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NEW BULGARIAN HIGH YIELDING COTTON VARIETIES - KRISTAL, ORFEY AND SNEJINA

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Abstract

Productivity and technological fiber properties of three new cotton varieties - Kristal, Orfey and Snejina, created by intraspecific (G. hirsutim L.) hybridization and included in varietal trials carried out at the Field Crops Institute in Chirpan, were studied. The three varieties, in seed cotton yield, on average over a three-year period, exceeded the standard cultivar Chirpan-539 by 9.1%, 12.8% and 23.0%, respectively. These varieties combined higher productivity with higher lint percentage, greater boll weight in Orfey and Snejina and higher 1st fruit branch in Kristal and Orfey. In the State Variety Test, Kristal variety in seed cotton yield was equal to the cultivar Chirpan-539, surpassed the cultivar Avangard-264 by 6.4%, and in lint yield exceeded both standards, respectively by 2.3% and 13.3%. Orfey variety in seed cotton yield and lint yield was equal to the standard cultivars. Snejina variety in seed cotton yield of 2155 kg.ha^{-1} and in lint yield of 876 kg.ha^{-1} exceeded both standards, Chirpan-539 by 3.5% and 3.2% respectively, Avangard-264 - by 6.1% and 4.4%. All three varieties had good fiber quality.

Key words*: cotton, G. hirsutum L., fiber properties, lint yield, seed cotton yield.*

INTRODUCTION

Cotton is a leading crop in the production of natural fibers for the textile industry (Voora et al., 2020). The main product is fiber for which cotton is grown. Various cotton fabrics are produced from it, which, in addition to clothing, are used to make tarpaulins, filters, etc. Seeds are a secondary product, they find different uses, mainly various oils are produced that are used in the food, pharmaceutical and cosmetic industries and for other technical purposes. Cotton is grown in many countries, in all continents. In Europe, cotton is grown on larger areas in Spain and Greece, and on very small areas in Portugal and Bulgaria. In Europe, cotton is subsidized by the European Union.

The success of breeding programs in cotton largely depends on the available genetic resources, the selection of parental forms in hybridization programs, the genetic and breeding research, the evaluation and effective use of genetic diversity. Although cotton genetic resources worldwide are limited, cotton breeding is developing dynamicaly. Many foreign varieties as Uzbek, American, Greek, Spanish and Ukrainian have played positive role in the cotton breeding in our country.

Global climate changes and warming are placing emphasis on the creation of varieties tolerant to prolonged droughts. Therefore, many studies with cotton are conducted in two backgrounds with and without irrigation or in different environments - years with different temperature sums and rainfall. Economic and ecological technologies require varieties highly responsive to intensive factors such as irrigation and fertilization. Vozhehova et al. (2022) evaluated cotton gene pool samples in different years of heat supply, with and witout irrigation, and identified more than 30 sources of economically valuable traits with high adaptability to different environmental conditions, including drought resistance, ultra early maturity and others. Two new high yielding and very early cotton varieties Dniprovskyi 5 and Pidozerski 4 have been created. Other researchers (Gospodinova & Stoyanova, 2020) studied the correlation dependences of productivity and its structural elements on irrigated and non-irrigated background and in another research (Gospodinova et al., 2020) they studied the productivity of irrigation water. Muhova & Dobreva (2022) studed the effect of mineral fertilization as well as the influence of year conditions on the seed cotton yield.

In Bulgaria, the cotton areas decreased sharply after 1989, due to the general crisis in agriculture, lack of incentives for cotton production and other economic reasons. In recent years, there is an unstable trend in the growth of cotton area.

Despite the difficult economic conditions, cotton breeding in our country continued to develop at a relatively good pace (Dimitrova et al., 2022).

After 2010 in a very short period significant results were achieved, many new cotton varieties were created: Dorina (Stoilova & Nistor, 2012); Rumi and IPK Nelina (Stoilova & Meluca, 2013); Philipopolis, Denitsa, Sirius (Valkova, 2014a; 2014b; 2017); Tsvetelina (Koleva & Valkova, 2019). Classical selection methods intra- and interspecific hybridization and experimental mutagenesis (Philipopolis, Sirius and Tsvetelina varieties) were applied. These methods have not yet exhausted their potential to create genetic diversity and new cotton varieties.

During this period colored brown cotton varieties Egea and Nike were created (Stoilova & Dimitrova, 2017). With these two varieties, considerable progress has been made in improving the fiber quality of colored cottons through selection. Both varieties were distinguished by longer fiber and better spinning characteristics than Izabell variety, the standard for coloured cotton.

New achievements are the varieties Aida, Anabel, Tiara, Melani (Dimitrova, 2022a; 2022b; 2023), Pirin, Perun (Koleva & Valkova, 2023) and Selena (Dimitrova & Nedyalkova, 2023).

