Biomedical Statistics and Informatics
2024, Vol. 9, No. 2, pp. 32-38
https://doi.org/10.11648/j.bsi.20240902.12

Research Article

Research in the Field of Anatomical Vegetative Organs of Cotton

Tutushkina Nina Viktorovna[1, *], **Safiulina Veronika Aleksandrovna**[2]

[1]Department of Botany and Ecology, Faculty of Natural Sciences, Tashkent State Pedagogical University, Tashkent, Uzbekistan

[2]Faculty of Natural Sciences, Tashkent State Pedagogical University, Tashkent, Uzbekistan

Abstract

This article presents data from scientists who have studied and are currently studying the morphology and structural features of cotton peel. Information is provided on the shape, size, and ultrastructure of the seed surface, including the structure and height of the outer and inner integuments. The studies involved both cultivated varieties and accessions, as well as wild diploid and tetraploid species and their subspecies from various habitats. During the study, a cross-section of cotton leaves was also analyzed. The height and dimensions of the various tissues that make up the cotton leaf were determined. As a result, a pattern was identified that correlates with the tolerance of leaves to pests. And so, if the mesophyll structure has an isolateral type of structure, then the possibility of tolerance to piercing-sucking parasites increases. The studied representatives have a dorsiventral type of mesophyll. And this, in turn, does not help protect the leaf from the penetration of the aphid stylet into the spongy parenchyma and the sucking of nutrients from the sieve tubes of the vascular bundles located closer to the abaxial side of the leaf, as well as the mesophyll. transport cells rich in metabolic products. The height of the columnar parenchyma in all studied representatives 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, and the thickness of the spongy parenchyma should not exceed 98.5 microns. Thus, that among the studied representatives, the most tolerant representatives to insect pests will be G. herbaceum ssp frutescens 2n=56, A-833 2n=56.

Keywords

Seed of Structure, Cotton Plant, Wild Species, Hairiness of the Seed, Seed Integuments, Evolutionary Advancement, Diploid Species, Tetraploid Species

1. Introduction

The genus *Gossypium L.* (family *Malvaceae*) includes about 50 species [5, 2, 7] growing on different continents in subtropical and tropical zones. Most of the representatives are wild diploid species (45), the rest are tetraploid. Of the whole variety, only 4 representatives are used in culture and spread only - tetraploid G. *hirsutum, G. barbadense and* diploid *G. herbaceum* and *G. arboreum*, the so-called cultivated species. Cotton seeds are ovoid or cube-shaped, covered with

*Corresponding author: Sail8484@mail.ru (Tutushkina Nina Viktorovna)

Received: 8 June 2024; **Accepted:** 15 July 2024; **Published:** 26 September 2024

one or two tiers of unicellular hairs (fiber and underbelly), sometimes completely naked, vary considerably in size and degree of pubescence. The seed rind is very tough, often "stony" in wild species.

Morphological features of seeds of plants useful for humans are not only of scientific, but also of great agrotechnical and economic importance. Along with anatomical ones, they are widely used by botanists as taxonomic ones, in solving controversial questions of systematics, evolution and phylogeny of representatives of various taxa [17-19].

In systematics, great importance is attached to the size, shape, surface character and coloration of the seed, as well as various appendages. When studying the morphology of cotton seeds, special attention was paid to the shape, degree and character of pubescence, absence or presence of down, coloration, and structure of the hair cover, as these features, according to many scientists, are considered more conservative than the size. In the literature on cotton, when characterizing seeds, the terms - large, medium, small - are more often used, sometimes the sizes of mature seeds are indicated, which, as studies have shown, also play an important role in the diagnosis of taxa of the genus *Gossypium L.* [20, 21, 26] In the practice of cotton growing and breeding works, the main attention is paid to the signs of seed size and weight, pubescence, coloration and fiber length. There is no information about changes in thesize of ovaries and bolls occurring in the process of seed development [32, 31, 34].

