Original Article

FEATURE STRUCTURE OF A COTTON LEAF AS A MECHANISM OF PROTECTION AGAINST INSECT PESTS

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DOI: 10.47750/pnr.2022.13.S06.285

Abstract

According to the International Cotton Advisory Committee, Uzbekistan accounts for about 4% of all cotton produced in the world and 10% of world exports. At the same time, cotton makes up 45% of all Uzbek exports. But besides the purely commercial meaning, "white gold" has always had a huge cultural significance for Uzbekistan. Cotton is a strategic agricultural crop, as after processing it is used in the chemical, light industry and many other industries. Currently, legal documents are being adopted at the national level to solve the problem of crop rotation in the cotton industry and the necessary mechanisms are being developed for their implementation. In addition, in the system of insect control in cotton fields, the issue of resource conservation is very relevant, since by reducing harmful insects it is necessary to achieve a reduction in resource costs in terms of increasing (or not reducing) the quantity and quality of the cotton crop. Protection of plants from pests by various methods is widely used in world agricultural production. At the same time, according to the FAO, the losses of agricultural products in the world still remain quite high and reach 30% of the volume of the world crop. To solve the problem of crop safety, extensive and systematic scientific and practical work is being carried out to improve and develop methods and means of plant protection in agriculture to prevent harm caused to plants by pests, diseases and weeds. In this regard, the purpose of this work was to establish the correlating structural features of the leaves of wild representatives of the genus Gossypium L with economically valuable traits. 19 representatives were studied, among which were 7 parental species and 12 hybrids of their first generation. As a result, signs were established that correlate with drought resistance and tolerance to insect pests.

Keywords: Leaf structure, cotton plant, wild species, insect pests, drought tolerance, stomata, leaf epidermis, spongy parenchyma, columnar parenchyma, mesophile..

INTRODUCTION

In the literature of past years, a large arsenal of knowledge about cotton has been accumulated [21]. Much attention is paid to the study of the anatomical structure of the vegetative and generative organs of cotton, which are of great scientific and practical importance. Thus, signs of the structure of the peel of leaves are used by scientists as taxonomic in solving controversial issues of taxonomy of representatives of various families and, in particular, this family. Malvaceae. [1, 5, 9, 10]

The anatomical structure of the leaf is more diverse than the morphological and is more conservative and often retains the characteristics of the parents in its structure.

In modern breeding, parents of promising varieties often use wild species, since they have very valuable biological properties for breeding. In modern literature, there are works devoted to the study of correlative relationships between the anatomical features of the vegetative organs and biologically valuable features. [4, 7, 8, 12]

Anatomical features of the leaf structure also play an important role in breeding new varieties. A leaf is a vegetative organ of cotton, which has long been studied by scientists of various profiles. But, despite the general plan of the structure, it is possible to distinguish species that are more resistant to piercing-sucking insect pests. Thus, in the literature on cotton, there is information about the existence of a relationship between a set of anatomical features (thickness of the cuticle, lower epidermis, and spongy layer, as well as the number, length, and type of leaf hairs) and damage by various insect pests [8, 16, 17, 19]. Such studies are of not only scientific but also practical interest.

Unfortunately, cotton crops are often affected by diseases: fusarium and verticillium wilt; gommosis of bolls and stem; root rot; microsporiosis and alternariosis; fiber curl and others.

There are several measures for the control and prevention of cotton diseases. These are timely elimination of pests, prevention of stem sticking, improved plowing, separate collection of healthy and diseased cotton, high-quality harvesting of predecessors in the stubble of which insect carriers winter, timely fertilization (to increase immunity), and, of course, chemical treatment and spraying with a solution urea in the phase of 3-4 leaves. Cotton pests are spider mites, thrips, aphids, different types of scoops, bollworms and some others.[6, 12, 18]

Control measures: chemical agents (certain preparations have been developed for each type of insect), biological methods (launching trichograms and gabrobrakon on the fields, which destroy larvae and caterpillars), high-quality autumn cleaning of fields from infected plants, their removal and destruction; removal of mulberries or other trees growing near crops, winter watering, deep autumn plowing.

The use of biological means of protection is perhaps the most interesting. Trichogramma and Gabrobrakon are parasites of most insects that damage crops. Moreover, trichograms infect eggs of pests, and gabrobracon - adult insects. The use of biological measures to control pests of crops can significantly reduce, if not completely cancel the insecticidal treatment of fields. On the one hand, this leads to a reduction in the cost of preparations with a high safety of plants, and on the other hand, it allows growing crops without the use of chemicals.

Material and methods

1. The research material was
2. G. mustelinum
3. G. hirsutum ssp. punctatum f. mary galante
4. G. hirsutum ssp. mexicanum var. microcarpum palmeri
5. G. hirsutum ssp. mexicanum var. nervosum
6. G. barbadense ssp. vitifolim f. brasilense
7. G. barbadense ssp. ruderale f. pisco
8. G. darwinii
9. G. hirsutum ssp. punctatum f. mary galante x G. mustelinum,
10. G. hirsutum ssp. mexicanum var. microcarpum palmeri x G. mustelinum,
11. G. hirsutum ssp. mexicanum var. nervosum x G. mustelinum,
12. G. mustelinum x G. hirsutum ssp. punctatum f. mary galante
13. G. mustelinum x G. hirsutum ssp. mexicanum var. microcarpum palmeri,
14. G. mustelinum x G. hirsutum ssp. mexicanum var. nervosum
15. G. barbadense ssp. vitifolim f. brasilense x G. mustelinum,

16. G. mustelinum x G. barbadense ssp. vitifolim f. brasilense,

17. G. barbadense ssp. ruderale f. pisco x G. mustelinum,

18. G. mustelinum x G. barbadense ssp. ruderale f. pisco.

19. G. mustelinum x G. darwinii

20. G. darwinii x G. mustelinum

Experimental studies were carried out in the conditions of plot experiments and on the photoperiodic site of the Laboratory of Taxonomy and Introduction of Cotton at the Institute of Genetics and Experimental Plant Biology of the Academy of Sciences of Uzbekistan. For anatomical analysis, fixation (in 70% ethanol) of true leaves, as well as mature seeds, was carried out. Measurements were taken and preparations of transverse and paradermal sections of true leaves, as well as transverse sections of mature seeds in the middle and chalazal parts were prepared. To analyze the paradermal and transverse sections of the leaf, 1 cm2 cuts were made from the central zone (on both sides of the main vein of the leaves of the middle formation). Morphometric processing of the collected material was performed, photos were taken, tables were compiled.

Anatomical studies were performed according to accepted methods [2, 3, 11, 13, 14, 15]. During the research, a trinocular microscope XSP-500SM (7-inch screen with the ability to connect to a PC), a measuring device MOV-15 and a portable digital microscope UM039 were used.

Results of anatomical studies of the leaf.

Cross-sectional analysis of the leaf.

There is an opinion that only the combination of most anatomical features of the leaf structure will give the results of resistance to insect pests - aphids and spider mites (Fig. 1). Also, individual anatomical features are of diagnostic value in clarifying the details of generic and specific differences. Signs can be divided into two groups - stable and variable. The stable ones include the nature of the pubescence, the type of stomatal apparatus. The variable ones are the thickness of the plate, the structure of the mesophyll, the height of the palisade and the presence of the lower layer, i.e. isolateral type of leaf structure, number of epidermal cells and stomata, number of hairs. Including such signs as dense leaf pubescence, and the presence of a thick cuticle, is an indicator of advancement.

For resistance to aphids (Aphis gossypii Glov.) and spider mites (Tetranychus urticae), the cuticle of a cotton leaf must be at least 0.85 µm. [8, 16, 17, 18, 19].

In the studied parental forms, the height of the cuticle is more than 0.85 µm, but the highest value is in G. hirsutum ssp. mexicanum var. microcarpum palmeri. (Table 1) Among G. hirsutum and G. mustelinum hybrids, G. mustelinum x G. hirsutum ssp. mexicanum var. nervesum. Among the hybrids of G. barbadense and G. mustelinum, G. mustelinum x G. barbadense ssp. ruderal f. pisco and G. darwinii x G. mustelinum.

The higher the height and thickness of the walls of the epidermal cells of the abaxial side of the leaf, the lower the infestation of aphids of the plant and should be at least 20.0 µm, according to these conditions,. among the parental forms corresponds G. hirsutum ssp. mexicanum var. microcarpum palmeri. Among the hybrids of G. hirsutum and G. mustelinum, G. hirsutum ssp. punctatum f. mary galante x G. mustelinum. Among the hybrids of G. barbadense and G. mustelinum, G. mustelinum x G. barbadense ssp. ruderal f. pisco, G. barbadense ssp. ruderal f. pisco x G. mustelinum, G. barbadense ssp. vitifolim f. brasilense x G. mustelinum. (Picture. 2, 3).

