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АНАТОМИЯ ЛИСТА КАК БИОЛОГИЧЕСКИЙ МЕХАНИЗМ УСТОЙЧИВОСТИ ХЛОПКА К НАСЕКОМЫМ ВРЕДИТЕЛЯМ.

Аннотация

В статье представлены результаты изучения структурных параметров мезофилла листа семи представителей рода *Gossypium* L. Для устойчивости к тлям (*Aphis gossypii* Glov.) и паутинному клещу (*Tetranychus urticae*) толщина кутикулы листа хлопчатника должна быть не менее 0,85 мкм. Высота столбчатой паренхимы у G. *hirsutum* ssp. *mexicanum* var. *microcarpum* f. *palmeri*, G. *hirsutum* ssp. *mexicanum* var. *nervosum,* G. *barbadense* ssp. *ruderale* f. *pisco* довольно высокая, но, возможно, на устойчивость влияет не толщина самого столбчатого слоя, а разница между толщиной губчатой и столбчатой паренхимы. В этом случае высота столбчатой паренхимы должна превышать высоту губчатой в 1,5 раза.

Ключевые слова: Хлопок, дикие виды, гибриды, мезофилл листа, паутинные клещи, тли, столбчатая паренхима, губчатая паренхима, трихомы.

BARAG ANATOMIYASI PAXTA HASHARTARLARGA QARShILISHNING BIOLOGIK MEXANIZMASI SIFATIDA.

Abstrakt

Maqolada *Gossypium* L turkumining ettita vakilining barg mezofillasining strukturaviy parametrlarini o‘rganish natijalari keltirilgan. Shira (*Aphis gossypii* Glov.) va o'rgimchak oqadilar (*Tetranychus urticae*) ga chidamliligi uchun g'o'za bargi kesikulasining qalinligi kamida 0,85 mkm bo'lishi kerak. G. *hirsutum* ssp. *mexicanum* var. *mikrokarpum* f. *palmeri*, G. *hirsutum* ssp. *mexicanum* var. *nervosum,*

G. *barbadense* ssp. *ruderale* f. *pisco* da ustunli parenximaning balandligi ancha yuqori, lekin, ehtimol, barqarorlikka ta'sir qiladigan ustunli qatlamning qalinligi emas, balki gubka va ustunli parenximaning qalinligi o'rtasidagi farq. Bunday holda, ustunli parenximaning balandligi shimgichli parenximaning balandligidan 1,5 marta oshib ketishi kerak.

Kalit so‘zlar: G‘o‘za, yovvoyi turlar, duragaylar, barg mezofilli, o‘rgimchak oqadilar, shira, ustunli parenxima, gubkali parenxima, trixomalar.

LEAF ANATOMY AS A BIOLOGICAL MECHANISM OF COTTON RESISTANCE TO INSECT PESTS.

Abstract

The article presents the results of studying the structural parameters of the leaf mesophyll of seven representatives of the genus *Gossypium* L. For resistance to aphids (*Aphis gossypii* Glov.) and spider mites (*Tetranychus urticae*), the thickness of the cotton leaf cuticle should be at least 0.85 μm. The height of the columnar parenchyma in G. *hirsutum* ssp. *mexicanum* var. *microcarpum palmeri*, G. *hirsutum* ssp. *mexicanum* var. *nervosum*, G. *barbadense* ssp. *ruderale* f. *pisco* is quite high, but it is possible that tolerance is affected not by the thickness of the columnar layer itself, but by the difference between the thickness of the spongy and columnar parenchyma. In this case, the height of the palisade parenchyma should exceed the height of the spongy parenchyma by 1.5 times.

Keywords: Cotton, wild species, hybrids, leaf mesophyll, spider mites, aphids, palisade parenchyma, spongy parenchyma, trichomes.

