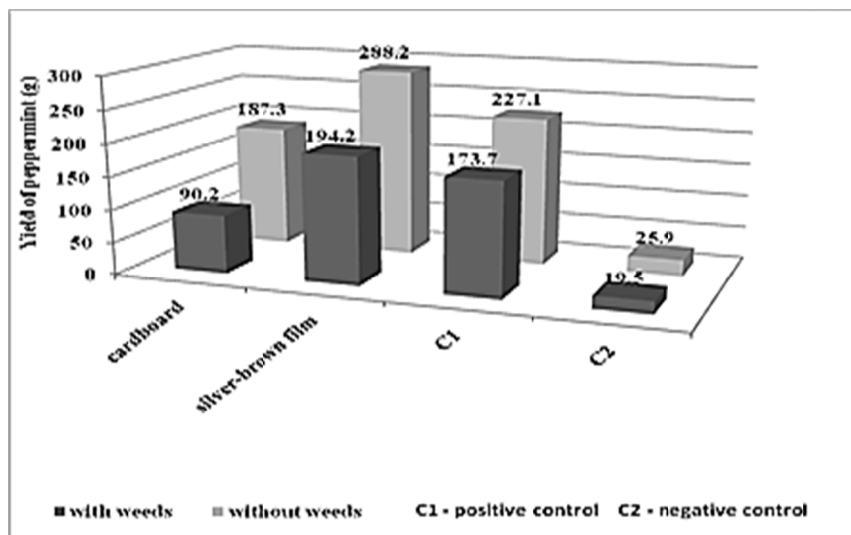


Figure 1b. Second harvest yields of peppermint (g) with mulches applied between the crop rows; the cardboard and the silver-brown polyethylene film (sPE).

Figura 1b. Prinosi druge žetve pitome nane (g) sa primenom malča u međurednom prostoru; karton i srebrno-braon film folija (sPE).

In our study, the obtained results are analysed and discussed in the context of three different methods used to set up mulch and film materials, regardless the fact that they didn't affect the yield. Different methods were applied so that each of them was chosen as the most appropriate for particular mulch or film (i.e. methods were applied in accordance to properties of material they are made of).

Both peppermint harvests revealed that application of mulches increased the yields in comparison to C2 control, as already reported for some other crops [11, 14, 16, 23]; the second harvest had higher yields than the first one, in each treatment, including control. This may be explained by the biological cycles of weeds before the first harvest and between the two peppermint harvests; following the first harvest, complete weeding was conducted.

Reduction in the crop biomass was highly correlated with the weeds biomass, as also confirmed in other investigations [6, 24]. Among all treatments, maximum average biomass of peppermint was recorded with application of silver-brown film that was set between the peppermint rows, with a hand weeding in the peppermint rows during vegetation.

The obtained peppermint yields, for the first and the second harvest, are presented in Figures 1a and 1b, respectively. The peppermint yields depended on applied mulch type; the highest yields were achieved on the sPE in plots with weed removal in the 10 cm diameter holes left for peppermint plants, in both harvests (197,6 g and 288,2 g), and they were better than those from the corresponding positive control (C1) (167,4 g and 227,1 g). The peppermint yields are also in accordance to the average weeds biomass (AWB); the highest were achieved on sPE (AWB=261,7 g) and the worst in negative control C2 (AWB=352,8 g).

Results reported in some other studies are not directly comparable with presented ones but they also proved positive effects on medicinal crops, such as, improved yields of yellow gentian roots also on sPE in comparison to bPE film [25] and improved quality of arnica on bPE in comparison to sPE film [26].

Results of our study also show that in efforts to achieve higher peppermint yields, it is always better to combine application of the cardboard or the sPE mulch with manual weeding around the crop, rather than to perform only mulching.

The yield of peppermint achieved in the first and the second peppermint harvests, under various mulching films (BB, bPP, bPE, BA), are presented in Figures 2a and 2b.

The first harvest yields of peppermint, achieved under bPP film (162,4 g), were quite similar to those achieved under BA film (151,5 g) in plots with weed removal in the holes left for peppermint plants, whereas in the plots with no manual weeding, the yields achieved under BA film (64,5 g) was approximately three times higher than those achieved under the other three films, BB (19,1g), bPP (20,5g), and bPE (26,5 g).

