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INFLUENCE OF GROWTH REGULATORS ON THE MORPHOGENESIS OF *PHYSALIS PHILADELPHICA* L.

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The article is devoted to the study of the influence of plant growth regulators with different directions of action (1-naphthylacetic acid, gibberellic acid, 6-benzylaminopurine, tebuconazole and chlormequat chloride) on the morphometry of seedlings of the physalis cv. Korolyok. Growth stimulants were enhanced, and inhibitors inhibited the linear growth of seedlings. All growth regulators had a positive effect on the leaf apparatus - increased the number of leaf blades on the plant, increased the weight of their raw matter and leaf area. Retardants and synthetic cytokinin increased the amount of chlorophyll in the leaves, and gibberellic acid decreased it. 6-benzylaminopurine increased the mass of raw matter of the stem and root, and 1-naphthylacetic acid increased the mass of raw matter of the root only. The dry matter mass of the whole plant increased under the action of growth regulators in the experimental variants.

Key words: *Physalis philadelphica* L., morphogenesis, leaf apparatus, chlorophyll, plant organ mass.

Introduction. An important task of modern phytophysiology is the development of methods and technologies that would ensure a fuller use of light energy by the plant to intensify the synthesis of assimilates and direct them to economically valuable tissues and organs. One of the key approaches in solving the problem of optimizing the production process of agricultural plants is the regulation of donor-acceptor relations, in particular by artificial redistribution of assimilate flows to economically important organs (fruits, roots, other reserves) [10, 19]. The main patterns of functioning of donor-acceptor relations (the concept of "source-sink") are studied mainly in the analysis of the ratio of intensity of growth processes and photosynthesis, where growth processes act as the main acceptor, and photosynthesis - as a donor of assimilates [11, 21, 23, 38]. Artificial regulation of growth processes is one of the effective means of increasing crop yields by changing donor-acceptor relations in plants [18], improving the quality of agricultural products [6, 8, 22] and increasing the resistance of cultivated plants to adverse abiotic and biotic environmental factors due to mobilization of potential capabilities of the plant organism [3, 12, 14, 25, 30, 37].

A promising direction of artificial regulation of growth processes is the use of native phytohormones and synthetic growth regulators, which by their nature are either analogues or modifiers of phytohormones. For practical purposes, growth-stimulating gibberellin drugs are widely used [5, 20, 24], as well as their antagonists - retardants, which either block the synthesis or formation of hormone-receptor complex, resulting in reduced intensity of linear growth in plants [21, 27]. The literature contains information about the use of gibberellin and antigiberellin drugs to optimize the production process as a result of

anatomical-morphological and physiological-biochemical changes in cereals [14, 34, 37], legumes [2, 25, 35, 36], oil [4 , 6, 7, 12], vegetable [3, 11, 16, 22, 31, 30], technical [13] and medicinal and decorative [26, 28, 39] crops. Native stimulatory hormones and their synthetic analogues are used in crop production to intensify histo- and morphogenesis, accelerate cell proliferation and differentiation, resulting in the formation of a more branched root system, changing anatomical-morphological, mesostructural and physiological-biochemical organization. Such changes lead to the formation of a more powerful assimilation apparatus, which is able to provide active synthesis of plastic compounds, the flow of which in greater quantities will be directed to the generative organs and organs of reserve [9, 18, 19]. The action of gibberellins is associated with increased activity of various groups of meristematic tissues and the formation of a more powerful plant organism, due to increased cell division and stretching, which can provide greater biological productivity [22, 23, 24]. Gibberellic acid increased leaf biomass and activated photosynthetic processes in *Polygonum cuspidatum* [28]. Native stimulant also contributed to the accumulation of dry matter by flax plants, increased the rate of net productivity of photosynthesis, seed yield, increased its oil content and fiber yield [13]. The same drug increased the resistance of seedlings of common beans [25], wheat [14], rice [3, 33] and cucumber [3] to salinity and increased their productivity.

