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PECULIARITIES OF THE GROWTH, FORMATION OF LEAF APPARATUS AND PRODUCTIVITY OF TOMATOES UNDER ACTION OF RETARDANTS FOLICUR AND ETHEPHON

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The influence of tryazol derivative retardant folicur and ethylene producer ethephon on morphogenesis, leaf mesostructure and yield of tomatoes variety Solerosso was studied. It has been established that the relative proportion of the total leaf mass of plants on the stage of fruit ripening was more under the action of retardants, at folicur variant there were maximum weight of dry and fresh matter of leaves and their area recorded. In this option there was a considerable thickening of leaf due to increase the volume and linear dimensions of palisade and spongy assimilation cells, the chlorophyll content, the chlorophyll index and the leaf index. The application of ethephon did not lead to such positive changes. The mesostructure and morphological changes of photosynthetic apparatus, the increasing of chlorophyll content in tissues caused by folicur are leading to significant increasing the productivity of culture.

Key words: *Lycopersicon esculentum*, retardants, ethylene producers, photosynthetic apparatus, source-sink relations, productivity

The application of different growth regulators allows to adjust the production process of agricultural crops through changes of source-sink relations in plants (Kiriziy, 2004; Kuryata, 2009). The physiological essence of such regulation is to stimulate or block the activity of the apical meristem, which leads to change the source-sink relations intensity as a result of changes in the activity of photosynthetic and growth processes (Kuryata et al., 2015).

In modern phytophysiology growth regulators of the inhibitor type – retardants (Kuryata, 2009) are widely used. However, the influence of modern drugs – representative of different classes of retardants – on the morphogenesis, photosynthetic apparatus and production of agricultural plants has been insufficiently studied. Recently, in crop production practices for the regulation of growth the folicur (tebuconazole) was started to use, that was effective on several agricultural crops: wheat, barley, canola (Kumar et al., 2012).

The representative of another class of retardants ethylene producers is ethephon – a derivative of 2-chloroethyl phosphonic acid. The prospect of using this drug is determined by the fact that its action is manifested through the native metabolic product – ethylene (Cicchino et al., 2013). However, the physiological basis of the application of these members of different classes of retardants on a number of several crops, particularly on the culture of tomatoes remains practically not studied.

It is known that the photosynthetic activity of plants is determined by morphological and mesostructural peculiarities of the leaf apparatus. In this regard, the research was aimed to determine peculiarities of the growth, formation of leaf apparatus and productivity of tomatoes under the action of retardants folicur and ethephon.

MATERIALS AND METHODS

Plants of tomatoes (*Lycopersicon esculentum* L.), variety Solerosso growing in microplot trials were treated at morning with aqueous solutions of 0.025 % folicur and 0.05 % ethephon by a knapsack sprayer OP-2 to complete wetting of leaves at budding stage in growing seasons of 2015 and 2016. Control plants were treated with water.

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Table 1. Relative proportion of the leaf weight of tomatoes variety Solerosso under the action of folicur and ethephon, %

Variant	Total weight of fresh matter of plant, g	Weight of fresh matter of leaf, g	Relative proportion of the leaf weight, %
Stage	Fruit formation		
Control	928.72 ± 16.44	260.67 ± 4.55	28.07 ± 0.35
0.05 % ethephon	986.92 ± 19.36*	241.08 ± 5.01*	24.42 ± 0.22*
0.025% folicur	889.29 ± 16.45*	247.09 ± 4.79*	27.78 ± 0.38
Stage	Fruit maturity (green stage of ripeness)		
Control	2554.56 ± 74.72	298.04 ± 8.12	11.67 ± 0.38
0.05 % ethephon	2240.59 ± 60.77*	342.64 ± 8.12*	15.29 ± 0.45*
0.025% folicur	3122.29 ± 80.88*	398.04 ± 13.64*	12.74 ± 0.37*

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

Phytometric measurements (plant height, leaf area, weight of dry and fresh matter of the leaves) were determined at the stage of fruits formation and maturity (stage of green ripeness) (Kazakov, 2000). Chlorophyll content was measured by spectrophotometric method in fresh material on a spectrophotometer SF-16 (Gavrilenko, 1975). The leaf index (LI) was defined as the area of all leaves per unit soil surface, the chlorophyll index (CI) as the product of leaf area of the plant and the content of total chlorophyll in them (Pryadkina et al., 2011).

The mesostructural organization of leaves was studied at the end of the vegetative season at a fixed material by conventional method (Mokronosov et al., 1978). For preservation a mixture of equal parts of ethanol, glycerol and water with addition of 1 % formalin was used. Macerative agent was chosen a 5% solution of acetic acid in 2 mol/l hydrochloric acid. For the analysis leaves of the middle layer, which completely ended their growth, were selected 30 days after the treatment of plants. The determination of cells sizes was performed by using a microscope "Mikmed-1" and ocular micrometer MOB-1-15×.

