Bulgarian Journal of Agricultural Science, 20 (No 2) 2014, 122-131
Agricultural Academy

AGROECOLOGICAL ASSESSMENT OF NEW BULGARIAN AND MACEDONIAN COTTON VARIETIES

A. STOILOVA[1], N. VALKOVA[1], D. SPASOVA[2], D. SPASOV[2] and L. MIHAJLOV[2]
[1]*Field Crops Institute, BG - 6200 Chirpan, Bulgaria*
[2] *Goce Delchev Univercity, Agricultural Faculty, 2000 Stip, 2400 Strumica, Macedonia*

Abstract

STOILOVA, A., N. VALKOVA, D. SPASOVA, D. SPASOV and L. MIHAJLOV, 2014. Agroecological assessment of new Bulgarian and Macedonian cotton varieties. *Bulg. J. Agric. Sci.,* 20: 122-131

The aim of this reaserch was to assess new Bulgarian and Macedonian cotton varieties under different ecological environments and to establish which of them are the best for introducing into production. The research included the newest Bulgarian and Macedonian cotton varieties. In 2008-2009 in the Field Crops Institute in Chirpan (Bulgaria) and Agricultural Faculty in Strumica to the Univercity "Goce Delchev" in Stip (Macedonia) field trials were carried out according to the adopted cotton growing technology in each country. The varieties were evaluated on the grounds of the obtained data for the most important economic traits. It was found that during the years of study in Bulgaria and in Macedonia, there was sufficient temperature sum and insufficient rainfall supply for cotton development. The region of Strumica was comparatively arid than that of Chirpan, but the longer growing season allowed the use of rainfall during the months of August and September, and seed cotton yield was almost twice higher. Of the studied factors (varieties, regions and years) the regions had the biggest share in the total variation of the seed cotton yield (73.2 %) and boll weight, while the varieties had the biggest share in the total variation of fiber length and lint percentage (44.5 % and 44.4 %, respectively). The effect of years was significant only for boll weight and fiber length. In Strumica the varieties differed more strongly in seed cotton yield and fiber lint percentage and more slightly in fiber length. Based on the average two-year data, for the conditions of Bulgaria, the varieties Darmi, Helius and Natalia proved to be the best and in seed cotton yield (2233 $kg.ha^{-1}$) exceeded the standard variety Chirpan-539 by 16 to 62 $g.kg^{-1}$. Darmi and Natalia varieties surpassed the standard in fiber length by 1.1-1.9 mm, but were inferior to it in lint percentage. Under the conditions of Chirpan the Macedonian variety 5140 was inferior to the standard in seed cotton yield (by 48 $g.kg^{-1}$) and in lint percentage (by 2.6 %). For the conditions of Strumica - Macedonia the Bulgarian varieties Helius, Natalia and Vega were found to be the best. The variety Helius in seed cotton yield significantly exceeded the standard (by 277$g.kg^{-1}$) and the Macedonian variety 5140. Natalia and Vega varieties in seed cotton yield exceeded the standard by 225$g.kg^{-1}$ and 186$g.kg^{-1}$ and the Macedonian variety. Both varieties had longer fiber. Average for the two regions and two years the highest yield was obtained from the variety Helius - 3895 kg/ha^{-1}, an increase of 198 $g.kg^{-1}$ over the standard variety Chirpan-539, and it was followed by Natalia - 3762 $kg.ha^{-1}$ and Vega – 3639 $kg.ha^{-1}$, or 154 $g.kg^{-1}$ and 119 $g.kg^{-1}$ above the standard. The variety Natalia outlined by the longest fiber, Chirpan-539 distinguished by the highest lint percentage.

Key words: cotton, *Gossypium hirsutum* L., regions, economic characters, agro-ecological assessment

Introduction

Cotton varieties grown in Bulgaria and Macedonia in order to meet the requirements of cotton production and textile industry should be early, with high and stable yields, and high fibre quality. To provide stable yields they need to have an increased resistance or tolerance to adverse abiotic (drought and low spring temperatures) and biotic factors – diseases (*Verticillium dahliae Kleb.*, *Fusarium, Rhizoctonia, Phythium*) and pests (*Thrips tabaci, Aphis gossypii*).