Relevance. The morphological characteristics of leaves of plants useful to humans are not only of scientific importance, but also have significant agronomic and economic significance [1,2]. Along with anatomical characteristics, they are widely used by botanists as taxonomic characteristics in resolving controversial issues of systematics, evolution, and phylogeny of representatives of various taxa [3,4]. Significant correlations between the density of insect pests and the structural features of leaves suggest that leaf structure may influence the functioning and composition of these insect communities [5,6]. Under the influence of pests, the world loses cotton crops worth 300 billion US dollars, 40% of the gross harvest is destroyed. The economic threshold of harmfulness depends only on the number of affected plants in the field and the cost of treatment. It is from 40 to 80 individuals per 100 leaves of all plants in the field [7,8]. Chemical treatment against spider mites is carried out when 5% of plants in the crop are infested with mites or when the number of pests is 150 or more per 100 leaves. With a strong infestation of crops with spider mites and failure to take appropriate control measures, the loss of raw cotton crops is 35-50% [9]. This study to a certain extent serves to fulfill the tasks provided for in the Resolutions of the President of the Republic of Uzbekistan No. PP-308 "On additional organizational measures to increase cotton yields, introduce science and innovation in cotton cultivation" dated 07.07.2022, No. PP-23 "On additional measures to further support the activities of raw cotton producers" dated 26.01.2023, as well as other regulatory documents adopted in this area. Cotton is damaged by seven species of aphids, but the most damage is caused by the alfalfa aphid (*Arhis medicaginis* Koch.), the cotton aphid (*Arhis gossypii* Glov.), and the large cotton aphid (*Acyrthosiphon gossypii* Mordv.) There is a view that only a combination of most anatomical features of leaf structure will result in resistance to insect pests such as aphids and spider mites. In addition, individual anatomical features are diagnostically significant in clarifying details of generic and species differences. Features can be divided into two groups: stable and variable. Stable features include the nature of pubescence and the type of stomatal apparatus. Variable characteristics include the thickness of the leaf blade, the structure of the mesophyll, the height of the palisade and the presence of the lower layer, i.e., the isothallic type of leaf structure, the number of epidermal cells and stomata, and the number of hairs. Signs such as dense leaf pubescence and the presence of a thick cuticle are indicators of advancement [9]. For resistance to aphids (Aphis gossypii Glov.) and spider mites (Tetranychus urticae), the cuticle of the cotton leaf must be at least 0.85 μm thick.

Experimental. Experimental studies were conducted from 2020 to 2024. For anatomical analysis, leaves were fixed (in 96% ethanol). Measurements were taken and preparations of transverse and paraderma sections of leaves were made. For the analysis of the paraderma and transverse sections of the leaf, 1 cm2 sections were cut from the central zone of the leaf [10]. Preparation of specimens from young leaves.The leaves were fixed, washed, and stored in a 70% alcohol solution. From the jars with a 70% alcohol solution, 1x1 cm leaf sections were placed in a methylene blue solution for staining, then the cell walls of the epidermis were stained. Morphometric processing of the collected material was performed, photographs were taken, and tables were compiled. An XSP-500SM trinocular microscope (7-inch screen with PC connectivity) was used to conduct the research. Statistical processing of quantitative data was performed using generally accepted criteria with the aid of a personal computer (MS Excel).

Results and discussion. According to our data, the thickness of the leaf blade in G. *mustelinum* is relatively average. The mesophyll type is dorsiventral. It consists of one row of palisade parenchyma and 8–9 layers of spongy parenchyma (Fig. 2, Table 1). The leaf blade thickness in G. *hirsutum* ssp. *glabrum* f. *marie galante* is quite thin. The mesophyll type is dorsiventral. It consists of one row of palisade parenchyma and 7-8 layers of spongy parenchyma. The leaf blade thickness in G. *hirsutum* ssp. *mexicanum* var. *microcarpum palmeri* is the largest. The mesophyll type is dorsiventral. It consists of one row of palisade parenchyma and 5-6 layers of spongy parenchyma. The leaf blade of G. *hirsutum* ssp. *mexicanum* var. *nervosum* is quite thick. The mesophyll type is dorsiventral. It consists of one row of palisade parenchyma and 6 layers of spongy parenchyma. The leaf blade of G. *barbadense* ssp. *vitifolim* f. *brasilense* is of medium thickness. The mesophyll type is dorsiventral. It consists of one row of palisade parenchyma and 8 layers of spongy parenchyma. The leaf blade of G. *barbadense* ssp. *ruderale* f. *pisco* is also quite thick. The mesophyll type is dorsiventral. It consists of one row of palisade parenchyma and 4-5 layers of spongy parenchyma. The leaf blade of G. *darwinii* is of relatively average size. The mesophyll type is dorsiventral. It consists of one row of palisade parenchyma and 3-4 layers of spongy parenchyma. If the mesophyll structure is of the isolateral type, the possibility of tolerance to piercing-sucking parasites

Table 1

Quantitative indicators of the cross-sectional structure of plant leaves of some species and intraspecific varieties of cotton, µm.