A mature cotton seed consists of an embryo and a rind, and develops from a seed pod. Seed bolls (seed pods), ready for fertilization, are anatropic, ovoid in shape, and attached to the placenta by a pedicel. The central part is occupied by the nucellus, covered with two integuments - external and internal.

The seed coat protects the embryo from mechanical damage, moisture loss and penetration of various parasites inside the seed, and plays an important role in germination and seed viability. It contains a number of valuable chemicals and is used to produce alcohols, acids, furfural, fodder yeast, pectin glue, and as coarse fodder for livestock. Seed rinds of flowering plants have attracted the attention of botanists of various profiles for more than 100 years, being the object of not only applied but also fundamental research. There is a huge number of works by foreign and domestic authors studying the structure of seed rinds of various plants [33, 36].

Analysis of the literature has shown that in flowering plants it develops from the integuments of seed pods and undergoes various structural changes depending on the taxonomic position and ecological conditions. The characters of morphological and anatomical structure of the seed rind are widely used by scientists as taxonomic characters and are used to solve controversial questions of systematics and phylogeny. It is these characters that are sometimes of decisive importance, on the basis of which species are attributed to certain tribes, families and genera [13].

The structure of the seed rind can also be used to judge the level of evolutionary advancement of a particular systematic group. The multivolume edition edited by Acad. A. L. Takhtazhdjan [16] includes the results of many years of research by renowned Soviet scientists on a huge number of representatives of various families of flowering plants. The interest of domestic and foreign researchers in the anatomy of mature seeds has not waned in recent decades. There are a number of works devoted to the study of spermoderm and ultrastructure of seed surface of representatives of various families, representatives of taxa of different ranks in connection with their systematics andphylogeny.

Japanese scientist Fukuhara Tatsundo [15] studying the seed coat of 7 species of the genus Corydalis (mainly Japanese flora) belonging to different sections: *Cheilanthifoliae, Sophorocaphos, Ramoso-Sibiricae, Corydalis, Diplotaber* and 2 species of the genus *Dicentra*, he distinguished 6 types of seed rinds, which appeared to be associated with belonging to a particular taxonomic group. Based on the study of development, growth, and differentiation of the structure of the integumental layers of seed bracts of representatives of various families, I. I. Shamrov [14] proposed a classification of the ways of integument formation, including types (origin criteria) and three variations based on a set of criteria. Later, in his monograph, he presented the data of many authors on the development and structure of the integuments of the seedpods of flowering plants of different families. A comparative study of the spermoderm structure of 39 species of the genus *Latyrus* allowed M. O. Burlyaeva [3] to establish that the height and degree of thickening of the epidermal cell walls and the structure of the seed coat surface are the most important diagnostic characters. Based on the results obtained, the types were identified and the direction of seed rind evolution was established. A. V. Bobrov [2] studied the morphology, anatomy, and ultrastructure of seed coatings of 14 known taxa of Cephalotaxa yew in order to confirm isolation and to clarify the intraspecific system of the genus Cephalotaxus. The results of the studies confirmed the originality and significant isolation of *Cephalotaxus* among conifers. All 14 taxa studied are clearly distinguished from each other by species-specific characters of seed structure. As the analysis of literature sources has shown, morphological and anatomical characters of mature cotton seeds have also been used in solving controversial issues of systematics and phylogeny of representatives of the family *Malvaceae* and, in particular, of the genus *Gossypium L.* Later, Dr. T. Netolitzky [11], Soomro, A. R. [15], I. A. Raikova and M. S. Kanash [12] presented data on the development and structure of individual layers of the seed peel of some cotton cultivars of the cultivated species *G. hirsutum, G. barbadense, G. herbaceum* and *G. arboreum* and other representatives of the family *Malvaceae* in the middle part of the seed.

