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Quality of cucumber seedlings grown in different substrate volumes

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Abstract

The production of vegetable seedlings is a part of horticultural production that is very intensive and requires a number of horticultural practices and measures. The standards of quality seedlings are not well defined, but mostly refer to the following facts: without infections of diseases or pests, ability to survive in unfavorable environments after transplanting, well developed root system, adequate root:shoot ratio, and well developed leaf area without visible physiological defects of leaves. In this study cucumber seedlings (*Cucumis sativus* L.) were grown in five different substrate volumes (100, 200, 300, 500 and 1000 cm^3) with aim to determine which substrate volume ensured production of seedlings with the highest quality in the shortest time. Research was conducted in controlled conditions (growing chambers) at the Faculty of Agriculture in Belgrade. The quality of the seedlings was monitored through the following growth parameters: plant height (cm), stem height (cm), stem diameter (cm), number of leaves, plant fresh weight (g), and leaf area per plant (cm^2). The results obtained show that the increase in substrate volume resulted in a linear increase in the values of all measured quality parameters of the seedlings. However, the seedlings grown in a smaller substrate volume (especially 200 and 300 cm^3) also had growth parameters that met the standards for high-quality seedlings, which is economically justified from several aspects: lower substrate consumption, greater number of pots per unit.

Key words: cucumber, seedlings, substrate volume, plant height

Introduction

The production of vegetable seedlings is a part of horticultural production that is very intensive and requires a number of horticultural practices and measures. Well-nourished seedlings are the main precondition for successful vegetable production, especially for a high yield and its good quality (Prunty et al., 2015). However, according to the Balliu et al. (2017), the standards of high-quality seedlings are not precisely defined, but mostly refer to the following facts: without infections of diseases or pests, ability to survive in unfavorable environments after transplanting, well developed root system, adequate root:shoot ratio, and well developed leaf area without visible physiological defects of leaves (chlorosis or necrosis).

In modern vegetable cultivation, seedlings are grown mainly in a protected area, in containers or pots (Nichols, 2013). In this case, the choice of substrate is of key importance, and in addition, special attention is paid to the water and fertilizer regime, as well as environmental conditions. The role of substrate are to provide the plant with physical support, a suitable conditions for root growth and development, aeration, water and an adequate amount of plant nutrients (Olle et al., 2012). Depending on local availability, various organic (peat, compost, coconut coir, rice husks, tree bark) and inorganic (perlite, clay, vermiculite and mineral wool) raw materials are used to produce the growing media-substrate (Schmilewski, 2009). In the production of vegetable seedling plants are often used industrial growing mixtures adapted to the nutritional regime for the corresponding phase of production.

The cucumber (*Cucumis sativus* L.) belong to the family Cucurbitaceae which include about 960 species. The center of origin of this species is the Asian continent, more precisely India, while China is mentioned as a secondary center of origin (Valcárcel et al., 2018). Cucumber is a highly valued vegetable plant grown worldwide for its immature fruits, which are used in human nutrition as fresh in various salads or processed into pickles.

During 2021, cucumber was grown on more than 2 million ha, and the total annual yield was over 93.5 million tons. Of the total area under cucumber cultivation, 89% is in the Asian continent, with China being the top producer, while areas in Europe account for 6.6% of total production. In Serbia, the area under cucumber cultivation in 2021 was 2.769 ha, and the total annual yield was 29.177 tons (FAOStat, 2021).

Because cucumber and other members of Cucurbitaceae family have a root systems that are sensitive to transplanting, i.e. do not tolerate or regenerate well from any damage, the production of seedling is specific (Melo et al., 2016). In this regard, this study investigated the effect of five different substrate volumes (100, 200, 300, 500, and 1000 cm^3) on the quality of

cucumber seedlings monitored through quality parameters (plant height, stem height, stem diameter, number of leaves, plant fresh weight, and leaf area). The aim of the study was to determine which substrate volume ensures the production of seedlings with the highest quality in the shortest time and at the same time is economically justifiable.

Material and Methods

The experiment was carried out at growing chambers at the Faculty of Agriculture, in Belgrade. For research purposes, cucumber seedlings (*Cucumis sativus* L, hyb. *Darina* F1) were grown in polypropylene pots filled with commercial substrate TKS 1 (Floragard) in five different volumes: 100, 200, 300, 500, 1000 cm^3. The experiment was carried out in triplicate. During the experiment the following conditions and measures were provided:

- air temperature of day/night cycle was 25/18^oC;
- during the whole experiment the day/night interval was 14/10 h. Artificial light was provided by lamps (Philips MH 600W);
- from sowing until the appearance of the first permanent leaf, 50 ml of water was added to each pot, and then the seedlings were watered with 70 ml of water until the end of the experiment;

After completion of the experiment (22 days after sowing), in the cucumber seedlings the following growth parameters were measured:

1. Plant height (cm) was measured from root collar to the top of the highest leaf, using meter scale;
2. Stem height (cm) was measured from root collar to the top of the stem, using meter scale;
3. Stem diameter (cm) was measured under the cotyledon leaves, with a digital caliper;
4. Plant fresh weight (g) was determined by weighing above-ground part of plants (stem and leaves) by scale (AXIS, model No. AD200, Poland);
5. Number of leaves was defined by counting leaves;
6. Leaf area per plant (cm^2) was measured by computer program ImageJ (Abramoff et al., 2004).

Significant differences between cucumber seedlings grown in different substrate volumes were estimated using one-way analysis of variance (ANOVA) with least significant difference (LSD) tests, at the $p<0.05$ and $p<0.01$ significance levels, by using RStudio software (version 2022.07.1) (RStudio Team, 2020). The results were expressed as mean and arranged in tables.