Restructuring of the hormonal complex under the influence of retardants and the corresponding inhibition of apical dominance led to important from the point of view of regulation of plant productivity strengthening of branching of a stalk. Due to the increased branching of the stems of these crops laid more leaves, flowers and fruits, which is an important prerequisite for increasing yields. Thus, the use of chlormequat chloride on soybean plants caused the inhibition of growth processes, which led to the formation of most fruits and increase the oil content and improve its quality [2]. Other researchers have found that uniconazole simultaneously with the inhibition of the linear size of plants caused increased development of the root system [35]. Treatment of soybean seeds by the same drug, in addition to inhibiting growth, led to a delay in the aging process in the leaves, an increase in the dry matter of plants and the net productivity of photosynthesis. At the same time, the drug increased the content of chlorophyll in the leaves, reduced leaf area and increased crop yields [36]. Optimization of photosynthetic processes in growth inhibition in cowpea plants was observed under the influence of CCC and maleic hydrazide [29].
Tebuconazole inhibited the growth of maize plants, but increased germination and resistance to cold stress. The content of photosynthetic pigments increased in the leaves of the culture under the action of the drug [37]. A mixture of ethylene producer DCPTA and quaternary ammonium salt CCC reduced plant height by reduction the length of the internodes. The mixture of antigibberellin drugs also increased the area of leaves and dry matter of leaves and the content of chlorophyll in them. Such morphological changes led to an increase in crop productivity [34].

Gibberellin inhibitors are also widely used in oilseeds. Excessive development of vegetative mass in autumn is negative for winter rape, which worsens the overwintering of

the crop and reduces its productivity for the next year. Treatment of winter rapeseed with tebuconazole and flucylazole reduced the growth rate and growth of vegetative mass with a simultaneous increase in seed yield, and the oil content in the seeds and its quality characteristics did not change [12]. It was shown that the use of paclobutrazol reduced plant height and leaf area, but increased the chlorophyll content in the leaves and seed yield by increasing the branching of the stem and increasing the number of pods [4]. Treatment of oil poppy with folicure against the background of reducing the linear size of plants had a positive effect on the indicator of the leaf apparatus of plants. The authors found an increase in the number of leaves on the plant, their weight and leaf surface area. The content of chlorophyll increased in the leaves and the net productivity of photosynthesis increased under the action of the retardant, at the same time the coenotic indicators of crop cultures - leaf and chlorophyll indices - improved. Changes in the leaf apparatus have become a prerequisite for increasing crop yields [7]. Similar changes in the leaf apparatus were recorded in oilseed flax culture with the use of chlormequat chloride. The retardant reduced the linear size of the plants, thickened the stem, increased the number of leaves, their dry matter weight and leaf area. Chlormequat chloride increased the volume of cells of the palisade parenchyma of the leaf and the size of the cells of the spongy parenchyma, as well as increased the number and the volume of chloroplasts in both tissues of the chlorenchyma. The drug increased the net productivity of photosynthesis, increased seed yield and oil yield and improved its quality characteristics [9]. Similar changes have been reported with the use of retardant-type growth inhibitors on other oilseeds.

Literature sources contain information about the effect of retardants on the leaf apparatus and the productivity of medicinal and ornamental plants. In particular, CCC increased the photosynthetic activity of *Ginkgo biloba* leaves due to the increase in chlorophyll content in the leaves, as well as the content of soluble sugars and amino acids, which improved their quality and medicinal properties [39]. The same drug altered the activity of carbohydrate accumulation by the leaves of cannabis plants [26]. Flurpyramidol reduced the linear size of poinsettia plants and increased the chlorophyll content in the leaves [17]. Uniconazole, another triazole-derived drug, reduced leaf biomass in *Polygonum cuspidatum* plants, but increased its ratio to the leaf surface area [28].

Vegetable crops are of great economic importance, so the study of the processes of regulation of their growth and development with the help of antigibberellin drugs and gibberellin is a topical issue of modern phytophysiology. Literature data indicate that treatment of potatoes with paclobutrazol reduced the linear size of the shoot and thickened it. The drug reduced the area of leaves but increased the thickness of the leaves and the weight of their raw and dry matter. The action of paclobutrazol improved the mesostructural parameters of the leaf - the volume of cells of the palisade parenchyma and the size of the cells of the spongy parenchyma. The use of the drug led to an increase in net productivity of photosynthesis and crop yields [31]. Also potato yields increased after CCC treatment [16]. Paclobutrazol reduced plant height and leaf index but increased the dry matter of the whole plant by increasing the mass of tubers of *Manihot esculenta* Crantz.