The aim of this research is to study the productive potential and evaluate the fiber quality of three new cotton varieties Kristal, Orfey and Snejina, in comparison with the approved standard varieties.

MATERIALS AND METHODS

Breeding material

Kristal variety. Kristal variety was obtained from intraspecific cross of Chirpan-539 × Helius (Bulgarian cultivars). The cultivar Chirpan-539 is very early, high yielding and is distinguished by high lint percentage, ecological plasticity and stability. The cultivar Helius was created by experimental mutagenesis, by irradiating seeds of the Uzbek variety C-6530 with gamma rays. Compared to the cultivar Chirpan-539, the cultivar Helius has better earliness, higher productivity and greater fiber strength. In 2010, the stabilized line (No. 710) was selected, which in 2011 was tested in a control nursery. Since 2012, the line has been in variety testing, in 2012 - in preliminary, and from 2013 to 2015 it was included in competitive variety trials.

Orfey variety. Orfey variety was obtained from the cross of Helius × Chirpan-539. In 2013, as selection line No. 778 was tested in a control nursery, in 2014 it was in a preliminary variety test, and during 2015-2017 it was included in competitive variety trials.

Snejina variety. Snejina variety was also created by intraspecific hybridization between the Bulgarian Boyana variety and selection line No. 456 (Boyana × No. 456). In 2015, as selection line No. 865 was tested in a control nursery, in 2016 - in a preliminary variety test, and during 2017-2019 it was included in competitive variety trials.

In the IASAS system, Kristal variety was tested in 2019-2020, while Orfey and Snejina varieties were tested in 2021-2022.

Experimental performances

The trials were carried out in the experimental field of the Field Crops Institute in town of Chirpan on pellic vertisol, by the block method, in 4 replications, and a 20 m^2 harvest plot. The cultivar Chirpan-539 was used as a standard. Standard cotton growing technology was applied. Ten plants of each replicate were observed. The assessment of economic qualities was based on the following characters: seed cotton yield ($kg.ha^{-1}$), lint yield ($kg.ha^{-1}$), boll weight (g), lint percentage (%) and mean fiber length (mm). A two-factor analysis of variance was performed on the results obtained (Genchev et al., 1975; Shanin, 1977; Lidanski, 1988). The ANOVA program was used.

In the IASAS system (Executive Agency for Variety Testing, Approbation and Seed Control - State Variety Testing), Kristal variety was tested (2019-2020) in only one location at the Experimental Station for Variety Testing in Radnevo, while Orfey and Snejina varieties (2021-2022) in 2021 were tested in one location in Radnevo, and in 2022 they were tested in two

locations in Radnevo and at the Experimental Station for Variety Testing in Plovdiv city.

The standard cultivars were Chirpan-539 for earliness and productivity and Avangard-264 for fiber quality. These two cultivars are the national cotton standards. In the State Variety Testing (IASAS) the new cotton varieties were compared with the two standard cultivars and with an average standard, the average of the two standards. Fiber properties were measured with HVI.

The three-year periods during which the competitive variety trials were conducted (2013-2015 for Kristal, 2015-2017 for Orfey and 2017-2019 for Snejina) included years with different temperature and rainfall supply.

The first period included two warm years - 2013 and 2015 (P=10.34%; 16.0%) and one average year - 2014 (P=55.17%); 2013 was moderately dry (P=78.16%), 2014 was wet to moderately wet (P=21.84%), 2015 was moderately wet to medium (P=40.0%).

The second period included two warm years - 2015 and 2017 (P=16.0%; 17.86%) and one moderately warm year - 2016 (P=34.62%), of which 2015 moderately wet to medium (P= 40.0%), 2016 very dry (P=115.38%) and 2017 medium (P=35.71%).

During the third period of the study, all three years (2017-2019) were warm (P=17.22-20.0%), of which 2017 moderately wet (P=35.71%), 2018 wet (P=13.79%) and 2019 moderately wet (P=23.33%).

P% is the coverage factor (coefficient of supply) for the temperature sum in May-September and for the rainfall in May-August. The years of study were compared with the multi-year averages of base period of the last 30 years (1991-2020). This period was taken as a climatic norm (Alexandrov et al., 2010).