The productivity and quality of fruits of tomatoes variety Solerosso were determined at the end of growing season. Quantitative determination of ascorbic acid was performed by using potassium hexacyanoferrate (III), acidity was determined by using titration with 0,1 N alkali solution in presence of an indicator (Ermakov, 1987). Determination of soluble sugars and starch was made by iodometric method according to H. M. Pochinok (Pochinok, 1976).

The statistical processing of results was performed using the computer program "Statistica". Tables and figures show mean values for the 2015-2016 and their standard errors (Dosphehov, 1985).

RESULTS AND DISCUSSION

The analysis of results shows that the treatment of tomato plants of variety Solerosso by triazol derivative and ethylene producer retardants during budding caused considerable inhibition on the linear growth. So, at the end of growing season, at the stage of fruit maturity (stage of green ripeness) mean plant height after folicur action was 46.31 ± 1.68 cm, after ethephon – 46.91 ± 1.18 cm, compared with the control mean 50.61 ± 1.08 cm.

In the early stage of drugs action (stage of fruit formation) the relative proportion of leaf weight in total weight of plants was less than in control (Table 1). In general, as seen in Fig. 1, the weight of fresh and dry matter of leaf, total leaf area and leaf area of tomatoes plants were reduced by the action of retardants at the stage of fruit formation.

However, 30 days after treatment (green ripeness) the relative proportion of leaf weight in total weight of plants influenced by drugs was increased, with the maximum weight of leaves observed at folicur variant. Both drugs increased the total weight of fresh and dry matter of leaf and leaf area, and the area of individual leaf was increased in the folicur variant (Fig. 1).

Physiological condition of the leaf is in close cooperation with its structural features defined in the scientific literature as a "mesostructure" (Kuryata et al., 2015). However, the influence of synthetic growth inhibitors with antigibberellin action mechanism on photosynthetic function of a leaf is rarely held on its mesostructure characteristics.

Analysis of mesostructure organization of leaf testified that changes in the thickness of the plants leaf lamina under the influence of drugs occurred through formation of the parenchyma (Table

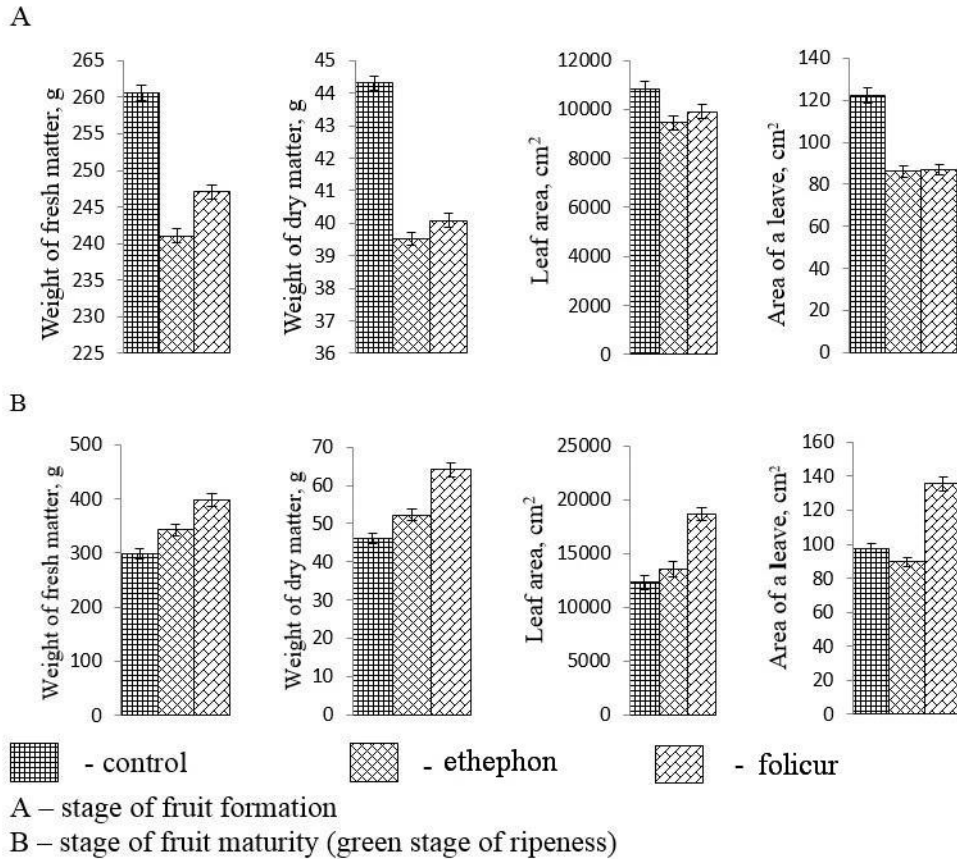


Fig. 1. Influence of folicur and ethephon on the foliage formation of tomatoes variety Solerosso.