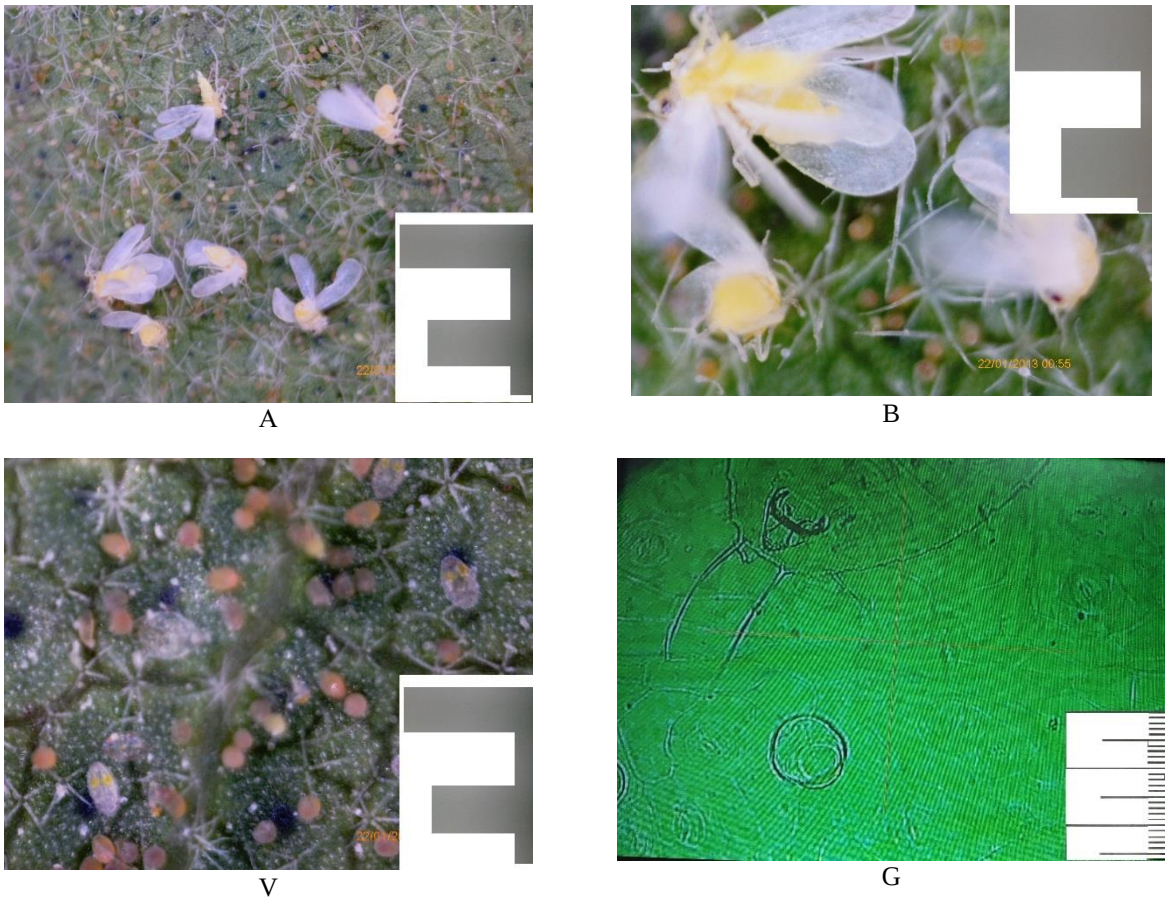
The height of the spongy parenchyma should be no more than 98.5 microns, since the greater the height of the spongy parenchyma, the more loose it becomes. G. mustelinum, G. hirsutum ssp. punctatum f. mary galante have the least loose leaf parenchyma among parental forms. Among the hybrids of G. hirsutum and G. mustelinum, G. hirsutum ssp. mexicanum var. nervosum x G. mustelinum, G. mustelinum x G. hirsutum ssp. punctatum f. mary galante, G. mustelinum x G. hirsutum ssp.

mexicanum var. microcarpum palmeri, G. mustelinum x G. hirsutum ssp. mexicanum var. nervesum. Among the G. barbadense and G. mustelinum hybrids, G. barbadense ssp. ruderal f. pisco x G. mustelinum, G. mustelinum x G. barbadense ssp. ruderal f. pisco.

If the structure of the mesophyll has an isolateral type of structure, then the possibility of tolerance to piercing-sucking parasites increases. And so, the studied representatives of the bifacial type of mesophyll. And this, in turn, does not contribute to the protection of the leaf from the penetration of the aphid stylet into the cancellous parenchyma and the suction of nutrients from the sieve tubes of the vascular bundles located closer to the abaxial side of the leaf, as well as from the mesophyll transport cells rich in metabolic products. (Picture. 4) Three parental forms of G. hirsutum ssp. mexicanum var. microcarpum palmeri, G. hirsutum ssp. mexicanum var. nervosum, G. barbadense ssp. ruderal f. pisco have the highest columnar parenchyma height.

Among the hybrids of G. hirsutum and G. mustelinum, G. hirsutum ssp. punctatum f. mary galante x G. mustelinum. Among the hybrids of G. barbadense and G. mustelinum, G. mustelinum x G. barbadense ssp. vitifolim f. brasilense

The mesophile is pierced by veins, which are bundles of conductive tissues from the primary xylem and phloem (Picture. 5, 6, 7, 8). Cotton has reticulate venation. With mesh venation, the main vein is well developed, the lateral veins, branching and connecting with branches, form a network.



A B V G

Picture 1. Stab-sucking pests of cotton.

A, B - cotton aphid (1 division - 1 mm)

V - (1 division - 1 mm)

G - spider mite (1 division - 0.01 mm)

Table 1. Dimensions of some structures of the transverse section of the leaf.

№	Leaf blade height	Height					
		upper		columnar	spongy	bottom	
		cuticle	epidermis	parenchyma		epidermis	cuticles
1	208,1±11,3	7,3±0,7	20,1±0,9	79,6±3,9	78,7±2,8	14,1±2,2	8,4±1,0
2	165,8±7,5	7,3±0,2	21,6±1,4	59,4±7,2	65,2±4,8	7,4±0,7	4,9±0,1
3	374,5±8,9	10,6±0,2	28,6±0,7	175,8±11,0	122,9±12,3	26,8±0,4	9,8±0,2
4	325,1±7,4	8,5±0,6	24,8±1,2	127,1±14,5	139,8±17,8	18,2±0,9	6,7±0,1
5	226,8±6,5	7,7±0,9	19,9±0,8	85,3±4,9	101,3±7,4	8,9±0,3	47±0,1
6	362,5±14,7	5,5±0,3	16,4±0,9	160,8±14,7	156,7±10,1	15,9±1,3	7,2±0,9
7	206,1±4,5	6,5±0,6	19,2±1,2	48,4±2,0	117,7±13,4	9,8±0,2	4,5±0,9
8	394,6±13,8	8,3±0,7	27,3±2,2	186,8±11,4	134,3±7,2	29,3±2,5	8,4±0,8
9	228,6±4,6	5,0±0,6	12,5±1,1	85,2±4,4	107,5±3,5	10,9±0,9	7,2±0,5
10	242,9±3,8	7,5±0,9	17,8±0,8	98,4±3,6	94,1±6,3	17,5±1,3	7,4±0,6
11	241,0±7,4	12,3±0,7	10,4±0,8	98,5±5,6	97,1±6,6	16,3±1,4	6,1±0,5
12	176,2±9,0	7,4±0,7	12,6±0,9	55,7±5,5	80,3±4,1	12,5±0,7	7,5±0,4
13	242,5±8,1	10,2±1,1	11,5±0,7	122,8±5,9	71,4±4,7	16,2±1,7	10,1±1,1
14	271,4±10,8	7,3±0,7	24,3±2,2	105,8±11,4	103,3±7,2	25,3±2,5	5,4±0,8
15	267,3±14,6	6,0±0,6	18,5±1,1	115,2±4,4	107,5±3,5	15,9±0,9	4,2±0,5
16	245,0±13,8	6,8±0,9	19,8±0,8	104,4±3,6	89,1±6,3	21,5±1,3	3,4±0,6
17	253,6±12,4	8,3±0,7	14,4±0,8	98,5±5,6	97,1±6,6	298,3±1,4	7,0±0,5
18	493,8±19,5	6,0±0,4	21,1±1,6	99,5±5,2	115,9±2,9	15,7±1,2	6,6±0,9
19	532,5±22,4	6,3±0,3	18,3±0,7	107,3±4,5	120,0±8,3	17,9±1,3	8,2±0,7

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17. G. mustelinum x G. barbadense ssp. ruderale f. pisco.