Stability of varieties is their basic ecological characteristics, which necessitates to extend the studies on genotype×environment interaction and ecological organization of quantitative characters at changeability of environ-

E-mail: saldzhieva@abv.bg; dragica@ugd.edu.mk

ments. Changeability of environmental conditions raises ecological variability by modifying the activity of genes of the polygene system. Therefore it is not necessary to control the specific environmental factors, it is only necessary to measure the ecological variability (Dragavtsev, 1994).

Ecological variety trials with cotton have been carried out on the decision of Inter-Regional Cooperative Research Network on Cotton for the Mediterranean and Near East contries and the results were reported to the international conferences (Borrero, 1996; Bojinov et al., 2000; Stoilova and Bozhinov, 2004).

The aim of this study was to do an agroecological assessment of new Bulgarian and Macedonian cotton varieties by examining their performance in different ecological environments regarding yield and fiber quality with a view to their introducing into production or efficient usage in breeding programs.

Material and Methods

The research included the newest Bulgarian and Macedonian varieties - Chirpan-539 (standard for earliness and productivity), Beli Iskar, Veno, Trakia, Helius, Avangard-264 (standard for fiber quality), Perla-267, Vega, Colorit, Natalia and Darmi (Bulgarian) and 5140 (Macedonian). In 2008-2009, in Field Crops Institute in Chirpan (Bulgaria) and Agricultural Faculty in Strumica to the "Goce Delchev" Univercity in Stip (Macedonia), field trials were carried out set up by block method in four replications and harvest plot of 20 m^2 (in Bulgaria), 7 m^2 (2008) and 10 m^2 (2009) (in Macedonia), according to the adopted agro-technologies for cotton growing in each country. The varieties were evaluated on the grounds of the obtained data for the most significant economic traits – seed cotton yield, boll weight, fiber length by "butterfly" method and lint percentage.

For statistical processing of data statistical program ANOVA 123 was used. Hierarchical cluster analysis was also applied to group the genotypes by similarity (Ward, 1963).

The trial in Chirpan was carried out on pellic vertisols (FAO) with powerful humus layer (70 up to 115 cm) and comparatively rich in humus content (1.8-3.0%). *Durum wheat* was used as predecessor during the two years of study.

In Strumica the trial was set up on alluvial type of soil, poor in humus, nitrogen and phosphorus, and a good security of active potassium. Predecessor was wheat (*Triticum aestivum*). Sub-Mediterranean and East-continental climate exert combined effect on the Strumica valley.

Results and Discussion

Average for a many year period the temperature sum during the vegetation period of cotton in Bulgaria (from May to September) was 3126^o, while in the Strumica region it was 3344^{o}C (by 218^o more) (Table 1). Rainfall sum for the same period was 258 mm in Chirpan and 243 mm in Strumica. The hydrothermal coefficient showed, that in the region of Chirpan the rainfall supply during the cotton growing season was better than in the region of Strumica, especially during the summer months – June, July and August. These results are presented on Figire 1. From the diagram, it is seen that in the Strumica region the period of semi-drought occurred in the first half of May and ended in the first decade of September. For the region of Chirpan this period occurred in the first decade of June and prolonged until early October. The period of drought stress in Chirpan began at the end of July and extended until early September. For the Strumica region, the drought occurred in the first decade of June and lasted until mid-August. Rainfall sum during the summer months in Strumica was by 26.2 mm less than in Chirpan. All this characterized the region of Strumica as more arid than of Chirpan, the hydro-thermal coefficient was 0.73 for the period May-September and 0.61 for the summer months (June, July and August) at values equal to 0.82 and 0.79 for the region of Chirpan.

For the region of Chirpan, 2008 was hot as regards temperature security and middle dry in rainfall supply. Rainfall sum (261 mm) was similar to that of long-term mean, but it was very irregularly distributed during the vegetation period. Thus in July and August (during the flowering and boll formation), the rainfall sum was 38.9 mm, which was by 56.6 mm less than average of many years. The strong and prolonged drought during this period gave strong negative effect on yield and fiber length. Excessive rainfall in September could not compensate the lack of moisture during the summer months because the cotton was already matured and caused only worsen of fiber quality.