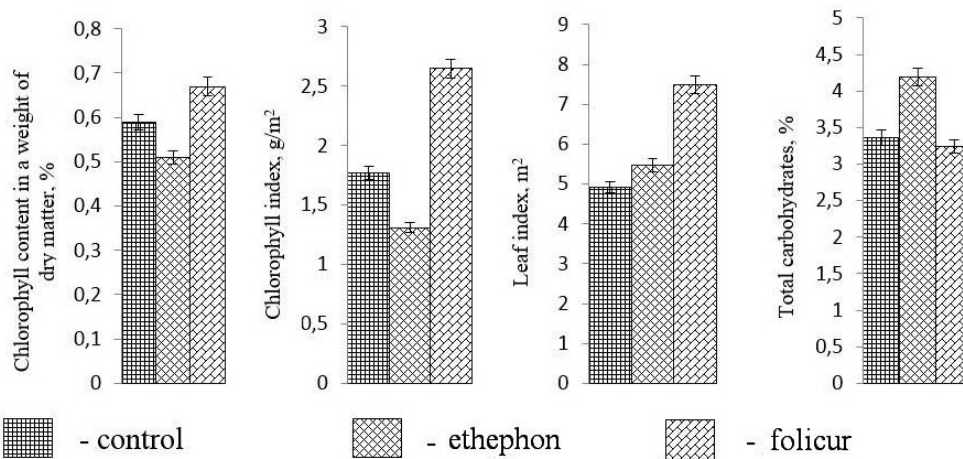


Fig. 2. Influence of ethephon and folicur on the content of chlorophylls, chlorophyll index, leaf index and total carbohydrates in leaves of tomato variety Solerosso.

2). So, the treatment with 0.025 % folicur caused increasing of linear dimensions of spongy cells and volume of palisade parenchyma –main assimilation tissue of a leaf. However, at the action of 0.05 % ethephon these indicators were lower than controls, apparently caused by the inhibitory effect of retardant to the marginal meristem of a leaf. These

results are consistent with the reduction of the leaf area for this drug.

Significant changes have occurred in the epidermal tissue of a leaf. Analysis of the survey shows that the use of triazol derivative drug led to increasing thickness of the upper and lower epidermis of a leaf compared to control. It has been

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Table 2. Influence of retardants on mesostructure characteristics of leaves of tomato variety Solerosso

Measurements	Control	0.05 % ethephon	0.025% folicur
Thickness of leave, mcm	246.0 ± 4.3	194.7 ± 3.5*	262.6 ± 3.0*
Thickness of chlorenchyma, µm	205.4 ± 4.3	165.6 ± 3.3*	213.7 ± 2.7
Volume of palisade parenchyma, µm ³	64125 ± 1615	56384 ± 1891*	68263 ± 1179*
Length of spongy cells, µm	20.92 ± 0.98	24.07 ± 0.51*	23.94 ± 0.15*
Width of spongy cells, µm	16.25 ± 0.41	14.91 ± 0.92	14.36 ± 0.53*
Thickness of upper epidermis, µm	21.61 ± 0.93	15.92 ± 0.69*	26.87 ± 1.13*
Thickness of lower epidermis, µm	18.97 ± 0.77	13.28 ± 0.45*	22.03 ± 0.58*
Number of epidermis cells on 1 mm ² of abaxial leaf surface, pieces	111.55 ± 3.11	118.54 ± 1.95*	91.55 ± 3.35*
Number of stomatas on 1 mm ² of abaxial leaf surface, pieces	20.55 ± 1.15	34.55 ± 1.35*	28.05 ± 1.11*
Area of a stomata, µm ²	462.09 ± 19.77	349.37 ± 14.74*	417.81 ± 17.51*

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

Table 3. Influence of retardants on product quality of tomato plants variety Solerosso

Measurements	Control	0.05 % ethephon	0.025% folicur
Yield, t/ha	111.6 ± 2.7	106.8 ± 2.1	144.4 ± 2.4*
Weight of fruits from one bush, kg	2.79 ± 0.05	2.67 ± 0.04*	3.61 ± 0.06*
Number of fruits on a bush, pieces	58.65 ± 1.82	54.21 ± 1.75*	59.81 ± 1.95
Weight of one fruit, g	48.04 ± 1.42	49.25 ± 1.85	61.32 ± 1.64*
Content of ascorbic acid, mg/100 g	101.7 ± 1.1	93.5 ± 1.1*	67.6 ± 1.0*
Titrated acidity, mg /100 g	0.65 ± 0.01	0.67 ± 0.02	0.94 ± 0.02*
Total sugars, %	2.11 ± 0.02	1.21 ± 0.02*	1.44 ± 0.03*

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

observed the opposite effect under the action of ethephon – thickness of the epidermal cells significantly decreased. Attention is drawn to the fact that the number of stomata per 1 mm² of the abaxial leaf surface and the number of epidermis cells increased in both variants of the experiment, the area of a stomata decreased.

