Scientific Papers. Series A. Agronomy, Vol. LXV, No. 2, 2022
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

EVALUATION OF COTTON GENE POOL SAMPLES IN DIFFERENT YEARS OF HEAT SUPPLY IN THE CONDITIONS OF THE SOUTHERN STEPPE OF UKRAINE

Raisa VOZHEHOVA, Vira BOROVIK, Serhiy KOKOVIKHIN, Iryna BILIAIEVA, Olena KOKOVIKHINA, Lubov BOIARKINA, Olena SHKODA

Institute of Irrigated Agriculture, National Academy of Agrarian Sciences of Ukraine, Naddniprianske, 73483, Kherson, Ukraine

Corresponding author email: veraborovik@meta.ua

Abstract

The article presents the results of studying of the gene pool of cotton in different years of heat supply, with and without irrigation. As a result of many years of research from the collection of the gene pool, more than 30 sources of economic and valuable traits have been identified, which are characterized by high adaptability to environmental factors, excellent indicators of product quality. On the basis of the studied material, two working signs and a training cotton collection were formed. Valuable samples of cotton were isolated from the gene pool on the basis of economically valuable features. These included drought resistance, fiber color, a combination of signs of precocity and partial pubescence of seeds, high attachment of the first sympodial branch and large capsule, long fiber, ultra-early maturity and high productivity. Also, medium-fiber high-yielding very early varieties of cotton - 'Dniprovskyi 5' and 'Pidozerskyi 4' were created.

Key words*: cotton collection, climate change, precocity, yield, ripening period.*

INTRODUCTION

In recent years, the climate has become drier, there are observed global changes on the planet (Adamenko, 2014; Barabash et al., 2004). Climate change in the conditions of the Southern Steppe of Ukraine is no exception (Vozhegova & Kovalenko, 2013; Vozhegova, 2014a). According to the Kherson Agrometeorological Station, significant climate changes have also taken place in the south of Ukraine over a 132-year period, as evidenced by the hydrothermal coefficient of 0.6-0.7 (Gusev et al., 2005; Melnichuk & Adamenko, 2011). The period with average daily air temperatures of 10°C and above, which suggests active growth and development of plants, lasts 183-189 days. The sum of positive air temperatures above 10°C during this period varies from 3285°C in the north to 3415°C in the center of the region. In some years, these figures ranged from 2850 to 3685°C.

In general, increasing the aridity of the climate in the southern region contributes to the probability of increasing arid years to 60-75% (Kovalenko, 2012), which allows to refer it to the zone of risky agriculture with unstable agro-ecological conditions, and in some years – with extreme (Netis, 2004). Researchers claim that over the past 50 years, the average annual air temperature has risen by 1.8ºC, winters have become warmer and shorter, while the autumn period - on the contrary, became longer (Adamenko, 2014; Vozhegova, 2014a). The duration of the vegetation period of agricultural crops in the Kherson region lasts 229-237 days: it starts on March 20-25 and ends on November 9-14.

Over the last five years, in 2011-2015, the amount of precipitation decreased compared to the period from 1972 to 2010, on average, from 457 to 381 mm or 76 mm. In this area there is a shortage of water supply to plants, so an important role is given to irrigation (Balyuk, 2009). Analysis of data on climate change in the Kherson region shows that the water and heat regimes of this zone for most crops have deteriorated over the past five years. The reasons for these changes may be global world processes, the cyclical nature of solar activity, anthropogenic factors of human economic activity and their combined action.

If for the majority of crops grown in the southern region of the country, the limiting factor is water, for cotton the limiting factor is

heat supply, to which it has high requirements. Scientists have found that the most risky for harvesting raw material, before the onset of frost, in this area are the years with the coincidence of cool temperatures and frequent precipitation in the period of August - September (Borovik et al., 2011). Therefore, the increase of air temperature, increase the amount of dry days, decrease of rainfall - cotton perceives all of it quite positively. The onset of the main phases of its development depends largely on the weather conditions of the year.

MATERIALS AND METHODS

The main task in conducting research is to obtain reliable comparative assessments of samples on the main economic and valuable features and biological properties provided by the criteria in collection nurseries. The subjects of research were samples of cotton from collection nursery. The research was conducted in non-irrigated and irrigated conditions in the fields of the selection department of the Institute of Irrigated Agriculture. Morphological description, classification by economic and biological properties was carried out according to the "Wide unified classifier" - reference book of the genus *Gossypium hirsutum* L. (Vozhegova et al., 2014). Statistical processing of the obtained data was performed according to the method by Vozhegova (Vozhegova, 2014b).

