The effect of root fertilizing with organic mineral fertilizer BioEcoss on the vegetable pepper plants development in the central zone of the Krasnodar Territory

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Abstract. The article presents the results of studies conducted to evaluate the effectiveness of BioEcoss fertilizers in various concentrations in hot vegetable pepper cultivation. The experiment was conducted in 2022/2023 in a glazed winter greenhouse, geographically located in the Kuban State Agrarian University Botanical Garden, Krasnodar. The object of research is the variety of hot vegetable pepper "Pikovaya Dama" ("Queen of Spades"). It was found that the introduction of the studied organomineral fertilizer in any studied concentration (from 1% to 3%) accelerated the plants flowering onset and fruits biological ripeness compared with the control, increased productivity and average fruit weight. The highest fertilizer concentration in the experiment (3%) contributed to earlier fruit harvest dates (earlier than the control for 18 days), fruiting period extension, increase in fruits number on branches of the first and second order to 10 pieces (at the control – 7), fruits average weight increase. The yield in this variant of the experiment was 0.66 kg / m^2, which was higher than the control by 0.42 kg / m^2, other variants with the addition of a less concentrated solution – by 1.4-2.1 times. The use of fertilizers in any concentration contributed to 100% marketability of fruits.

1 Introduction

The demand for the vegetable pepper culture (Capsicum annuum L.) is explained by the fruits good taste and dietary qualities. A steady and constant demand for pepper fruits throughout the year is ensured due to their high nutritional and healing properties: vitamin C (up to 450 mg%) and rutin bind free radicals in the human body and prevent the formation of malignant tumors, cataracts, and arthritis; capsaicin, vitamins A and B, pectin substances effectively fight against inflammatory processes, strengthen blood vessels, promote the elimination of cholesterol, improve digestion.

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Fruit products of the most valuable vegetable crop are used in many ways: they are consumed fresh, processed and in the canning industry, exported to various regions of the country [1-2].

The interaction of sciences and their methods forms interdisciplinary research, for example, in agrochemistry and vegetable growing, the share of which increases with the development of scientific activity. The most important achievement in the field of plant physiology, including vegetable ones, is the discovery of plant growth regulators (RRRs) and the study of their ability to influence the intensity of all processes occurring in the plant organism [3].

Due to the increasing demand for environmentally friendly high-quality products, the most relevant in improving modern crop cultivation technology is the study of various humic preparations effect on plant growth and development processes.

An important element of modern crop cultivation technology is the humic preparations use in leaf and root top dressing, identifying the most effective of them, contributing to an increase in plants productivity and resistance to adverse environmental factors, root formation stimulation, and crop quality improvement [4].

Currently, one of the promising directions in vegetable growing is the use of environmentally safe and inexpensive humic preparations that effectively stimulate plant growth processes. Among such fertilizers is the drug BioEcoss. It is a universal organomineral fertilizer based on humic and fulvic acid salts contained in a natural product. According to the manufacturer (LLC "Kuban Agrobiocomplex", Krasnodar), the drug stimulates growth and flowering, reduces stress, strengthens the immune system, increases productivity and plant survival [5].

Despite the results of a number of studies that have confirmed this drug effectiveness in the cultivation of vegetable crops, there are no recommendations for its use on vegetable pepper culture, which determined the purpose of our research.

2 Materials and methods

The research was carried out in the central zone of the Krasnodar Territory in 2022/2023, in a glazed winter greenhouse located on the territory of the Kuban State Agrarian University Botanical Garden, Krasnodar. The substrate used in the cultivation of vegetable pepper was a soil mixture prepared from ordinary chernozem, peat and perlite – 2:1:0.2.

2.1 Object of research

The object of our research is the hot vegetable pepper zoned variety “Pikovaya Dama” of the Gavrish companies’ selection.

The variety is medium-early: from germination to technical ripeness 85-90 days, to biological 105-110 days. The shape of the bush is rounded, the foliage is good. The plant is stemmed, low-growing, 20-30 cm high. The fruits are small, with a glossy smooth surface, weighing 8-10 g, lanceolate in shape with a pointed tip; the fruit pericarp is thin and durable.

The plant has a decorative effect: the fruits color changes from greenish to purple-violet in the period from technical to biological maturity, and at the end of ripening the fruits acquire a dark red color (Figure 1).

2.2 Subject of research

The subject of research is the organic mineral fertilizer BioEcoss, designed for pepper plants root fertilization during the growing season (Figure 2).

Fig. 1. Hot pepper, “Pikovaya dama” variety.

Fig. 2. Organic mineral fertilizer BioEcoss.

The studied plants were vegetated at an average daily temperature: +20.0... +23.0 °C during the day, +15.0... +17.0 ° C at night, air humidity was maintained at 70%. The soil temperature was + 16 °C, humidity - about 70% HB.

The plants were planted according to a two-line ribbon scheme of 90 + 50 × 30 cm, the repetition was threefold. The area of the accounting plot is 10 m2. The location of the plots is tiered, systematic.