Peel of mature seeds of 11 representatives of the genus *Gossypium L.* among which 4 are cultivated (*G. hirsutum, G. barbadense, G. herbaceum, G. arboreum.*) 4 wild (*G. anomalum, G. davidsonii, G. harknesii, G. trilobum) and 3 sub-*

species of G. hirsutum L. (ssp. mexicanum, ssp. anomalum, G. davidsonii, *G. harknesii, G. trilobum*) and 3 subspecies of *G. hirsutum L.* (ssp. *mexicanum*, ssp. *peruvianum*, ssp. *purpurascens) have* been studied in sufficient detail by N. N. Konstantinov [10]. A comparative analysis of the data obtained by the author revealed no significant differences between wild and cultivated representatives. It should be noted that the structure of the rind of representatives of the family *Malvaceae*, also paid attention in systematic and phylogenetic constructions. As a result of A. S. Dariev's [4] study of mature seed rinds of 10 genera of the family *Malvaceae*, including *Gossypium L.*, 2 genera of the family *Bombacaceae*, revealed features characteristic of genera and individual species, which allowed the author to judge the direction of evolutionary changes occurring in the structure of the rind and to establish features characteristic of the ancestral type, such as thick spermoderm, multilayered parenchyma of the external integument and a large number of conductive bundles in it.

When studying the peels of mature seeds of 9 wild cotton species belonging to 2 life forms - trees and shrubs (*G. raimondii, G. thurberi, G. gossypioides, G. trilobum, G. davidsonii, G. klotzschianum, G. sturtianum, G. australe, G. bickii*), V. P. Klat [8, 9] revealed clear signs of difference and similarity. The distinctive features, according to the author, are related to the life form and conditioned by ecological conditions of habitat in different geographical zones. The general plan of spermoderm structure and similar features indicate the monophyletic origin of species.

Thus, studies by V. P. Klyat and I. A. Berezin [9] on the structure of integuments of different-aged seedpods of wild representatives of *G. herbaceum* (ssp. *africanum*, ssp. *pseudoarboreum*), G. *arboreum* (ssp. *obtusifolium*, ssp. *perenne*, ssp. *neglectum*, ssp. *nanking)*, and *G. soudanense* revealed distinctive features characteristic of the species. Based on these data, they found that the Madagascar species *G. soudanense*, the taxonomic rank of which is controversial, is close to representatives of *G. arboreum* in terms of the studied characters and the rate of development of the seed peel integuments and is obviously, as other researchers believe [6], its species.

The study of seed peel formation in wild representatives of American, African and Australian cotton species revealed a positive correlation of mature seed peel thickness and rates of its formation with early maturity. There is very little information in the cotton literature on the growth and development rates of tissues composing boll integuments, especially in cultivated varieties. Similarities and differences, peculiarities of seed peel formation of wild representatives and cultivated varieties of diploid and tetraploid species of the genus *Gossypium L. have* not been determined.

Taking into account all the above-mentioned and the fact that there are about 50 species in the genus *Gossypium L.*, most of which have not been studied yet, consider it relevant to conduct studies involving in the experiment not only wild representatives, but also poorly studied intraspecific diversity of *G. herbaceum*, *G. arboreum*, *G. hirsutum*, *G. barbadense*, cultivated varieties and varieties obtained on their basis. The obtained new data will considerably complete the characterization of species and contribute to the knowledge of biology, anatomy, systematics and evolution of the studied representatives of *the* genus *Gossypium L.*

2. Materials and Methods

Thus, in the literature on cotton there is information about the existence of a relationship between a set of anatomical characteristics (thickness of the cuticle, lower epidermis and spongy layer, as well as the number, length and type of leaf hairs) and damage to various insect pests [27]. Such studies are of not only scientific but also practical interest.