18. G. mustelinum x G. darwinii

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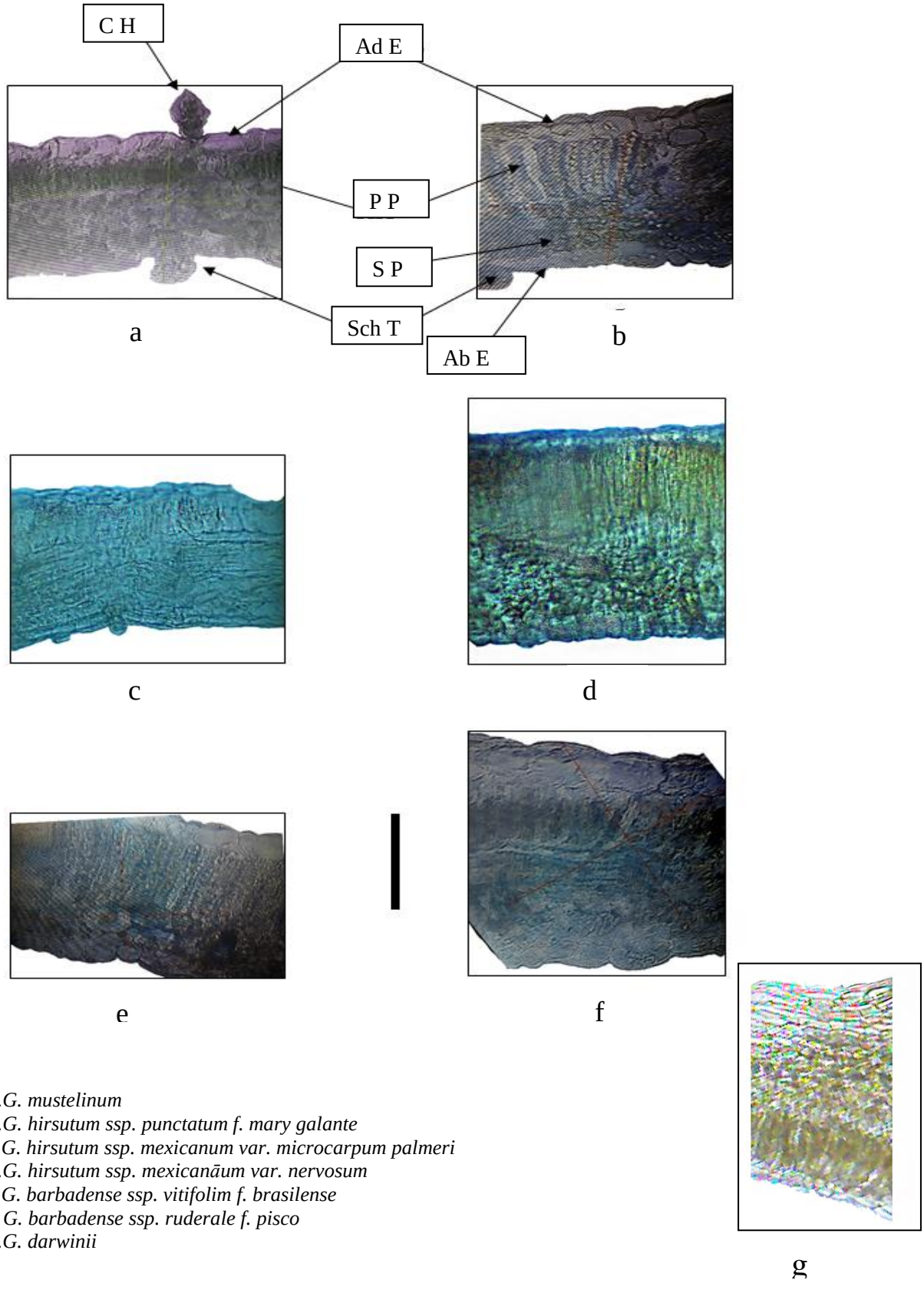
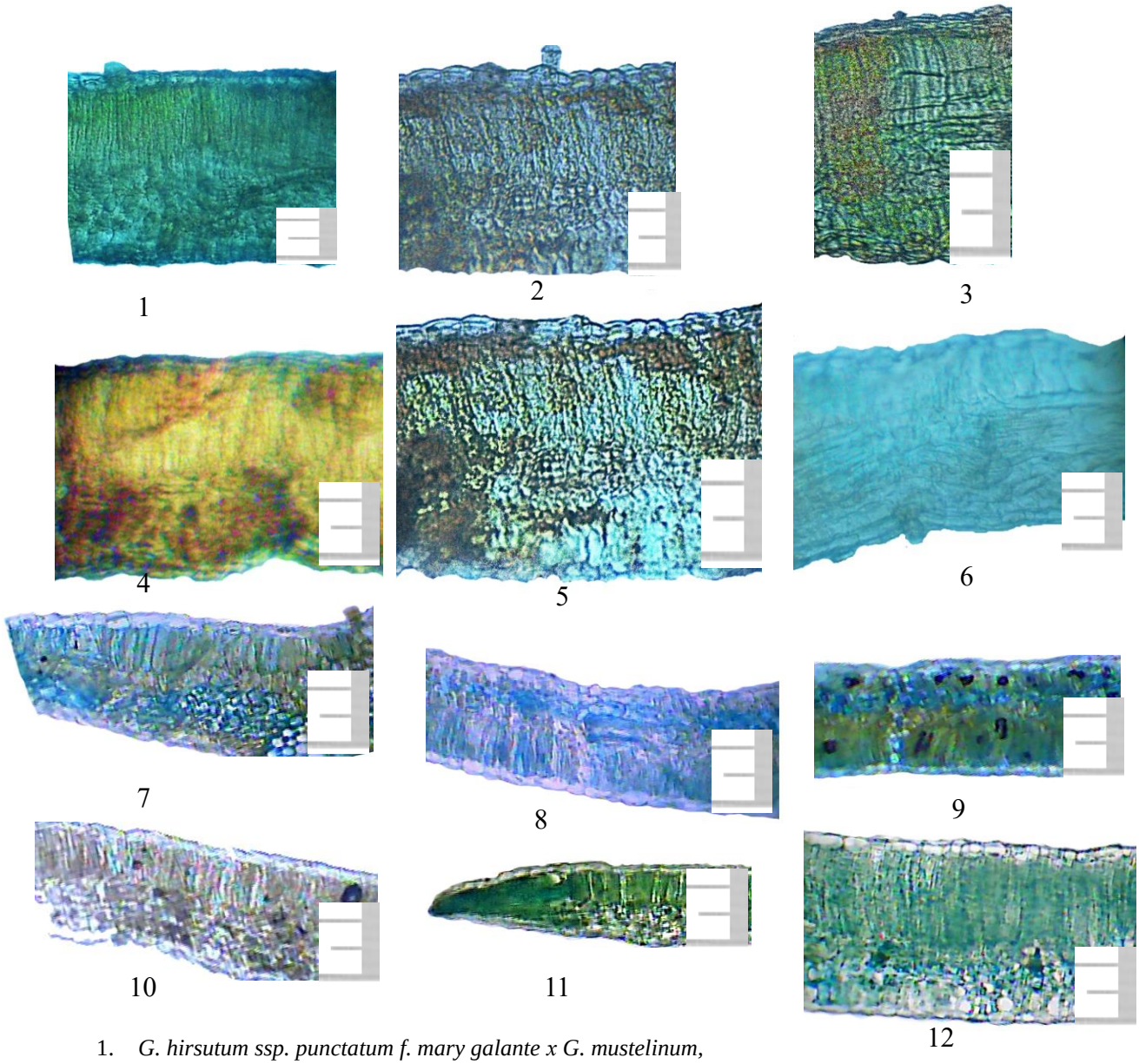


a.G. mustelinum
b.G. hirsutum ssp. punctatum f. mary galante
c.G. hirsutum ssp. mexicanum var. microcarpum palmeri
d.G. hirsutum ssp. mexicanāum var. nervosum
e.G. barbadense ssp. vitifolim f. brasilense
f. G. barbadense ssp. ruderale f. pisco
g.G. darwinii

Picture. 2. Cross section of the leaf blade of a true leaf of the parental forms of cotton



1. *G. hirsutum ssp. punctatum f. mary galante x G. mustelinum,*
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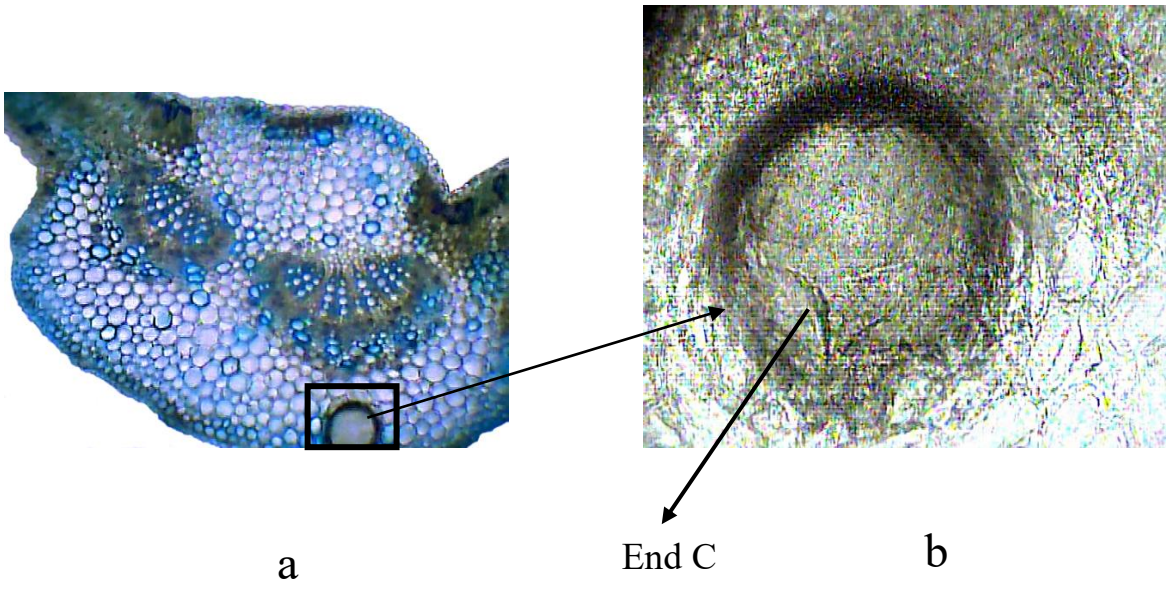
9. *G. barbadense ssp. ruderale f. pisco x G. mustelinum,*
10. *G. mustelinum x G. barbadense ssp. ruderale f. pisco.*
11. *G. mustelinum x G. darwinii*
12. *G. darwinii x G. mustelinum*

Picture. 3 Transverse section of the leaf blade of a true leaf of hybrid forms of cotton



Picture. 4 Fragment of a leaf in the region of the central vascular bundle, endogenous receptacle. a - 10-fold increase, b - 40-fold increase.

