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Original Scientific paper

THE INFLUENCE OF DIFFERENT SUBSTRATE MIXTURES ON SEEDLINGS QUALITY AND ECONOMICALLY HIGH YIELD OF TOMATO, PEPPER AND BASIL

Abstract

In this paper, the influence of different substrate mixtures on seedlings quality and yield of tomato, pepper and basil were investigated. The experiments were carried out in the plastic greenhouse and experimental field of the Institute for Medicinal Plant Research "Dr. Josif Pančić" in Pančevo, during year 2016. Four treatments (different substrate mixtures) and a control treatment (soil from the investigated location) were tested. The best characteristics of morphological traits of transplants were achieved using the commercial Klasmann Potgrond H substrate. On the other hand, the plants that were grown on the compost produced during the production and processing of medicinal plants (IMPR) had the highest yield of fruits (tomatoes and peppers) and yield of fresh aboveground mass (basil).

Key words: *substrate mixtures, tomato, pepper, basil, yield*

INTRODUCTION

There is almost no part of the world where tomatoes, peppers and basil are not used. They are used as a fresh vegetable or as a raw material for processing and various product preparation. In order to enable transport over long distances and a long period of manipulation and storage, new hybrids with "long shelf life" properties have taken

over 90% of the domestic market. Such hybrids are more suitable for producers. But, without pleasant taste, aroma (without any, in some cases) and texture, they are not appreciated among consumers and processing technologists. The major disadvantage of old varieties is its softness and inability to survive on store shelves for more than a day or two. However, in recent times, old varieties that have a recognizable taste and aroma are increasingly "requested", such as tomato varieties: *Novosadski jabučar*, *Volovsko srce*, *Roma* and others, and pepper varieties *Kurtovska kapija*, *Dukat*, *Župska rana*, *Šhorokšari*, *Somborka*, *Strižanka* or basil variety *Sitnolisni aromatični* and similar. One of the above-mentioned varieties is the *Volovsko srce* variety. This variety has taken a special place in our region primarily because of its specific taste and smell, but also because of the tradition in its consumption. It is a variety characterized by large fruits and specific color, and distinctive heart-like shape, which is how this variety got its name. One of the most important shortcomings in the production of this variety is the impossibility of long-term storage, due to the fact that its fruits ripen quickly and cannot withstand long-term transport. The second variety is the *Župska rana* pepper variety. *Župska rana* is a variety of early pepper. It is highly valued and cultivated in these areas. It is one of the tastiest pepper varieties. It often has good growth and stem height and is very yielding. The fruits are very long and fleshy and it is suitable for both greenhouse and field production. When the fruits are fully ripe, they are distinctly red in color. The third variety is the small-leaved aromatic basil variety. This variety of basil is the most cultivated in our country. It tolerates our agroecological conditions well, achieving a satisfactory yield and quality every year (Filipović et al., 2016). It is mostly used as a spice, but also in religious ceremonies and as an ornamental plant. In addition, it also contains significant amounts of essential oil of good quality. Since all three plant species, i.e. the mentioned varieties, are grown from seedlings for that purpose, it is necessary to provide appropriate growing media that can be used for the production of quality transplants (Filipović and Ugrenović, 2013). The market offers a large number of commercial substrate mixtures, which often have high prices and sometimes unsatisfactory quality. Choosing the substrate which can improve the plants' traits during the cultivation of selected tomato, pepper and basil varieties is another important task. Therefore, the aim of this research was to determine the possible influence of different autochthonous substrate mixtures on seedling quality and productivity of selected tomato, pepper and basil varieties.

MATERIAL AND METHODS

The following plant material was used in the research: tomato (*Lycopersicon lycopersicum* L.) variety *Volovsko srce* produced by "Superior" d.o.o. from Velika Plana, pepper (*Capsicum annuum* L.) variety *Župska rana* produced by the Institute for Vegetable Crops from Smederevska Palanka and basil (*Ocimum basilicum* L.) variety *Sitnolisni aromatični* produced by the Institute for Medicinal Plant Research "Dr Josif Pančić" from Belgrade. Research was conducted during 2016 in the greenhouse and experimental field of the Institute for Medicinal Plant Research "Dr Josif Pančić" located in Pančevo (44°52'20"N; 20°42'06"E; 74 m.a.s.l.).