The content of starch in the cassava tubers increased under the action of the drug [15]. Another triazole-derived retardant - hexaconazole reduced the stem length of cucumber plants, the weight of its raw and dry matter and the leaf area but increased the thickness of leaf blades, chlorophyll content in them and increased the resistance to ultraviolet radiation due to activation of antioxidants enzymes and increasing the content of ascorbic acid in the leaves [30]. Earlier, we found an increase in yield due to the action of different growth regulators in vegetable crops of the genus Solanum. In particular, treatment with gibberellic acid, tebuconazole and chlormequat chloride had a positive effect on the leaf apparatus of eggplant and potato plants, which optimized the productivity of these crops [11, 21-24].

Thus, numerous data from the literature show that exogenously used stimulators of plant growth and development, as well as their antagonists (retardants) often lead to the same result - optimization of the production process of crops and increase their yields. However, in the literature there are virtually no comparative systematic studies of regulation of growth rate, morphogenesis, formation of photosynthetic apparatus under the action of stimulants and growth inhibitors, the components of the system of regulation of donor-acceptor relations in plants under the action of these multidirectional drugs remain unknown. In connection with the above, the aim of the study was to establish the role of anatomical and morphological component in the regulation of donor-acceptor relations of physalis plants under the action of regulators of growth and development of plants that differ in the direction of action.

Research methods. Study of the effect of growth stimulants 1-naphthylacetic acid (1-NAA), gibberellic acid (GA_3) and 6-benzylaminopurine (6-BAP) at a dose of 0.005% and retardants 0.025% tebuconazole (EW-250) and 0.25% chlormequat chloride (CCC-750) was performed on plants grown under growing conditions. Physalis plants of the vegetable variety (*Physalis philadelphica* L.) cv. Korolyok were grown by the sand culture method in glass vessels with a capacity of 1 l with the addition of Knop mixture to the sand in quantities similar to the water culture [1]. Humidity was maintained at 65% of total moisture content during the experiment. Physalis seedlings were treated once with growth regulators with different directions of action on the 75th day after emergence. Control plants were treated with distilled water. Morphometric parameters and chlorophyll content in the leaves were determined on the 130th day of development. The obtained materials were processed statistically with the help of the computer program "STATISTICA - 6.1". The table and figures show the average values and their standard errors [32].

Results and discussion. The results of our research show that the growth regulators have different effects on the linear size of plants. In particular, synthetic analogues of the main stimulant hormones 1-naphthylacetic, gibberellic acid and 6-benzylaminopurine increased the height of physalis plants by 7, 73 and 19%. Gibberellin inhibitors tebuconazole and chlormequat chloride reduced the linear size of physalis by 22 and 15%, respectively (Table 1). We found that growth regulators, regardless of the direction of action, increased the number of leaf blades. In our opinion, the increase in the number of leaves on physalis plants after the use of growth stimulants is associated with the overall

stimulating effect of these drugs, intensification of proliferation and additional formation of the lateral organs of the shoot. The action of antigibberellin drugs is associated with the interruption of gibberellins synthesis and, accordingly, inhibition of growth processes in plants, and especially inhibition of apical meristem activity, which in turn can lead to a compensatory effect with increased activity of lateral and marginal meristems and leads to formation more leaves and growth their area. The maximum number of leaves was recorded after the use of synthetic cytokinin - 6-benzylaminopurine.

We found that under the action of auxin, gibberellin and cytokinin growth stimulants, as well as onium retardant, the leaf surface area of experimental plants increased by 14, 12, 21 and 20%, respectively. At the same time, under the action of all growth regulators, the mass of raw matter of the leaves also increased. It should be noted that with the use of triazole-derived retardant tebuconazole, the mass of the raw matter of the leaves increased due to the thickening of the leaf blades, as indicated by the highest, among all growth regulators, the specific surface density of leaves (26%).

