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Influence of Substrate on Germination and Fruiting of Tomatoes

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The production of tomatoes from seedlings is safer, fruiting and harvesting occur earlier, and due to the more uniform distribution of plants in the field, the fruits formed are larger and more uniform. Various substrates from own production and substrates from industrial production are used for cultivation.

The research was conducted in a greenhouse, at the location of Gornji Lukavac, Gradačac.

The aim of this study was to determine the influence of different substrates on germination, vegetative growth and yield of tomatoes (*Solanum lycopersicum*).

For the purposes of this research, four nutrient substrates were used: Potgrond H, own compost, sand-soil mixture in a ratio of 1: 1, and lumbri humus.

The research was conducted during 2021.

The seeds first germinated in the soil substrate: sand (1: 1), the best marketable fruits were on lumbra humus.

Keywords: Seedlings; substrates; marketable tomato fruits.

1. INTRODUCTION

Tomato is one of the most economically important vegetable species. It is produced by direct sowing of seeds and more often from seedlings. Seedling production is one of the most sensitive stages in tomato production. Quality tomato seedlings are produced in different types

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of protected space, which enables maximum control of microclimatic conditions necessary for the production of seedlings.

Most often, errors occur in the phase of cotyledon leaves and at the time of formation of the first true leaf. If the temperatures are high and the light is low, the subcotyledonous part of the sinkhole lengthens. In the rhizogenesis phase, it is necessary to lower the temperatures to 12-15^{0}C during the day and to 8-10^{0}C during the night. After this phase, it is necessary to raise the temperature to 16-22^{0}C, which again depends on the length and intensity of light [1], [2]. In case of lack of light, tomato seedlings are additionally illuminated and the photo period is extended to 14-16 hours. It should be emphasized that the composition of the visible spectrum affects the quality (Fig. 1). Especially the exposure of tomato seedlings to the blue and red part of the spectrum.

Fig. 1. Influence of light color on tomato seedlings (Photo: B. Salkić)

For the production of tomato seedlings are used: warm beds, greenhouses and hothouses. Modern production of seedlings is carried out in greenhouses or in special rooms in greenhouses, but more than 70% of rural producers still produce seedlings in warm beds, for this reason a common problem is poor quality beds and disinfection of the same area [3].

Nutrient substrate, in addition to the microclimate, significantly affects the quality of tomato seedlings [4,5,6]. The main properties of the substrate lie in its high water retention capacity combined with high air capacity. Both parameters can be controlled by specific structures of different raw materials for the substrate.

Choosing the right substrate is one of the most important steps in the successful production of seedlings of vegetables and flower species. In this selection, special attention must be paid to the preservation of natural reserves of substrates such as peatlands, and one of the solutions is the selection of alternative substrates [7]. Today, there are a number of by-products of manufacturing industries that are mainly treated as waste, and by their physicochemical properties can be an excellent medium for the production of seedlings, both flower and other plant species. Abad et al. point out that coconut fiber is the most popular alternative substrate whose use has increased from 17 to 40% in the last ten years [8]. Other alternative components that are often used are rice husks, sawdust, perlite, river silt, willow bark and compost [9,10,11]. Also, very often mixtures of different alternative substrates are used, which include a mixture of two or more alternative components. The physicochemical properties of the substrate should be taken into account in order to ensure appropriate conditions for plant development.

Substrate moisture is another limiting factor in seedling production (Fig. 2). In insufficiently moist substrate, the seedlings can dry out and thus their decay occurs. In pre-moist substrate, the causes of lodging and rot attack seedlings and young plants. In the germination stage, the optimum humidity is around 80%, and after germination it decreases.

Fig. 2. Maintenance of favorable relative humidity (Photo: B. Salkić)

In general, we can say that the choice of alternative substrates and their mixtures should go in the direction of satisfying the properties of ideal substrates because it is a guarantee of successful production of planting material.

Therefore, it is imperative to choose the best material or alternative component for successful plant growth and development and improving plant productivity.