During mid February 2016, seeds for the production of seedlings were sown in the greenhouse without additional heating. The seedlings were transplanted into the four examined substrates and one commercial substrate after the appearance of the first regular leaf (end of March 2016). Seedlings were produced in plastic round pots with a diameter of 10.5 cm, a depth of 9.0 cm and a substrate volume of 525 cm³. After three months, more precisely in the middle of May 2016, developed seedlings were transplanted in the field, when the seedlings reached the most optimal stage for reception. Planting was done manually, for tomato/pepper at a distance between rows of 80 cm, and in a row 40 cm plant from plant, while for basil the distance between rows was 50 cm, and in a row 30 cm plant from plant. In the experimental field, oil flax was grown (*Linum usitatissimum* L.) as a pre-crop to all examined species. The trial was based on a completely randomized block design with a base plot size of 24.5 m² (10.0 m x 2.45 m) in four replications. The impact of different types of substrate mixtures was investigated and compared with the control variant: as a control variant, marshy black soil type (collected at the experimental location) was used. This soil has the following agrochemical characteristics: pH value = 5.4, humus content = 2.3%, P₂O₅ content 3.6 mg/100 g of soil and K₂O 36.2 mg/100 g of soil. The second variant was a mixture (25% marshy black soil type : 25% sand : 50% compost created from the waste obtained from green areas (parks and gardens) with the following agrochemical properties: pH in KCl = 6.98, humus content = 3.86%, CaCO₃ content = 3.0%, P₂O₅ 6.8 mg/100 g soil and K₂O 10.3 mg/100 g soil. The fourth variant was represented by the compost created during the production and processing of medicinal plants (IMPR – product of the Institute for Medicinal Plant Research "Dr. Josif Pančić" from Belgrade). The properties of this compost are: pH in KCl = 6.02, humus content = 3.86%, nitrogen = 2.2%, 0.46% P₂O₅ and 0.48% K₂O, 2%, Fe 0.6%, Zn 0.08% and 26% organic matter. The last, fifth variant was represented by the commercial substrate Klasmann Potgrond H, which is a mixture of black sphagnum peat and very fine white sphagnum peat to which soluble fertilizer and microelements have been added, pH values 5.5-6.5, 1, 5 kg/m³ has an average of 14% N, 16% P₂O₅ and 18% K₂O (Glamočlija et al., 2015). Meteorological data during the experimental vegetation period were obtained from the meteorological station of the Institute "Tamiš" Pančevo (Table 1).

Table 1. Meteorological data for vegetation period in 2016

Parameters	May	June	July	August	Sum / Average
Precipitation	26.8	160.6	103.2	14.2	304.8
Temperatures	18.2	23.3	23.0	21.1	21.1

During the growing season, classic measures of care of seedlings and old plants from pests, diseases and weeds were applied. The first watering was done immediately after planting, and subsequents were done as needed.

Ten plants were taken from each repetition (some in the seedling stage, some for the purposes of measuring examined traits in adult plants). In our research, the follo-

wing were measured: seedling height (cm), seedling leaf number, seedling stem thickness at the base (mm), seedling root mass (g/plant), fruit width (cm), fruit length (cm) and fruit/fresh herb yield (g/plant). In the case of tomatoes and peppers, only three harvests were carried out, while the other harvests were not recorded, which, depending on the year, range from 10 to 15. Tomato and pepper fruits were harvested at the technological stage of ripening, and the basil plants were harvested by hand with a sickle at the cut height of 8 cm above the ground. The first mowing of the above ground mass of basil was done in full bloom at the end of July. The second harvest was done at the beginning of October (Filipović et al., 2016). The obtained data were processed with indicators of descriptive statistics: mean value, standard deviation (StdDev) and coefficient of variation (Cv). Statistical analysis was performed with the statistical software Statistica for Windows 10 (STATISTICA, 2010).