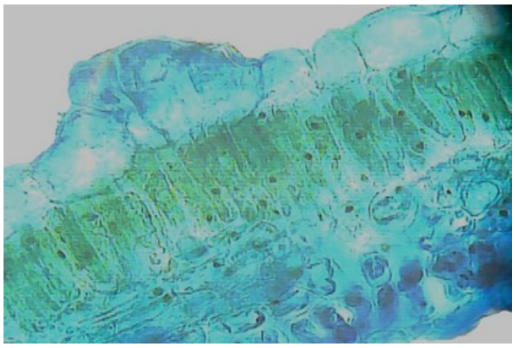
	G. mustelinum	*G. hirsutum* ssp. *glabrum* f. *marie galante*	*G. hirsutum* ssp. *mexicanum* var. *microcarpum palmeri*	*G. hirsutum* ssp. *mexicanum* var. *nervosum*	*G. barbadense* ssp. *vitifolim* f. *brasilense*	*G. barbadense* ssp. *ruderale* f. *pisco*	*G. Darwinii*
Thickness of sheet plate, µm	208,1±11,3	165,8±5,9	374,5±3,2	325,1±12,6	226,8±4,8	362,5±3,8	206,1±4,2
Height of the outer wall of the adaxial epidermis, µm	7,3±0,7	7,3±0,3	10,6±0,3	8,5±0,4	7,7±0,7	5,5±0,3	6,5±0,6
Height of the adaxial epidermis, µm	27,1±0,6	28,6±0,9	38,6±0,7	32,8±0,9	16,9±0,9	21,4±0,5	25,2±0,7
Height of palisade parenchyma, µm	79,6±1,4	59,4±2,2	175,8±5,6	127,1±3,5	85,3±2,9	160,8±3,2	48,4±1,3
Height of spongy parenchyma, µm	78,7±2,1	65,2±1,8	122,9±4,2	139,8±4,5	101,3±3,6	156,7±4,4	117,7±4,7
Height of the abaxial epidermis, µm	22,1±0,3	11,4±0,2	35,8±0,9	24,2±0,6	12,9±0,4	22,9±0,4	13,8±0,5
Height of the outer wall of the abaxial epidermis, µm.	8,4±0,3	4,9±0,2	9,8±0,4	6,7±0,5	4,7±0,4	7,2±0,5	4,5±0,1
Height of central vein, µm	457,1±11,2	303,4±11,2	617,5±38,5	578,6±31,5	539,4±14,5	641,5±19,3	512,3±12,3

trichoma

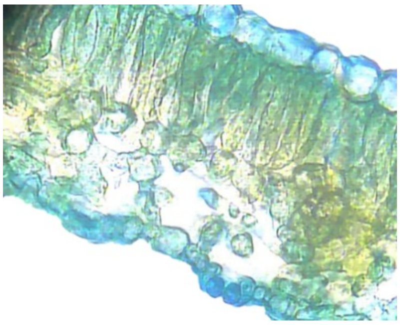
G. mustelinum

G. hirsutum ssp. *glabrum* f. *marie galante*

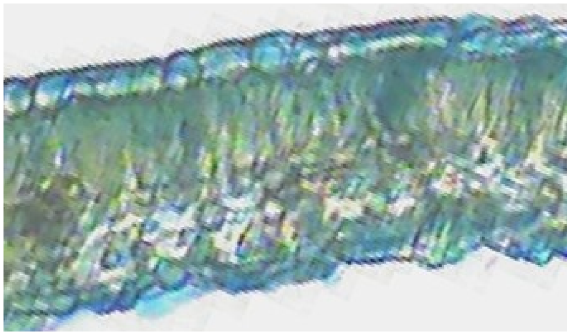
G. hirsutum ssp. *mexicanum* var. *microcarpum palmeri*



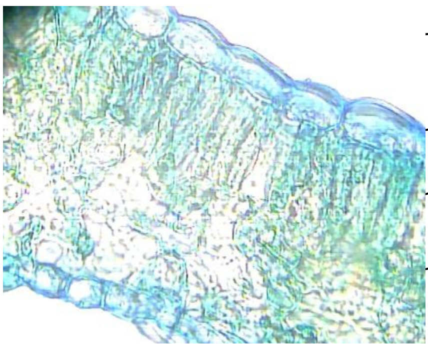
G. hirsutum ssp. *mexicanum* var. *nervosum*



G. *barbadense* ssp. *vitifolim* f. *brasilense*



G. barbadense ssp. *ruderale* f. *pisco*



Adaxial epidermis

Palisade parenchyma

Spongy parenchyma

Abaxial epidermis

G. darwinii

Figure 2. Cross-sectional structure of leaves in cotton species and intraspecific varieties.