Results and Discussion

Table 1 shows the average plant growth parameters (plant height, stem height and stem diameter) corresponding to five different substrate volumes.

Table 1. Growth parameters of cucumber seedlings (plant height, stem height and stem diameter) produced in different substrate volumes

Substrate volume (cm^3)		Plant height (cm)	Stem height (cm)	Stem diameter (cm)
100		13.26	3.94	4.91
200		13.52	4.66	5.53
300		14.26	4.62	5.86
500		17.72	6.63	6.57
1000		21.30	7.76	6.59
LSD	*p≤0.05*	**1.77**	**0.82**	**0.51**
	p≤0.01	**2.42**	**1.12**	**0.70**

The values of plant height, stem height, and stem diameter of cucumber seedlings increased linearly with increasing substrate volume. The heights of plants grown in pots with substrate volumes of 100, 200, and 300 cm^3 were not statistically significantly different from each other, but they were statistically significantly differ (*p≤0.01*) compared to plants grown in substrate volumes of 500 and 1000 cm^3. In addition, there was a statistically significant difference between the height of the plants produced in the 500 and 1000 cm^3 volume substrates. Also, in the case of stem height, there was no statistically significant difference with smaller substrate volumes (100, 200 and 300 cm^3), while the difference in stem height measured in plants grown in pots with substrate volumes of 500 and 1000 cm^3 was statistically significant (*p≤0.01*). As for stem diameter, the lowest value was observed in pots with a substrate volume of 100 cm^3, which was statistically significantly lower (*p≤0.05*) than the stem diameter measured in plants grown in other substrate volumes (200, 300, 500, and 1000 cm^3). The stem diameter achieved at substrate volumes 200 and 300 cm^3, as well as substrate volumes of 500 and 1000 cm^3 did not differ statistically significantly.

Number of leaves, plant weight, and leaf area of cucumber seedlings grown in five different substrate volumes (100, 200, 300, 500, 1000 cm^3) are shown in Table 2.

The number of leaves, plant fresh weight and leaf area increased in a linear way with the increase in substrate volume.

The lowest number of leaves (2.00) was obtained in seedlings grown in pots with substrate volume of 100 cm^3, and the highest number of leaves (4.00) in the pots with maximum tested

substrate volume (1000 cm^3). However, there was no statistically significant difference between the analyzed groups of cucumber seedlings. The volume of the substrate had a statistically very significant effect on the plants fresh weight, except for cucumber seedlings grown in substrate volumes of 200 and 300 cm^3, where no statistically significant difference was found. In the case of leaf area, there was also no statistically significant difference between the groups of cucumber seedlings grown in substrate volumes of 200 and 300 cm^3, while between the other groups there was a statistically significant difference, especially between seedlings grown in the minimum (100 cm^3) and maximum (1000 cm^3) tested substrate volume.

Table 2. Number of leaves, plant weight (g), and leaf area (cm^2) of cucumber seedlings grown in different substrate volumes

Substrate volume (cm^3)		Number of leaves	Plant fresh weight (g)	Leaf area (cm^2)
100		2.00	5.86	136.0
200		3.00	7.11	148.1
300		3.00	7.34	169.3
500		4.00	12.52	282.2
1000		4.00	15.64	372.2
LSD	*p<0.05*	**2.49**	**1.37**	**31.37**
	p<0.01	**3.92**	**1.87**	**42.79**

In research of Mello et al. (2016) were cucumber seedlings grown in substrate volume of 30, 60, 120 and 180 cm^3 , the results indicate that with the increase in the volume of the substrate, the quality of the cucumber seedlings also increases. Namely, according to growth parameters (shoot length, root length, root volume) the cucumber seedlings produced in the volumes of 60, 120 and 180 cm^3 were rated as high quality, while the seedlings in the smallest substrate volume (30 cm^3) were of unsatisfactory quality. Similar results were obtained in the research by Bjelić et al. (2010), in which the effect of substrate volume on the quality of pepper seedlings was investigated. These results can be explained by the fact that in the larger volume of the substrate there is a greater amount of water and nutrients, and at the same time there is more space for the growth and development of the root system.

Furthermore, similar studies indicate the optimal volume of container cells or pots for production of vegetable seedlings: 72 cell container (about 50 cm^3) for cucumber (Costa et al., 2012), also for eggplant (Costa et al., 2013) and tomato (Rodrigues et al., 2010). Certainly, when choosing the volume of the substrate, should take into consideration the vegetable species

to be grown, the duration of cultivation in containers or pots, as well as the economic justification.

Conclusion

Cucumber (*Cucumis sativus* L.) is a nutritionally and economically important horticultural crop. The first stage of cucumber production is the production of seedlings, and the success of production depends on their quality. Besides the basic conditions (temperature, humidity, light, water), the choice of substrate and the volume of the pot are the most important. In this study, it was found that cucumber seedlings grown in pots with a larger substrate volume had higher values of the growth parameters studied (plant height, stem height, stem diameter, number of leaves, plant weight and leaf area) than plants grown in smaller substrate volumes. More precisely, the values of the mentioned growth parameters of the cucumber seedlings increased linearly with increasing substrate volume. Although the cucumber seedlings showed the highest values of the growth parameters when grown in the largest substrate volume, seedlings grown in a smaller substrate volume (200 and 300 cm^3) also had growth parameters that met the standards for high-quality seedlings. These points out the numerous advantages of growing cucumber seedlings in pots of smaller volume: lower substrate consumption, greater number of pots per unit, especially in protected area, and particularly greater economic profitability.
The idea is certainly to continue to expand research to introduce more hybrids into production and use more different substrates.

Aknowlegment

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