RESULTS AND DISCUSSIONS

Results of the new varieties tested at the Field Crops Institute in Chirpan

Economic indicators

Kristal variety. Results for the economic indicators show that in the period 2013-2015 the seed cotton yields for the standard cultivars and for variety were the highest in the first year of study (Table 1). In 2013, the cotton growing season passed under relatively favorable conditions in terms of rainfall (in the month of July they were 35.8 mm above the norm) and higher temperatures. In this year, Kristal variety in seed cotton yield of 2,054 kg.ha^{-1} was equal to the standard cultivar. In 2014, yields were lower due to lower temperatures during the cotton growing season. Rainfall in July was also below normal. In this year, the seed cotton yield of Kristal variety was 2,022 kg.ha^{-1}, by 14.2% above the standard cultivar and the difference was statistically significant at $p \leq 0.001$. In the third year, the seed cotton yields were the lowest, which was due to the scanty rainfall (13 mm or 42.2 mm below the norm) and high stressful temperatures (35ºC above the norm) in the month of July. In this year, seed cotton yield of 1,588 kg.ha^{-1} was obtained from Kristal variety, exceeding the standard cultivar by 16.4%, statistically significant at $p \leq 0.001$. Averaged over the three years, Kristal variety in seed cotton yield of 1,864 kg.ha^{-1} exceeded the standard cultivar by 7.7%, significant at $p \leq 0.05$. Kristal variety had 0.3 g less boll weight than the standard cultivar. In lint percentage it exceeded the standard cultivar by 0.7%, in fiber length was equal to it. Kristal variety formed a higher first fruit branch at 18.1 cm, which makes it very suitable for machine harvesting.

Orfey variety. Results for the economic indicators of Orfey variety (2015-2017) are presented in Table 2. Seed cotton yields were lower in the first test year and slightly higher in the third year. The most unfavorable year for cotton during this period was 2016, rainfall during the cotton growing season was very scarce, the drought was prolonged and covered the summer months of June, July and early August, and the temperatures were higher. For the month of July, rainfall was only 4 mm, which was 51.2 mm less than the multi-year average. In 2017, the cotton growing season also passed with insufficient rainfall in July – 35.4 mm, which was 19.8 mm less than the average for many years, and higher temperatures in the summer months.

Table 1. Economic indicators of Kristal variety in competitive variety trials for a three year period (2013-2015)

Variety	Seed cotton yield kg.ha^{-1}			Average	St %	Boll weight, g	Lint percentage, %	Fiber length, mm	Height of the 1st fruit branch, cm
	2013	2014	2015						
Chirpan-539	2,055	1,771	1,364	1,730	100.0	5.5	37.6	25.7	17.1
Kristal	2,055	2,022 ***	1,588 ***	1,888 ***	109.1	5.2	38.3	25.5	18.1
GD 5%		81.70	52.0	54.6	3.1				
GD 1%		123.9	78.7	75.5	4.6				
GD 0.1%		198.9	126.5	104.4	6.0				

Table 2. Economic indicators of Orfey variety in competitive variety trials for a three year period (2015-2017)

Variety	Seed cotton yield kg.ha^{-1}			Average	St %	Boll weight, g	Lint percentage, %	Fiber length, mm	Height of first fruit branch, cm
	2015	2016	2017						
Chirpan-539	1,337	1,361	1,471	1,390	100.0	4.9	36.9	25.3	17.7
Orfey	1,508 ***	1,551 ***	1,646 ***	1,568 ***	112.8	5.1	37.5	25.3	18.2
GD 5%	56.0	46.1	55.9	27.0	1.9				
GD 1%	84.8	69.8	84.7	37.3	2.7				
GD 0.1%	136.3	112.1	136.0	51.6	3.7				

For Orfey variety seed cotton yields by years ranged from 1,508 kg.ha^{-1} in 2015 to 1,646 kg.ha^{-1} in 2017 and exceeded the standard cultivar by 12.8% in 2015 to 14.0% in 2016. Differences in all three years of study were statistically significant at $p \leq 0.001$. On average for the three years, Orfey variety in seed cotton yield of 1,568 kg.ha^{-1} exceeded the standard cultivar by 12.8% significant at $p \leq 0.001$. The boll weight was by 0.2 g greater than that of the standard cultivar. The lint percentage was higher by 0.6%. In fiber length it was equal to the standard cultivar. Orfey variety also formed a littel higher first fruit branch.

Snejina variety. Seed cotton yields for Snejina variety and the standard cultivar (2017-2019) were highest in the third test year and lowest in the second one, but were close to those in the first year (Table 3). The last two years were characterized by excessive above-normal rainfall in the months of June and July, in larger amounts in 2019 (91.6 mm above the norm) and lower temperatures in July (31ºC and 14ºC below the norm, for 2018 and 2019, respectively). During all test years from Snejina variety higher yields than the standard cultivar were obtained, from 1,755 kg.ha^{-1} in 2018 to 2,110 kg.ha^{-1} in 2019, exceeding it by 20.9% to 28.9%. On average for the three years, seed cotton yield of 1,891 kg.ha^{-1} was obtained from Snejina variety, exceeding the standard cultivar by 23.9%.

