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FEATURES OF SHEET APPARATUS OF SUGAR BEET UNDER RETARDANTS TREATMENT

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Abstract
We studied the influence of antigibberellin compounds with different mechanisms of action-Paclobutrazole (0,05 %) and Dextrel (0,3 %) on the formation of leaf surface, structure of photosynthetic apparatus and features of leaf functioning under retardants artificial growth control on sugar beet plants. We found that retardants treatment slowed the growth of total leaf surface of sugar beet. At the same time, application of Paclobutrazole (0,05 %) caused a greater retardation effect on plant growth. The number of dead leaves of treated plants during vegetation season was unchanged compared to control. We established that decrease in the leaf area was accompanied by their thickening due to increase in the size of palisade and spongy parenchyma cells, decrease in the size of epidermal cells and increase in the number of stomatas per unit leaf area. Stomatal index which characterizes the ratio of number of stomata form to the total number of epidermal cells on the same leaf area was identical for all experimental variants, notably, the ratio of stomata and other epidermal cells not changed under retardants application. Retardants are a powerful means to regulate the assimilation apparatus activity, one of the donor-acceptor system component, and can be used for the targeted regulation of plastic substances redistribution in sugar beet.

Keywords: Retardants; mesostructural organization; sugar beet (*Beta vulgaris* L.)

According to modern concepts, the higher plants represent a single donor-acceptor system ("source-sink"), whose functioning is determined by the genetic development program. There are three zones of assimilates acceptance: growth zones, nutrient uptake zones and active metabolism zones (Kiriziy et al., 2014). Formation of economic harvest is determined by the strategy of assimilate redistribution between these basic acceptors. The development of donor-acceptor ("source-sink") systems of plant opens the prospects of artificially redistributing of assimilates flows from vegetative growth processes to the fruits formation and growth needs, and therefore, it is a potential factor in increasing the agricultural crops productivity (Shevchuk et al., 2020; Shevchuk and Shevchuk, 2020; Bonelli et al., 2016; Dewi and Darussalam, 2018; Yu et al., 2015).

Phytohormonal growth regulators or their antagonists affect to enhance the attracting activity of acceptor zones, which results in intensification of carbon dioxide fixation during photosynthesis, increased photosynthetic productivity and redistribution of assimilates from leaves to growth or storage zones (Cai et al., 2014; Mohammad and Mohammad, 2013; Ljung et al. 2015; Zheng et al., 2012).

Synthetic growth inhibitors - retardants - received the greatest value in agricultural practice among the numerous plant growth regulators. Despite the fact that these substances have different chemical nature, they all exhibit antigibberellin action and are united by their ability to inhibit plant growth (Koutroubas and Damalas, 2016).

Retardants due to the regulation of growth processes, insertion in metabolic processes, can improve the water regime, increase plant resistance to unfavorable environmental factors, in particular extreme temperatures, increase drought and high-temperature strength, frost, phytopathogenic microorganisms and pests resistance (Ullah et al., 2018; Dwivedi et al., 2017; Zhao et al., 2017).

It is highly effective to use retardants in cereals, which increased their resistance to lodging (Shevchuk et al., 2019). Application of retardants, ethyleneproducer and their derivatives leads to an increase in the productivity of oilseed (Khodanitska et al., 2019; Polyvanyi et al., 2020; Skavronska et al., 2018; Khodanitska et al., 2019); legumes (Shevchuk et al., 2014; Shevchuk et al., 2014), vegetable crops (Shevchuk et al., 2020; Pervachuk et al., 2018). Broadly used retardants in floriculture to shorten shoots of ornamental plants and increase the number of vegetative propagation organs (Wu et al., 2018).

It is known that productivity of sugar beet in many respects depends on the rate of formation and functional activity of the first and second decimal leaves. At the same time, the plants of this culture have a high leaf-forming potential, in some cases in the first year of life on the plant can be formed 40-90 leaves with a total area of 3 to 6 thousand cm^2. In addition, the fourth and subsequent dozens leaves often not complete their development as a result of low night temperatures. Since the leave a significant period of time stays as an acceptor of assimilates, until 50-60% of the maximum length, an additional powerful attractive zone is created. The enhancement of leaf surface indexes above 3.5 not bring any benefit, since the leaves obscure each other and compete with root in assimilates. It is shown that the removal of apices and part of late leaf not affect the productivity of plants (Kiriziy et al., 2014). Since it is not practical to limit the growth of excess leaves by surgical means, it is necessary to search for other, more effective means of leaf growth inhibition processes. In this case, the issue of this study was to find out the effect of retardant Paclobutrazole and Dextrel on the leaf surface formation, features of leaf functioning under artificial regulating growth retardants application on sugar beet plants.

Sugar beet plants of sort Eldorado were grown in vegetative vessels with 32 kg of soil capacity with the addition of nutritional mixture VNIS. The lower irrigation was applied, soil moisture content during the vegetation maintained at 60 % of the total moisture content.

The experiment was carried out with the application of triazole derivative Paclobutrazole (P 333) -4,4-Dimethyl-2- (1,2,4- triazolyl-1) -1 (4-chlorophenyl) pentane-3 derivative of 1,2,4-triazole, which is synthesized by «ACI» (United Kingdom) (Soumya et al., 2017) and ethylenereleasing compound Dextrel D-(+)-threo-1-(p-nitrophenol)-1,3-dixispropylammonium, 2-chloroethylphosphonic acid, which is synthesized at the Institute of Organic Chemistry of the National Academy of Sciences of Ukraine.