One of the important indicators related to the improvement of photosynthetic productivity of plants is the leaf chlorophyll content and the value of chlorophyll index. Analysis of the results testified that the chlorophyll content significantly increased under the action of folicur and it was lower compared to the control under the action of ethephon (Fig. 2). Changes in the accumulation of chlorophylls and significant morphological changes of the leaf apparatus under the actions of drugs led to significant differences in the chlorophyll index of plants according to options. So, the maximum value of chlorophyll index was noted under the action of folicur due to increasing of leaf area and chlorophyll content in them.

In our opinion, the low content of total carbohydrates (sugars + starch) in the variant with application of folicur caused by increasing load of

bushes with fruits (Table 3) and enhanced outflow of carbohydrates from leaves.

It has been found that the action of drugs increased the important coenotic indicator of plants – the leaf index.

Thus, the action of folicur formed more powerful photosynthetic potential, which creates preconditions for more efficient functioning of the culture. However, not always increasing the leaf index is a positive coenotic indicator, as this can lead to thickening of plants and its shade. Productivity analysis of tomato plants variety Solerosso under the actions of drugs suggests that the treatment with folicur does not lead to such negative consequences. In this embodiment, there is a yield significant growth due to the mass of individual fruits. Significant differences between experiment and control weren't noted with the ethephon using.

However, the increasing of yield in the variant with folicur is accompanied by the decreasing in content of sugars, ascorbic acid and increasing of fruit acidity.

Consequently, the application of retardant folicur leads to improved mesostructural and morphological characteristics of leaf apparatus of to-

matoes, elevated levels of the chlorophyll content and the leaf index of plants, which creates conditions for increasing the productivity of culture.

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ОСОБЛИВОСТІ РОСТУ, ФОРМУВАННЯ ЛИСТКОВОГО АПАРАТУ ТА ПРОДУКТИВНІСТЬ ТОМАТІВ ЗА ДІЇ РЕТАРДАНТІВ ФОЛІКУРУ ТА ЕСФОНУ

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Досліджено вплив ретардантів триазолпохідного препарату фолікуру та етиленпродуценту есфону на морфогенез, мезоструктуру листка та урожайність томатів сорту Солероссо. Встановлено, що за дії ретардантів на стадії дозрівання плодів відносна частка листків від загальної маси рослини була більшою, причому максимальна маса сухої та сирої речовини листків та їх площа відзначалися у варіанті з фолікуром. Саме у цьому варіанті відбувалося суттєве потовщення листка за рахунок збільшення об'єму і лінійних розмірів клітин стовпчастої і губчастої асиміляційної тканини, збільшувався вміст хлорофілу, підвищувалися хлорофільний та листковий індекси. Застосування есфону не призводило до таких позитивних змін. Спричинені фолікуром морфологічні і мезоструктурні зміни листкового апарату, підвищення вмісту хлорофілів в тканинах призводили до достовірного підвищення урожайності культури.

Ключові слова: *Lycopersicon esculentum*, ретарданти, етиленпродуценти, фотосинтетичний апарат, донорно-акцепторні відносини, продуктивність

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И ПРОДУКТИВНОСТЬ ТОМАТОВ ПРИ ДЕЙСТВИИ РЕТАРДАНТОВ
ФОЛИКУРА И ЭСФОНА**

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Исследовано влияние ретардантов триазолпроизводного препарата фоликура и этиленпродуцента эсфона на морфогенез, мезоструктуру листа и урожайность томатов сорта Солероссо. Установлено, что при действии ретардантов на стадии созревания плодов относительная доля листьев от общей массы растения была больше, причем максимальная масса сухого и сырого вещества листьев и их площадь отмечались в варианте с фоликуром. Именно в этом варианте происходило существенное утолщение листа за счет увеличения объема и линейных размеров клеток столбчатой и губчатой ассимиляционной ткани, увеличивалось содержание хлорофилла, повышались хлорофилльный и листовой индексы. Применение эсфона не приводило к таким позитивным изменениям. Вызванные фоликуром морфологические и мезоструктурные изменения листового аппарата, повышение содержания хлорофиллов в тканях приводили к достоверному повышению урожайности культуры.

Ключевые слова: *Lycopersicon esculentum, ретарданты, этиленпродуценты, фотосинтетический аппарат, донорно-акцепторные отношения, продуктивность*