Cucumber cultivation technology using tunnel covers

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Obtaining early cucumber production in the Volgograd region sharp-continent climate with frequent early spring frosts is possible only with using tunnel covers. A distinctive feature of the considered technology is cucumber cultivation using tunnel covers with insulated zone organization by making cracks in the soil with filling them with straw. This provides the comfortable conditions creation for the plants preservation when there is a sharp drop in air and soil temperature in spring and a possible return of spring frosts. Maintaining soil moisture in the 0.5 m layer at the level of 90% of the lowest moisture capacity by drip irrigation allowed to obtain a cucumber yield at the level of 85.9 t/ha, which is 7.8 t/ha more than in the basic option.

1. Introduction
Cucumber is a valuable, dietary, widely consumed product that is in unlimited demand throughout the year. According to the agribusiness expert-analytical center "AB-Center" in agricultural enterprises and peasant farms in Russia in 2018, the cucumber sown area was 4.6 thousand hectares. However, it should be noted that over the past 10 years, the cucumbers area has decreased by 2.1 thousand hectares (31%) [1]. In the Volgograd Region in 2018, 0.42 thousand hectares were sown, which was 9% in all-Russian indicators. 18.3 thousand tones were harvested with an average yield of 43.6 t/ha.

In the spring and autumn periods, cucumbers are kept at a high price every year. In this regard, practical and economic interest is to obtain early products of this crop. If earlier off-season fresh vegetable products were obtained from greenhouse factories with glazed heated greenhouses, today polycarbonate greenhouses are widely used [1, 2] In the Lower Volga region, temporary tunnel-type film covers, as well as greenhouses with hangar and arched roof types, as well as frame and block-arched ones with a spherical roof have become the most widespread. The dimensions of temporary tunnel-type film covers, and hence the planting schemes used, depend on the film size used for coating [3-5].
2. Materials and methods

Field and laboratory studies were carried out in the peasant farm "Vybornov V. D.", Leninsky district, Volgograd region in 2018-2019. The soils of the experimental site are characterized by a low-power humus horizon of 0.15-0.25 m and a low humus content in the arable layer. The soil solution reaction is slightly alkaline (pH 7.2 – 8.1). According to the available nutrients forms content, the soils are characterized by a low easy hydrolyzable nitrogen supply (39 mg/kg of dry soil) and dissolved phosphorus (35.6 mg/kg of dry soil), an exchangeable potassium average supply (331.3 mg/kg of dry soil). According to the soil texture, the soils are medium-loamy. The studies were conducted according to generally accepted methods [6-8].

3. Results and discussion

The field experiment was carried out according to a three-factor scheme, which considers the study of water supply, mineral nutrition regimes, and ways to organize an insulated zone using tunnel covers influence on the production process and cucumber yield in light chestnut soils of the Lower Volga region (Figure 2).

The experiment scheme for factor A (cucumber plants water supply regime) included the following options: option A1-maintaining a constant pre-irrigation soil moisture threshold of 70 % lowest moisture capacity in a layer of 0.5 m; option A2-maintaining a constant pre-irrigation soil moisture threshold of 80 % lowest moisture capacity in a layer of 0.5 m; option A3-maintaining a constant pre-irrigation soil moisture threshold of 90 % lowest moisture capacity in a layer of 0.5 m.

The experiment scheme on the soil nutritional regime (factor B) considered for 3 mineral fertilizers doses options, to obtain three different cucumber yield levels: option B1-application of mineral fertilizers with a total dose N105P60K40, focused on the cucumber planned yield formation at the level of 50 t/ha; option B2 – application of mineral fertilizers with a total dose N145P80K60, focused on cucumber planned yield formation at the level of 70 t/ha; option B3 – application of mineral fertilizers with a total dose N185P100K80, focused on the formation cucumber planned yield formation at the level of 90 t/ha.

The experiment scheme on the insulated zone organizing using tunnel covers method provided for the following options: option C1 is the basic technology for forming tunnel covers using polymer
materials (control); option C2 is the proposed method using tunnel covers and cracks in the soil (Figure 2). The cracks were made with a specially designed slit cutter with a device for filling the cracks with straw.

![Diagram](image)

a) the basic technology of forming tunnel covers; b) the tunnel covers formation with the insulated zone organization by making cracks in the soil with straw filling; 1 – the soil surface; 2-tunnel covers made of polymer material; 3 - irrigation pipeline of the drip irrigation system; 4-plants; 5-vertically oriented slit; 6-organic insulation (straw cutting); 7-soil

**Figure 2.** Organization scheme of the insulated zone using tunnel covers made of polymer materials

The doses of mineral fertilizers were calculated according to generally accepted methods [7, 8]. The cucumbers planned yield considered, taking into account the nutrients removal, the dissolved mineral nutrition elements content in the soil, the degree of its provision with nitrogen, phosphorus and potassium was determined to differentiate the calculated fertilizers doses.