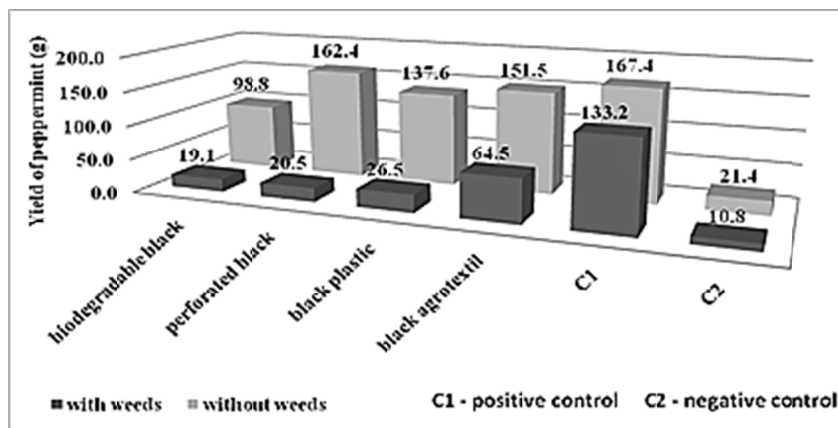


Figure 2a. First harvest yields of peppermint (g) achieved on various mulch films covering the crop rows; biodegradable black film (BB), perforated black polyethylene film (bPP), black polyethylene film (bPE), black “agrotexstil” film (BA).

Figura 2a. Prinosi prve žetve pitom nane (g) ostvareni pod različitim folijama postavljenim u redovima sa usevom; biorazgradiva crna (BB), perforirana crna (bPP), crna (bPE), crna „agrotekstil“ (BA).

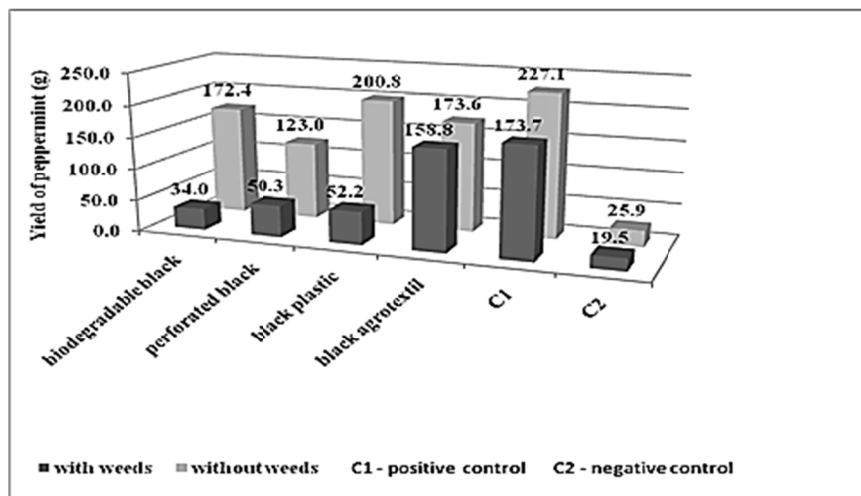


Figure 2b. Second harvest yields of peppermint (g) achieved on various mulch films covering the crop rows; biodegradable black film (BB), perforated black polyethylene film (bPP), black polyethylene film (bPE), black “agrotexstil” film (BA).

Figura 2b. Prinosi druge žetve pitom nane (g) ostvareni pod različitim folijama postavljenim u redovima sa usevom; biorazgradiva crna (BB), perforirana crna (bPP), crna (bPE), crna „agrotekstil“ (BA).

On the other hand, in the second harvest, in plots with weed removal, the yields of peppermint achieved under bPE (200,8 g) proved to be very good in comparison to other 3 corresponding film treatments, and the negative control (C2).

Stable and almost constantly good peppermint yields were also achieved with BA film application, almost regardless the plots were weeded or not. Due to this and in addition to the fact that in the first peppermint harvest, the AWB in BA = 333,1g vs. AWB in C2 = 352,8g, while in the second one the AWB in BA = 8,62g vs. AWB in C2 = 41,33g, this mulch is considered as a best for both, the weeds suppression and the high peppermint yields.

In research conducted on black and white polyethylene mulch films, Hanna [27] concluded that the colours of mulch films had no significant effects on total yields of cultivated cucumbers, which is in disagreement with findings in our study, in which we also used two films, the silver-brown (sPE) and the black (bPE), but our sPE film enhanced achievement of higher peppermint yields in all methods in comparison to the other one, in bought harvest (Figures 1a and b, and Figures 2a and b).