For the region of Strumica, 2008 was hot and very dry, by 70 mm in the period May-September and by 88.1 mm during the summer months less rainfall in comparison with the five-year period – 2005-2009 (Table 1 and Figure 1).

For the region of Chirpan 2009 was also hot and dry in rainfall supply. Temperature sum during the vegetation period (May-September) was 3264^o, which was by 138^o more than the average value of many years period. Rainfall sum was 211 mm, by 47 mm below average of many years. The initial development of cotton passed over under extremely insufficient rainfall security – 14.4 mm in June compared to 65.7 mm of many years and cotton growth was strongly depressed. Excessive rainfall of 88.7 mm in July, by 34.7 mm above the norm, favored the cotton growth, accumulation of flowers and retention of bolls. Drought in August (during the period of boll formation) in combination with the average-monthly higher temperature than of many years accelerated

Table 1
Meteorological characterization of the cotton vegetation period in 2008 and 2009 in comparison with of many years period for the regions of Chirpan and Strumica

Години Years	Months							Σ/Average June-August
	April	May	June	July	August	September	May-September	
An average monthly air temperature, °C - Chirpan								
2008	12.9	16.8	21.2	23.1	25.6	18.5	21.1	23.3
2009	11.9	18.3	21.6	24.2	23.4	19.0	21.3	23.1
1928-2007	11.9	16.9	20.8	23.3	22.3	18.7	20.4	22.1
Temperature sum, Σ °C- Chirpan								
2008	386	521	637	717	793	555	3223	2147
2009	357	569	648	751	725	571	3264	2124
1928-2007	357	524	624	722	694	561	3126	2035
Rainfall, *mm* - Chirpan								
2008	65.9	35.8	95.4	35.5	3.4	90.9	261	134
2009	16.6	15.6	14.4	88.7	34.6	58.0	211	138
1928-2007	44.9	62.4	65.7	54.0	41.5	34.4	258	161
Hydrothermal Coefficient - Chirpan								
2008	1.71	0.69	1.50	0.50	0.04	1.64	0.81	0.62
2009	0.47	0.27	0.22	1.18	0.48	1.02	0.65	0.65
1928-2007	1.26	1.19	1.05	0.75	0.60	0.61	0.82	0.79
Temperature sum, Σ °C - Strumica								
2008	405	561	696	781	856	543	3437	2333
2009	396	586	657	772	735	579	3329	2164
1995-09	381	574	678	778	750	564	3344	2206
Rainfall, mm - Strumica								
2008	62.2	49.8	35.5	8.7	2.5	76.7	173	46.7
2009	31.6	67.1	72.3	17.5	101.0	13.0	271	190.8
1995-09	43.6	55.0	51.1	42.3	41.4	53.1	243	134.8
Hydrothermal Coefficient - HTC (by Selyaninov) - Strumica								
2008	1.54	0.89	0.51	0.11	0.00	1.41	0.50	0.20
2009	0.80	1.14	1.10	0.23	1.37	0.23	0.81	0.88
1995-09	1.14	0.96	0.75	0.54	0.55	0.94	0.73	0.61

this phase and brought about to shortening of the cotton vegetation period. In 2009 cotton matured at the end of August, while in normal years it usually matures in the middle of September. This reflected unfavorably on the seed cotton yield and fiber quality, stronger expressed for the varieties with longer fiber and longer vegetative period.

In 2009, rainfall in the region of Strumica during the cotton vegetation period was by 11.5% above the norm. Excessive rainfall in August (101.0 mm), by 59.6 mm above the norm (Table 1, Figure 1) extended the cotton vegetation, but contributed to the formation of a high yield (Table 3).

Temperature sums in both areas were within or slightly above the average of many years.

The data in Table 2 show that the regions of Chirpan and Strumica had the biggest share in the total variation of seed cotton yield (73.1 %) and boll weight (63.9 %), while as for the fiber length and lint percentage the varieties had the biggest share, respectively 44.5 % and 44.4 %. The effect of years was significant for the seed cotton yield, boll weight and fiber length, and irrelevant to the lint percentage. The genotype × region × year interaction (A × B × C) was significant for all traits (with the exception of lint percentage) that means by these traits the genotypes interacted with the years and regions.

