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THE IMPACT OF AN ENVIRONMENTALLY SAFE GROWTH REGULATOR ON THE REDISTRIBUTION OF CARBOHYDRATES AND NITROGEN BETWEEN THE ORGANS OF OIL CROP PLANTS

The aim of the research. Given that the existing data on the effect of growth inhibitors on the redistribution of assimilates in oil crops are not numerous and the controversial data on the effect of the anti-gibberellin drug chlormequat chloride on the content of carbohydrates and nitrogen the purpose of the experiment was to find out the influence of CCC on the redistribution of assimilates in oil crops.

Methodology. Oil poppy and rapeseed plants of the Halytsky variety were treated during the budding period with a 0.5% solution of chlormequat chloride with a Mastertool hydraulic sprayer, while the plants of the control sample were treated with water. Experimental plots were laid in farms of the Podilskyi region in 2020-2021. The number of experimental plots of each of the experimental options is 5, the area is 5 m². The content of total nitrogen was determined by the Kjeldahl method, sugars and starch content was measured using the iodometric method.

The novelty of the research. The effect of a growth regulator on the redistribution of carbohydrates between plant organs during the growing season was for the first time investigated on the oil poppy culture. The accumulation of excessive carbohydrates in the leaves and roots of the experimental samples has a positive meaning due to the creation of a powerful reserve fund of assimilates. It is used for the formation and growth of the fruits of the oil poppy, the number of which increased. An increase in the content of carbohydrates in the vegetative organs of oil poppy plants under the action of chlormequat chloride was found to go along with a decrease in the content of total nitrogen in the roots and leaves both in the control sample and in the plants of the experimental variant.

Conclusions. The usage of growth regulators in the budding phase causes an increase in the productivity of oil poppy and rapeseed culture. Under the action of these preparations, a correction of donor-acceptor relations in the plant is observed. It is implemented through the redistribution of assimilates from vegetative organs to the needs of carpogenesis. The formation of a more powerful acceptor sphere is associated with laying a larger number of fruits - the main acceptors of assimilates in the second half of

the growing season. An increase in the load of the plant with fruits in the plants of the experimental variants also affected a more intensive flow of carbohydrates and nitrogen-containing compounds to them, which ultimately led to an increase in the seed yield.

Keywords: oil poppy (*Papaver somniferum*), rapeseed (*Brassica napus*), chlormequat chloride, carbohydrate content, nitrogen content.

Introduction. A high level of soil contamination with toxic substances has led to the search for effective measures to suppress such impacts, while maintaining high soil productivity and achieving maximum productivity. Therefore, one of the crucial tasks in this regard in rational environmental management is the search for effective and safe technologies in the cultivation of agricultural plants. At the current stage of its development, plant growth regulators of a new generation have been created. They are characterized by high efficiency and environmental safety, consequently, the exploration of optimal conditions of use, taking into consideration complex features of their action on various agricultural plants remains an important practical task of modern phytophysiology. The successful use of the anti-gibberellin preparation chlormequat chloride in crop production is owing to its non-toxicity, low half-life, as well as lack of harmful effects on living organisms.

The influence of physiologically active substances is known to lead to the restructuring of the plant assimilation apparatus, a change in the habit, the ratio of the masses of its organs, the appearance of additional attraction centres and either strengthening or weakening of the functioning of already existing ones. It, in its turn, indicates changes in the nature of donor-acceptor relations within plants. Inasmuch as the essence of changes in the nature of donor-acceptor relations is the redistribution of assimilate flows between plant organs, it is pivotal to clearly understand the dynamics of the accumulation and distribution of plastic substances in the plant organism in order to develop measures of exogenous regulation of ontogenesis with the help of growth regulators.