During the growing season, observations and records were carried out according to generally accepted methods [6-7]. The care consisted in loosening the soil, regular weeding and weed removal. Agro-protective measures were used to combat pests and diseases using approved preparations [8]. Root fertilization with BioEcoss fertilizer was applied in

concentrations according to the experimental options: 1 – water (control); 2 – BioEcoss (1%); 3 – BioEcoss (2%); 4 – BioEcoss (3%).

The following records and observations were carried out during the growing season:

- Phenological observations: the dates of planting seedlings in the open ground, flowering, fruit ripening, the first and the last harvest were noted.
- Biometric observations: the number of flowers and fruits on the first and second branches of plants was determined. The calculations were carried out on 5 typical plants of each variant of the experiment, taken in 1 and 3 repetitions, which were marked in advance for biometric observations [9].
- Fruit harvesting was carried out in biological ripeness. The fruits were collected systematically, once a week, while taking into account the weight and quantity of all fruits. The marketability of the products was evaluated, deformed, damaged by diseases and pests were attributed to non-marketable fruits.

The results on fruit yield were processed by the dispersion analysis method according to B. A. Dospekhov [10].

3 Results

The results of the scientific work are presented in tabular form. The phenological phases onset in plants of the spicy pepper variety "Pikovaya Dama" is shown in Table 1.

Table 1. The phenological phases onset in plants of the spicy vegetable pepper variety "Pikovaya Dama", 2022 (sowing 08/10/2022).

Experiment option	Date of the phenological phase onset			biological ripeness
	the emergence of mass shoots	blossom		
		a single appearance of seedlings	mass emergence of seedlings	
Water (control)	18.08.	21.10	27.10.	16.12.
BioEcoss (1 %)	17.08.	20.10	25.10.	12.12.
BioEcoss (2 %)	16.08.	18.10	22.10.	07.12.
BioEcoss (3 %)	17.08.	16.10	20.10.	28.11.

In accordance with the dates of the phenological phases' onset in plants of different experimental variants, the interphase period's duration was calculated (Table 2).

Table 2. The interphase and vegetation period's duration in plants of the spicy vegetable pepper variety "Pikovaya Dama", 2022.

Experiment option	Duration of interphase periods, days		The duration of the fruiting period, days	The duration of the growing season (emergence of seedlings – the end of vegetation of plants), days.
	seedlings emergence - flowering	flowering - fruits ripening		
Water (control)	69	49	174	292
BioEcoss (1 %)	63	49	178	290
BioEcoss (2 %)	66	45	183	294
BioEcoss (3 %)	63	38	192	293

Yield is an important indicator of the growing crops economic efficiency. Table 3 shows data on the fruit yield structure of various options of the experiment.

Table 3. The harvest structure of the fruits of the spicy vegetable pepper variety "Pikovaya Dama", 2023.

Experiment option	Number of fruits, pcs		The average fruits weight per plant, g	Yield, kg/bush
	on the 1st branch	on the 2nd branch		
Water (control)	4	3	4.0	0.048
BioEcoss (1 %)	3	3	5.2	0.062
BioEcoss (2 %)	4	4	7.4	0.096
BioEcoss (3 %)	5	5	10.2	0.132

The assessment of the hot vegetable pepper plants yield is presented in Table 4.

Table 4. The fruits yield of hot vegetable pepper "Pikovaya Dama", 2023.

Experiment option	Fruit yield			
	total		marketable	
	kg/m^2	% to control	kg/m^2	% of the total
Water (control)	0.24	100	0.22	92
BioEcoss (1 %)	0.31	125	0.31	100
BioEcoss (2 %)	0.48	200	0.48	100
BioEcoss (3 %)	0.66	275	0.66	100
HCP	0.05		0.04	

4 Discussion

The life cycle of hot pepper plants consists of separate growth and development phenological phases. Pepper plants are perennial in their biology, but under favorable weather conditions, the entire development cycle takes place during the first year of life, and they manage to form fruits and seeds, which allows them to be used in annual culture. From the beginning of growth to the maturation of seeds, pepper undergoes the following phenological phases: seed germination (lasts until the appearance of cotyledon leaves), budding, flowering, technical and biological ripeness of fruits [1, 11].

Single shoots of hot pepper seeds were observed in the period from 15 to 08/17/2022, mass shoots – 16-18.08.2022 – 6-8 days after sowing. According to our observations, the sprouting was even in all variants of the experiment.

Seedlings were grown in cassettes, so they quickly have taken roots and began to grow in a winter greenhouse with weekly watering (Table 3). According to the manufacturer, the recommended rate of the BioEcoss preparation is 10-30 ml/l of water. The concentration of the BioEcoss preparation (2%) contributed to a faster emergence of single and mass shoots – 2 days earlier in comparison with the control.

During the seedlings growing period, and then pepper plants, root top dressing was carried out at the experimental site with concentrations of the studied drug 1%, 2% and 3% once every 10 days, starting from the phase of 1-2 real leaves in the variants of experiment No. 2-4. In the first option of the experiment (control), the plants were watered at the same time.