RESULTS AND DISCUSSION

The influence of different substrate mixtures on various traits of seedlings and fruits of tomato *Volovsko srce* variety is shown in table 2.

Table 2. Different mixtures of substrates and parameters nursery-plants and tomato fruit

Tretmants	Nursery-plants – Protected area				Open field					
	Height of seedlings (cm)	Leaf number per plant	The thickness of the stem in the grounds (mm)	Mass of seedling root (g/plant)	Width fruit (cm)	Fruit length (cm)	First harvest - fruit yield (g/plant)	Second harvest - fruit yield (g/plant)	Third harvest - fruit yield (g/plant)	Fruit yield per plant (g/plant)
Control	16.0	6.0	6.8	1.1	6.1	6.2	218.6	330.8	259.5	808.9
Mixture (25:25:50)	19.7	7.3	7.6	1.6	8.9	8.0	355.4	345.3	236.4	937.1
Compost – plant and wood waste	22.2	7.8	8.2	2.0	7.2	6.7	210.4	308.2	339.9	858.5
Compost – IMPR	22.7	8.2	8.4	2.0	11.3	9.0	491.8	518.9	436.0	1446.7
Potgrond H	23.2	8.7	9.4	2.1	5.3	8.4	213.3	312.0	288.2	813.5
Average	20.8	7.6	8.1	1.8	7.7	7.7	297.9	363.0	311.9	972.9
StdDev	2.789	0.974	0.901	0.434	2.59	1.51	140.5	109.34	100.60	307.80
Cv (%)	13.42	12.82	11.17	24.61	33.50	19.74	47.18	30.12	32.25	31.64

The highest tomato seedling height was achieved by the plants grown on the Potgrond H substrate (23.2 cm). Seedlings produced on compost IMPR (22.7 cm) and compost from plant and wood waste (22.2 cm) had almost identical seedling heights. As expected, the lowest tomato seedling height was recorded in the control treatment (16.0 cm). The highest number of leaves per plant was recorded for the Potgrond H substrate (8.7), and the lowest number of leaves per plant was recorded in the control variant (6.0). A similar trend was observed for the stem thickness at the base and the root mass of the tomato seedlings of the *Volovsko srce* variety. In the open field, the widest and longest tomato fruits were achieved by plants produced by transplants grown on the compost IMPR, which were 11.3 cm wide on average and 9.0 cm long, respectively 8.9 cm wide and 8.0 cm long. Tomato plants produced from transplants grown on Potgrond H substrate had the smallest average fruit width (5.3 cm), while the smallest fruit length was recorded in the control treatment (6.2 cm). Regarding the most productive harvest, the best results were achieved during the second harvest, with an average of 363.0 g of fruit weight per plant. Overall, the highest individual yield of tomato fruits after three harvests was achieved by plants whose seedlings were produced on compost IMPR (1446.7 g/plant), while the lowest fruit yield per plant was recorded on plants from the control treatment (808.9 g/plant). As can be seen, in the examined year, the agroecological conditions were favorable for the cultivation of this tomato variety. *Volovsko srce* is an early tomato variety, and it ripens in 80 days from planting. Some amounts of cow manure have an extremely good effect on the yield of tomatoes (Castro Pacheco, 2021). Growing tomato seedlings on different substrate mixtures, with a special emphasis on mixtures with vermicompost, gives satisfactory results, and the best results are obtained with the combination of vermicompost and zeoplant (Đorđević et al., 2004). In Malek's research (2012), the *Volovsko srce* variety achieved a yield of 38 t/ha when treated with 40 g/plant of cow manure, which is an economically justified yield when growing tomatoes. Fruit yield of *Volovsko srce* cultivar at Bangladesh Agricultural University farm after induced mutation treatment had yield per plant ranging from 2.2 to 3.9 kg (Nahyan et al., 2014).