The treatment was applied with aqueous solution of Paclobutrazole (0.05%) and Dextrel (0.3%) at the period of 14-16 leaves formation. Mesostructural characteristics of leaves was determined at a fixed material. For preservation was used a mixture of equal parts of ethanol, glycerol and water with addition of 1 % formalin. It was used as maceration agent 5 % solution of acetic acid in 2 mol/l hydrochloric acid. For analysis, it was selected the middle-layer leaves of the shoots, which completely ended their growth, after 30 days drugs-treated plants.

Determination of epidermal cells size was carried out by the maceration of partial leaf tissue method. The estimation of epidermal cells area was performed by using a microscope and ocular micrometer MOB-1-15x, counted the number of cells in the tissue per unit vision area, followed by the calculation of one cell and its volume.

The pigments content was determined in the fresh material by spectrophotometric method on the spectrophotometer SF-18. It was determined the total leaf surface area, number of leaves and number of dead leaves during the vegetation once every 10 days.

The statistical processing of results was carried out using the statistical software Statistica 6,0. The reliability of obtained results between control and experiment varient was assessed with the use of Student's t-test. Tables and figures show mean values for the years of research and their standard errors.

It was found that the growth of total leaf surface of experimental sort Eldorado plants inhibited under redardants application (Table 1). At the same time, a more growth-inhibiting effect was found under 0,05 % Paclobutrazole interaction. In treated plant, number of leaves that died during the period of vegetation was unchanged compared to control. The obtained results suggest that Paclobutrazole treatment caused formation of rooting habitus of experimental plants.

It is known that the character of photosynthetic process, energy and substrate support of morphogenesis is largely determined by the anatomical and morphological features of leaf.

Table 1

Area of leaf surface and number of leaves under retardants treatment on sugar beet Eldorado

Measurem ents	Area of leaf surface at the end of vegetation, cm^2	Number of leaves formed during vegetation	Area of dead leaves during vegetation, cm^2	Number of dead leaves during vegetation
Control	1751 ± 74	48,1 ± 1,82	1335 ± 81	12.0 ± 0,52
0,3% Dextrel	1498 ± 50*	50,0 ± 1,63	1254 ± 75	12.1 ± 0,62
0,05% Paclobutrazole	1290 ± 43*	49.3 ± 1,61	1495 ± 95	11.0 ± 0,53

Note: * – difference is significant at $p<0,05$.

The analysis of mesostructural organization of sugar beet leaf treated by retardants indicate significant anatomical changes. In particular, decrease in the leaf area of treated plants was accompanied by thickening of lamina, and this thickening was achieved due to increased volume of palisade and linear dimensions of spongy parenchyma of leave with increment of chlorophyll content in tissues (Table 2).

Table 2

Leaf mesostructural organization of sugar beet Eldorado under retardants treatment

Measurement	Control	0,3 % Dextrel	0,05 % Paclobutrazole
Thickness of leave, µm	169,0 ± 2,12	254,2 ± 4,06*	221,3 ± 6,14*
Partial volume tissue on leaf cross section, % : epidermis chlorenchyma	 22,5 ± 0,92 77,5 ± 2,14	 19,3 ± 0,71* 80,7 ± 1,42	 14,4 ± 1,80* 85,6 ± 2,43*
Volume of palisade parenchyma, μm^3	6069 ± 137	6884 ± 280*	7840 ± 207*
Length of spongy cells, µm	26,9 ± 0,50	28,1 ± 0,42	27,3 ± 0,70
Width of spongy cells, µm	23,6 ± 0,50	24,7 ± 0,84	22,5 ± 0,43
Number of stomatas on 1 mm^2 of the abaxial leaf surface	350,1 ± 3,02	400,0 ± 5,11*	400,2 ± 5,04*
Area of a stoma, µm 2	267,1 ± 6,02	333,1 ± 3,11*	280,2 ± 7,05
Area of an epidermal cell, μm^2	505,0 ± 5,02	434,3 ± 4,11*	415,2 ± 5,07*
Stomatal index	0,15	0,15	0,15
Total chlorophyll content (a+b), % per leaf fresh matter weight	0,52 ± 0,014	0,58 ± 0,011*	0,63 ± 0,010*

Note: * – difference is significant at $p<0.05$.

The volume of spongy cells parenchyma wasn't count, due to the fact that the cells are in the wrong shape. Reduction of leaf area of experimental plants was accompanied by an increase in size of main leaf cells weight, the results indicate that retardants caused a decrease in the meristematic activity of marginal meristems. At the same time, it is drawn attention to the fact that experimental plants were characterized an increase in the number of stomata per unit area of leaf and an increase in the area of a stoma. It should be noted that an increase in the number of stomata per unit area of epidermis correlated with the decrease in the size of main epidermal cells.

The calculation of stomatal index, which characterizes the ratio of number of stomata form to the total number of epidermal cells on the same leaf area, indicates that for all variants of experiment it was the same, the ratio of stomata and other cells of epidermis under retardants not changed (Table 2).

It was visually marked the reduction of intercellular space in chlorenchyma leaves of experimental plants. It is known that the growth of epidermal cells with normal development of leave lasts longer than the growth of chlorenchyma cells. Consequantly, intercellularities are formed and the distance between formed chlorenchyma cells increased. Accordinly, it was noted a pattern, in our opinion, that indicates an earlier termination of epidermal cells growth under the influence of retardants.

Plant growth retardants – Dextrel and Paclobutrazole – affect the anatomical and physiological parameters of photosynthetic apparatus of sugar beet, which results in a decrease of leaf surface area, apparent photosynthesis and an increase in the share of respiratory costs on carbon dioxide gas balance. Retardants are a powerful regulators of assimilative activity, one of the components of plant donor-acceptor system and can be used for the targeted regulation of plastic substances redistribution in sugar beet.

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