The results testify to the fact that an increase in the content of carbohydrates in sugar beet root crops was established when applying paclobutrazol [12]. Concurrently, a decrease in the content of sugars in the above-ground vegetative organs of plants was spotted when black-fruited rowan and raspberry were treated with a CCC-solution [6], and in epy potatoes under the action of paclobutrazol [13]. The data on the effect of growth inhibitors on the nitrogen content of oil crops are scarce. Nevertheless, an excess of nitrogen in the tissues during the development of oilseed plants is known to lead to an increase in protein accumulation and a simultaneous decrease in the oil content in the seeds as well as a decrease in the content of unsaturated fatty acids [10].

Alongside this, the influence of chlormequat chloride on the redistribution of assimilates has not been studied enough. The data on the effect of this anti-gibberellin preparation on the content of carbohydrates and nitrogen seem rather controversial [2, 9]. In this respect, the purpose of the experiment was to find out the influence of CCC on the redistribution of assimilates in oilseed plants.

Material and methods. Oil poppy plants and rapeseed plants of the Halytsky variety were processed during the budding period with a 0.5% solution of chlormequat chloride with a Mastertool hydraulic sprayer, while the plants of the control variant were sprayed with water. Experimental plots were laid in farms of the Podilskyi region in 2020-2021. The number of experimental plots of each of the experimental options is 5, the area is 5 m².

Chlormequat chloride (CCC) is an organic substance $[C_1CH_2CH_2N(CN)_3]+Cl$, used as an onium-type growth inhibitor. It has Toxicity Class III (slightly dangerous for humans). The preparation does not accumulate, and is not absorbed by the body thus is excreted within 2 days. These features grant its use in agriculture.

The Oslava white mustard variety was created by the method of individual - family selection from the Karolina variety against the background of the late spring sowing period. It has been listed in the Register of Plant Varieties of Ukraine since 2011. Podillia Institute of Fodder and Agriculture of the National Academy of Sciences is the originator of this variety. It is recommended for use as fodder, technical and cider culture. Its characteristics include increased fodder and seed productivity. Its vegetation period until harvest maturity is 40-45 days, before harvesting seeds - 85-95 days.

The Halytsky winter rape variety was bred at the Institute of Cruciferous Crops of the Ukrainian Academy of Sciences (Ivano-Frankivsk). It has been listed in the State Register of Plant Varieties of Ukraine (1997). Its yield is 18-35 t/ha. It is suitable for obtaining edible oil, the yield of which is 42-44%. Rape is also grown for the purpose of using its green mass for animal feed. Its productivity is 440 t/ha. This variety is early ripening, the growing season is 300-305 days. The content of total nitrogen was determined

by the Kjeldahl method, sugars and starch - by the iodometric method [1].

The obtained research results were processed statistically according to the Student's test, the difference is significant at the $P=0.05$.

Research results. The results of our research clearly indicate the following: the changes in the accumulation and redistribution of carbohydrates between the organs of poppy plants occur during the growing season under the influence of growth regulators.

In the leaves and roots treated with the retardant, the total content of carbohydrates (sugars and starch) in the experimental sample during the entire growing season was higher than in the control one (Fig. 1). Enhancement of starch accumulation in plants of *Landoltia punctata* L. under the influence of paclobutrazol was also noted in another research [7].

The accumulation of excessive carbohydrates in the leaves and roots of the experimental sample has a positive meaning, since a powerful reserve fund of assimilates is thus created. It is used for the fruit formation and growth of the oil poppy, the number of which increased significantly.

The analysis of the dynamics of the content of different forms of carbohydrates makes it possible to draw the following conclusion: there occurs a gradual decrease in the total content of sugars on account of reducing sugars and the increase in the content of starch in poppy leaves both in the control and in the experiment samples during the growing season (Fig. 2).

