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THE IMPACT OF MARS EL GROWTH REGULATOR ON THE YIELD OF CARROTS

Abstract.
Studies have shown, that the laboratory germination of carrot seeds after soaking in Mars EL solution increased by 13% in Abaco hybrid, and by 12% in Canada hybrid, and field germination - by 9% and 10%, respectively. Under the action of Mars EL growth regulator the number of leaves increased on average by 2-3 pcs. per carrot in Abaco hybrid, and 2-4 pcs. in Canada hybrid. The highest yield in the experiment was provided by the use of Mars EL for soaking seeds and spraying plants three times during the growing season. On average, in three years of research, 48.4 t / ha were obtained in the areas, where Abaco hybrid was grown, and 52.0 t / ha in the areas, where Canada hybrid was grown. In the same case due to the use of Mars EL growth regulator the marketability of carrot roots increased by 6-7%.

Keywords: *carrots, hybrids, plant growth regulator, yield, marketability.*

Formulation of the problem. Population growth on Earth and global changes in weather and climate conditions require the improvement of cultivation technologies to increase crop yields. Farmers are faced with the task of obtaining stable and high-quality yields of marketable carrot roots under different weather and soil growing conditions. Therefore, it is necessary to introduce new elements of technology in farms, which are characterized by economical use of resources and have high efficiency. It is worth considering the possible export potential of Ukraine for growing carrots as organic products.

Global warming complicates the growing conditions of cultivated plants and therefore can lead to a shortage of carrot root crops and an increase in the number of non-commodity products. Substances belonging to the group of growth regulators can improve physiological processes in cultivated plants under conditions of unstable moisture supply, reduce the negative impact of temperature stresses. Low price, high efficiency, safety for the environment allow to use them widely in agrophytocenoses.

Analysis of recent research and publications. For the past 18 years, the area under vegetable crops in Ukraine has decreased by 95.4 thousand hectares, and their production has increased in 1.6 times. For the same period the areas under carrots in our country increased by 2.1 thousand hectares, and the production increased in 1.7 times. Carrot yield in Ukraine in 2000 was 121.0 c / ha, and in 2018 - 197.2 c / ha [13]. But the potential yield of this crop is much higher. Some farms in our country receive up to 100 t / ha of carrot roots. Therefore, there is a need to study the impact of certain technological techniques on the formation of yields and increase the marketability of this vegetable crop.

The development of effective activation mechanisms and implementing the concept of environmentally safe production should be a continuous and well-established process [5].

In technologies the use of effective biological products, that do not harm the environment, improve the ecosystem and at the same time increase yields, reducing production costs is of great importance [1].

Due to bacterization, more active assimilation and involvement in the constructive metabolism of nutrients is ensured, which leads to an increase in the content of complex organic substances in the obtained products [10, 15].

An important role in solving the problem of increasing the yields belongs to drugs from the group of plant growth regulators, as their use increases yields and is an effective and safe means of crop protection from difficult growing conditions [7, 8, 9].

Not only stressful growing conditions, but also the negative impact of pathogens on plants can be the reason for the decrease in crop yield. The activity of pathogenic micro flora inhibits the growth and development of cultivated plants, and can also be the cause of spoilage of products during storage. Plant growth regulators help plants to resist infection.

In the areas where the drugs were used, there is intensive plant growth and a much weaker manifestation of disease [6].

Regarding the use of growth regulators, information on their effect on plants during the growing season is very necessary. Usually the recommendations indicate the level of yield growth due to treatment with a growth regulator. But what other indicators, besides the final ones, these substances have influence - it is necessary to investigate. When growing carrots, it is difficult to determine the area of the leaf surface, so the number of leaves is counted and their weight is determined in relation to the weight of the plant. The characteristics of each variety and hybrid should also be considered as a reaction to growing conditions.

In the phase of 3-4 leaves, the weight of the aboveground part of the table carrot was the smallest. At the beginning of the formation of the root of the table carrot, the weight of the aboveground part increased significantly. We determined the indicators of the yield

structure of table carrot roots, depending on the factors studied. The obtained results indicate that in the case of decrease in crop yield, the number of non-standard roots increases in direct proportion [15].

According to Romanyuk N. and others pre-sowing treatment of Lange Rote Stumpfe and Carlen carrot seeds with Ivin and Emistim C growth regulators, as well as soaking the seeds in water, leads to intensification of germination processes and stimulation of initial plant growth. In the field conditions, the effect of the study drugs significantly depends on the method of application, plant variety and weather conditions. In general, the use of growth regulators contributed to stimulating the initial growth of plants and accelerating the phases of plant ontogenesis [12].