Compost is one of the quality media for growing tomatoes. Compost can be of different composition, depending on the starting material and the production process. Composts are organic fertilizers produced by controlled oxidative microbiological degradation of various mixtures of primarily plant residues, mixed with manure, animal residues and mineral additives. It follows that composting is a controlled aerobic microbiological decomposition of organic matter [12]. Compost as a result of the recycling process can be a suitable material for organic production, given that the composting process is well done, input materials are not contaminated, and the result is a product that is applicable to the needs of the ecological system [13].

Quality compost, no matter how it is prepared, must have an appropriate ratio of carbon because it is a source of energy and nitrogen, which is a basic element of plant nutrition. Nitrogen-rich substances are grasses, legumes, remains of fruits, vegetables, fish, seeds, and so-called dark or dry substances rich in carbon are corn cobs and stalks, sunflower stalks, straw, hay or wood shavings. Gariglio et al. studied the influence of the willow sawdust composting process on lettuce germination. The composting process reduces the negative effect of uncomposted sawdust and increases the germination of lettuce from 5% without composting to 93.3% at 40 days of composting [14].

The pH reaction of compost is valid primarily because it can be used to monitor the decomposition process. Compost microorganisms work best in neutral to acidic conditions, and the pH is in the range of 5.5 to 8. During the initial stages of decomposition, organic acids are formed. Acidic conditions are favorable for the growth of fungi and the breakdown of lignin and cellulose. As composting lasts, organic acids are neutralized, and mature compost generally has a pH between 6 and 8.

The heat of compost is produced as a by-product of the microbiological decomposition of organic material. Degradation occurs most rapidly during the thermophilic composting phase (40-60°C), which lasts several weeks or months, depending on the size of the system and the composition of the ingredients. Compost tends to stay around 65^0C because high temperatures cause beneficial microbes to die. If the pile gets too hot, turning or ventilating will help dissipate the heat.

The end result of composting depends on the material used to apply the compost.

In addition to compost, which can be made on the farm, for the cultivation of tomatoes are used industrially prepared media such as: Podgrond H, Lumbri humus, Class Potgrond H, multi-purpose substrate for vegetable seedling production. A mixture of frozen black sphagnum peat and fine white sphagnum peat. Added water-soluble fertilizer and microelements. Recommended for containers and nutrient cubes larger than 6 cm (tomato, paprika, cucumber, watermelon, melon).

Vermicompost (lumbripost, biohumus) is an organic fertilizer or substrate for the production of seedlings produced by microbiological decomposition of bovine manure through the digestive system of California earthworm (*Eisenia foetida*), (Fig. 3).

The starting material for the production of vermicompost is beef manure from the family farm with the use of wheat straw as litter.

Fresh manure was deposited on dry and drained soil, forming a pile 80 cm high, 1 m wide, 12 m long, covered with a layer of straw 20 cm thick and fenced with slabs to reduce drying.

Manure matured in piles for 6 months without aeration and was then used as a substrate for composting using California earthworms (*Eisenia foetida*).

Inoculation of the compost bin with California earthworms was performed by placing previously produced mature vermicompost with California earthworms on the bottom of the compost bin in a layer 5 cm thick.

Fig. 3. Lumbri composting site (Photo: A. Pašalić)

The aim of this study was to determine the influence of different substrates on germination, vegetative growth and yield of tomatoes (*Solanum lycopersicum*).

2. MATERIALS AND METHODS

For the purposes of this research, four nutrient substrates were used: Potgrond H, own compost, sand-soil mixture in a ratio of 1: 1, and lumbri humus.

Klasmann Potgrond H, multi-purpose substrate for vegetable seedling production. A mixture of frozen black sphagnum peat and fine white sphagnum peat. Added water-soluble fertilizer and microelements.

The material for making the compost mass consisted of: grass, leaves, tree branches, sawdust, vegetable remains, a piece of apples, straw, chicken and beef manure. These materials are stacked in boxes and then mixed every couple of weeks to allow new air to enter the compost mass. In order to calculate the optimal ratio between certain components in the compost material, the computer program "Polymath" was used.