The research material was

1. G. herbaceum ssp. pseudoarboreum f. harga 2n=52
2. G. herbaceum ssp pseudoarboreum 2n=56
3. G. herbaceum ssp frutescens 2n=56
4. G. herbaceum ssp africanum 2n=56
5. A-833 2n=56

G. Experimental studies were carried out in the conditions of plot experiments and on the photoperiodic site of the laboratory of systematics and introduction of cotton at the Institute of Genetics and Experimental Plant Biology of the Academy of Sciences of Uzbekistan. For anatomical analysis, real leaves were fixed (in 70% ethanol). Measurements were taken and preparations of transverse and paradermal sections of real leaves were prepared. To analyze the paradermal and cross-section of the leaf, cuttings with an area of 1 cm^2 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 carried out, photographs were taken, tables were compiled.

Anatomical studies were performed according to accepted methods [24, 23, 30, 32, 1]. 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.

3. Result

Transverse leaf analysis.

There is an opinion that only the combination of most of the anatomical characteristics of the leaf structure will give results of resistance to insect pests - aphids and spider mites (Figure 1). Also, individual anatomical features have diagnostic value in clarifying the details of generic and species differences [22]. Signs can be divided into two groups - stable and variable. Stable ones include the nature of pubescence and the type of stomatal apparatus [25]. Variables include the thickness of the plate, the structure of the mesophyll, the height of the palisade and the presence of a lower layer, i.e. isolateral type of leaf structure, number of epidermal cells and stomata, number of hairs [28, 29, 35]. Including such signs as dense leaf pubescence and the presence of a thick cuticle, which is an indicator of advancement.

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 and should be at least 20.0 µm; these conditions, among the studied representatives, correspond to G. herbaceum ssp pseudoarboreum, G. herbaceum ssp frutescens. (Figure 1).

The height of the spongy parenchyma should be no more than 98.5 microns, since the greater the height of the spongy parenchyma, the looser it becomes. G. herbaceum ssp frutescens, G. herbaceum ssp africanum, A-833 are distinguished by the least loose leaf parenchyma.

A B

Figure 1. *Piercing pests are sucking pests of cotton.*

A - cotton aphid
B – spider mite

For resistance to aphids (Aphis gossypii Glov.) and spider mites (Tetranychus urticae), the cuticle of a cotton leaf must be at least 0.85 microns. [29, 37-40].

In the studied polyploids, the cuticle height is more than 0.85 µm, but the highest value is in G. herbaceum ssp. pseudoarboreum f. harga. (Table 1, Figure 2)

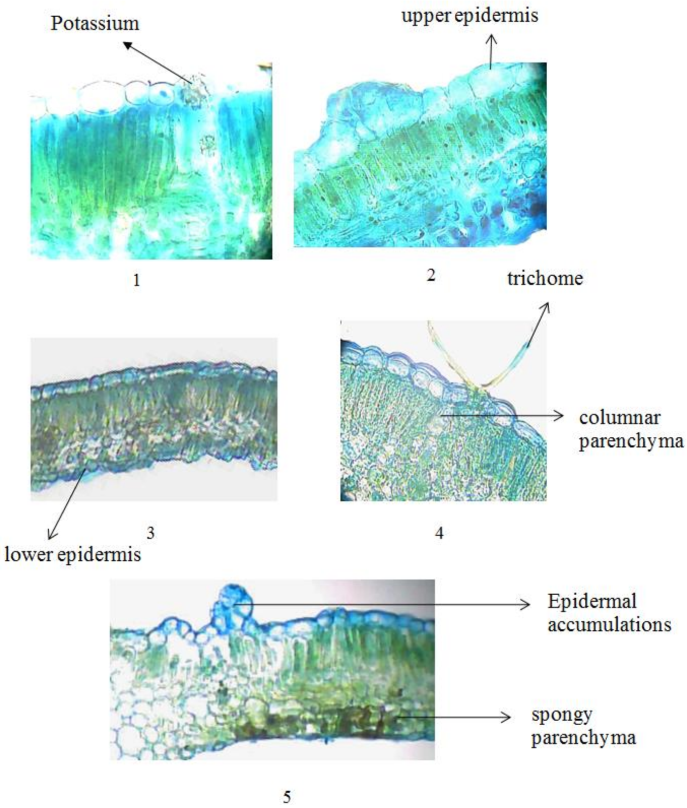

Figure 2. *Fragments of transverse sections of leaves from the studied representatives.*

Table 1. Dimensions of some leaf cross-section structures.