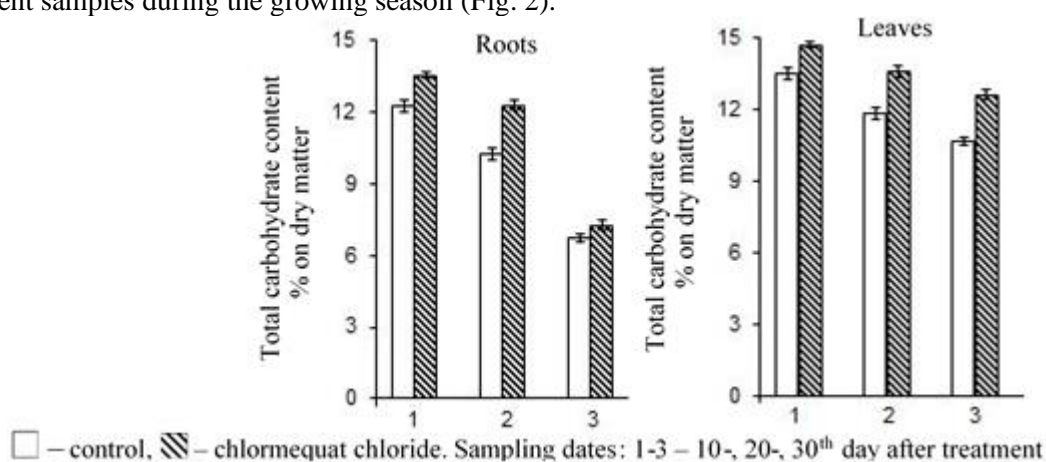
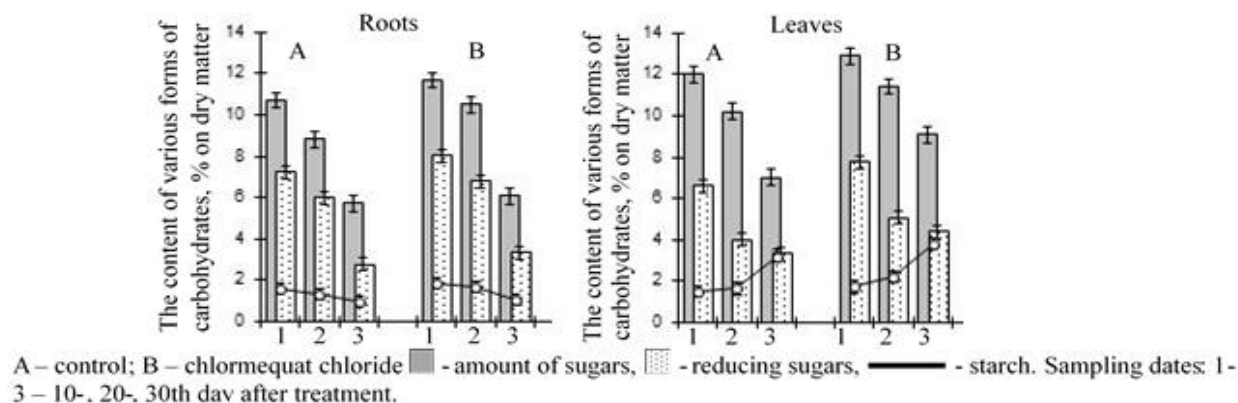


Figure 1. The effect of chlormequat chloride on the total content of carbohydrates (sugars + starch) in the vegetative organs of oil poppy plants.

There is a decrease in the content of both the amount of sugars and the content of starch in the roots. Since after the budding phase, the growth processes in the vegetative organs slow down considerably, and at the same time powerful acceptor zones - boxes - appear, the main flow of assimilates is aimed at the formation of fruits, which is associated with a gradual decrease in the content of carbohydrates in the