To characterize the weather conditions were used data from the Kherson Agrometeorological Station, located near the experimental field. Weather conditions in the years of research were typical for the zone of the southern region of Ukraine, which contributed to the objective assessment of the introduced material, the selection of the best samples on the basis of economic and valuable features. The soil of the experimental field is dark brown, hard loamy, residually weakly saline with humus content in the arable layer of 2.15-2.3%. Soil density is 1.2-1.3 g/cm^3, wilting moisture is 7.8-9.8%, and the lowest moisture content of 0.7 m layer is 20.5-22.4%. Groundwater lies deeper than 15 m. Cotton growing techniques were typical for the Southern Steppe of Ukraine.

RESULTS AND DISCUSSIONS

Evaluation of 282 samples of cotton gene pool was carried out during 1993 and 1999-2012. Meteorological indicators for the test years, according to the sum of effective temperatures above 10°C, were as follows: the most favorable were 1999, 2002 and 2005, 2011, 2012, close to them - 1998, 2001, 2008, 2009, 2010; medium - 1996, 2000, 2003, 2006, 2007 and very cold and wet - 1993 and 2004. Too cold 1993 (the sum of effective temperatures above 10°C was 1397°C) accelerated the differential brutal culling of collection material according to their maturity groups (Borovik, 2009). Practically, the ripening phase before frost was recorded in only 30% of cotton varieties of Bulgarian selection.

1999 was characterized by favorable temperature conditions for most varieties of different maturity groups. During the growing season, the sum of positive temperatures above 10°C reached its maximum - 1735°C (norm 1492°C). Ripening of most varieties and even late ripening came almost simultaneously with the standard - 23-27.09. The opening of the capsules, even in mid-late varieties, occurred in the 2nd - 3rd decades of September, which is 3 weeks earlier than the optimal time. 2006 and 2007 were characterized by similar weather conditions.

The length of the growing season in varieties of different maturity groups in 2000 was differentiated and ranged from 110 to 144 days. In 2001, the maturity of most samples, even medium-late ones, was 14 to 28 days earlier. Before the frosts it was obtained the 90-98% of raw materials. Despite the fact that in 2003 the sum of effective temperatures above 10°C was 1614.1°C (norm 1475.2°C), there was a delay in the onset of the phase of full ripeness of cotton due to damage of silver Y (*Autographa gamma*) and cotton bollworm (*Helicoverpa armigera*). Scoops caused great damage to the culture by damaging almost all the first buds at the 2nd - 5th sympodial branching and thus contributed to mass decline. As a result, the onset of mass flowering and ripening in 2003 was delayed for 20-30 days, regardless of the maturity group of the variety. In fact, before the frost, which was observed on October 25, ripening of raw material took place only in single plants of precocious forms.

The onset of phases of growth and development and their duration is determined by the biological characteristics of the variety and agro-climatic conditions of the growing area. In years with a large amount of precipitation, the duration of the development phases is prolonged, and in drought is reduced (Kruchinina, 2014). It is established that the years with the coincidence of cool temperatures and frequent precipitation during the period of formation - ripening of boxes are the most risky for obtaining the harvest of raw materials before the onset of frost in the south of Ukraine, and 2004 can be considered as an example. In the extreme conditions of 2004, the result of effective temperatures above 10°C was 1424°C (norm 1546°C). The maximum air temperature rose to 38.0ºC (August 3). There were 39 days of drought during the summer, and 23 days were normal. Precipitation for the season was 104.5 mm (79.2% of normal), most of which was observed in the second (28.6 mm) and third (64.4 mm) decades of June, as well as in the third decade of July (19, 4 mm). Weather with a large amount of precipitation led to low yield – only 1.4 t/ha. Capsules of these plants were formed at the 4th - 9th sympodial branching. Before the onset of frost 0.62 t/ha of raw material was harvested (Figure 1).