According to Ovcharuk V.I. and Bezvikonny P.V. the use of growth regulators stimulated the accumulation of chlorophyll, dry matter, sugars in the leaves of table beets and increased the productivity of photosynthesis, which had a positive effect on the dynamics of root formation.

The use of plant growth regulators of the stimulating direction of action affects the development of vegetative organs, the formation of crop elements, increases the resistance of plants to adverse environmental factors, as well as creates technological advantages in harvesting. Regulation of plant growth due to exogenous application of development stimulants is a promising way to increase crop productivity [11].

In recent years, the production of carrot roots has a low level of marketability due to changes in agro-climatic growing conditions. This trend exists both in Ukraine and around the world [4].

The use of plant grows regulators with different mechanisms of action in agricultural practice is profitable and in the long run makes it possible to ensure a high economic effect. When using restrictive substances, it is necessary to take into account toxicological evaluations of active substances and preparative forms, as well as to pay attention to the receipt and transformation of drugs in plants, soil and water, their effect on soil micro flora, chemical parameters and biological value of agricultural products [14].

Analysis of the mechanisms of action of retardants and ethylene producers, as well as the synthesis of new drugs with a similar type of physiological activity, creates a reliable scientific basis for improving the efficiency and environmental safety of synthetic plant growth regulators [16].

Presenting main material. The aim of our research was to study the effect of Mars EL growth regulator on table carrot plants: seed germination in laboratory and field conditions, biometrics, marketability and yield of root crops. A set of studies was conducted using the following methods: laboratory, field, calculation, analytical. The obtained results were summarized.

Studies were performed with the early-maturing Abaco hybrid and the mid-late Canada hybrid. The accounting area of the plots was 5 m^2, the recurrence was threefold. Biometric parameters of carrot plants were determined with the onset of the beam production phase and during technical maturity. The yield from each experimental plot was accounted for separately. At the same time carrot roots were divided by marketability. Statistical processing of the obtained data was performed annually by the method of analysis of variance (according to B.O. Dospekhov [2]).

Scheme of the experiment:

Option 1: carrot seeds were soaked in water (control),

Option 2: carrot seeds were soaked in a solution of growth regulator Mars EL (0.2 ml/kg),

Option 3: carrot seeds were soaked in a solution of grows regulator Mars EL (0.2 ml/kg) and sprayed once after germination (5 ml/100 m^2),

Option 4: carrot seeds were soaked in a solution of growth regulator Mars EL (0.2 ml / kg) and the plants were sprayed 3 times with an interval of 10 days during the growing season (3 ml/100 m^2).

For three years of research weather conditions were difficult, but generally favorable for growing table carrots. The soil cover of the experimental plot is gray forest with a humus content of 2.5%. In the experiment, the technology of growing carrots was common [3].

The main results of the study. It is well known, that from seeds, that have high germination energy it is possible to get friendly and even germination. The rapid process of seed germination provides seedlings with better starting opportunities and higher competitiveness. If the emergence of seedlings in the field is stretched, it increases the risk of damage to seedlings by fungal diseases and pests, or leads to the death of seedlings.

We have to wait a long time for the emergence of carrot seedlings due to the high content of essential oils, which inhibit the germination of its seeds. Plant growth regulators are used to stimulate seed germination in order to obtain friendly germination. They are also recommended in order to eliminate the negative effect on cultivated plants of various adverse factors at the beginning of the growing season.

Carrot is a cold-resistant crop. Its seeds begin to germinate at a temperature of 3-5 ° C. However, then the seedlings appear on the soil surface in 20-30 days. With increasing temperature to 10-12 ° C - for 15-17 days, and up to 18-20 ° C - for 7-10 days. In the cotyledon phase, the plants tolerate the decrease in temperature to minus 3 ° C. Insufficient lighting of plants leads to elongation and dissection of leaves, which slows down the growth of the photosynthetic apparatus and the root system in the later stages of plant growth and development. It also impairs the taste characteristics of roots. Thickening of crops and their weeding can lead to plant damage by phomos and changes in the chemical composition of roots. For normal growth and development, carrots are quite demanding to uniform soil moisture throughout the growing season.

During the experiment, it was found, that pre-sowing treatment of carrot seeds with growth regulator Mars EL increased its germination (Table 1).