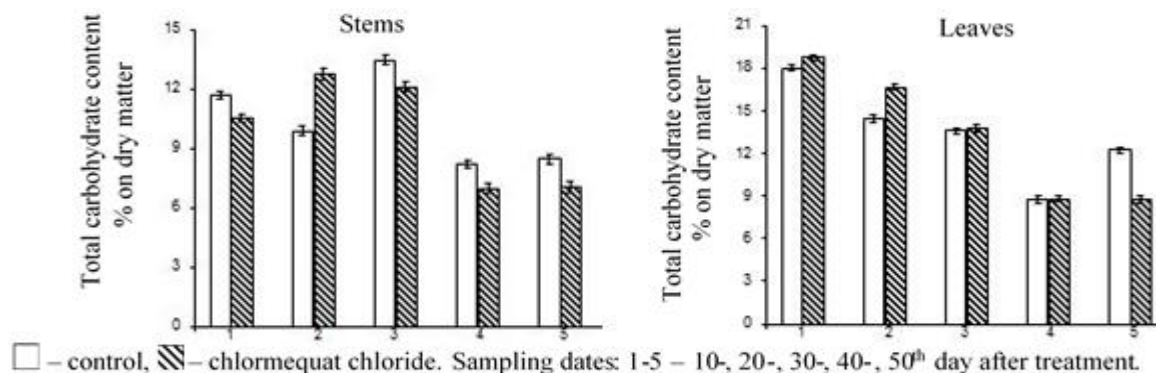
vegetative organs (Fig. 2).

Figure 2. The influence of chlormequat chloride on the dynamics of the accumulation of various forms of carbohydrates in poppy plants.

In consequence, under the influence of the growth inhibitor, the donor potential of the leaves of the

experimental plants increased. The surplus of carbohydrates was used for the formation of a more powerful plant stem as well as for the growth of fruits, the number of which multiplied under the action of chlormequat chloride.

In the leaves and stems of rapeseed plants treated with the retardant, the total amount of



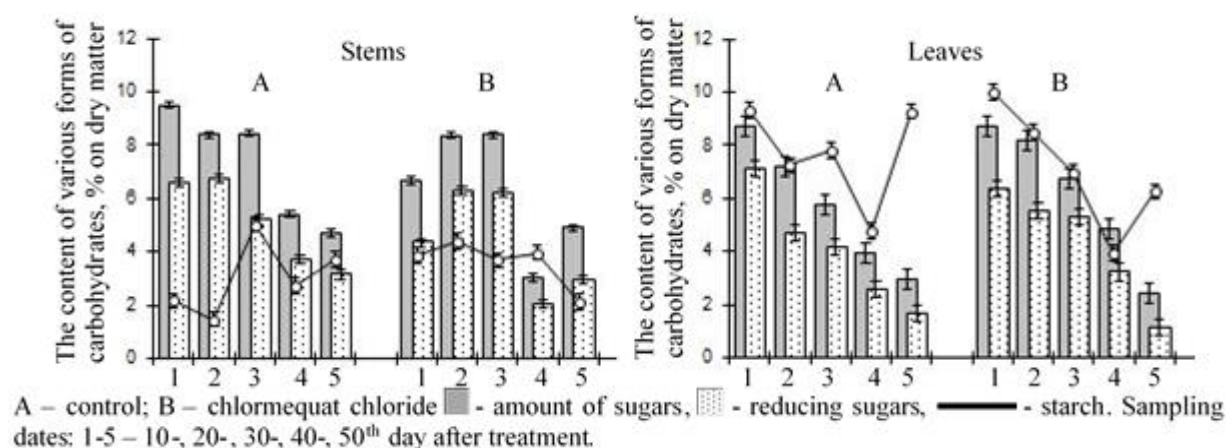
carbohydrates during the growing season was higher than in the control sample (Fig. 3).

Figure 3. The effect of chlormequat chloride on the total content of carbohydrates (sugars + starch) in the vegetative organs of winter rapeseed plants.

The analysis of the dynamics of the content of various forms of carbohydrates allows drawing a conclusion about the gradual decrease in the total content of sugars and starch in the leaves and stems of winter rape both in the control and in the experiment samples within the growing season (Fig. 4). After the budding phase, growth processes in vegetative organs slow down significantly, and at the same time powerful acceptor zones - pods – appear. Given that the main flow of assimilates is aimed at the formation of fruits, which is associated with a gradual decrease in the content of carbohydrates in vegetative organs. Such results are confirmed by other researchers [5].