increases.Thus, the studied representatives have a dorsiventral mesophyll type. This, in turn, does not help protect the leaf from the penetration of aphid stylets into the spongy parenchyma and the sucking of nutrients from the sieve tubes of the conducting bundles located closer to the abaxial side of the leaf, as well as from the transport cells of the mesophyll rich in metabolic products. When comparing the linear indicators of the upper cuticle height in the studied wild representatives, it can be said that in all representatives, the cuticle is greater than 0.85 μm, with G. *hirsutum* ssp. *mexicanum* var. *microcarpum palmeri* (10.6±0.3 μm) having the highest indicators. When comparing two representatives, G. *barbadense* ssp. *vitifolim* f. *brasilense* and G. *barbadense* ssp. *ruderale* f. *pisco*, G. *barbadense* ssp. *vitifolim* f. *brasilense* has the highest values (7.7±0.7 μm). When comparing the indicators of the lower cuticle, the same trend is observed. That is, the highest indicators of the lower cuticle are found in G. *hirsutum* ssp. *mexicanum* var. *microcarpum palmeri* (9.8±0.4 μm). However, when comparing representatives of G. *barbadense* among the two studied, G. *barbadense* ssp. *ruderale* f. *pisco* has a higher cuticle (7.2±0.5 μm). When studying the height of the epidermis, it is observed that the higher the height and thickness of the walls of the epidermal cells of the abaxial side of the leaf, the lower the aphid infestation of the plant. At the same time, it must be at least 20.0 μm. Among the studied representatives, G. *hirsutum* ssp. *mexicanum* var. *microcarpum palmeri* again meets these conditions, with both the upper and lower epidermis (28.6±0.7 and 26.8±0.9 μm, respectively). G. *hirsutum* ssp. *glabrum* f. *marie galante* and G. *hirsutum* ssp. *mexicanum* var. *nervosum* meet these conditions only on the adaxial side. When comparing the two studied representatives of G. *barbadense*, the same trend is observed as for the height of the cuticle, with G. *barbadense* ssp. *vitifolim* f. *brasilense* (19.9±0.9 μm) having the highest upper epidermis values and G. *barbadense* ssp. *ruderale* f. *pisco* (15.9±0.4 μm). The height of the columnar parenchyma in G. *hirsutum* ssp. *mexicanum* var. *microcarpum palmeri*, G. *hirsutum* ssp. *mexicanum* var. *nervosum*, G. *barbadense* ssp. *ruderale* f. *pisco* is quite high, but it is possible that tolerance is influenced not by the thickness of the columnar layer itself, but by the difference between the thicknesses of the spongy and columnar parenchyma. Moreover, the height of the palisade parenchyma should exceed that of the spongy parenchyma by 1.5 times. The height of the spongy parenchyma should be no more than 98.5 μm, since the greater the height of the spongy parenchyma, the looser it becomes. Only two studied representatives, G. *mustelinum* and G. *hirsutum* ssp. *glabrum* f. *marie galante,* meet this condition. Analyzing the ratio of the height of the palisade and spongy parenchyma in representatives such as G. *hirsutum* ssp. *glabrum* f. *marie galante*, G. *hirsutum* ssp. *mexicanum* var. *nervosum*, G. *barbadense* ssp. *vitifolim* f. *brasilense,* and G. *darwinii*, it was found that the ratio is negative, since in the above-mentioned representatives, the spongy parenchyma is higher than the columnar parenchyma. In this regard, it can be said that these representatives will not meet this condition, which reduces their tolerance to piercing-sucking insect pests. The mesophyll is permeated by veins, which are bundles of conducting tissues from the primarie xylem and phloem. Cotton has reticulate venation. With reticulate venation, the main vein is well developed, and the lateral veins branch and connect with branches to form a network. The central vein of the leaf contains xylem and phloem and is connected to the conducting system of the stem. In all studied representatives, the conducting bundle is bicollateral, and there are hairs and trichomes along the central vein. The height of the vein in the parent forms has distinctive features. Thus, the highest vein is found in G. *barbadense* ssp. *ruderale* f. *pisco,* and the lowest in G. *hirsutum* ssp. *punctatum* f. *marie galante*. Only three representatives have a positive ratio of columnar to spongy tissue (Table 2). These are G. *mustelinum*, G. *hirsutum* ssp. *mexicanum* var. *microcarpum palmeri*, and G. *barbadense* ssp. *ruderale* f. *pisco*. Thus, var. *microcarpum palmeri* has the highest ratio of columnar to spongy parenchyma (1.4). When comparing the height of the spongy parenchyma among these three representatives, only G. *mustelinum* (78.7±2.1 μm) meets the condition that the height of the spongy parenchyma should be no more than 98.5 μm.

Table 2.

Indicators of xeromorphism of leaves of original forms and intraspecific diversity of cotton

	G. mustelinum	G. hirsutum ssp. glabrum f. marie galante	var. microcarpum palmeri	var. nervosum	f. brasilense	f. pisco	G. Darwinii
1.	+	+	+	+	-	-	-
2.	+	+	+	+	-	-	-
3.	+	-	+	+	-	+	-
4.	+	+	-	-	-	-	-
5.	-	-	+	-	-	-	-
6.	+	-	+	-	-	+	-

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