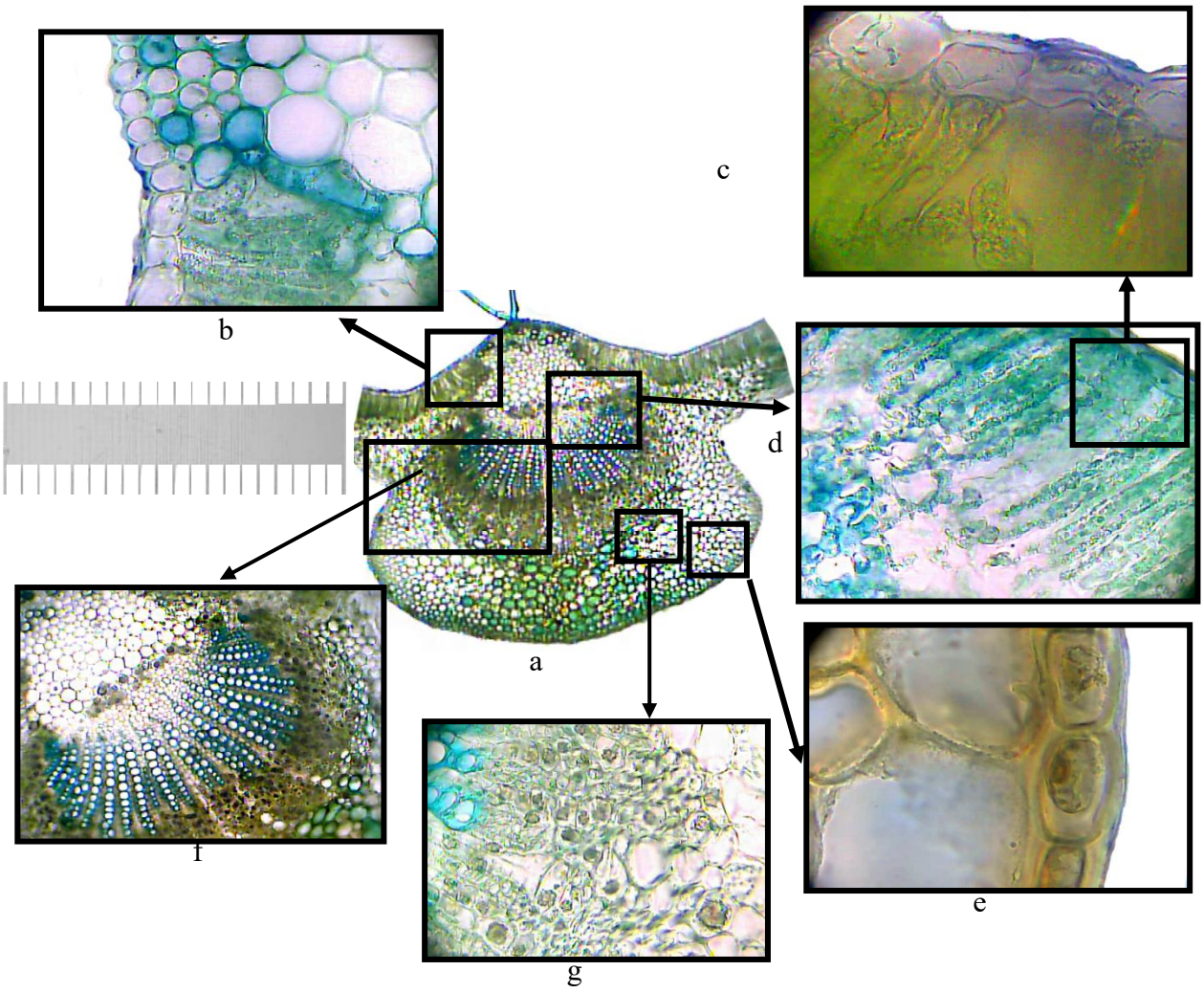
The central vein of the leaf contains xylem and phloem and is connected to the vascular system of the stem. All studied representatives have a conducting bundle, bicollateral. All studied representatives have hairs and trichomes along the central vein. The height of the vein in parental forms has distinctive features. So, the highest in G. barbadense ssp. ruderal f. pisco, the lowest in G. hirsutum ssp. punctatum f. mary galante. Among the hybrids G. hirsutum and G. mustelinum, G. barbadense and G. mustelinum there are no significant differences, as well as the total leaf height. But the backcross hybrids G. darwinii and G. mustelinum are distinguished by higher rates of both the leaf blade itself and the central vein.

Paradermal leaf analysis

The epidermis of a leaf is the skin or integumentary tissue of the leaf. The epidermis consists of a single layer of flattened cells that are tightly adjacent to each other. Cells of the skin of the leaf look transparent, light. This is due to the fact that in each of the cells the main space inside them is occupied by the central vacuole with cell sap. All organelles contained in the cell and the nucleus are pushed aside by the vacuole to the membrane. However, the nucleus, which is the custodian of all hereditary information, is clearly defined in each cell. The main cells of the skin of the leaf are devoid of chloroplasts.

The epidermis performs extremely important functions in the life of a plant leaf. The peel of the leaf has a characteristic structure, thanks to which it protects the leaf from moisture loss and damage.

Attention is drawn to cells that have a shape different from the main ones and are arranged in pairs. It is they who form the stomata. Any stomata has a characteristic structure: it consists of two interlocking bean-shaped cells, and between these cells there is a gap that resembles a lens in its appearance. This intercellular space is called the stomata fissure. In most cases, stomata are located in much greater numbers on the underside of the leaf blades than on the top. In this case, the stomata are not exposed to direct sunlight and heat up less. The size and shape of the stomatal opening is not constant. Its variability is due to the tightness of the guard stomatal cells to each other [4].



Picture. 5 Fragments of the main elements of the sheet in the area of the central conductive bundle (ruler 1 mm, 4 edges)

a - detail of the cut of the central conducting beam of 4 cr.uv.

b - the place of formation of the columnar parenchyma 10 kr.uv.

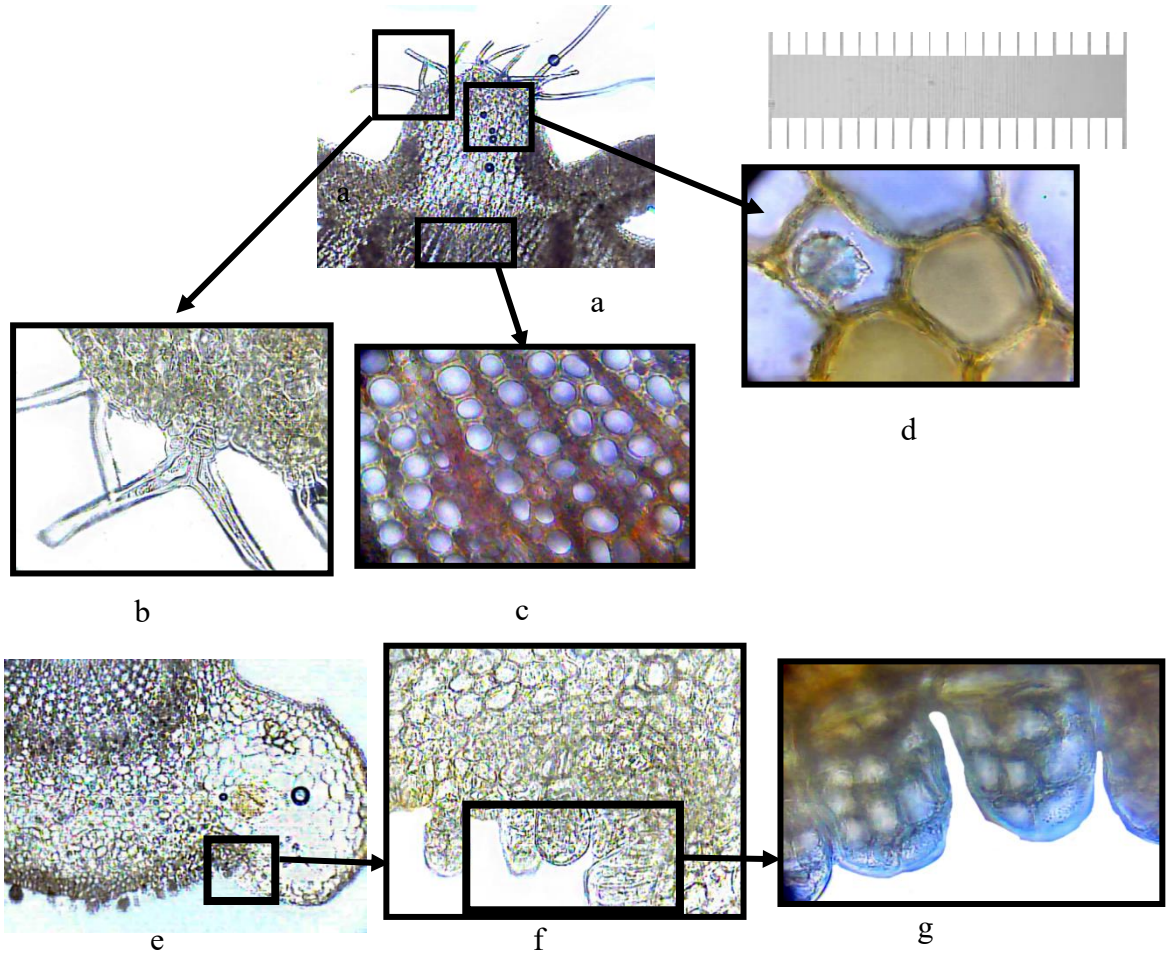
c – columnar parenchyma with upper epidermis 100 cr.

d - columnar parenchyma 40 cr.uv.

e - epidermis and parenchyma 100 cr.

f - phloem 10 cr.uv

g - parenchymal cells with inclusions of 40 cr.uv.