Our research points out that under the action of the retardant in general, a decrease in the starch content in the leaves was observed during the growing season. An increase in the starch content under the action of the preparation was also spotted in the stems at the beginning of the growing season.

The content of starch in the stem of the experimental plants decreased compared to the control sample with the beginning of the period of active pod formation. To the best of our knowledge, this indicates that the decrease in the intensity of plant growth due to the action of retardants leads to the deposition of part of the assimilates in the form of starch. The increase in the content of carbohydrates in the vegetative organs of winter rape under the action of retardants also occurred at the expense of sugars. The growth occurred



first and foremost due to the accumulation of the main transport form of sugars - sucrose.

Figure 4. The effect of chlormequat chloride on the dynamics of the accumulation of various forms of carbohydrates in winter rapeseed plants.

Accordingly, the treatment of rapeseed plants with chlormequat chloride was accompanied by the deposition of sugars and starch in the tissues of vegetative organs owing to a decrease in the intensity of

their use for growth processes.

There are limited data on the effect of retardants on the accumulation and transport of nitrogen-containing compounds by plant roots. Specifically, the application of uniconazole increased the content of nitrate, ammonium nitrogen and amino acids in soybean xylem sap [14].

The results of our research demonstrate that the increase in the content of carbohydrates in the vegetative organs of oil poppy plants under the action of the aforementioned preparations (Fig. 5) was accompanied by a decrease in the content of total nitrogen in the roots and leaves both in the control variant and in the plants of the experimental variant.

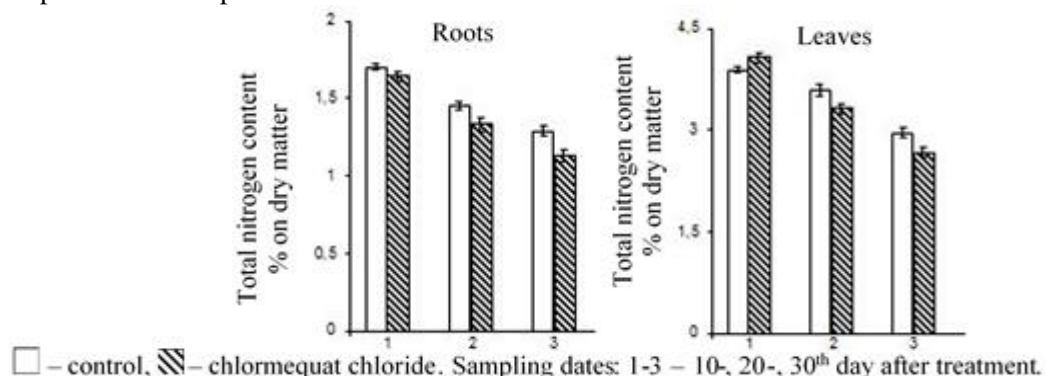
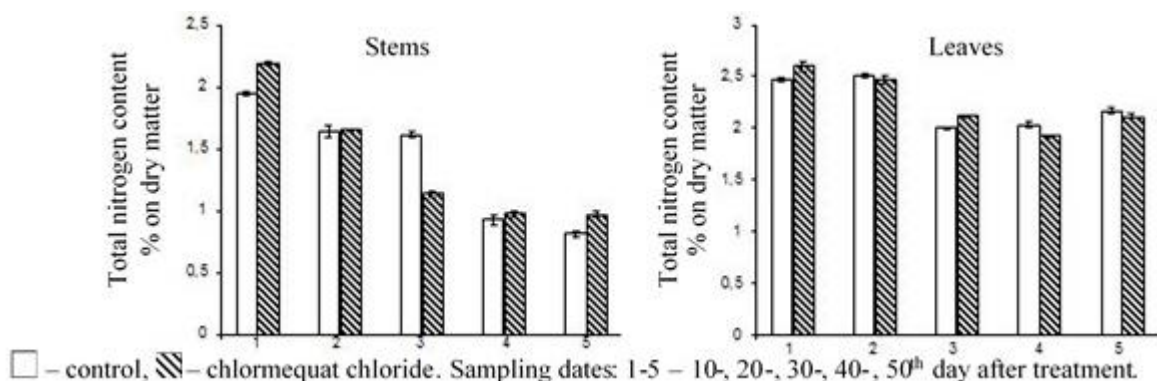


Figure 5. Effect of chlormequat chloride on the content of total nitrogen in the vegetative organs of oil poppy.

