Influence of mineral and organic artificial substrates on productivity of covered ground tomato under additional lighting

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Abstract. The article presents the results of studying the reaction of tomato plants to an artificial substrate on which they are grown with all other things being equal — lighting, nutrition, temperature, and etc. Among the studied parameters, the plants reacted to the greatest extent with an average daily growth, filling of fruits, which mainly influenced the yield of tomatoes.

1 Introduction

Modern greenhouse vegetable growing is one of the most innovative and knowledge-intensive branches of the Russian agrarian and industrial complex. Industrial vegetable-growing complexes are created with the purpose of highly profitable production by saving fuel and energy resources, increasing yields, reducing production costs, and efficient use of investments [1].

The possibility to regulate a wide range of plant growth and development factors significantly reduces the climatic risks in soil production and makes it possible to maximize the genetic potential of varieties and hybrids of various vegetables, including tomatoes, planted by breeders. Controlled conditions include temperature, nutrient, gas, light and many other modes. Recently, special attention has been paid to the study of the effect of artificial substrates of various origins on the further ability to increase the productivity of vegetables in greenhouse and vegetable growing complexes. The most often opposed to each other are substrates of mineral and organic origin, the characteristics of which differ, namely, in density, structure, homogeneity, moisture capacity, thermal conductivity, and etc.

The high degree of vulnerability of greenhouse plants to disruptions in mineral nutrition is associated with the low stability of nutrient solutions (buffering). The buffering capacity of solutions is due to presence of buffer systems in them, represented by a mixture of weak acids, including carbonic acid [2].

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Optimization of the conditions for the growth and development of plants in cultivation facilities is based on creation of a microclimate that covers the resulting effect of a system of technological equipment — heating, ventilation, irrigation, fertilizing nutrients and CO2, as well as artificial lighting [3, 4].

The microclimate inside the greenhouse is significantly influenced by environmental factors. These are solar radiation, the strength and direction of the wind, temperature and relative humidity, the amount of precipitation. The most important and determining factor in the external environment is solar radiation. It has a direct effect on the thermal regime of the greenhouse, serves as the main source of energy and determines such microclimate regimes as temperature, humidity, irrigation, food and carbon dioxide [5, 6, 7, 8].

In this regard, making evaluative comparisons in compliance with the scientific principle of a single difference is one of the most relevant areas of study in modern TOK.

2 Materials and Methods

The production experiment was carried out in the greenhouse complex of Yug-Agroholding LLC (Chechen Republic, Grozny) in 2020-2021, in unit 2 (1.8 hectares) when growing a tomato hybrid Merlis F1 with a density of 2.4 plants per square meter.

Substrates from GRODAN and BIOGROW were selected as objects for the assessment studies.

Mineral wool from the Dutch company GRODAN is a versatile substrate for growing vegetables in a greenhouse. Grodan substrates provide greater precision in fertilization and prevent root burns, are nutrient-free and have a neutral pH of 7. The product is characterized by increased porosity, which improves drainage and aeration of the roots, does not have buffering properties, therefore, it easily adopts the acidity and nutritional regime of the nutrient solution. Mineral wool has a temperature 2 degrees lower than other substrates. It has increased capillary properties, so it evaporates well and absorbs water. Most of the nutrient solution is retained in mineral wool, it needs one-fourth less water than peat. It is a sterile substrate, it does not contain pathogenic microorganisms, pests and toxic substances. Reuse of the substrate is allowed.

BIOGROW coconut mats are compressed coconut fiber substrate packaged in black and white polyethylene with UV protection and tightened with rubber bands for better shape retention during watering. Coconut fiber has excellent hygroscopicity and air permeability, allowing for an ideal air-water balance in the root zone.

Presence of coconut particles of different sizes in Biogrow coconut substract mats allows them to simultaneously function as a substrate and a drainage material. Fine – more moisture-absorbing – fiber fraction is located on top, allowing to reduce evaporation from the substrate surface; large - at the bottom, to improve removal of moisture from plant roots.

Coconut fiber substrates can easily replace peat. Wherein, if peat is depleted quickly enough, the coconut substrate has the ability to recover on its own, being saturated with fertilizer components. The moisture content of Bio-Grow coconut mats is higher than that of mineral counterparts. Fibers can absorb up to seven times their own moisture content.

The study program included the solution of the following tasks:

- to evaluate the effect of the substrate on the linear growth of tomato plants;
- the intensity of the fruit filling within 30 days;
- to study the beginning of flowering from the moment of sowing;
- to reveal the reaction of tomato plants to changes in Ec and pH of the solution;
- to determine the yield of tomato depending on the substrates used;

– to determine the economic efficiency of production depending on the substrates used.

3 Results and Discussion

The data obtained as a result of observations (Table 1) indicate a different reaction of tomato plants to the artificial substrate on which they are grown, all other things being equal - lighting, nutrition, temperature, and etc.

Table 1. Comparison result.

No	Name of substrate	Average daily linear growth, cm	Filling the fruit in 30 days	Days before flowering	Ec avg	PH avg	yield for vegetation
1	GRODAN	3.09	0.9-5.7	30	3.7	5.6	70.06
2	BIOGROW	3.19	0.9-6.2	30	3.6	5.6	73.40

Among the studied parameters, the plants reacted to the greatest extent with an average daily growth, filling of fruits, which mainly influenced the yield of tomatoes.

The growing season was 302 days. During this time, tomato plants on GRODAN mineral wool have reached 934 cm, which in terms of the average daily rate is 3.09 cm. The organic substrate based on coconut fiber influenced more accelerated growth of plants, the length of which was 966.7 cm (+3.5 %). The average daily gain was 3.19 cm.

Fruit size and filling rate are the leading parameters affecting the final yield in greenhouse complexes. Measurements and weighing the fruits during the growing season made it possible to calculate the average values. So, the highest productivity of tomato was revealed when grown on coconut fiber. For 30 days, the fruits gained an average diameter of 62 mm, while the diameter on mineral wool was 57 mm (-8.8 %). The size of the fruit also affected its weight. The effectiveness of the organic substrate was manifested in an increase in the mass of fruits by 6 % (140 g), in relation to the mass of fruits grown on a mineral substrate (132 g).

As a result, the final yield on coconut substrate was 4.8 % higher than on mineral wool, which in absolute terms is 3.34 kg/m ^{2}.

To a lesser extent, changes were noted in the concentration of EC salts of the nutrient solution in the mats. Although the difference in EC is only 0.1 units, nevertheless, this may indicate a higher utilization rate of minerals from the nutrient solution by plants growing on organic substrates.

The origin of the substrate did not in any way affect the rate of passage of phenological phases by plants. So in both cases, the flowering phase began at the same time — 30 days after sowing.

Despite the fact that the average indicators of the acidity of the solution are relatively equal, nevertheless, during the season, trends were noted indicating the presence of a greater buffering capacity of the coconut substrate, expressed in smaller fluctuations in the pH of the solution during the day.

Despite the fact that the initial cost of an organic substrate is higher than mineral wool, the economic efficiency of production with coconut fiber is significantly higher. So, with an average cost of a tomato 95 rubles/kga, n additional increase in monetary terms per hectare is 3,173,000 rubles.

4 Conclusions

R&D activities arranged on a permanent basis in production conditions at Yug-Agroholding LLC allow to develop cost-effective solutions and improve production technologies, leading to a decrease in production costs from season to season. So, according to the results of testing various artificial substrates, it was decided to increase use of coconut substrate in the greenhouse complex and to continue the search for scientific ways to implement the genetic potential of tomato hybrids, which reaches 95-105 kg/m^2.

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