Picture. 6 Fragments of the main elements of the sheet in the area of the central conductive bundle (ruler 1 mm, 4 edges)

a - detail of the cut of the central conducting bundle from the adaxial side of the 4-fold cr.

b - multi-beam trichomes 10 cr.uv.

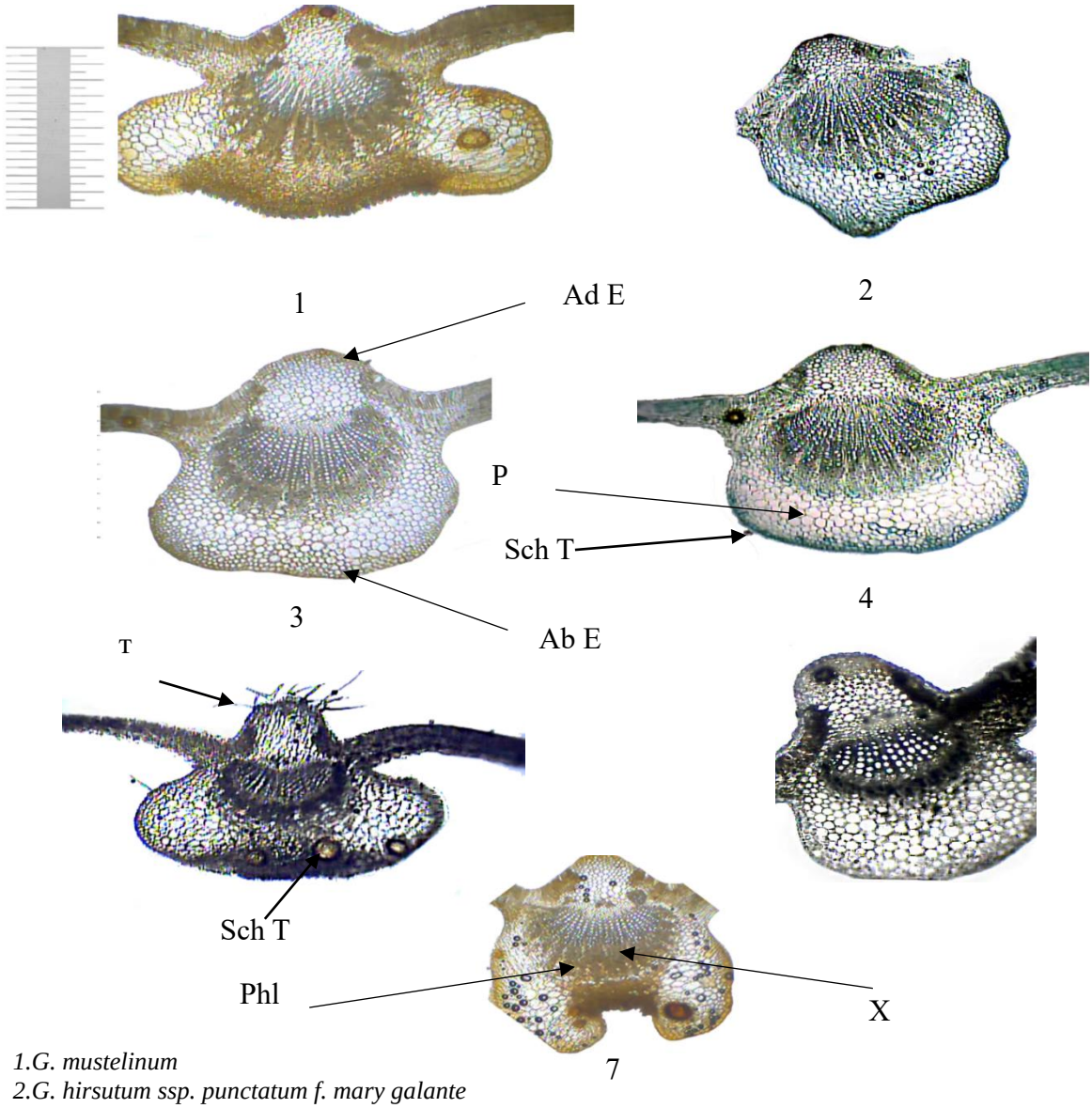
c - phloem 40 cr.uv.

d – parenchymal cells with inclusions of 100 cr.

e - detail of the cut of the central conducting bundle from the abaxal side of the 4-fold cr.

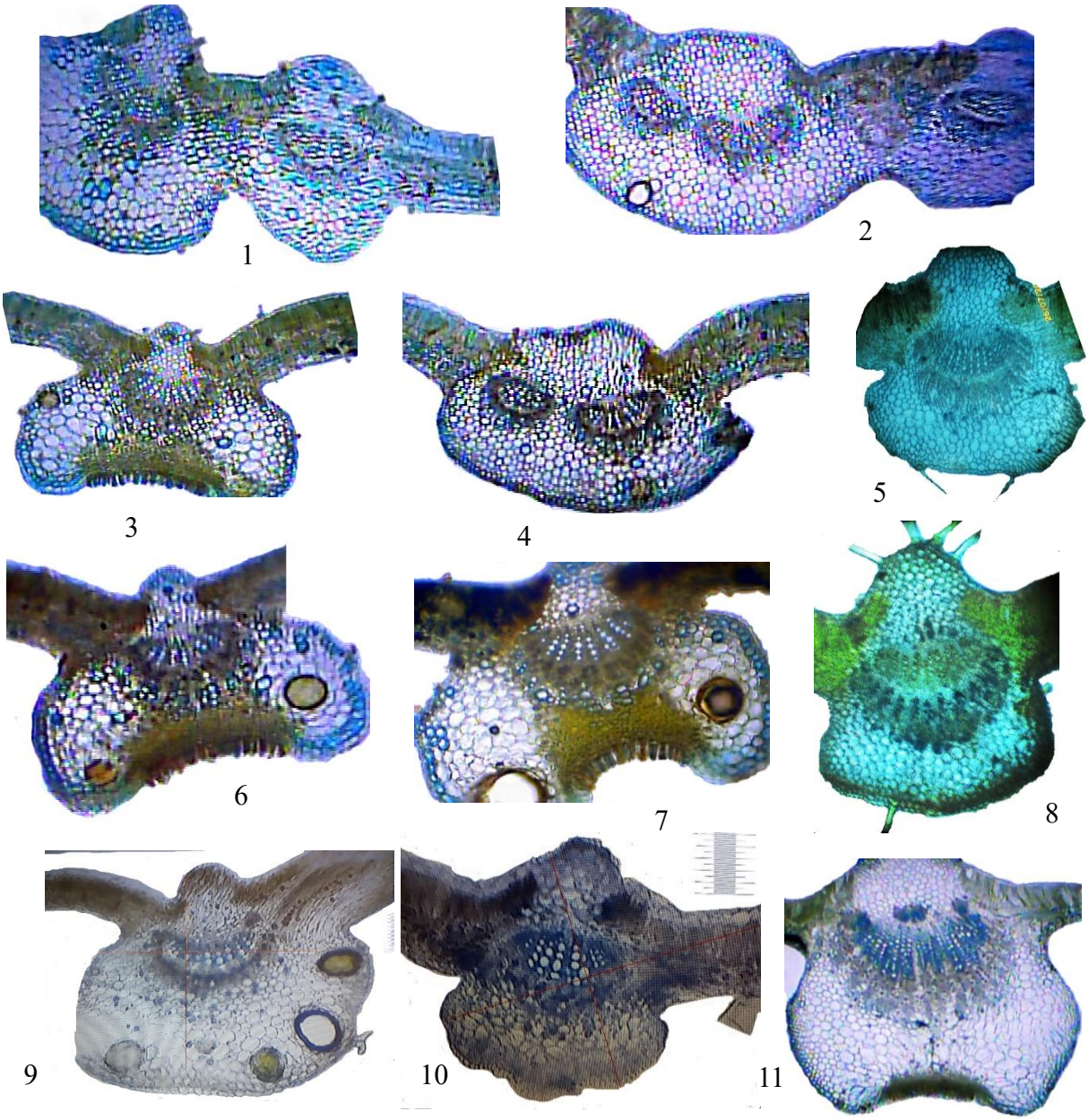
f - accumulation of glandular trichomes 40 cr.uv.

g - accumulation of glandular trichomes 100 cr.uv.