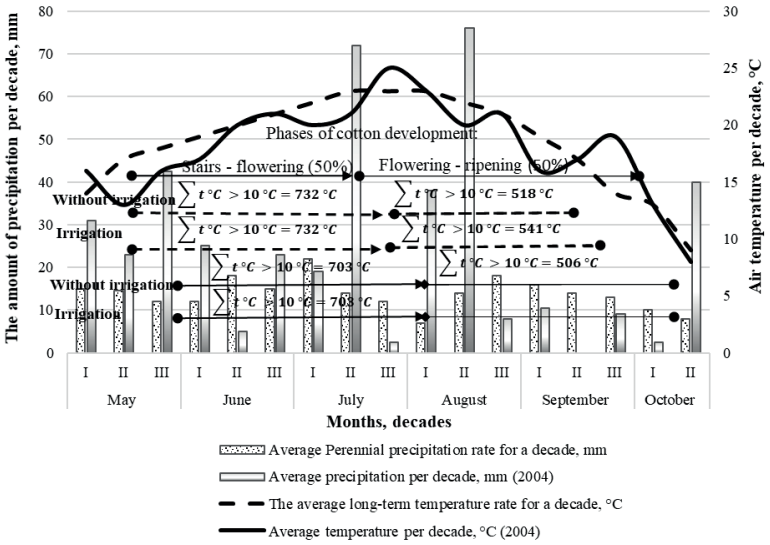

Figure 1. The course of the main indicators of weather and phases of development of cotton in 2004

The maximum potential of cotton appeared in 2002 and 2005-2012, when, practically, only pre-frost yield of raw material was obtained - 70-90% of the total, and the maturation of varieties of different maturity groups accelerated: their growing season was 105-115 days. Groups of cotton ripeness, formed on average over the years of research, are presented in Table 1.

Table 1. Classification of cotton collection samples by maturity groups depending on the sum of effective temperatures above 10°C (average for 1993, 1999-2012*)

Maturity group	The sum of effective temperatures from sowing to			The number of plants that have entered the ripening phase, %
	stairs	flowering	maturation in 50% of plants	
Ultra-early (110-115 days)	146*	1398/1399	1532/1534	3.7/2.1
Precocious (116-130 days)	146	1416/1417	1560/1562	13.4/7.9
Medium ripe (131-140 days)	146	1433/1434	1597/1598	30.5/29.7
Late ripening (141-150 days)	146	1476/1478	1735/1737	22.2/25.2
Very late ripening (> 150 days)	146	1490/1491	1742 and more	30.2/35.1

*With the exception of 2004, when a very small yield of pre-frost raw material was obtained;
*The numerator presents the results of research in non-irrigated conditions, the denominator - with irrigation;
*Results of research in the conditions of irrigation are presented for 1993-2002.

During studying the collection of the cotton gene pool both on non-irrigated and irrigated lands, it was found that the formation of different groups of maturity of samples largely depends on the weather conditions in the south of Ukraine. During the years of research in non-irrigated conditions, in fact, ultra-early forms were observed in 3.7%, and in irrigated - 2.1% (Borovik & Stepanov, 2014). Watering delayed the process of maturing cotton. The ripening phase of late-maturing specimens under irrigation was also somewhat prolonged with the change of the maturity group in the direction of increase. Significant rainfall (68.4 mm) in the first decade of May 2009, as well as warm weather in the second and third, contributed to the friendly germination of cotton, which appeared on 29.05 (long-term average – 19.05). In comparison, late seedlings were obtained because of late sowing dates. The further course of positive temperatures and the distribution of precipitation during the growing season accelerated the development cycle of varieties of all maturity groups. Flowering took place in most varieties in long-term calendar terms - July 28-29. An important factor determining the suitability of the variety for mechanized harvesting is the height of the bookmark of the first sympodial branching. In 2009, this value was in the range of 7.8-12.3 cm.

Table 2. The best samples of cotton in the collection nursery by economic-valuable features (average for 2011-2012)