Differences during all three years and the average for the test period were statistically significant at $p \leq 0.001$. Snejina variety had higher boll weight by 0.2 g and higher lint percentage by 0.6% than the standard cultivar. In fiber length and height of 1st fruit branch Snejina variety was equal to the standard cultivar.

The results obtained show that in all three years of study higher yields were realized from the new varieties compared to the standard cultivar, except for Crystal variety in the first test year, when it was leveled with the standard. Their higher productivity was combined with other valuable economic qualities: higher lint percentage; higher boll weight in Orfey and Snejina varieties and higher setting of the 1st fruit branch in Kristal and Orfey. In terms of fiber length, all three varieties were equal to the standard cultivar.

Table 3. Economic indicators of Snejina variety in competitive variety trials for a three year period (2017-2019)

Variety	Seed cotton yield kg.ha^{-1}			Average	St %	Boll weight, g	Lint percentage, %	Fiber length, mm	Height of first fruit branch, cm
	2017	2018	2019						
Chirpan-539	1,471	1,362	1,745	1,526	100.0	4.9	36.9	25.3	18.3
Snejina	1,807 ***	1,755 ***	2,110 ***	1,891 ***	123.9	5.1	37.5	25.3	18.7
GD 5%	160.3	66.1	87.8	52.4	3.4				
GD 1%	242.8	100.0	132.9	72.5	4.7				
GD 0.1%	390.3	160.7	213.5	100.2	6.6				

Results of the State Variety Test

Biological and economic qualities

Kristal variety. Results of the State Variety Test of Kristal variety in 2019-2020 are presented in Table 4. Seed cotton yields of the standard cultivars and the new Kristal variety were higher in the first test year. In this year, Kristal variety realized the highest seed cotton yield of 3,511 kg.ha^{-1} exceeding insignificant the average standard by 4.2%, the cultivar Chirpan-539 - by 3.7%, the cultivar Avangard-264 - by 4.8%. In the second test year, Kristal variety in seed cotton yield of 2,055 kg.ha^{-1} was insignificant inferior to the cultivar Chirpan-539 by 5.7%, superior to the cultivar Avangard-264 by 9.3%, significant at $p \leq 0.05$, and to the average standard by 1.2%, insignificant. On average for the two years, Kristal variety yielded 2,783 kg.ha^{-1}, leveling with the standard for productivity Chirpan-539, surpassing the cultivar Avangard-264 by 6.4% and the average standard by 3.1%.

Regarding lint yield, the same trend was observed as for seed cotton yield. Lint yields of the standard varieties and Kristal variety were higher in the first test year, which was due to the higher seed cotton yields obtained. The highest lint yield of 1,478 kg.ha^{-1} was obtained from Kristal variety, exceeding by 12.0% the cultivar Avangard-264, by 7.3% the cultivar Chirpan-539 and by 9.6% the average standard. In the second test year, Kristal variety in lint yield was inferior to the cultivar Chirpan-539 by 5.6%, exceeded the cultivar Avangard-264 by 15.8% and the average standard by 4.0%. Averaged over the two years, lint yield was highest for Kristal variety – 1,142 kg.ha^{-1}, exceeding the two standard cultivars Chirpan-539 and Avangard-264 by 2.3% and 13.3%, respectively, and the average standard by 7.5%.

In 2019, the highest lint percentage was recorded for Kristal variety - 42.1%, at 40.7% for Chirpan-539 and 39.4% for Avangard-264 (Table 5).

Table 4. Seed cotton yield and lint yield of Kristal variety tested at the Experimental Station for Variety Testing in Radnevo at the IASAS in 2019-2020

Varieties		Seed cotton yield kg.ha^{-1}				Lint yield kg.ha^{-1}			
		2019	2020	Mean	%	2019	2020	Mean	%
Av. standard		3,368	2,031	2,699	100.0	1,349	775	1,062	100.0
Chirpan-539		3,384	2,180	2,782	103.1	1,378	854	1,116	105.1
Avangard-264		3,351	1,881	2,616	96.9	1,320	696	1,008	94.9
Kristal		3,511	2,055	2,783	103.1	1,478	806	1,142	107.5
	5%	204	95						
GD	1%	274	126						
	0.1%	361	165						

In the second year, Kristal variety by this indicator was leveled with the cultivar Chirpan-539. On average for the two years, Kristal variety in lint percentage of 40.7% exceeded the cultivar Chirpan-539 by 0.8%, the cultivar Avangard-264 - by 2.5%, the average standard -

by 1.6%, which also contributes to an increase in lint yield per hectare, but the realized higher seed cotton yield in the first test year had decisive role.

Kristal variety in the length of growing season was equal to Chirpan-539. This variety attached higher first fruit branch than the standard cultivars.