During the plants phenological phases, morphological changes occurred in their structure. Pepper seedlings were planted on the site of a ground greenhouse on September 27, 2022.

One of the most important phases of hot pepper plants is the flowering phase, which indicates the transition of plants from the vegetative to the generative phase – fruiting. The

flowering of the experimental plants began: a single one – in the second decade of October, a massive one – in the third decade of this month. Hot pepper plants in all variants with the use of the drug entered this phase earlier than the control variant.

Despite the fact that the concentration of BioEcoss fertilizer 2% had a stimulating effect on the germination of pepper seeds, earlier dates for the entry of plants into the generative phase (flowering) were noted when using a 3% concentration of fertilizer: single and mass flowering in this option of the experiment was observed by us on 10/16/2022 and 10/20/2022, that is, for 5-7 days earlier than the control plants.

Pepper fruits were harvested in the experiment in the biological ripeness phase.

The earlier ripening of fruits in pepper plants is a sign of their precocity. In our experience, we observed how the concentration of the drug affected the timing of their biological ripeness phase onset. The earlier the plants enter fruiting, the potentially higher fruit yield can be obtained.

Earlier than in others, the phase of biological ripeness of the first fruits was noted in plants in the variant of using the drug at a concentration of 3% – on 11/28/2022, 18 days earlier than the plants of the control experiment variant (12/16/2022g).

Plants of the experimental variants fertilized with 1% and 2% concentrations of the drug reached this phenological phase 4-9 days earlier than the control variant of the experiment, but 9-14 days later than plants of the variant with the maximum concentration of the drug in the experiment (3%).

Since we grew shrub pepper in a greenhouse, the processes of plant growth and development took place simultaneously, but periods of active flowering and fruiting alternated with periods of decreasing generative organs formation intensity, therefore, the period of productivity decline was chosen for the end of pepper vegetation in our experiment, and the last fruit harvest in all variants of the experiment was carried out on 06/10/2023.

The timing of the first and last fruit harvest determines the duration of the fruiting phase of hot pepper and the potential yield. We noted a longer fruiting period in plants in the variants of fertilization at concentrations of 2% and 3% – 183-192 days.

The research results presented in Table 2 indicate that pepper plants in the experimental variants bloomed 63-69 days after the emergence of seedlings. This interphase period was the longest under control. 38-49 days passed from the beginning of flowering to fruit ripening in experimental plants. Fertilization at a concentration of 3% significantly accelerated the fruit ripening process; it turned out to be shorter than the control by 10 days.

The length of the pepper plants growing season is an important indicator of the studied agronomic practice. In our experiment, we have taken the growing season duration as the period from sowing to the end of fruiting. We did not find significant differences in this indicator (290-294 days) in terms of variants.

The pepper plant productivity depends on the number of fruits on the plant and their average weight. The observations showed that in terms of the number of flowers on the 1st and 2nd branches (that is, potentially possible fruits), the variants of the experiment differed within 1-2 pieces. The largest number of fruits on the 1st and 2nd branching orders was formed by plants when applying fertilizer in a 3% concentration - a total of 10 pieces. The drug in a 2% concentration contributed to the formation of 8 fruits on the plant. The variant with the lowest concentration of fertilizer (1%) was inferior to the control in terms of the number of fruits per plant (6 pcs.), but exceeded their average weight by 1.2 g. The largest average weight of fruits per plant (10.2 g) was obtained at the maximum concentration of the drug in the experiment (3%) and was higher than the control by 6.2 g. In comparison with other fertilizer application options, this option1.4-2.0 times exceeded the fruit weight per plant.

The highest yield (Table 4) was obtained from pepper plants when fertilizing at a concentration of 3%, the indicator was 2.75 times higher than the control. With a decrease in the drug concentration, the total yield of harvested fruits decreased, but still significantly exceeded the control.

The studied fertilizer significantly increased the fruits marketability; all harvested products met the requirements. In the control variant, marketability decreased to 92% due to the production of deformed and disease-damaged fruits in the crop.

5 Conclusion

We suggest that producers of hot vegetable pepper in seedling culture to use the BioEcoss preparation by root application with a solution concentration of 3%, starting from the phase of 1-2 real leaves with a periodicity of 10 days.

Hot vegetable pepper plants in all variants of the experiment entered the flowering phase earlier than the control variant with the introduction of the BioEcoss preparation. Despite the fact that the concentration of BioEcoss fertilizer 2% had a stimulating effect on the germination of pepper seeds, the 3% concentration of fertilizer activated the development processes to a greater extent. A single and massive flowering in this variant of the experiment was observed by us 5-7 days earlier than in the control plants.

A longer fruiting period was observed in plants in the fertilization options in concentrations of 2% and 3% – 183-192 days (174 days under control).

The BioEcoss preparation with a maximum concentration of 3% in the experiment contributed to an increase in fruit yield from 1 m^2 of area in comparison with control plants – by 2.75 times, with plants of other drug application options – by 1.4-2.1 times.

The use of organic mineral fertilizer BioEcoss in any concentration increased the marketability of hot pepper fruits to 100%.

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