The starting material for the production of vermicompost is beef manure from the family farm with the use of wheat straw as litter. Fresh beef manure was deposited on dry and drained soil, forming a pile 80 cm high, 1 m wide, 12 m long, covered with a layer of straw 20 cm thick and fenced with slabs to reduce drying. Manure matured for 6 months without aeration and was then used as a substrate for composting using California earthworms (*Eisenia foetida*).

The research was conducted during 2021.

The experiment was conducted in a greenhouse, at the location of Gornji Lukavac, Gradačac, at the optimal temperature and humidity, where the temperature and humidity of the compost inside the container were measured every day, in order to determine possible oscillations. The pH was measured at the beginning of the experiment, as well as at the end of the experiment to determine possible changes between the initial and final pH. Tomato seeds were planted at 2 cm, and its growth and development was monitored during the vegetation. After a month, the morphometry of the sprouted plants was performed, and in that way it was determined which medium is the most suitable for growing tomato seeds. At the end of the experiment, the yield was weighed and based on the yield, it was determined which medium gave the highest yields.

3. RESULTS AND DISCUSSION

Sowing of seeds in containers was done on March 21, 2021. Germination was performed in the living room, the daytime temperature varied between 19 - 26^{0}C, while the nighttime temperature was between 12 - 19^{0}C.

The relative humidity of the room was between 45 and 69%.

During the month of April, the containers stayed in a protected area (greenhouse), where the temperature and relative humidity were measured. The average daily air temperature during the month of April was 25°C, while the relative humidity was 65%.

The average night temperature in the greenhouse was 14°C.

The first half of May was slightly colder, where the average daily temperature varied from 14 to 24°C, while in the second half of the month there was a sharp warming.

The night average temperature for the second half of May was 17.2°C, with a relative humidity of 70%, while the average day temperature was 33°C.

The temperature in the month of June varied, the lowest morning temperature was 14.1°C while the highest temperature was 26.7°C. Also, large oscillations occur when measuring day and night temperatures. The lowest daytime temperature was 29.1°C while the lowest nighttime temperature was 23.3°C. The highest daytime temperature was 49.2°C, and nighttime 41.3°C.

Due to the large oscillations in temperatures, poor flowering and fertilization occurred.

Tomato picking was done when the plants developed the first true leaves. The average plant height was 9.8 cm and the average stem thickness was 3.6 mm.

Tomatos planted in the medium sand: soil (1: 1) were much thinner than plants planted in other media and had a lighter color of leaves and stems. The fruits were irregular in shape with cracks around the stalk, so there were almost no marketable fruits. During the entire vegetation, spots appeared on the leaves and fruits, which is proof that the plant lacks calcium, and very often other nutrients. Due to frequent drying of the medium, watering was done twice a day. Tomato stalks did not reach the appropriate size, which caused the absence of the formation of the third floor of the fruit in most seedlings.

Tomato seedlings that were planted in lumbra humus gave uniform fruits, of appropriate shape, size and color. 5 floors of tomato fruits and a very small number of non-market fruits were formed. The medium retained moisture well, so watering was done once a day in the evening.

Tomatoes grown in the medium of Potgrond X had solid yields, with a larger number of marketable fruits. Potgrond X proved to be a good medium for growing tomatoes, with the fact that during the vegetation, the leaves and fruits often showed a lack of calcium. 4 floors of fruits were formed.

Tomato fruits grown in compost had a dark beautiful color and appropriate shape. After the formation of the first and second floors, the formation of the third and fourth floors followed, where the fruits lost their size and much smaller non-market fruits appeared. The tomato plant looked pretty good, thick dark green stems with dark leaves. Watering was done every other day, and in the phase of intensive fruiting once a day in the evening.

4. CONCLUSION

The influence of the substrate on the germination of tomato seeds as well as the yield of tomatoes is evident. So the seeds first germinated in the substrate soil: sand (1: 1. The best results showed lumbri humus, as a substrate, because it gave the most marketable fruit, it was developed and the fifth floor of the fruit and well regulated humidity. substrate, Podgrond X, the plants were less developed and showed a lack of calcium.

In compost as a substrate, the fruits were much smaller on the third and fourth floors of fertility.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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