Table 5. Economic indicators of Kristal variety tested at the Experimental Station for Variety Testing in Radnevo at the IASAS in 2019-2020

Varieties	Lint percentage - %			Height of first fruiting branch, cm			Vegetation period, days		
	2019	2020	Mean	2019	2020	Mean	2019	2020	Mean
Av. standard	40.1	38.1	39.1	18.2	20.6	19.4	-	105	-
Chirpan-539	40.7	39.2	39.9	18.5	21.4	19.9	-	104	-
Avangard-264	39.4	37.0	38.2	17.8	19.7	18.7	-	105	-
Kristal	42.1	39.2	40.7	19.3	21.9	20.6	-	104	-

Orfey and Snejina varieties. In the State Variety Test, in the first year, Orfey variety in seed cotton yield of 1,968 kg.ha^{-1} was insignificant inferior to the cultivar Chirpan-539 by 4.4% and to the average standard by 1.1% and insignificant surpassed the cultivar Avangard-264 by 2.1% (Table 6). The highest seed cotton yield was obtained from Snejina variety – 2,111 kg.ha^{-1} surpassing insignificant the cultivar Chirpan-539 by 2.8%, the cultivar Avangard-264 – by 9.5%, significant at $p \leq 0.01$, and the average standard – by 6.1%, significant at $p \leq 0.05$.

In the second year, the testing of the two varieties took place in two locations - Radnevo and Plovdiv. Seed cotton yields were higher in the typical for cotton Radnevo region. In this location, the highest seed cotton yield was obtained from the cultivar Avangard-264. Difference between the two standards was insignificant. The two new varieties achieved almost equal yields, slightly lower than the culrivar Avangard-264, but the differences were statistically insignificant. In the region of Plovdiv, Orfey variety leveled with Chirpan-539 and insignificantly surpassed Avangard-264 by 3.4%. Snejina variety achieved the highest seed cotton yield of 1,969 kg.ha^{-1}, by 8.2% more than the cultivar Chirpan-539, 11.5% more than the cultivar Avangard-264, and 9.8% more than the average standard. Averaged the results of the two locations show that the difference between the two standards in seed cotton yield was very small, the cultivar Avangard-264 had very slight superiority. Orfey variety in seed cotton yield was equal to the standard cultivar Avangard-264. Snejina variety outperformed both standard cultivars, Avangard-264 by 3.0%, significant at $p \leq 0.05$, Chirpan-539 - by 3.9%, significant at $p \leq 0.01$, and the average standard - by 3.5%, significant at $p \leq 0.05$.

Table 6. Seed cotton yield of Orfey and Snejina varieties tested in the IASAS system in 2021-2022

Varieties		Seed cotton yield, kg.ha^{-1}				Mean kg.ha^{-1} 2021-2022	%
		2021	2022				
		Radnevo	Radnevo	Plovdiv	Average 2022		
Av. standard		1,990	2,456	1,793	2,125	2,057	100.0
Chirpan-539		2,053	2,411	1,820	2,115	2,084	101.3
Avangard-264		1,928	2,501	1,766	2,134	2,031	98.7
Orfey		1,968	2,444	1,826	2,135	2,051	99.7
Snejina		2,111	2,430	1,969	2,199	2,155	104.8
GD	5%	106	155	63	63		
	1%	141	206	84	83		
	0.1%	183	267	109	108		

Averaged over the two years, Orfey variety very slightly outperformed the cultivar Avangard-264, very slightly was inferior to the cultivar Chirpan-539 and was equal to the average standard. Snejina variety realized higher seed cotton yield than the two standards - 2,155 kg.ha^{-1},

surpassing Chirpan-539 by 3.4%, Avangard-264 - by 6.1% and the average standard - by 4.8%. This was due to the better performance of Snejina variety in the region of Plovdiv.

In the first test year, higher lint yield was obtained from the cultivar Chirpan-539, while in the second test year the lint yield was higher for the cultivar Avangard-264 (Table 7). In the first year, Orfey variety in lint yield was inferior to Chirpan-539 by 1.8%, surpassed Avangard-264 by 4.7%, the average standard - by 1.3%. In this year, Snejina variety in lint yield exceeded both standards by 4.1% and 11.1%, respectively, the average standard – by 7.5%. In the second year, Orfey variety had the lowest lint yield, approaching Chirpan-539, it was inferior to Avangard-264 by 3.8% and to the average standard by 2.3%. Snejina variety exceeded Chirpan-539 by 2.3% and was equal to the average standard. On average for the two years, Orfey variety in lint yieald of 738 kg.ha^{-1} was equal to the cultivar Avangard-264, very slightly was inferior to the cultivar Chirpan-539 and to the average standard. Snejina variety realized the highest lint yield of 876 kg.ha^{-1}, surpassing both standard cultivars, Chirpan-539 - by 3.2%, Avangard-264 - by 4.4%, the average standard - by 3.8%.