1.G. mustelinum
2.G. hirsutum ssp. punctatum f. mary galante
3.G. hirsutum ssp. mexicanum var. microcarpum palmeri
4.G. hirsutum ssp. mexicanum var. nervosum
5.G. barbadense ssp. vitifolim f. brasilense
6.G. barbadense ssp. ruderale f. pisco
7.G. darwinii

Picture. 7 Cross section of the leaf in the area of the central conducting bundle in the parental forms of cotton



1. *G. hirsutum ssp. punctatum f. mary galante x G. mustelinum,*
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11. *G. mustelinum x G. darwinii*
12. *G. darwinii x G. mustelinum*

Picture. 8 Cross section of a leaf in the region of the central conducting

bundle in hybrid forms of cotton

The main difference is that stomatal cells contain chloroplasts in which photosynthesis takes place. Open stomatal gaps are a kind of gate for the release of oxygen formed during photosynthesis and water vapor. In the case when the plant feels a lack of moisture in warm and dry weather, the stomatal gaps in the skin are in a closed state. This helps the plant protect itself from excess water loss. At night, the stomata are also closed in most plants. Also, the nucleus is clearly visible in them, as in other cells of the leaf epidermis. An increase in the number of stomata and a decrease in their size contribute to the development of plant resistance to drought. Also, the sign of drought resistance is affected by an increase in the number of hairs and glands. And the more their number, the more drought resistance is manifested. [14]

Analyzing the data obtained from the paradermal sections of the adaxial and abaxial leaf surfaces in the studied representatives, it can be said that the most large-celled epidermis among the parental forms in G. barbadense ssp. ruderal f. pisco, G. hirsutum ssp. punctatum f. mary galante, G. hirsutum ssp. mexicanum var. microcarpum palmeri. (Table 2, picture 9, 10)

When counting stomata, it can be concluded that the largest number on both sides of the leaf among the parental forms of G. barbadense ssp. vitifolim f. brasilense, among the hybrids of G. hirsutum and G. mustelinum in G. hirsutum ssp. mexicanum var. nervosum x G. mustelinum. Among the hybrids of G. barbadense and G. mustelinum, G. mustelinum x G. barbadense ssp. vitifolim f. brasilense. Backcross hybrids G. darwinii and G. mustelinum do not have high rates of stomata.

Trichomes, or hairs (from the Greek τρίχωμα - hair) are epidermal cells that form external outgrowths on plant organs. These include hairs (glandular and non-glandular), scales, glands, nectaries and some other formations. The whole variety of trichomes is divided into two functional types: covering and glandular. The former are formed from integumentary tissues and serve to protect the plant from the adverse effects of the external environment, the latter belong to the excretory tissues of external secretion and participate in the processes of accumulation and release of substances of various functional purposes. Trichomes perform a variety of functions that have not yet been fully explored. It is generally accepted that they physiologically protect the leaf tissue - chlorenchyma from overheating, mechanically the whole plant from damage by insects, help reduce moisture evaporation, remove salts from leaf tissues and carry out chemical protection of plants. Trichomes are unicellular and multicellular, dead and living. Dead - filled with air and give the plant a white color. The shape of trichomes can be varied (capitate, stellate, hooked, etc.). Often trichomes are mineralized - impregnated with silica and calcium. The sizes of trichomes vary considerably.

More often, a single hair, scale or piece of iron is clearly visible in a strong magnifying glass or microscope. The longest trichomes (up to 5-6 cm) cover cotton seeds. So that a peculiar microclimate and a favorable habitat for aphids are not created on the leaf surface, the hairs on the leaf surface of the plant should be short, and their number should not exceed 17.5 per 1 mm2.

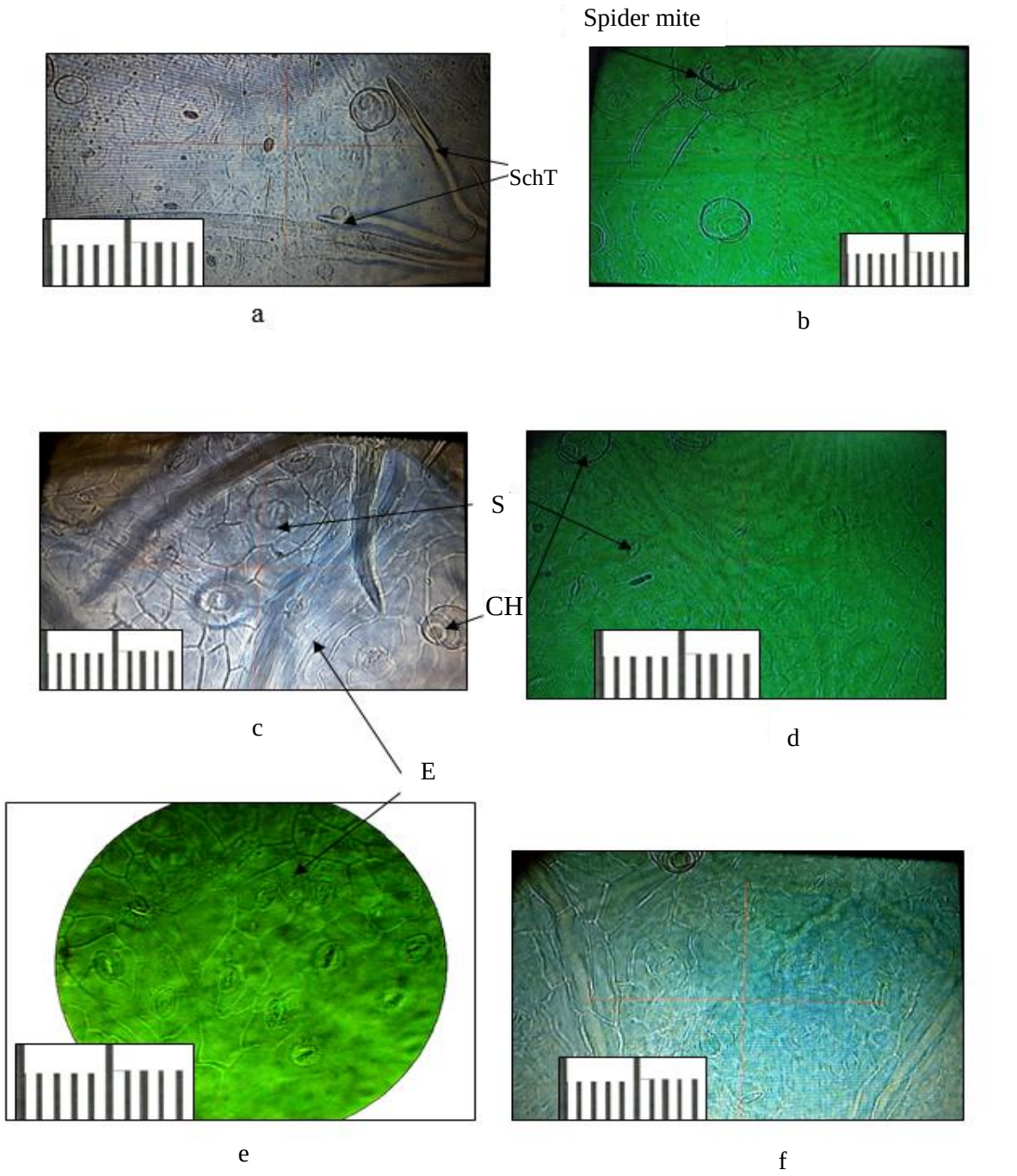
When analyzing the number of hairs on the adaxial and abaxial leaf surface in the studied representatives, it was found that on the adaxial leaf surface, all studied parental forms correspond to these conditions. Among the hybrids G. hirsutum and G. mustelinum, G. hirsutum ssp. mexicanum var. nervosum x G. mustelinum does not correspond to this condition and among the hybrids of G. barbadense and G. mustelinum - G. mustelinum x G. barbadense ssp. vitifolim f. brasilense. (Picture. 9, 10, 11, 12).

Table 2 Quantitative indicators of some structures of the paradermal section of the leaf.

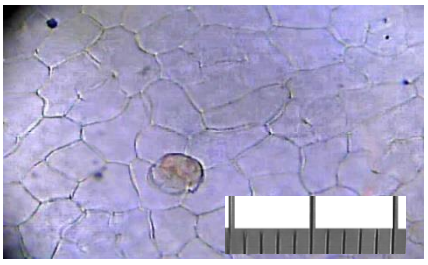
№	Vein height	Quantity, 1 mm^2					
		stomata on		hairs on		epidermis. cells on	
		upper	bottom	upper	bottom	upper	bottom
		epidermis					
1	457,1±11,2	101,8±8,2	300,0±19,3	7,2±3,6	24,6±7,1	1387,7±75,2	1912,3±29,1
2	303,4±11,2	20,4±1,2	100,8±4,3	0,1±0,02	0,8±0,04	450,3±10,1	487,8±24,1
3	617,5±38,5	68,4±2,3	165,7±11,1	4,7±1,1	5,9±1,7	729,4±15,3	867,1±18,4
4	578,6±31,5	8,4±0,9	69,5±3,7	0,5±0,02	0,7±0,01	1102,1±24,7	1004,5±19,5
5	539,4±14,5	104,3±12,3	247,5±14,5	2,0±0,01	2,5±0,01	814,3±8,5	869,1±11,36
6	641,5±19,3	68,3±3,2	137,3±9,5	1,4±0,01	2,7±0,01	651,3±1,2	783,3±4,7