Table

Influence of plant growth and development regulators on anatomical and morphometric parameters of *Physalis philadelphica* L. cv. Korolyok

Indicators	Height, cm	Number of leaves per plant, pcs.	Weight of leaves from the plant, g	Stem weight, g	Stem diameter, cm	Root weight, g	Root neck diameter, cm	Leaf area, cm^2	Specific surface density leaf, mg/cm^2
Control sample	27,04 ±1,23	16,16 ±0,81	2,36 ±0,11	3,18 ±0,15	0,41 ±0,02	0,84 ±0,04	0,41 ±0,02	142,65 ±7,09	1,54 ±0,07
1-NAA	29,93 ±1,42	*21,12 ±0,99	2,51 ±0,12	3,26 ±0,17	0,39 ±0,02	*1,49 ±0,05	0,44 ±0,02	162,92 ±8,11	1,53 ±0,07
GA_3	*46,82 ±1,98	*25,53 ± 1,21	2,64 ±0,13	3,39 ±0,16	*0,32 ±0,01	0,72 ±0,06	*0,31 ±0,01	160,28 ±8,02	1,81 ±0,08
6-BAP	32,32 ±1,58	*29,19 ± 1,31	*3,47 ±0,14	*4,47 ±0,17	0,44 ±0,02	*1,72 ±0,06	0,49 ±0,02	171,07 ±8,28	1,87 ±0,09
EW-250	*21,13 ±1,01	19,03 ±0,93	2,46 ±0,12	3,49 ±0,17	0,48 ±0,02	*1,06 ±0,05	0,47 ±0,02	132,43 ±6,55	*1,94 ±0,08
CCC-750	23,08 ±1,12	*23,15 ± 1,11	2,84 ±0,13	3,36 ±0,16	0,46 ±0,02	*1,37 ±0,06	0,45 ±0,02	170,84 ±8,18	1,64 ±0,08

Note: * - the difference is significant at $P \leq 0.05$.

An important indicator that influences on the biological productivity of plants is the content of chlorophyll in the leaves (Fig. 1). Growth regulators that differ in the direction of action, differently affected the content of the main photosynthetic pigment in the leaves.

Retardants tebuconazole and chlormequat chloride increased the amount of chlorophyll in the leaves by 18 and 11%, respectively. The maximum increase in the pigment content was observed under the action of 6-benzylaminopurine - 26%, while gibberellic acid reduced its content by 10%, and 1-naphthylacetic acid did not change the concentration. The drugs also affected the morphometric parameters of the axial organs of

physalis. The cytokinin growth stimulant 6-benzylaminopurine and the triazole-derived retardant tebuconazole increased stem weight by 50% and 10%, respectively. Under the action of other drugs, this indicator did not change significantly. The same drugs and retardant chlormequat chloride thickened the stems of physalis plants by 7, 17 and 12%. Other growth stimulants thinned the stems of experimental plants.

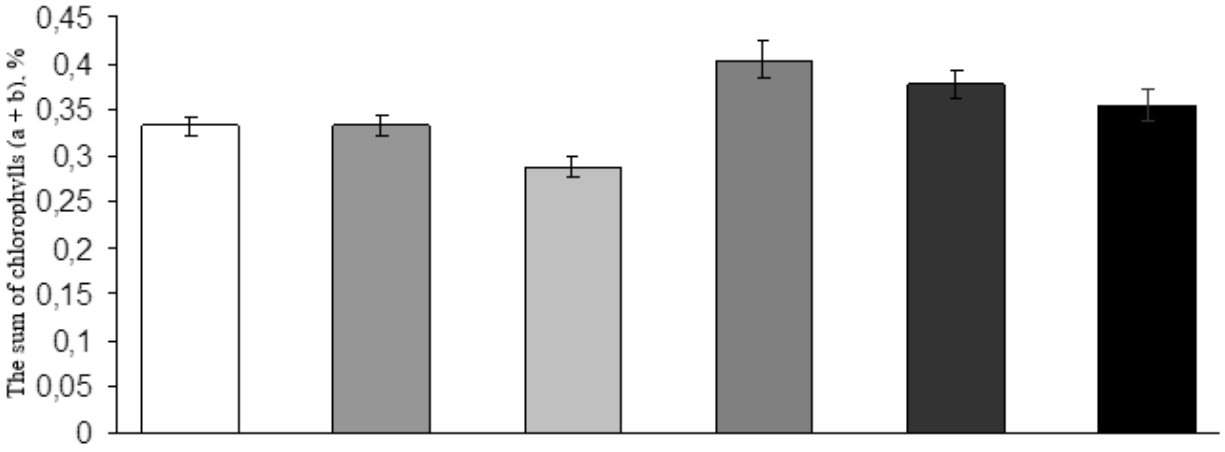

Fig. 1. Influence of growth regulators on the content of the sum of chlorophylls in physalis leaves cv. Korolyok. 130 days of vegetation.
□ - control; ▩ 0.005% 1-naphthylacetic acid, ▩ - 0.005% gibberellic acid, ▩ - 6-benzylaminopurine, ■ - 0.025% tebuconazole, ■ - 0.25% chlormequat chloride.