Snejina variety had the highest lint percentage on average for the two years and the highest first fruit branch. Orfey variety in lint percentage was equal to Chirpan-539 and attached the first fruit lower than the two standard varieties.

Orfey variety has matured on a par with the cultivar Chirpan-539, Snejina variety two days later. Vegetation period of the standard cultivars was on average 107 days and 109 days for Chirpan-539 and Avangard-264, respectively, and 107 days and 109 days for Orfey and Snejina varieties.

All three varieties on a natural infection background did not show the development of verticillium wilt and bacteriosis. On an artificial infectious background, Orfey variety was sensitive to the agents of verticillium wilt, while the other two varieties were resistant.

Kristal variety was approved by the IASAS in 2021, Orfey and Snejina varieties were approved one yiear later in 2022. All three varieties were protected by certificates.

Table 7. Economic indicators of Orfey and Snejina varieties tested in the IASAS system in 2021-2022

Varieties	Lint yield in Radnevo, kg.ha^{-1}				Lint percentage, %			Height of first fruiting branch, cm		
	2021	2022	Average	%	2021	2022	Average	2021	2022	Average
Av. standard	747	941	844	100.0	37.5	38.3	37.9	28	24.6	26.3
Chirpan-539	771	928	849	100.6	37.5	38.5	38.0	27	24.6	25.8
Avangard-264	723	955	839	99.4	37.5	38.2	37.9	28	24.5	26.3
Orfey	757	919	838	99.3	38.5	37.6	38.1	24	24.8	24.4
Snejina	803	949	876	103.8	38.0	39.1	38.5	29	26.0	27.5

Technological fiber qualities

Kristal variety. Technological fiber qualities of Kristal variety are presented in Table 8. In terms of spinning, consistency index, micronaire, maturity index, uniformity in length, elongation, spectroscopy with reflectance of the difference and yellowness, averaged over the two years, Kristal variety was equal to the standard cultivars. The cultivar Avangard-264 had longer fiber length and lower fiber strength than the cultivar Chirpan-539. Kristal variety in Upper Half Mean Length of 24.68 mm, on average for the two years, was equal to the cultivar Chirpan-539 and was inferior to the cultivar Avangard-264 by 0.58 mm, to the average standard - by 0.23 mm. In fiber strength - 26.5 g.tex^{-1} it was on a par with the cultivar Avangard-264, slightly inferior to Chirpan-539 (27.5 g.tex^{-1}) and the average standard. Kristal variety showed a lower content of short fibers than the standard cultivar Chirpan-539 although it was equal to it in fiber length and a higher degree of color (Good Middling) in 2019 than the two standard cultivars (Strict Middling). In 2020, Kristal variety and the standard cultivars had very white fiber, i.e. they were of very high Good Middling (GM) quality regarding coloration for white cotton.

Table 8. Technological fiber qualities of Kristal variety according to IASAS data (2019-2020)

Mean 2019-2020		Average standard	Chirpan-539	Avangard-264	Kristal
Spinning Consistency Index (SCI)		107.5	107.5	107.0	107
Micronaire (Mic)		4.99	5.09	4.88	4.99
Maturity (Mat) Index		0.88	0.88	0.87	0.87
Upper Half Mean Length (UHML), mm		24.91	24.55	25.26	24.68
Uniformity (UL) %		81.3	81.5	81.1	81.7
Short fibers (SFL), 12.7 mm		9.5	10.1	9.1	8.9
Strength (Str), g tex^{-1}		27.1	27.5	26.7	26.5
Elongation (Elg), %		7.3	7.2	7.3	7.2
Spectroscopy with reflectance of the difference RD		81.3	81.2	81.5	81.7
Yellowness (+b)		8.9	8.8	8.9	9.0
Colour Grade(C Grad) Upland	2019	-	21-1	21-1	11-1
	2020	11-1	11-1	11-1	11-1

Orfey and Snejina varieties. Orfey variety in spinning, consistency index, maturity and uniformity in fiber length was equal to the standard cultivars (Table 9). This variety had slightly higher micronaire than the two standard cultivars, meaning the fiber was slightly coarser. Fiber was shorter by 0.5 mm than that of the cultivar Chirpan-539. Its fiber strength was slightly better than both standards, more pronounced with respect to Avangard-264. In fiber elongation it was slightly inferior to the two standard cultivars. By spectroscopy with reflectance of the difference and yellowness it was inferior to Avangard-264 and was equal to Chirpan-539. In terms of color, in the first year, Orfey variety (21-2) was equal to the standard cultivars (21-2) for Chirpan-539 and (21-1) for Avangard-264, while in the second year it was in a slightly lower class (21-1 SM) of both standards (11-2 GM).