№	Height of leaf blade	Height					
		of the upper		of columnar	of spongy	lower	
		cuticle	epidermis	parenchyma		cuticle	epidermis
1	328,1±11,3	8,8±0,9	25,1±0,9	247,9±8,6	133,7±9,3	12,5±2,9	10,1±0,9
2	425,8±7,5	5,6±0,2	25,6±1,4	198,4±7,2	155,2±4,8	27,4±0,7	7,9±0,1
3	274,5±8,9	9,6±0,	10,6±0,2	125,8±11,0	92,9±12,3	26,8±0,4	8,8±0,2
4	225,1±7,4	5,5±0,6	7,5±1,2	107,1±14,5	89,8±17,8	8,5±0,9	6,7±0,1
5	276,8±6,5	3,7±0,9	20,9±0,8	157,3±4,9	81,3±7,4	9,9±0,3	3,7±0,1

1. G. herbaceum ssp. pseudoarboreum f. harga 2n=52
2. G. herbaceum ssp pseudoarboreum 2n=56
3. G. herbaceum ssp frutescens 2n=56
4. G. herbaceum ssp africanum 2n=56
5. A-833 2n=56

4. Conclusion

If the mesophyll structure has an isolateral type of structure, then the possibility of tolerance to piercing-sucking parasites increases. And so, the studied representatives have a dorsiventral type of mesophyll. And this, in turn, does not help protect the leaf from the penetration of the aphid stylet into the spongy parenchyma and the sucking of nutrients from the sieve tubes of the vascular bundles located closer to the abaxial side of the leaf, as well as mesophyll transport cells rich in metabolic products. The height of the columnar parenchyma in all studied representatives 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, and the thickness of the spongy parenchyma should still not exceed 98.5 µm. Thus, that among the studied representatives, the most tolerant representatives to insect pests will be G. herbaceum ssp frutescens 2n=56, A-833 2n=56.

Abbreviations

Acad.	Academician
G.	Gossypium
Ssp.	Subspecies

Conflicts of Interest

The authors declare no conflicts of interest.

References

[1] Barykina R. P., Veselova T. D., Devyatov A. G., Dzhalilova H. Kh., Ilyina G. M., Chubatova N. V. Fundamentals of microtechnical research of botany. Reference guide. -. Moscow, 2000. -129 p.

[2] Bobrov A. V. Morphology and ultrastructure of *Cephalotaxus* seeds in connection with the problems of the genus system // Botanical Journal. - 2001. - № 5. - С. 50-65.

[3] Burlyaeva M. O. Comparative-anatomical characterization of seed rinds of species of *Lathyrus* r. in connection with its systematics // Problems of botany at the turn of XX-XXI centuries. Thes. doc. presented to the II (X) Congress of the Russian Botanical Society May 26-29, 1998. - С.-Р., 1998. - т1. - 17с.

[4] Dariev A. S., Abdullaev A. A. Cotton: anatomy, morphology, origin. - Tashkent: Fan, 1985. - 303 c.

[5] Dilovar T. Khamraeva, Tutushkina Nina V., Rainer W. Bussmann, Olim K. Khojimatov. Leaf morphological and anatomical structure of pregenerativeindividuals of Ferula tadshikorum in ex situ conditions. / Acta Biologica Sibirica 7: 193-210 (2021) https://doi.org/10.3897/abs.7.e63714

[6] Fryxell P. A. A classification of *Gossypium L. (Malvaceae*) - Taxon: 1969. - v. 18. - № 5. - P. 585-591.

[7] Glen L. Ritchie, Craig W. Bednarz Cotton Growth and Development. Bulletin 1252, September, 2004. The University of Georgia and Ft. Valley State University.

[8] Klyat V. P. Structure of spermoderm of some species of *Gossypium* r. *L.*// Uzb. biol. zhurn. - 1983. - № 6. - С. 50-53.