In Bulgaria, average for two years, the highest seed cotton yields were obtained from Darmi - 2233 kg.ha^{-1}, Helius - 2171 kg.ha^{-1} and Natalia - 2133 kg.ha^{-1}, which was by 14-62

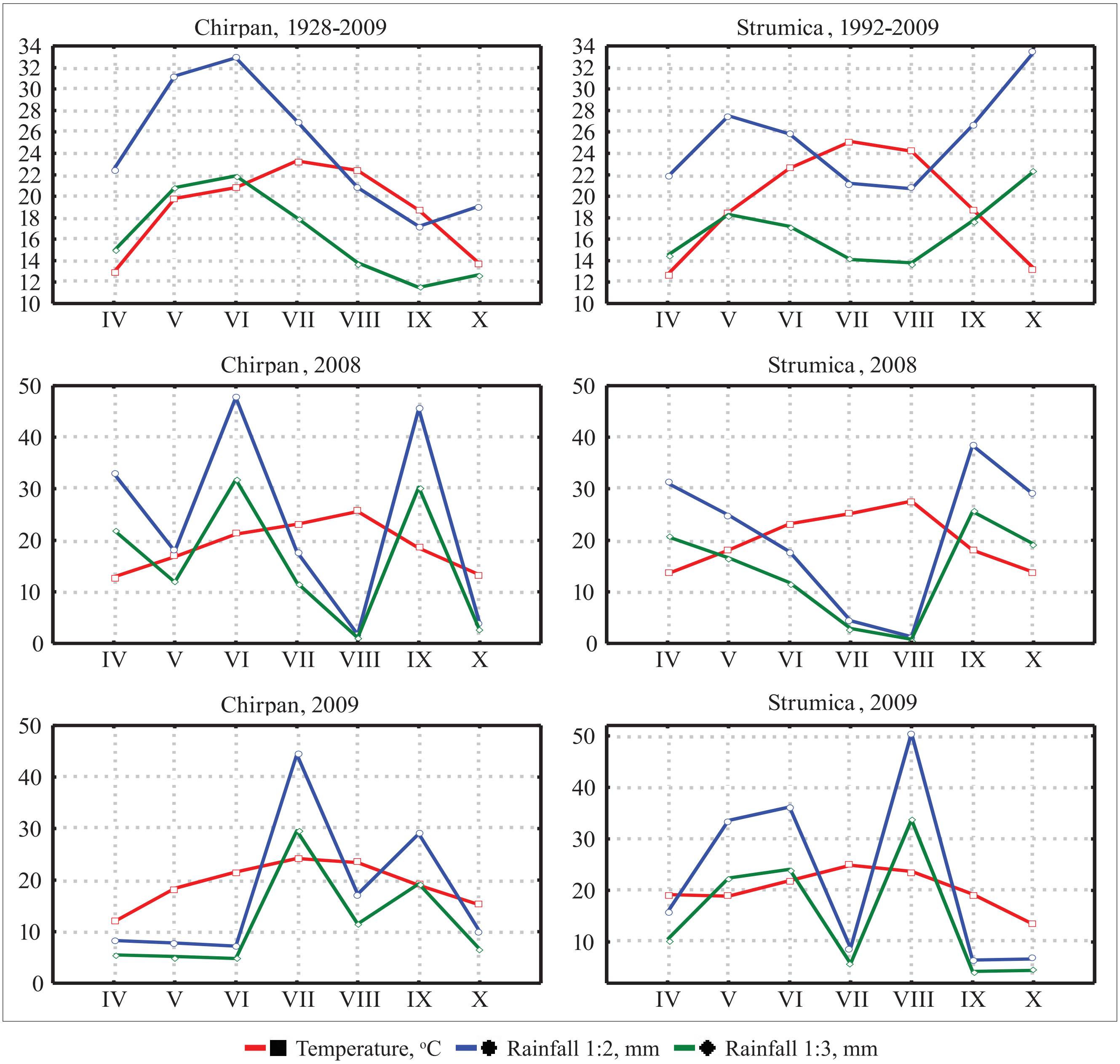

Fig. 1. Drought periods in Chirpan (Bulgaria) and Strumica (Macedonia)