Snejina variety in terms of spinning, consistency index (99), fiber length (23.86 mm) and fiber strength (26.7 g.tex^{-1}) was inferior to the standard cultivars and the average standard. As for micronaire value it exceeded both standards, meaning the fiber was slightly coarser. In terms of maturity and elongation of the fiber it was equal to the standards. Regarding uniformity in fiber length and content of short fibers, Snejina variety was inferior to Chirpan-539 and was equal to Avangard-264. As regards spectroscopy with reflectance of the difference (81.3) it was superior to Chirpan-539 and was equal to Avangard-264. In terms of yellowness, it very slightly exceeded Chirpan-539 and was equal to Avangard-264.

According to the international cotton fiber quality standards and cotton classification (Official Cotton Standards, 2009-2010) by micronaire value, the standard cultivars (5.09 mic and 4.88 mic and 5.42 mic and 5.39 mic, for both periods) and the new varieties (4.99 mic for Kristal, 5.50 mic and 5.57 mic for Orfey and Snejina) refered to the groups “medium fine” (from 4.0 mic to 4.9 mic, Kristal variety) and “medium coarse” (from 5.0 mic to 5.9 mic). In terms of fiber maturity all three varieties (0.86-0.89) were equal to the standard varieties (0.86-0.88) and belonged to the group “mature” (0.85-0.95). In fiber elongation the standard cultivars (7.2-7.3% and 8.9-9.1%) and the new varieties 7.2% for Kristal and 8.4-8.9% for Orfey and Snejina belonged to the groups “medium” (7-8) and “fairly good” (8-9). The standard cultivars in fiber length (24.55-25.26 mm) and the new varieties (23.86-24.68 mm) belonged to the group “medium staple” (20.6-25.4 mm). Regarding uniformity in fiber length the two standards (81.1-82.1%) and the three varieties (81.3-81.7%) belonged to the group “high uniformity”. In terms of fiber strength, the standard cultivars (26.7-27.5 g.tex^{-1} and 28.0-28.3 g.tex^{-1} for the two periods) and the three new varieties (26.5-26.7 g.tex^{-1} for Kristal and Snejina, and 28.5 g.tex^{-1} for Orfey) were related to the group “healthy” (26-29 g tex^{-1}).

Kristal and Snejina varieties had very white fiber (GM), Orfey was one grade below them (SM).

Table 9. Technological fiber qualities of Orfey and Snejina varietes according to IASAS data (2021-2022)

Mean 2021-2022		Average standard	Chirpan-539	Avangard-264	Orfey	Snejina
Spinning Consistency Index (SCI)		108	111	106	108	99
Micronaire (Mic)		5.41	5.42	5.39	5.50	5.57
Maturity (Mat) Index		0.87	0.87	0.87	0.87	0.87
Upper Half Mean Length (UHML), mm		24.77	24.97	24.55	24.47	23.86
Uniformity (UL) %		81.8	82.1	81.4	81.7	81.3
Short fibers (SFL), 12.7 mm		8.8	8.3	9.3	8.7	9.4
Strength (Str), g tex^{-1}		28.1	28.3	28.0	28.5	26.7
Elongation (Elg), %		9.1	8.9	9.1	8.4	8.9
Spectroscopy with reflectance of the difference RD		80.9	80.3	81.3	80.4	81.3
Yellowness (+b)		8.8	8.6	8.9	8.5	8.9
Color Grade (C Grad) Upland	2021	21-2	21-2	21-1	21-2	11-2
	2022	11-2	11-2	11-2	21-1	11-1

According to the international qualifications, the standard cultivars and the new varieties were generally of good fiber quality.

CONCLUSIONS

Kristal, Orfey and Snejina varieties emerged as more productive than the cultivar Chirpan-539, the standard for productivity, and on average over a three-year period exceeded it by 9.1%, 12.8% and 23.9%, respectively. Their higher productivity was combined with other valuable economic qualities as higher lint percentage, greater boll weight in Orfey and Snejina and higher setting of the 1st fruit branch in Kristal and Orfey.

In the State Variety Test, Kristal variety in seed cotton yield of 2,783 $kg.ha^{-1}$, on average for the two years, was equal to the cultivar Chirpan-539, surpassed the cultivar Avangard-264 by 6.4% and the average standard by 3.1%. In terms of lint yield of 1,142 $kg.ha^{-1}$ it exceeded both standards by 2.3% and 13.3%, respectively, and the average standard by 7.5%. Orfey variety in seed cotton yield and lint yield was equal to the standards.

Snejina variety realized the highest productivity and in seed cotton yield of 2,155 $kg.ha^{-1}$ and lint yield of 876 $kg.ha^{-1}$ surpassed both standard cultivars, Chirpan-539 by 3.5% and 3.2% respectively, Avangard-264 - by 6.1% and 4.4%, and the average standard - by 4.8% and 3.8%.