7	512,3±12,3	36,7±1,4	87,5±4,3	3,2±0,4	4,7±0,01	757,2±53,1	894,1±24,5
8	646,7±19,1	156,6±11,3	372,6±20,9	10,8±3,78	3,0±2,8	1530,0±72,4	1182,6±54,4
9	662,0±22,7	268,2±25,8	277,2±22,6	14,4±3,4	32,4±8,3	1652,4±68,7	1260,0±46,3
10	621,1±13,6	226,8±20,1	414,0±24,6	18,0±5,6	64,8±11,1	1580,4±107,3	1285,2±61,3
11	662,3±17,6	109,8±11,5	273,6±23,5	5,4±2,6	10,8±2,7	1654,2±36,9	1294,2±55,7
12	694,4±22,9	136,8±20,8	147,6±13,8	13,4±0,9	48,6±11,3	1728,0±82,5	1384,2±76,0
13	619,2±26,3	171,0±18,5	241,2±29,7	5,4±2,6	43,2±11,3	1351,8±83,7	1267,2±89,1
14	657,7±19,1	105,6±11,3	272,6±20,9	15,8±3,7	19,0±2,8	1130,0±72,4	1342,6±54,4
15	624,0±22,7	258,2±25,8	357,2±22,6	24,4±3,4	42,4±8,3	1127,4±68,7	1265,0±46,3
16	672,1±13,6	236,8±20,1	306,0M24,6	11,0±5,6	24,8±11,1	1285,4±107,3	1386,2±61,3
17	603,3±17,6	152,8±11,5	296,6±23,5	10,4±2,6	16,8±2,7	1154,2±36,9	1003,2±55,7
18	812,8±19,5	42,2±5,3	229,7±10,4	9,9±2,6	5,5±1,7	1347,5±50,3	929,1±70,9
19	766,6±20,7	47,7±4,4	108,8±6,8	8,8±2,6	9,9±2,4	1229,8±21,3	1181,0±30,2

1. G. mustelinum
2. G. hirsutum ssp. punctatum f. mary galante
3. G. hirsutum ssp. mexicanum var. microcarpum palmeri
4. G. hirsutum ssp. mexicanum var. nervosum
5. G. barbadense ssp. vitifolim f. brasilense
6. G. barbadense ssp. ruderale f. pisco
7. G. darwinii
8. G. hirsutum ssp. punctatum f. mary galante x G. mustelinum,
9. G. hirsutum ssp. mexicanum var. microcarpum palmeri x G. mustelinum,
10. G. hirsutum ssp. mexicanum var. nervosum x G. mustelinum,
11. G. mustelinum x G. hirsutum ssp. punctatum f. mary galante
12. G. mustelinum x G. hirsutum ssp. mexicanum var. microcarpum palmeri,
13. G. mustelinum x G. hirsutum ssp. mexicanum var. nervosum
14. G. barbadense ssp. vitifolim f. brasilense x G. mustelinum,
15. G. mustelinum x G. barbadense ssp. vitifolim f. brasilense,
16. G. barbadense ssp. ruderale f. pisco x G. mustelinum,
17. G. mustelinum x G. barbadense ssp. ruderale f. pisco.
18. G. mustelinum x G. darwinii
19. G. darwinii x G. mustelinum

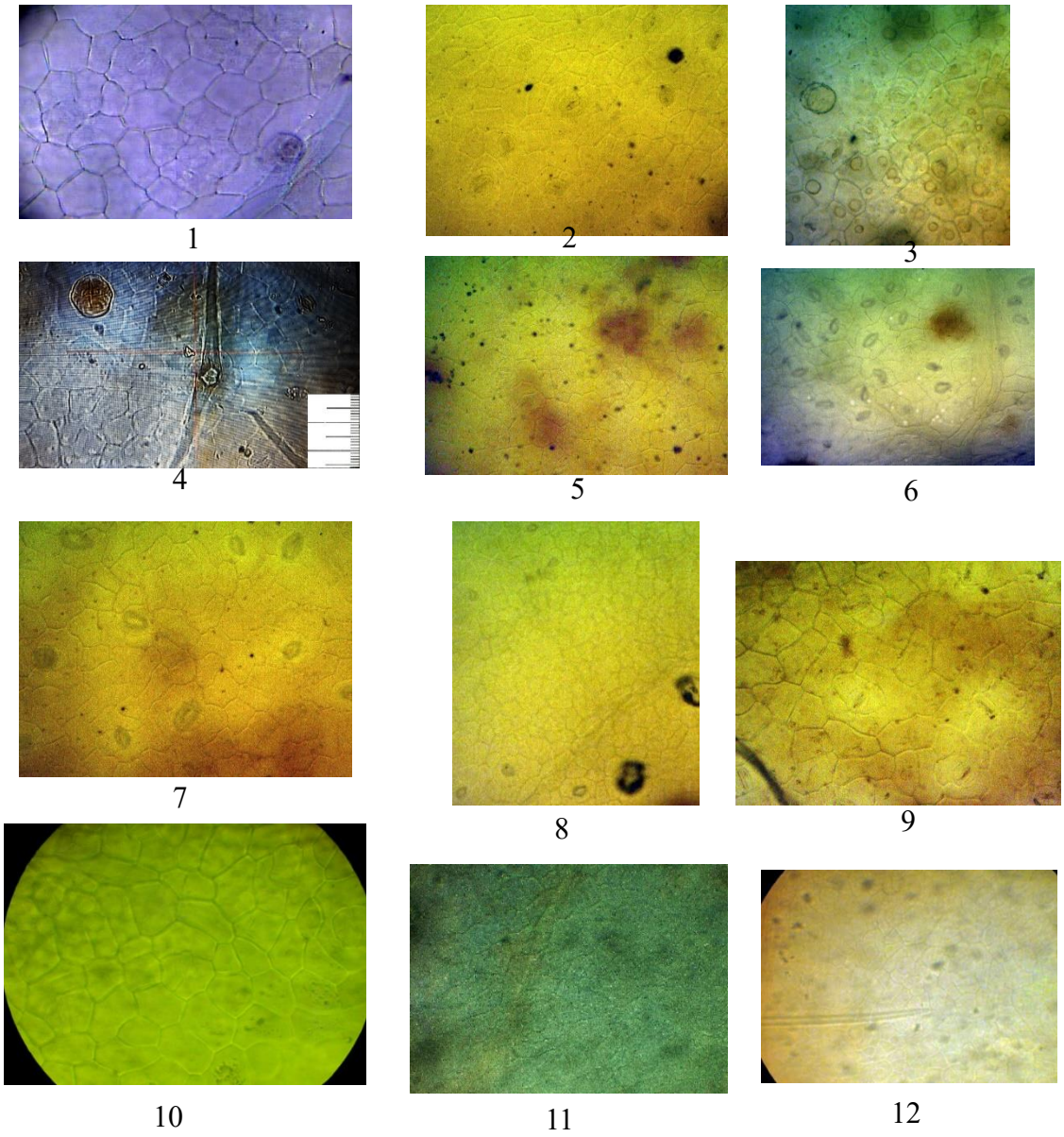


a.G. mustelinum
b.G. hirsutum ssp. punctatum f. mary galante
c.G. hirsutum ssp. mexicanum var. microcarpum palmeri
d.G. hirsutum ssp. mexicanum var. nervosum
e.G. barbadense ssp. vitifolim f. brasilense
f.G. barbadense ssp. ruderale f. pisco
a.G. darwinii



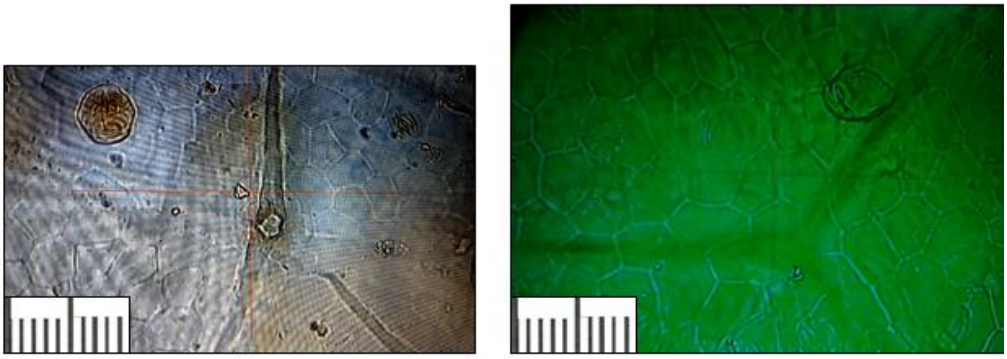
g

Picture. 9 Paradermal section of a leaf from the adaxal side of the parent cotton forms