The application of film mulches is very frequent in vegetable crops, as it is confirmed that it improves the soil properties, such as temperature and humidity [21-23, 28]. Peppermint plant is of Mediterranean origin and it likes warmth and requires enough water for its best achievements. With regard to these, the films seem to be quite acceptable choice for providing better growing conditions and preventing weeds to fight for the same.

The yield of peppermint achieved in the first and the second peppermint harvests, under various organic mulches (straw, pine bark, sawdust of acacia, pine needles, maize sedge, acacia bark, herbal composts 1 and 2.), are presented in Figures 3a and 3b.

The differences between organic mulches and already described films are in the models of mulch application, the permeability of atmospheric precipitations, and as well in the colour of mulch that can lead to faster warming surface of the soil, and generally changes the soil surface temperature more slowly. Organic mulches are environmental friendly and show worse results on yield and weed suppression than the polyethylene films. Therefore, our experimental plots with no weed removal were generally lower in peppermint yields and corresponding AWB values, in comparison to those achieved in plots with manual weed removal, conducted ones in 10 days (from March till the first harvest).

If we compare the applied organic mulches with the C1 and the C2 controls, the yields of achieved peppermint, in plots with manual weeding, in the first harvest ranged 32 - 90,4 g (Figure 3a), and for second one, 75,7 - 145,3 g (Figure 3b). The best result for organic mulches in the second harvest was achieved on the sawdust of acacia mulch (145,3 g), while for the first harvest it was on the pine needles mulch (90,4 g).

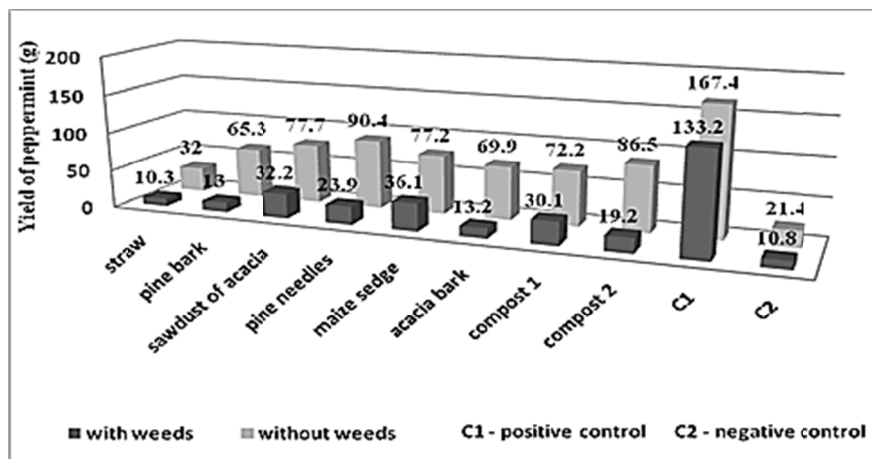


Figure 3a. First harvest yields of peppermint (g) achieved on various organic mulches between the peppermint rows; straw, pine bark, sawdust of acacia, pine needles, maize sedge, acacia bark, herbal composts 1 and 2.

Figura 3a. Prinosi prve žetve pitome nane (g) ostvareni na organskim malčevima postavljenim u međuredu nane; slama, kora bora, bagremova piljevina, karton, iglice bora, kukuruzovina, kora bagrema, biljni komposti 1 i 2.

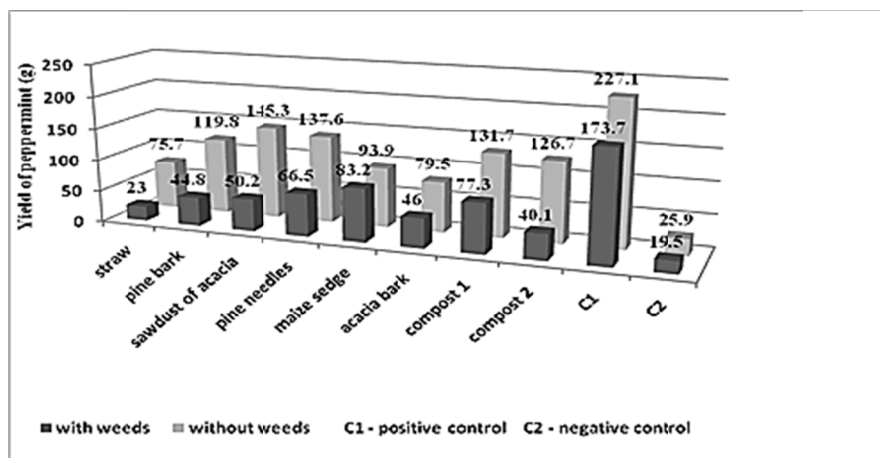


Figure 3 b. Second harvest yields of peppermint (g) achieved on various organic mulches between the peppermint rows; straw, pine bark, sawdust of acacia, pine needles, maize sedge, acacia bark, herbal composts 1 and 2.