The influence of different substrate mixtures on various traits of seedlings and fruits of the *Župska rana* pepper variety is shown in table 3.

When it comes to the production of pepper seedlings of the *Župska rana* variety, the best results (seedling height, number of seedling leaves, seedling stem thickness at the base and seedling root mass) were achieved by plants that were grown on the substrate Potgrond H. Slightly lower values of the mentioned indicators were recorded for seedlings that were grown on IMPR compost and compost from plant and wood waste. The lowest values of examined traits of pepper seedlings were achieved by plants produced on a mixture-based substrate and on the control treatment. As for the cultivation of pepper variety *Župska rana* in the open field, the largest fruits (the highest values of width and length) were recorded in plants with seedlings produced on the IMPR compost based mixture and seedlings produced on the substrate Potgrond H. The weight of the fruit, as well as the number of fruits per plant, play a decisive role in the formation of the yield of peppers. Overall, for all three harvests, the highest yield of pepper fruits was achieved using transplants grown on substrate based on IMPR compost (283.9 g/plant). Next in rank was the yield achieved by plants whose seedlings

Table 3. Different mixtures of substrates and parameters, nursery-plants and pepper fruit

Tretmants	Nursery-plants – Protected area				Open field					
	Height of seedlings (cm)	Leaf number per plant	The thickness of the stem in the grounds (mm)	Mass of seedling root (g/plant)	Width fruit (cm)	Fruit length (cm)	First harvest - fruit yield (g/plant)	Second harvest - fruit yield (g/plant)	Third harvest - fruit yield (g/plant)	Fruit yield per plant (g/plant)
Control	15.8	5.9	6.3	0.16	4.1	7.5	30.7	37.7	32.7	101.1
Mixture (25:25:50)	18.5	6.9	7.0	0.17	5.7	11.0	63.4	76.3	58.6	198.3
Compost – plant and wood waste	20.7	8.1	7.5	0.19	4.8	7.9	35.1	57.1	48.4	140.6
Compost – IMPR	20.1	8.7	8.1	0.20	5.7	11.2	91.9	112.6	79.5	283.9
Potgrond H	20.8	9.4	8.4	0.20	5.3	11.0	71.6	84.0	52.0	207.5
Average	19.2	7,80	7.44	0.18	5.12	9.7	58.5	73.5	54.2	186.3
StdDev	1.971	1.334	0.806	0.019	0.853	2.110	28.575	34.582	21.544	73.481
Cv (%)	10.28	17.12	10.84	10.66	16.69	21.69	48.82	47.04	39.74	39.45

were produced on the Potgrond H substrate (207.5 g/plant), which was about 27% less, while the lowest fruit yield per pepper plant was recorded on plants from the control treatment (101,1 g/plant). In research by Đukić et al. (2003) the average length of the fruit of the variety Župska rana was 16.7 cm, and the width was 4.95 cm, while the weight of the fruit was 94.65 g. This pepper variety can be successfully grown in conventional as well as organic growing conditions in which it achieves more than satisfactory results (Bicikliski et al., 2018).

The influence of different substrate mixtures on examined traits of seedlings and yield of the fresh above-ground part of basil plant of the *Sitnolisni aromatični* variety is shown in table 4.

As with the previous two plant species, the best results of the examined morphological traits (height of seedlings, number of leaves, thickness of the stem and mass of seedling roots) were achieved by the plants grown on the Potgrond H substrate, which are closely followed by the values of seedlings grown on the IMPR based compost. The control treatment had the lowest values for examined traits, but also for both individual and total yield of fresh above-ground biomass. The highest values (563.4 g/plant) of the total yield of the fresh above-ground biomass were obtained from plants whose seedlings were grown on IMPR compost, while the lowest values were achieved by plants whose seedlings were grown on compost from vegetable and wood. waste (308.4 g/plant), in the control (327.0 g/plant) and on the substrate Potgrond H (331.7 g/plant).