[9] Klyat V. P., Berezina I. A. Structure and development of seed peel in representatives of the genus *Gossypium L.* (family *Malvaceae*). International Conference, St. Petersburg. - ST. PETERSBURG, 1997. - С. 70-71.

[10] Konstantinov N. N. Morphological and physiological bases of ontogenesis and phylogenesis of cotton. - Moscow: Nauka, 1967. - 298 с.

[11] Netolitzky Dr. T. Anatomic der Angiospermen - Samen. - Berlin, 1926. - 245 p.

[12] Raikova I. A., Kanash M. S. Development of embryo, seed skin and fiber of cotton. - Tashkent, 1936. - 50 с.

[13] Shahid, M. R., J. Farooq, A. Mahmood, F. Ilahi, M. Riaz, A. Shakeel, I. V. P. Mag and A. Farooq (2012). Seasonal occurance of sucking insect pest in cotton ecosystem of Punjab, Pakistan. Adv.Agri. Bot. 4: 26-30.

[14] Shamrov I. I. Integument of flowering plants: structural and evolutionary aspects.// Proceedings of the International Conference on Plant Anatomy and Morphology. - S.-P., 1997. - С. 372-373.

[15] Soomro, A. R., R. Anjum, G. H. Mallah, and M. A. Leghari (2001). Host plant resistance to insects in cotton at Central Cotton Research Institute, Sakaran Sindh, Pakistan. Pakistan J. Bot. 33: 641-645.

[16] Takhtajyan A. L. Comparative anatomy of seeds. - Leningrad: Nauka, 1988- 1991.

[17] Thomas R. Fasulo & H. A. Denmark. Two spotted spider mite. Featured Creatures. University of Florida / Institute of Food and Agricultural Sciences (December 2009). Дата обращения 20 мая 2011. Архивировано 22 ноября 2012г.

[18] Tutushkina N. V. Feature structure of a cotton leaf as a Mechanism of protection against insect pests. Journal of Pharmaceutical Negative Results. Volume 13. Special Issue 6. 2022 Pages: 2187–2022 https://doi.org/10.47750/pnr.2022.13.S06.285

[19] Nina Tutushkina, Abdumavlyan Abdullaev, Ziroat Ernazarova. (2023). The Characterization of Anatomical Indices of Seed Coat Formation of Diploid and Tetraploid Representatives of the Genus Gossypium L. *Journal of Plant Sciences, 11(3)*, 86-92. https://doi.org/10.11648/j.jps.20231103.17

[20] Z. M. Din, T. A. Malik, F. M. Azhar and M. Ashraf. Natural resistance against insect pests in cotton.// The Journal of Animal & Plant Sciences, 26(5): 2016, Page: 1346-1353 ISSN: 1018-7081.

[21] Абдуллаев А. А., Дариев А. С., Омельченко М. В., Клят В. П., Ризаева С. М., Сайдалиев С., Амантурдиев А. Б., Халикова М. Б. Атлас рода *Gossypium.* [Atlas of the genus Gossypium] – Ташкент: Фан, 2010. – 263с.

[22] Аксенов Е. С. Новый метод окрашивания растительных тканей для приготовления постоянных анатомических препаратов. [A new method of staining plant tissues for the preparation of permanent anatomical preparations] //. Биол. науки. 1967. №. 11. С. 125— 126.

[23] Анатомические методы исследования культурных растений (методические указания) [Anatomical methods for studying cultivated plants (guidelines)] / Под ред. Л. И. Орел. Л., 1989.

[24] Влияние геометрии замыкающих клеток на работу устьичного аппарата у растений [The influence of guard cell geometry on the functioning of the stomatal apparatus in plants] / Бауэр С. М., Иванова О. В., Крылова Е. Г., Паутов А. А., Сапач Ю. О. // VI Поляховские чтения. М., 2012. С. 303–306.