Table 1

The impact of Mars EL growth regulator on germination of carrot seeds,% (average for 2018-2020)

Variant	Germination,%	
	laboratory	field
Abaco hybrid		
1- carrot seeds were soaked in water (control)	73	69
2- carrot seeds were soaked in a solution of Mars EL growth regulator (0.2 ml/kg)	86	78
Canada hybrid		
1- carrot seeds soaked in water (control)	74	69
2- carrot seeds were soaked in a solution of Mars EL growth regulator (0.2 ml/kg)	86	79

Germination of table carrot seeds after soaking in a solution of Mars EL increased. In particular, in the control variant, the laboratory germination of seeds was 73% in Abaco hybrid and 74% in Canada hybrid. In the field conditions, the germination in the same variant was characterized by slightly lower rates - 69% for both hybrids.

When carrot seeds were treated with growth regulator Mars EL before sowing at a consumption rate of 0.2 ml / kg, the laboratory germination reached 86%. Seed germination was 78% and 79%, respectively, which was 9% higher than for Abaco and 10% for Canada hybrids.

It was later found, that the treatment with growth regulator Mars EL has a stimulating effect on seedlings and has a positive effect on the formation of carrot leaves. At the beginning of its vegetation, a faster accumulation of the vegetative part of plants in experimental hybrids was observed in all variants.

The main root of carrots penetrates into the soil to a depth of 2 m, and the lateral roots grow in diameter to a distance of 90 cm. But the bulk of the root system is located in the soil layer up to 50 cm. It is believed that there is direct dependence between the development of the root system and the leaf apparatus. Therefore, when the root system reaches the largest size, then the plant forms the most leaves, and this contributes to the formation of a large food organ - the root crop. When there is a lack of moisture in the soil, a small rosette of leaves is formed, the roots become woody and acquire a specific unpleasant taste. Uneven soil moisture during the growing season, especially in the second half, negatively affects the formation of the commodity harvest.

Over three years of research, it has been found, that due to the use of growth regulator Mars EL the number and weight of leaves in carrot plants increased. During the beam ripeness of carrots in plants of both experimental hybrids the number of leaves was greater by 2-4 pcs. than in the control version. Large leaves on the plant are formed in summer. They function on the plant for the longest time. Increasing the area of the assimilation apparatus provides more intensive formation of organic matter, which at the final stage of the growing season is reflected in the growth of root yields.

At the time of technical maturity of carrots, the difference in the number of leaves between the experimental options and control was 1-3 pcs. in Abaco hybrid and 1-4 pcs. in Canada hybrid (Table 2).

Table 2

The impact of Mars EL growth regulator on quantity and weight of leaves of carrot plants, (average for 2018-2020)

Variant	In the phase of beam maturity		In the phase of technical maturity	
	Number of leaves, pcs. per 1 plant	% by weight of leaves to the total weight of plants	Number of leaves, pcs. per 1 plant	% by weight of leaves to the total weight of plants
Abaco hybrid				
1 - carrot seeds were soaked in water (control)	11	16,0	9	4,3
2 - carrot seeds were soaked in a solution of Mars EL growth regulator (0.2 ml/kg)	12	16,1	10	4,4
3 - carrot seeds were soaked in a solution of grows regulator Mars EL (0.2 ml/kg) and sprayed once after germination (5 ml/100 m^2)	14	17,0	11	4,7
4 - carrot seeds were soaked in a solution of growth regulator Mars EL (0.2 ml / kg) and the plants were sprayed 3 times with an interval of 10 days during the growing season (3 ml/100 m^2)	15	16,7	12	4,9

Canada hybrid				
1 - carrot seeds were soaked in water (control)	11	16,6	9	4,4
2 - carrot seeds were soaked in a solution of Mars EL growth regulator (0.2 ml/kg)	12	16,8	10	4,5
3 - carrot seeds were soaked in a solution of grows regulator Mars EL (0.2 ml/kg) and sprayed once after germination (5 ml/100 m^2)	13	17,1	12	5,0
4 - carrot seeds were soaked in a solution of growth regulator Mars EL (0.2 ml / kg) and the plants were sprayed 3 times with an interval of 10 days during the growing season (3 ml/100 m^2)	15	18,7	13	5,2

The ratio of leaf weight to the total weight of carrot plants in beam maturity was 16.0-16.7% in Abaco hybrid and 16.6-18.7% in Canada hybrid. During the technical maturity of carrots, the ratio of leaf weight to total plant weight was 4.3-4.9% in Abaco hybrid and 4.4-5.2% in Canada hybrid. The decrease in the proportion of leaf weight in relation to the total plant weight is due to increased growth and weight gain of the root crop. This is also due to the end of the growing season and leaves drying. The results of the studies confirmed the effectiveness of the use of Mars EL growth regulator in the cultivation of carrot hybrids Abaco and Canada.