For each yield ton, the removal of cucumber nutrition elements per 1 ton of yield is 3 kg of nitrogen, 1.3 kg of phosphorus and 3.8 kg of potassium, including removal to the vegetative mass. The calculation considered the compensation coefficients for nitrogen 0.7, phosphorus 1.0 and potassium 0.25 [8].

To conduct a research, a hybrid German F1 was used in experiments. In all experiment options, the relief, soil, and hydrological conditions were identical. To exclude the influence of soil differences, the experiments were in a four-fold repetition. The placement of options within the factor A is randomized. The area of the accounting plots according to the experiment options is 225 m², the area of repetition is 2025 m² (Figure 3).
For irrigation, the NETAFIM drip irrigation system was used with semi-compensated drips built in through 0.4 m and a water discharge of 1.6 l/s. According to the results of the conducted researches, statistically reliable data on the cucumber yield accounting were obtained, depending on the studied factors (Table 1).

| Pre-irrigation moisture level, % lowest moisture capacity | Fertilizer dose, kg of active substance per ha | The method of insulated zone organizing | Research year | ΔY depending on the insulated zone organizing |
|----------------------------------------------------------|---------------------------------------------|----------------------------------------|---------------|---------------------------------------------|
| 70 NPK (50 t/ha)                                         | Basic                                       |                                        | 2018          | 31.0                                        |
|                                                          |                                             |                                        | 2019          | 35.2                                        |
|                                                          |                                             |                                        | Average       | 33.1                                        |
|                                                          | Proposed                                    |                                        | 2018          | 36.7                                        |
|                                                          |                                             |                                        | 2019          | 46.1                                        |
|                                                          |                                             |                                        | Average       | 41.4                                        |
|                                                          | Basic                                       |                                        | 2018          | 38.8                                        |
|                                                          |                                             |                                        | 2019          | 40.6                                        |
|                                                          |                                             |                                        | Average       | 39.7                                        |
|                                                          |                                             |                                        |               | 8.3                                         |
|                                                          |                                             |                                        |               | 25.1                                        |
|                                                          |                                             |                                        |               |                                             |

**Table 1.** The yield of standard cucumber depending on the studied factors combination, 2018-2019

**Figure 3.** Experiment scheme
(70 t/ha) Proposed 45.8 53.2 49.5 9.8 24.7
NPK Basic 39.3 45.5 42.4 - -
(90 t/ha) Proposed 44.6 63.3 54.0 11.6 27.2
NPK Basic 43.5 49.9 46.7 - -
(50 t/ha) Proposed 54.0 56.4 55.2 8.5 18.2
NPK Basic 52.0 62.2 57.1 - -
(70 t/ha) Proposed 64.9 73.7 69.3 12.2 21.4
NPK Basic 55.7 79.1 67.4 - -
(90 t/ha) Proposed 75.7 84.7 80.2 12.8 19.0
NPK Basic 47.2 52.2 49.7 - -
(50 t/ha) Proposed 54.4 60.0 57.2 7.5 15.1
NPK Basic 59.7 65.1 62.4 - -
(70 t/ha) Proposed 70.7 78.3 74.5 12.1 19.4
NPK Basic 76.7 79.5 78.1 - -
(90 t/ha) Proposed 82.6 89.2 85.9 7.8 10.0
Factor A 0.74 0.37 - - -
Factor B 0.74 0.37 - - -
Factor C 0.60 0.30 - - -
For average values 1.81 0.90 - - -

4. Conclusion
In the continental conditions of the Volgograd region, spring return frosts are possible until mid-May, according to the average long-term data. Therefore, when growing cucumbers in the open ground, it is advisable to use temporary tunnel covers, which allow you to avoid damage to plants by spring frosts and receive the first products already in the 3rd decade of June. Planting seedlings in tunnel covers should be carried out depending on the prevailing weather conditions in the period from April 10 to 25 at a soil temperature at a depth of 8-10 cm not lower than 12° C. It is recommended to use drip irrigation when growing cucumbers using tunnel covers with the mandatory organization of an insulated zone by making cracks in the soil to a depth of 0.5 m with filling them with straw. This ensures the creation of comfortable conditions for the plants preservation with a sharp drop in air temperature and the return of spring frosts. Maintaining soil moisture in a layer of 0.5 m at the level of 90% lowest moisture capacity by drip irrigation and applying mineral fertilizers with a dose of N185P100K80, allowed to obtain a cucumber yield at the level of 85.9 t/ha, which is 7.8 t/ha more than in the basic option.

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