g.kg-[1] over the standard variety Chirpan-539 (Table 3). Yields in 2008 were slightly higher than in 2009. In 2008 the highest seed cotton yield was obtained from Darmi - 2395 kg.ha^{-1} (by 103 g.kg^{-1} over the standard) followed by Natalia - 2283 kg.ha^{-1}, in 2009 – from Helius - 2108 kg.ha-[1] which exceeded the standard variety Chirpan-539 by 36g.kg^{-1}. Macedonian variety 5140 in seed cotton yield - 2240 kg.ha^{-1} in 2008 surpassed Chirpan-539 by 31 g.kg^{-1}, but in 2009 - 1764 kg.ha^{-1} it was inferior to the standard by 133 g.kg^{-1} as a result it was inferior by 49 g.kg^{-1} average for the two years. This variety stood behind Helius, Natalia and Darmi. Other investigations on performance of foreign cotton varieties in Bulgaria also showed that they are not suitable for direct use in cotton production because of their lateness and insecure yields under Bulgarian conditions (Bojinovet al., 2000; Stoilova and Bozhinov, 2004).

Table 2
Three-way factor dispersion analysis of data for economic traits of the varieties studied in Chirpan and Strumica in 2008-2009

Sources of variation	Degree of freedom	Sum of squares	Sum of squares %	Dispersion	F-exp.
Seed cotton yield					
Varieties-A	10	124836	7.1	12483.60	37.3^{+++}
Regions-B	1	128447	73.1	1231447	3833. 5 $^{+++}$
Years -C	1	2439	0.14	2439	7.3^{++}
Interaction A×B	10	94206	5.4	9420.60	28.2 $^{+++}$
Interaction A×C	10	91357	5.2	9135.70	27.3 $^{+++}$
Interaction B×C	1	3096	0.2	3096.00	9.3 $^{++}$
Interaction A×B×C	10	138014	7.9	13801.40	41.3 $^{+++}$
Error	43	14374	0.8	334.28	
Boll weight					
Varieties-A	10	6.6	9.6	0.66	10.7^{+++}
Regions-B	1	43.8	63.9	43.80	718^{+++}
Years -C	1	0.7	0.9	0.64	10.5^{+++}
Interaction A×B	10	6.0	8.8	0.60	9.9^{+++}
Interaction A×C	10	2.4	3.6	0.24	4.0^{+++}
Interaction B×C	1	0.02	0.03	0.02	0.3
Interaction A×B×C	10	6.3	9.3	0.63	10.4^{+++}
Error	43	2.6	3.8	0.06	
Fiber length					
Varieties-A	10	42.3	44.5	4.23	30.0^{+++}
Regions-B	1	6.5	6.84	6.51	46.3^{+++}
Years -C	1	4.8	5.03	4.78	14.0^{+++}
Interaction A×B	10	12.9	13.6	1.29	9.2^{+++}
Interaction A×C	10	6.9	7.2	0.69	4.8^{+++}
Interaction B×C	1	6.0	6.3	6.0	43.0^{+++}
Interaction A×B×C	10	9.1	9.6	0.91	6.5^{+++}
Error	43	6.1	6.4	0.14	
Lint percentage					
Varieties-A	10	68.9	44.4	6.89	14.6^{+++}
Regions-B	1	3.2	2.1	3.19	6.7^{+}
Years -C	1	0.01	0.01	0.01	0.03
Interaction A×B	10	13.9	8.9	1.39	2.9^{++}
Interaction A×C	10	18.7	12.0	1.86	3.9^{+++}
Interaction B×C	1	18.1	11.6	18.06	38.2^{+++}
Interaction A×B×C	10	7.3	4.7	0.73	1.5
Error	43	20.3	13.1	0.47	