Crop yields depend on the action of many factors and their interaction. And for vegetable crops the marketability of the grown production is still important. This indicator affects the demand, price, appearance and shelf life of vegetables. On average over three years the yield of carrot roots of Abaco hybrid ranged from 43.2 t/ha in the control variant to 48.4 t / ha in the variant of Mars EL seed treatment and 3-time spraying of plants with it. The yield of carrot roots of Canada hybrid was 45.5 t/ha and 52.0 t/ha, respectively. The use of Mars EL growth regulator provided an increase in the yield of Abaco hybrid from 2.7 t/ha to 5.2 t/ha, and Canada hybrid - from 2.8 t/ha to 6.5 t/ha (Table 3).

Table 3

The impact of Mars EL growth regulator on the yield and marketability of carrot roots (average for 2018-2020)

Variant	Yield, t / ha				± to the control, t / ha	Marketability of root crops,%
	2018	2019	2020	The average for 2018-2020		
Abaco hybrid						
1 - carrot seeds were soaked in water (control)	47,1	45,3	37,1	43,2	0	80
2 - carrot seeds were soaked in a solution of Mars EL growth regulator (0.2 ml/kg)	49,0	49,2	39,5	45,9	+2,7	82
3- carrot seeds were soaked in a solution of grows regulator Mars EL (0.2 ml/kg) and sprayed once after germination (5 ml/100 m^2)	50,2	50,1	40,7	47,0	3,8	84
4 - carrot seeds were soaked in a solution of growth regulator Mars EL (0.2 ml / kg) and the plants were sprayed 3 times with an interval of 10 days during the growing season (3 ml/100 m^2)	51,7	51,6	41,9	48,4	5,2	86
Canada hybrid						
1 - carrot seeds were soaked in water (control)	50,3	47,1	39,2	45,5	**0**	80
2 - carrot seeds were soaked in a solution of Mars EL growth regulator (0.2 ml/kg)	52,3	51,3	41,3	48,3	+2,8	83
3- carrot seeds were soaked in a solution of grows regulator Mars EL (0.2 ml/kg) and sprayed once after germination (5 ml/100 m^2)	53,8	52,2	44,1	50,0	+4,5	85
4 - carrot seeds were soaked in a solution of growth regulator Mars EL (0.2 ml / kg) and the plants were sprayed 3 times with an interval of 10 days during the growing season (3 ml/100 m^2)	57,4	53,8	44,8	52,0	+6,5	87
LSD_{05}	2,6	2,7	2,1			

In the variant, where Mars EL growth regulator was used for soaking the seeds and spraying the cultivated plants three times during the growing season, the highest yield level was recorded: 48.4 t / ha were obtained in the areas, where Abaco hybrid was grown, and in the areas, where Canada hybrid was grown - 52,0 t/ha. The marketability of carrot roots increased by 6% and 7% in this case.

For modern vegetable growing it is a problem to obtain high yields of crops with stable and high-quality productivity under changing agrometeorological conditions of their cultivation. The use of drugs that belong to the group of regulators of plant growth and development provides a positive impact on the formation of crop yields. But especially valuable is the fact, that there is no increase in the chemical load on the agrophytocenosis.

Summarizing all the above, it was found that the treatment with Mars EL growth regulator had a positive effect on seed germination, plant growth and development and increased productivity and marketability of carrots. This information is consistent with the literature on the action of growth regulators.

Conclusions.

1. Laboratory germination of carrot seeds after soaking in a solution of Mars EL increased by 13% in Abaco hybrid and 12% in Canada hybrid, and field germination, respectively, 9% and 10%.

2. Due to the use of Mars EL growth regulator in carrot plants, the number of leaves increased by 2-3 pcs. per plant in Abaco hybrid and 2-4 pcs. in Canada hybrid.

3. The use of Mars EL growth regulator increased the marketability of carrot roots by 6-7% in the variant of soaking the seeds and spraying the cultivated plants three times during the growing season.

4. The use of Mars EL growth regulator for seed soaking and spraying three times during the growing season of cultivated plants provided the highest yield in the experiment. On average, over three years of research, root crops were obtained in areas where Abaco hybrid was grown 48.4 t/ha and in areas where Canada hybrid was grown - 52.0 t/ha.

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