Figura 3b. Prinosi druge žetve pitome nane (g) ostvareni na organskim malčevima postavljenim u međuredu nane; slama, kora bora, bagremova piljevina, karton, iglice bora, kukuruzovina, kora bagrema, biljni komposti 1 i 2.

Skroch et al. [29] also investigated several organic mulches used alone or in combination with black PE or woven PP films on weed control, and find out that the longleaf pine needles was the most effective, with and without black PE or woven PP films, which is in disagreement with results from our study. On the other hand, Gupta and Acharya [30] shown results which are in accordance to ours; out of several film and organic mulches, application of bPE film induced higher yields of strawberry then while in combination with the pine needles mulch.

If we compare the range for the yields of peppermint under organic mulches in the second harvest (75,7 - 145,3 g) with the range of films (123- 200,8 g), better results showed mulch films, especially the bPE (200,8 g), which proved to be the best one.

CONCLUSION

Production of peppermint with application of different models of mulches has a special impact on weed control and the achieved crop yields. Preliminary results confirmed that all mulches might be considered as a choice for weed control in peppermint cultivated in Serbia. Combination of two methods, the physical weeding method (mulching) and mechanical (hand) weeding method, as a model for weed suppression, resulted in best peppermint yields. Such results have a special significance for organic production, where the crop biomass reduces weeds without use of herbicides, thus contributing to higher yield achievements.

From the results presented for both peppermint harvests, it can be concluded that if the mulches are used between the rows with crops, the silver-brown polyethylene film (sPE) will enhance the achievement of very high peppermint yields. Mulch films covering the rows provide high effectiveness in both, the weeds reduction and the yields of peppermint. The black "agrotexil" film (BA) gave uniform result in the second peppermint harvest, regardless the hand weeding. If we compare organic mulches applied between the rows with both controls and in both harvests, the best result in the first harvest provides the pine needles mulch, while in the second harvest this was accomplished by the sawdust of acacia. Silver-brown polyethylene film (sPE), black "agrotexil" film (BA), pine needles and the sawdust of acacia, all enhanced better peppermint yields and therefore are nominated for our further investigation.

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**PRELIMINARNA ISTRAŽIVANJA EFIKASNOSTI MULČEVA I DRUGIH
MEHNIČKIH MERA BORBE PROTIV KOROVA PRIMENJENIH U
USEVU *MENTHA PIPERITA* L.**

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IZVOD

Pitoma nana (*Mentha x piperita*) je višegodišnja lekovita i aromatična biljka, koja pripada familiji Lamiaceae (usnatice). U ovom istraživanju je ispitivano 9 organskih malčeva (slama, usitnjena kora bora, bagremova piljevina, karton, suve iglice bora, usitnjena kukuruzovina, usitnjena kora bagrema, kompost od ostataka iz proizvodnje lekovitog bilja 1 i 2), biorazgradiva crna malč folija i 4 malč folije (srebrno-braon, perforirana crna, crna, crna „agrotekstil“) u eksperimentalnom ogledu pitome nane koji je postavljen na lokalitetu u Pančevu, u Srbiji. U proleće 2015. godine korišćene su tri različite metode za postavljanje malča. Ogled je podeljen na dva dela, jedan koji je ručno plevljen i drugi gde korovi nisu uklanjani. U ogled su uključene i dve kontrole bez postavke malča, s tim što su u jednoj kontroli korovi uklanjani redovno (C1), dok su se u drugoj korovi slobodno razvijali i rasli zajedno sa nanom (C2). U poredjenju sa kontrolama, pozitivan efekat na prinos pitome nane, kao i na redukciju biomase korova pokazali su sledeći tretmani: srebrno-braon folija (sPE), crni „agrotekstil“ (BA) i dva organska malča (bagremova piljevina i iglice bora). Navedeni mačevi su uključeni u dalja istraživanja. Cilj ovog istraživanja bio je procena i odabir najboljeg modela primene organskog malča kao i malč folija za dalja istraživanja, koja će garantovati visok prinos gajene nane odličnog kvaliteta.

Ključne reči: *Mentha piperita*, pitoma nana, malč, suzbijanje korova, prinos.