[25] Захваткин Ю. А. Акарология — наука о клещах: История развития. Современное состояние. Систематика: Учебное пособие. [Acarology - the science of ticks: History of development. Modern condition. Systematics: Textbook.]—М.: Книжный дом «ЛИБРОКОМ», 2012.— С. 121. — ISBN 978-5-397-02126-5.

[26] Ле Диуен Анх Факторы устойчивости диких и культивируемых представителей рода *Gossypium* L. к хлопковой тле (Aphis Gossypii Glov.) [Factors of resistance of wild and cultivated representatives of the genus Gossypium L. to cotton aphid (Aphis Gossypii Glov.)]: Автореф. дисс… канд. биол. наук. Ташкент, 1995. 23 с.

[27] Мирославов Е. А., Кравкина И. М. Сравнительная анатомия листа растений, произрастающих в горах на разных высотах [Comparative leaf anatomy of plants growing in the mountains at different altitudes]// Ботанический журнал: 1990. Т. 75. № 3. С. 368—375. Научная библиотека диссертаций и авторефератов disser Cat http://www.dissercat.com/content/izmenenie-morfologii-i-struktury-lista-betula-pendula-roth-i-betula-pubescens-ehrh-pri-adapt#ixzz5T8Rnnu3V

[28] Паутов А. А., Васильева В. А. Роль формы основных клеток эпидермы в морфогенезе листа представителей Hamamelidaceae [The role of the shape of the main cells of the epidermis in the morphogenesis of leaves of representatives of Hamamelidaceae]// Бот. журн. 2010. Т. 95, № 3. С. 338–345.

[29] Паушева З. П. Практикум по цитологии растений. [Workshop on plant cytology] М.: Колос, 1988.

[30] Пермякова В. Н. Защита растений от вредителей и болезней. [Protection of plants from pests and diseases.] — Петрозаводск: Карелия, 1988. — ISBN 5—7545—0025—4.

[31] Радцев В. С, Осокин Б. С, Чистова Н. П. Способ определения количества клеток в растительных тканях [Method for determining the number of cells in plant tissues]: Авт. свид. № 510195 СССР, кл. A01 G7/00. 17.04.1974.

[32] Яковлев Г. П., Челомбитько В. А. Ботаника. [Botany] – СПб.: «Специальная литература», 2008.

[33] Agro archive of crops. National economic importance of cotton growing. Available from: http://agro-archive.ru/hlopkovodstvo/1173-narodnohozyaystvennoe-znachenie-hlopkovodstva.html [Accessed 10 February 2014].

[34] Project "Integrated water resources management in the Fergana Valley". Under the section "Pest and disease controlcotton" Available from: http://www.cawater-info.net/library/rus/iwrm/iwrm13.pdf [Accessed February 2005].

[35] Dictionaries and encyclopedias. Available from: https://dic.academic.ru/dic.nsf/ruwiki/1376290 [Accessed 15August 2023].

[36] Agro xxi. Cotton is an indispensable agricultural crop. Available from: https://www.agroxxi.ru/tehnicheskie/tehnicheskie-pererabotka/hlopchatnik-nezamenimaja-selskohozjaistvennaja-kultura.html [Accessed 12 August 2016].

[37] BBC news. Russian version. Cotton picking in Uzbekistan: labor conscription? Available from: https://www.bbc.com/russian/society/2012/10/121015_uzbek_cotton [Accessed October 16, 2012].

[38] Britannica. Cotton - fibre and plant. Available from: https://www.britannica.com/topic/cotton-fibre-and-plant [Accessed May 27, 2024].

[39] Britannica. list of plants in the family Malvaceae Available from: https://www.britannica.com/topic/list-of-plants-in-the-family-Malvaceae-2040580 [Accessed May 17, 2024].

[40] N. V. Tutushkina Structura of ripe seed of wild diploid representatives of Gossypium L. July 2024 BIO Web of Conferences, 116. https://doi.org/10.1051/bioconf/202411601018