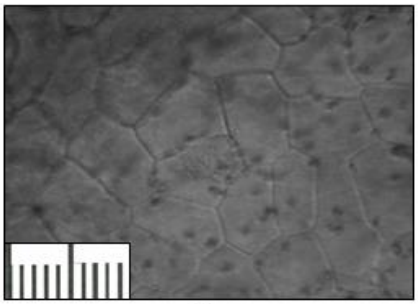
1. *G. hirsutum ssp. punctatum f. mary galante x G. mustelinum,*
2. *G. hirsutum ssp. mexicanum var. microcarpum palmeri x G. mustelinum,*
3. *G. hirsutum ssp. mexicanum var. nervosum x G. mustelinum,*
4. *G. mustelinum x G. hirsutum ssp. punctatum f. mary galante*
5. *G. mustelinum x G. hirsutum ssp. mexicanum var. microcarpum palmeri,*
6. *G. mustelinum x G. hirsutum ssp. mexicanum var. nervosum*
7. *G. barbadense ssp. vitifolim f. brasilense x G. mustelinum,*
8. *G. mustelinum x G. barbadense ssp. vitifolim f. brasilense,*
9. *G. barbadense ssp. ruderale f. pisco x G. mustelinum,*
10. *G. mustelinum x G. barbadense ssp. ruderale f. pisco.*
11. *G. mustelinum x G. darwinii*
12. *G. darwinii x G. mustelinum*

Picture. 10 Paradermal section of a leaf from the adaxial side in hybrid forms of cotton



a

b



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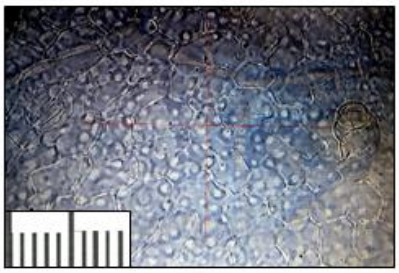

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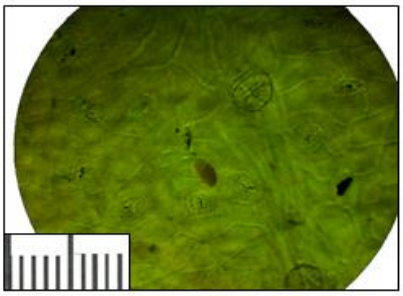
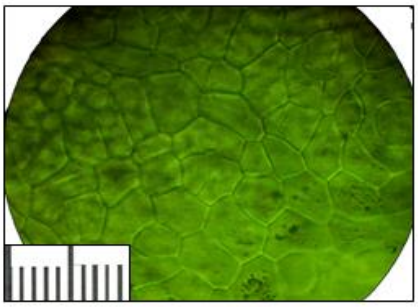
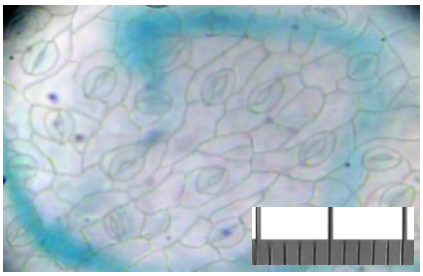


e



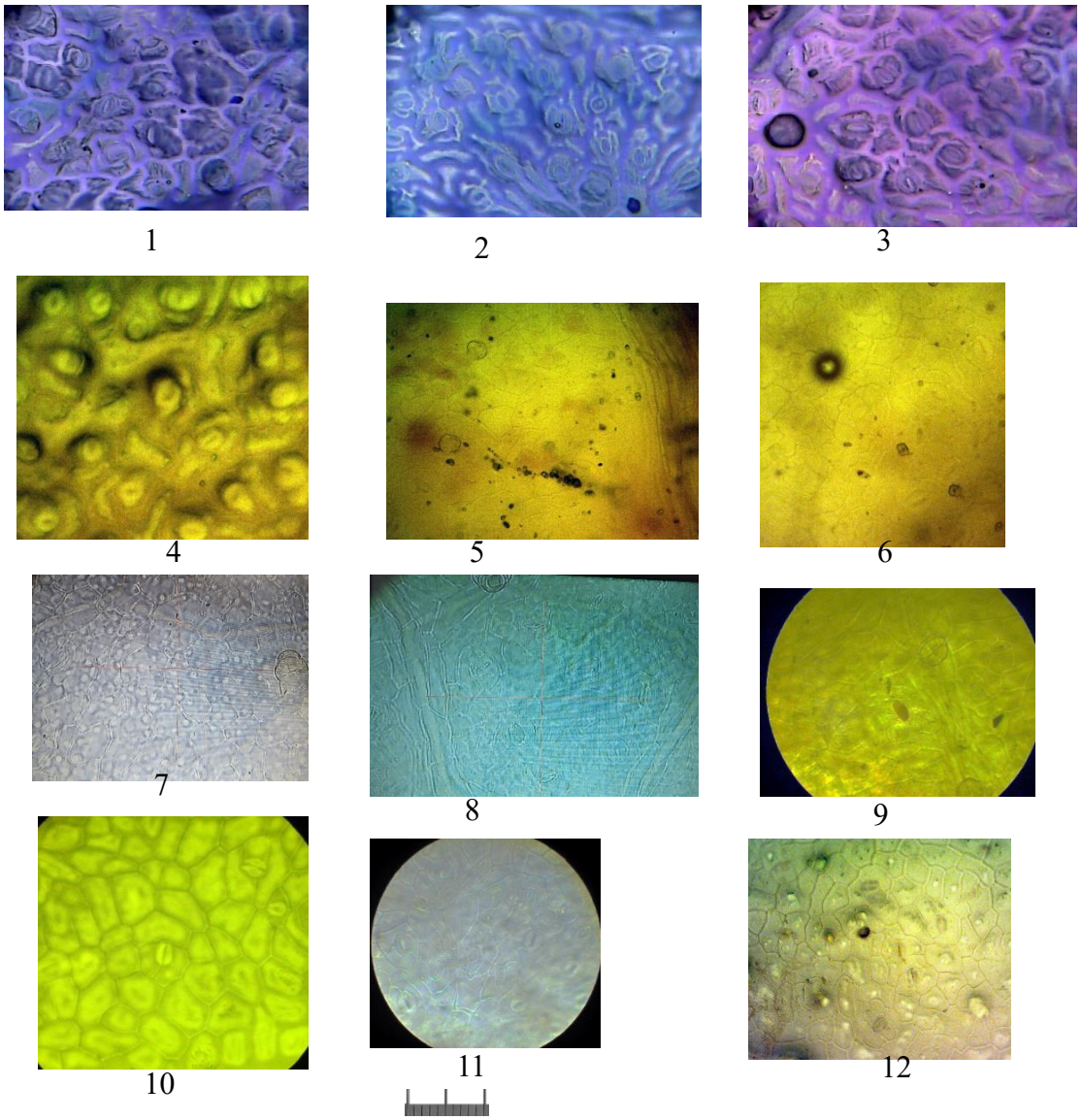
f



g

a.G. mustelinum
b.G. hirsutum ssp. punctatum f. mary galante
c.G. hirsutum ssp. mexicanum var. microcarpum palmeri
d.G. hirsutum ssp. mexicanum var. nervosum
e.G. barbadense ssp. vitifolim f. brasilense
f.G. barbadense ssp. ruderale f. pisco
g.G. darwinii

Picture. 11. Paradermal section of a leaf from the abaxial side of parental forms of cotton



1. *G. hirsutum ssp. punctatum f. mary galante x G. mustelinum,*
2. *G. hirsutum ssp. mexicanum var. microcarpum palmeri x G. mustelinum,*
3. *G. hirsutum ssp. mexicanum var. nervosum x G. mustelinum,*
4. *G. mustelinum x G. hirsutum ssp. punctatum f. mary galante*
5. *G. mustelinum x G. hirsutum ssp. mexicanum var. microcarpum palmeri,*
6. *G. mustelinum x G. hirsutum ssp. mexicanum var. nervosum*
7. *G. barbadense ssp. vitifolim f. brasilense x G. mustelinum,*
8. *G. mustelinum x G. barbadense ssp. vitifolim f. brasilense,*
9. *G. barbadense ssp. ruderale f. pisco x G. mustelinum,*
10. *G. mustelinum x G. barbadense ssp. ruderale f. pisco.*
11. *G. mustelinum x G. darwinii*
12. *G. darwinii x G. mustelinum*

Picture 12. Paradermal section of a leaf from the abaxial side in hybrid forms of cotton

On the abaxial surface of the leaf, only G. mustelinum does not meet these conditions. Among the backcross of G. hirsutum and G. mustelinum hybrids, G. hirsutum ssp. mexicanum var. microcarpum palmeri x G. mustelinum does not correspond to this condition, G. hirsutum ssp. mexicanum var. nervosum x G. mustelinum, G. mustelinum x G. hirsutum ssp. mexicanum var. microcarpum palmeri, G. mustelinum x G. hirsutum ssp. mexicanum var. nervosum, and among the hybrids of G. barbadense and G. mustelinum, G. barbadense ssp. vitifolim f. brasilense x G. mustelinum, G. mustelinum x G. barbadense ssp. vitifolim f. brasilense, G. barbadense ssp. ruderal f. pisco x G. mustelinum.

Conclusions:

1. Thus, we can conclude that the most aphid tolerant hybrid is G. hirsutum ssp. punctatum f. mary galante x G. mustelinum, and G. mustelinum x G. barbadense ssp. ruderal f. pisco. The most drought tolerant among the hybrids studied are G. hirsutum ssp. mexicanum var. microcarpum palmeri x G. mustelinum, G. hirsutum ssp. mexicanum var. nervosum x G. mustelinum.

Conditional designation

C H – covering hair

Ad E – adaxial epidermis

P P – palisade parenchyma

S P – spongy parenchyma

Sch T– schizogenic trichome

Ab E- abaxial epidermis

End C– endogenous container

P – parenchyma

T – trichome

Phl– phloem

X – xylem

S – stomata

E – epidermis

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