Table 4 Different mixtures of substrates and parameters nursery-plants and basil herba

Tretmants	Nursery-plants – Protected area				Open field		
	Height of seedlings (cm)	Leaf number per plant	The thickness of the stem in the grounds (mm)	Mass of seedling root (g/plant)	Fresh aboveground yield – First harvest (g/plant)	Fresh aboveground yield – Second harvest (g/plant)	Total fresh aboveground yield (g/plant)
Control	9.2	6.3	3.4	0.07	180.8	146.2	327.0
Mixture (25:25:50)	9.5	6.9	3.9	0.11	229.9	203.5	433.3
Compost – plant and wood waste	10.0	7.5	4.2	0.13	152.8	155.6	308.4
Compost – IMPR	10.6	7.6	4.3	0.13	265.7	297.7	563.4
Potgrond H	11.4	8.0	4.3	0.13	179.8	151.9	331.7
Average	10.1	7.3	4.0	0.11	201.8	191.0	392.8
StdDev	0.846	0.616	0.361	0.028	52.100	67.863	110.105
Cv (%)	8.36	8.49	9.02	25.17	25.82	35.54	28.03

The results obtained in the research of Čolik (2015) showed that there is a significant difference between basil seedlings grown on soil and on substrate. In this case too, the quality of the substrate affected the yield of basil. Thus, the mass of the fresh basil leaf grown on the substrate was 24.57 g, which is 9.38 g more than the one grown on the soil. Beatović et al. (2009) conducted a study on the effect of different substrates on basil yield, in which the most suitable substrate for basil production was a combination of Gaj peat and manure in a ratio of 70%:30%. Hewidy et al. (2014) conducted a study in which loamy soil was enriched with peat, compost and vermicompost. The best results when growing basil seedlings were obtained in a combination of soil and compost 70%:30%. The achieved values were in accordance with the values obtained during fertilizing with vermi-compost and biological fertilizers in the research of Rezaee and Nabavi (2012).

CONCLUSION

Based on the conducted research and analysis of the data obtained during the application of different substrate mixtures on seedling quality and productivity of selected tomato, pepper and basil varieties, it was concluded that the best results of the examined traits (seedling height, number of leaves, thickness of the stem and mass

of seedling roots) were achieved in plants that were grown on the substrate Potgrond H. Satisfactory results were also achieved using seedlings grown on the IMPR based compost mixture. As for the productive traits of the tomato crop, the highest yield of fruits was achieved using seedlings grown on the IMPR compost based mixture, while the lowest yield of fruit per plant was recorded for plants from the control treatment. The same situation was recorded when measuring the yield of pepper fruits and the yield of the fresh aboveground biomass of basil, where the highest values of this trait were achieved in plants produced on IMPR compost based mixture.

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Оригинални научни рад

УТИЦАЈ РАЗЛИЧИТИХ СУПСТРАТНИХ СМЕША НА КВАЛИТЕТ РАСАДА И ЕКОНОМИЧНО ВИСОК ПРИНОС ПАРАДАЈЗА, ПАПРИКЕ И БОСИЉКА

Резиме

У раду је истраживан утицај различитих супстратних смеша на квалитет расада и продуктивност усева парадајза, паприке и босиљка. Истраживања су обављена на локацији колекције Института за проучавање лековитог биља „Др Јосиф Панчић“ у Панчеву, у току 2016. године. Испитивано је четири варијанте супстрата и контролна варијанта (земљиште без супстрата). Најбоље карактеристике морфолошких показатеља остварили су биљнице произведене на комерцијалном супстрату за производњу расада Класманн Поттронд Х. С друге стране, биљке које су произведене на компосту насталом у производњи и преради лековитог биља, код свих испитиваних врста имале су највеће плодове (парадајз и паприка) и принос свежег надземног дела (босиљак).

Кључне речи: *супстратне смеше, парадајз, паприка, босиљак, принос*