Auxin growth stimulant significantly increased the weight of the raw matter of the root (70%), and cytokinin thickened the root (20%). Gibberellic acid reduced the mass of the root system by 14% and thinned the root by 22%. The above-mentioned indicators tended to increase under the influence of other growth regulators. One of the indicators of the activity of the photosynthetic apparatus is the mass of dry matter of the whole plant. The results of our research show that both synthetic stimulators of plant growth and development and inhibitors of growth processes increased the dry weight of the plant. The most significant such increase was under the action of 6-benzylaminopurine (Fig. 2).

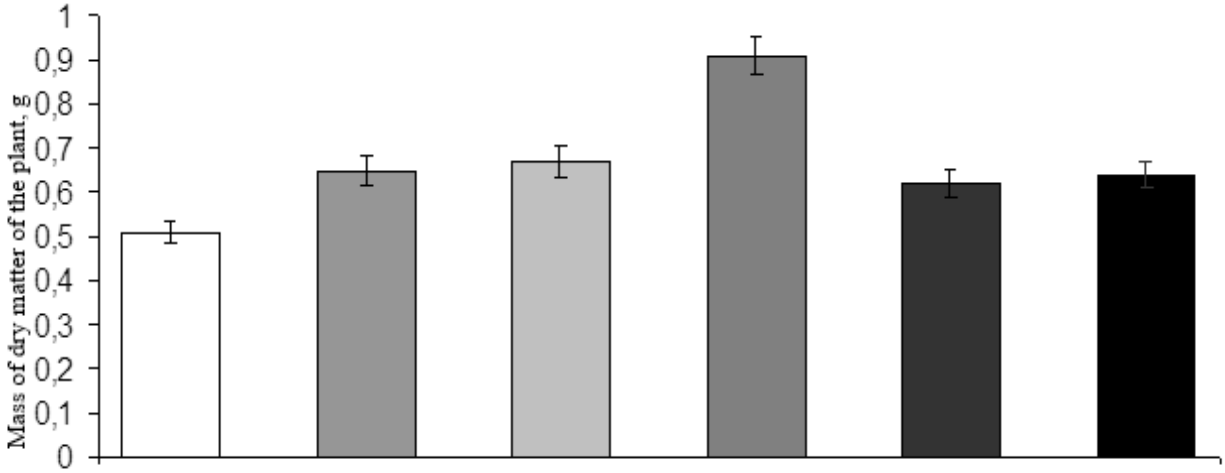

Fig. 2. Influence of growth regulators on the mass of dry matter of physalis plants cv. Korolyok. 130 days of vegetation.
□ - control; ▩ - 0.005% 1-naphthylacetic acid, ▩ 0.005% gibberellic acid, ▩ - 6-benzylaminopurine, ■ - 0.025% tebuconazole, ■ - 0.25% chlormequat chloride

Thus, the most significant stimulating effect on physalis plants had a cytokinin growth stimulant - 6-benzylaminopurine. The effect of retardants, gibberellic acid and 1-naphthylacetic acid was significantly lower.

Conclusions. 1. Growth stimulants increased the height of seedlings of *Physalis philadelphica* L. cv. Korolyok, and retardants decreased it. 2. All growth regulators increased the number of leaf blades on the plant, the weight of their raw matter and the leaf area. 3. Tebuconazole, chlormequat chloride and 6-benzylaminopurine increased the content of chlorophyll in the leaves, but gibberellic acid decreased it. 4. Synthetic cytokinin increased the weight of the raw matter of the stem and root significantly, and auxin preparation increased the weight of the raw matter of the root only. 5. Both inhibitors and stimulators of growth and development increased the weight of the dry matter of the whole plant.

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