All three varieties were of good fiber quality, medium long, medium fine to slightly coarse, strong to very strong for Orfey, with high uniformity and medium to medium good elongation, and very good whiteness.

These three new varieties enrich the gene pool of Bulgarian cotton and are valuable starting material for selection. Snejina variety can be implemented in cotton production.

REFERENCES

Alexandrov, V., Simeonov, P., Kazandzhiev, V., Korchev, G., Yotova, A. (2010). *Climate change*. NIMH BAS.

Dimitrova, V., Nedyalkova, S. (2023). Selena – a new cotton variety. *Bulg. J. Agric. Sci* (in press).

Dimitrova, V. (2022a). A new cotton variety Aida. *Bulgarian Journal of Crop Science*, 59(1), 43–50.

Dimitrova, V. (2022b). Anabel – a new cotton variety. *Bulgarian Journal of Crop Science*, 59(4), 56–63.

Dimitrova, V. (2023). Agronomic performance and fiber quality of the new cotton varieties Tiara and Melani. *Bulg. J. Agric. Sci*., 29(4), 632–640.

Dimitrova, V., Valkova, N., Koleva, M., Nedyalkova, S. (2022). Directions and achievements of cotton breeding in Bulgaria. *Proceedings of IV International Agricultural, Biological & Life Science Conference*, Edirne, Turkey, 29-31 August 2022, 865–882.

Genchev, G., Marinkov, V., Yovcheva, V., Ognyanova, A. (1975). *Biometrical methods in plant science, genetics and breeding*. ZEMIZDAT, Sofia (Bg).

Gospodinova, G., Stoyanova, A. (2020). Study on the productivity of irrigation water on cotton crop. *Scientific Papers. Series A. Agronomy,* LXIII(1), 308–313.

Gospodinova, G., Stoyanova, A., Kuneva, V. (2020). Correlation dependence between biometric indicators and productivity in three cotton varieties. *Scientific Papers. Series A. Agronomy*, LXIII(2), 107–112.

Koleva, M., Valkova, N. (2019). "Tsvetelina" - new high yielding variety of cotton. *Field Crops Studies*, 12(1), 93–102, http://fcs.dai-gt.org/bg/.

Koleva, M., Valkova, N.(2023). Characteristics of the new cotton varieties Pirin and Perun. *Bulgarian Journal of Crop Science*, 60(1), 69–77.

Lidanski, T. (1988). *Statistical methods in biology and agriculture*. ZEMIZDAT, Sofia (Bg).

Muhova, A., Stefanova-Dobreva, S. (2022). Seed cotton yield and yield components affected by the mineral fertilization and the weather conditions. *Scientific Papers. Series A. Agronomy*, LXV(1), 440–446.

Official Cotton Standards (2009-2010). Cotton Council International.

Shanin, Y. (1977). *Methodology of field experience*. Publishing House of the Bulgarian Academy of Sciences, Sofia. Institute of Soil Science and Production Planning "N. Pushkarov" – Sofia (Bg).

Stoilova, A., Dimitrova, V. (2017). Egea and Nike - new brown cotton varieties. *Bulgarian Journal of Crop Science*, 54(4), 41–51.

Stoilova, A., Meluca, Cr. (2013). Rumi and IPK Nelina – new cotton varieties. *Agricultural Science and Technology*, 5(3), 247–251 (Bg).

Stoilova, A., Nistor, T. (2012). Dorina – new cotton variety. *Rastenievadni nauki*, 49(1), 7–12 (Bg).

Valkova, N. (2014a). Characteristics of "Philipopolis" cotton variety. Jubilee Scientific Conference, 90 years Maize Institute, Kneja, September 10-11, 2014, Kneja. In: *Proceedings "Selection and Genetic and Technological Innovations in Cultivation of Cultural Plants"*, 206–214 (Bg).

Valkova, N. (2014b). Denitsa - a new high yielding cotton variety. *Field Crop Studies* 9(2), 227–232 (Bg).

Valkova, N. (2017). New cotton variety Sirius. *Rastenievadni nauki (Bulgarian Journal of Crop Science*) 54(1), 40–45 (Bg).

Voora, V., Larrea, C., Bermudez, S. (2020). Global market report: Cotton (Winnepeg, Canada: International Institute for Sustainable Development (IISD), JSTOR).

www.cottoninc.com/fiber/quality/Classification-of-Cotton/Classification-of-U…

Vozhehova, R., Borovik, V., Kokovikhin, S., Biliaieva, I., Kokovikhina, O., Bolarkina, L., Shkoda, O. (2022). Evaluation of cotton gene pool samples in different years of heat suplay in the conditions of the Southern steppe of Ukraine. *Scientific Papers. Series A. Agronomy*, LXV(2), 313–3018.