National Catalogue Number	Sample name	Country of origin	Duration of the growing season, days	Plant height / attachment of the 1st sympodial branching, cm	Resistance to the most common diseases, score		Weight of the 1 capsule, g	Productivity of the 1 plant, piece	Fiber length, mm
					Verticillium dahliae (verticillium wilt)	*Xantomonas malvaceanum* (homoz)			
1	2	3	4	5	6	7	8	9	10
UF0800001	Dniprovskyi 5	UKR	105	58.1/14.1	9	9	5.2	6.6	30.4
UF0800220	500y	UKR	104	58.3/12.8	9	9	5.4	6.8	28.9
UF0800212	1135/94	UZB	104	64.9/14.2	9	9	4.8	7.9	30.7
UF0800031	Pidozerskyi 4	UKR	103	63.6/18.1	9	9	5.9	10.2	32.4
UF0800238	Sort 534	RUS	104	60.6/14.2	9	9	5.4	6.4	31.2
UF0800050	2362	BGR	107	59.8/14.2	9	9	5.5	6.4	29.6
UF0800281	Trakiya	BGR	106	60.7/15.1	9	9	5.7	9.4	29.4
UF0800123	N267	BGR	108	62.4/14.6	9	9	5.2	6.6	28.5
UF0800062	144F	UZB	106	56.2/12.4	9	9	5.4	10.1	28.4
UF0800159	Acala 90	USA	108	64.6/16.2	9	9	5.5	6.2	31.5
UF0800019	Chyrpan 603	BGR	109	74.6/15.3	9	9	5.1	7.1	29.6
UF0800185	Interlinear hybrid №64 irradiated	BGR	108	66.9/15.1	9	9	5.4	7.6	30.2
UF0800282	Joloten 14	KGZ	135	86.1/15.6	9	9	6.5	9.7	31.9
LSD_{05}								5.4	

In 2010, the height of attachment of the first fruit branch of all Bulgarian varieties was not lower than 13.1 cm. In warm and hot years, a larger number of capsules was formed on plants under irrigation conditions, especially in 2011 and 2012. The course of weather conditions had a positive effect on the development of cotton. At the sum of effective temperatures more than 1600ºC (norm 1491.8ºC), at the time of harvest, samples of all maturity groups reached their maturity. The exception was UF0800282 Joloten 14, the maturation period of which was 135 days (Table 2). Samples with such a maturation period (131-140 days) cannot be grown in the southern region of Ukraine, as with the sum of effective temperatures less than 1598ºC there is a risk of obtaining the maximum yield of open capsules for the period of collection of raw material. As a result of many years of research, breeders of the Institute have selected from the collection of more than 30 sources of economic and valuable

features, which are characterized by high adaptability to environmental factors, excellent indicators of product quality. In 2010, a working feature collection of cotton was formed in the amount of 40 samples of basic economic and valuable features and received a Certificate of registration of the collection of plant gene pool in Ukraine (№ 107, 22.12.10) (Borovik et al., 2010). In 2014 a working collection of cotton was formed on the basis of valuable economic and main features of differences in irrigation conditions (Certificate №164, 10.12.2014). A training collection was also created (Certificate №179, 11.12.2014). Valuable specimens were selected and registered from the collection on the basis of economically valuable features: cotton sample UF0800031 Pidozerskyi 4 - a source of drought resistance (Certificate № 736, 22.12.10); UF0800265 Rude - a source of colored fiber (Certificate № 737, 22.12.10); UKR006 0850 L 191/13 - source of combination of signs of precocity and partial pubescence of seeds (Certificate № 1227, 22.10.2014); UKR006 0851 L 165/13 - source of combination of very high attachment of the first sympodial branch and large capsule (Certificate № 1228, 22.10.2014); UF0800029 417u - a source of ultra-early maturity and high productivity (Certificate № 1229, 22.10.2014); UKR006 0852 Dovhovoloknystyi - a source of long fiber (Certificate № 1226, 22.10.2014).

The formed basic collection of cotton is a component of the European Integrated System of Gene Banks (AEGIS): Agreement dated by March 26, 2012 between the Institute of Irrigated Agriculture of the National Academy of Agrarian Sciences of Ukraine in the person of Director R. Vozhegova and the National Coordinator [AEGIS] of the ECPGR for Ukraine, Ryabchun V. – the head of the National Center for Plant Genetic Resources of Ukraine of the Institute of Plant Breeding named after V. Yuriev. For introduction into production, the Institute of Irrigated Agriculture NAAS recommends the best medium-fiber varieties created by breeders: very early-maturing (95-105 days) cotton varieties: Dniprovskyi 5 with a potential yield of 2.0-2.5 t/ha for non-irrigated and irrigated conditions and variety Pidozerskyi 4 with a potential yield of 2.5-3.0 t/ha, which is best sown on irrigated lands of the arid climate of southern Ukraine.

CONCLUSIONS

Climate change on the planet and, accordingly, in the conditions of the Southern Steppe of Ukraine in the direction of warming has had a positive effect on the maturity of cotton. As a result of research of 282 samples of cotton gene pool during 1993, 1999-2012 in different heat supply years both on non-irrigated and irrigated lands, it was found that the formation of different maturity groups of samples largely depends on weather conditions in southern Ukraine. During the years of research in non-irrigated conditions, in fact, ultra-early forms were observed in 3.7%, and in irrigated in 2.1%.