The maximum amount of nitrogen-containing substances in the leaves and roots was observed at the initial stages of the study, while the leaves were characterized by a higher nitrogen content in comparison with the roots. The total nitrogen content in the leaves was twice as high as in the roots. By the end of the growing season, the nitrogen content in the tissues of the vegetative organs decreased actively under the influence of the applied growth regulator, which, in our opinion, indicates the intensive hydrolysis of proteins and the outflow of nitrogen-containing compounds to new attracting centres - boxes, the number of which is increasing. Since the growth of vegetative organs actually stopped during this period, the gradual decrease in nitrogen content in leaves and roots cannot be explained by simple biodilution. During this period, new acceptor centres - boxes - are actively formed and grow. Such a dynamics of nitrogen content points out its active reutilization for the needs of carpogenesis.

We got similar results of nitrogen outflow from vegetative to generative organs on winter rapeseed culture. The results of this research testify to the fact that the increase in the content of carbohydrates in the vegetative organs of winter rape plants under the influence of the retardant was similarly gone along with a decrease in the nitrogen content in the leaves. (Fig. 6). Concomitantly, an increase in nitrogen content is



observed in the stems at the end of the growing season.

Figure 6. Effect of chlormequat chloride on the content of total nitrogen in the vegetative organs of winter rape.

Growth regulators of the inhibitory type are widely used to increase productivity. For this purpose, quaternary ammonium salts are also made use of on vegetable [3] and oil [8] crops. In particular, an increase in the seed yield occurred in flax plants [4] and mustard [11] under the influence of CCC.

We found out that there was a redistribution of assimilates, which are used for the formation of fruits under the action of the retardant. The application of an anti-gibberellin preparation on poppy and rapeseed plants caused changes in the crop structure: an increase in the number of capsules, an increase in the weight of a thousand seeds and the weight of seeds in a capsule in oil poppy plants, an increase in the number of pods, the number of seeds in one pod on a rapeseed plant. The abovementioned changes ensure an increase in productivity of the cultures under reserach (Table 1).

Table 1 The effect of CCC on the productivity of mustard and rape plants

Indicators	Control	CCC
	Oil poppy	
Number of pods per plant, pcs.	2,5 ± 0,09	*3,1 ± 0,12
Weight of seed in a pod, g	3,0 ± 0,10	*3,5 ± 0,11
Weight of 1000 seeds, g	0,5 ± 0,02	*0,6 ± 0,01
Yield, c / ha	8,4 ± 0,25	*10,1 ± 0,26
	Winter rape	
Number of pods per plant, pcs.	39,6 ± 1,11	42,5 ± 1,04
Number of seeds ped pod, pcs.	26,3 ± 0,38	27,8 ± 0,07
Weight of 1000 seeds, g	4,3 ± 0,42	4,4 ± 0,11
Yield, c / ha	25,6 ± 0,73	*28,4 ± 0,74

Conclusion. The application of growth regulators in the budding phase brings about an increase in the productivity of oil poppy and rapeseed culture. Under the action of these preparations, there is a correction of donor-acceptor relations in the plant, which is implemented through the redistribution of assimilates from vegetative organs to the needs of carpogenesis. The formation of a more powerful acceptor sphere is associated with laying a larger number of fruits - the main acceptors of assimilates in the second half of the growing season. The amplification of the load of the plant with fruits in the plants of the experimental variants also determined a more intensive flow of carbohydrates and nitrogen-containing compounds to them, which eventually caused an increase in the seed yield.

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