As a result of many years of research from the collection of the gene pool, more than 30 sources of economic and valuable traits have been identified, which are characterized by high adaptability to environmental factors, excellent indicators of product quality. Based on the studied material, two working collections and a training collection for cotton were formed. Also from the gene pool on economically valuable features were selected and registered valuable samples of cotton, sources of: drought resistance (UF0800031 Pidozerskyi 4), colored fiber (UF0800265 Rude), a combination of signs of precocity and partial pubescence of seeds (UKR006 0850 L), combination the first sympodial branch and large capsule (UKR006 0851 L 165/13); ultra-early and high productivity (UF0800029 417y); long fiber (UKR006 0852 Dovhovoloknystyi).

It was created medium-fiber high-yielding very early-maturing varieties of cotton: Dniprovskyi 5 with a potential yield of 2.0-2.5 t/ha for non-irrigated and irrigated conditions and Pidozerskyi 4 with a potential yield of 2.5-3.0 t/ha, which is best sown on non-irrigated lands of the arid climate of southern Ukraine.

REFERENCES

Adamenko T.I. (2014). Agroclimatic zoning of the territory of Ukraine taking into account climate change, 18.

Balyuk S.A. (2009). Scientific bases of protection and rational use of irrigated lands of Ukraine: *Agrarian science*, 40-45.

Barabash M., Kulbida M. & Korzh T. (2004). Global climate change and the problem of desertification of Ukraine. *Scientific notes of Ternopil, 2*, 82-88.

Borovik V.O. & Stepanov Y.O. (2014). The historical path of development of cotton breeding at the Institute of Irrigated Agriculture. *Irrigated agriculture, 62*, 95-98.

Borovik V.O. (2009). Formation of different maturity groups of cotton in a collection nursery, depending on the sum of effective temperatures above 10 °C in the conditions of irrigation of the south of Ukraine. *Irrigated agriculture, 52*, 279-284.

Borovik V.O., Stepanov Y.O., Klubuk V.V., Baranchuk V.A., Osiniy M.L. & Kuzmich V.I. (2011). Ecological testing of Bulgarian cotton varieties in the southern region of Ukraine. *Irrigated agriculture, 55*, 274-282.

Borovik V.O., Tishchenko O.D. & Kobilina N.O. (2010). Formation and effective use of genetic resources of agricultural crops at the Institute of Agriculture of the southern region of NAAS of Ukraine. *Irrigated agriculture, 53*, 421-429.

Gusev M.G., Snihovyi V.S., Kokovikhin S.V. & Sevidov O.F. (2007). Intensification of field fodder production on irrigated lands of the South of Ukraine. Kyiv: *Agrarian Science*, 240.

Kovalenko A.M. (2012). Adaptation of steppe agriculture to increasing the aridity of the climate. Kherson: Aylant. *Irrigated agriculture: interdepartmental, 58*, 21-23.

Kruchinina A. (2014). Blue prospects. *Agro-Perspective, 4*, 22-29.

Melnichuk S.I & Adamenko T.I. (2011). Agroclimatic guide to the Kherson region: 1986-2005. Ministry of Emergency Situations of Ukraine; Kherson. reg. Center for Hydrometeorology. Odesa: Astroprint, 208.

Netis I.T. (2004). The nature of autumn and spring and winter wheat crops. Kherson: Aylant, 151.

Vozhehova R.A. & Kovalenko A.M. (2013). Climate change in the southern region and directions of adaptation of agriculture to them. Handbook of Ukrainian farmers "Adaptive Agriculture": Kyiv: ACADEMPRESS LLC (1), 189-190.

Vozhehova R.A. (2014a). Adaptation of agricultural systems in southern Ukraine to climate change. Agrarian Week. Ukraine. Retrieved from: https://a7d.com.ua/plants/39730–adaptacya–sistem–zemlerobstva–na–pvdn–ukrayini–do–zmn–klmatu.html

Vozhehova R.A. (2014b). Methods of field and laboratory research on irrigated lands, 286.

Vozhehova R.A., Ryabchun V.K. & Borovik V.O. (2014). Wide unified classifier – directory of the genus *Gossypium hirsutum L.* NAAS, Institute of Irrigated Agriculture, 49.