In Strumica average seed cotton yields were about twice higher than in Chirpan. The highest yields were obtained from Helius - 5619 kg.ha^{-1}, Natalia – 5390 kg.ha^{-1} and Vega – 5222 kg.ha^{-1}, by 187-277 g.kg^{-1} over Chirpan-539. In 2008 the highest yields were obtained from Helius and Natalia – 5714 kg.ha^{-1}, by 244 g.kg^{-1} over Chirpan-539, followed by Vega – 5429 kg.ha^{-1} (18.2 g.kg^{-1}), in 2009 - from Helius (5525 kg.ha^{-1}) followed by Natalia (5065 kg.ha^{-1}) and Vega (5015 kg.ha^{-1}), by 190 to 312 g.kg^{-1} more than the standard. Macedonian variety 5140 under the condition of Strumica realized 4425 kg.ha^{-1} average for the two years and was equal to the standard, but was inferior to Helius, Natalia and Vega. In

Table 3
Economic traits of the varieties studied in Chirpan (Bulgaria) and Strumica (Macedonia) in 2008 and 2009

Variety	Bulgaria			Macedonia			Average
	2008	2009	Average	2008	2009	Average	
Seed cotton yield, *kg.ha*$^{-1}$							
Chirpan-539	2172	2034	2103	4592	4210	4401	3252
Veno	1763	2047	1904	5143	1150	3146	2505
Trakia	2145	1997	2070	4000	5000	4500	3285
Helius	2234	2108	2171	5714	5525	5619	3895
Avangard-264	2171	1935	2053	2871	4200	3536	2794
Perla-267	2158	1862	2009	3857	4935	4396	3203
Natalia	2283	1985	2133	5714	5065	5390	3762
Darmi	2395	2072	2233	4000	4655	4327	3280
Colorit	2211	1898	2053	3942	4805	4374	3213
Vega	2254	1897	2057	5429	5015	5222	3639
5140 (Macedonia)	2240	1764	2001	4000	4850	4425	3213
Average – years	2184	1963	-	4478	4491	-	3279
Average - regions	-	-	2072	-	-	4485	3278
Boll weight, *g*							
Chirpan-539	5.5	5.0	5.3	6.0	6.5	6.3	5.7
Veno	5.4	5.1	5.2	5.7	6.2	6.0	5.6
Trakia	5.1	5.1	5.1	**7.7**	7.0	7.4	6.2
Helius	5.4	5.1	5.2	5.8	6.7	6.3	5.7
Avangard-264	5.1	5.1	5.1	6.7	6.4	6.6	5.8
Perla-267	5.0	5.4	5.2	**7.7**	6.6	7.2	6.2
Natalia	5.3	5.1	5.2	7.0	6.7	6.9	6.0
Darmi	5.3	5.1	5.2	5.4	6.1	5.8	5.5
Colorit	5.7	5.2	5.5	6.9	6.6	6.8	6.1
Vega	5.7	5.0	5.4	6.4	7.0	6.7	6.0
5140 (Macedonia)	5.4	5.5	5.5	8.4	6.3	7.4	6.4
Average - years	5.3	5.1	-	6.7	6.5	-	5.9
Average - regions	-	-	5.2	-	-	6.6	5.9

Significance	Factors:						
	A-Varieties	B-Regions	C- Years	A × B	A × C	B × C	A×B×C
	Seed cotton yield, *kg.ha*$^{-1}$						
P=5.0 %	184	79	79	261	261	111	369
P=1%	246	105	105	348	348	148	493
P=0.1 %	323	138	138	456	456	195	646
Boll weight, *g*							
P=5.0 %	0.2	0.1	0.1	0.3	0.3	0.1	0.5
P=1%	0.3	0.1	0.1	0.5	0.5	0.2	0.7
P=0.1 %	0.4	0.2	0.2	0.6	0.6	0.3	0.9

2008, this variety produced lower yield than of the standard, but in 2009 was higher.

Average for the two regions the highest yield was obtained from Helius - 3895 kg.ha^{-1}, an increase of 198 g.kg^{-1} over the standard Chirpan-539, followed by Natalia - 3762 kg.ha^{-1} (157 g.kg^{-1}) and Vega - 3639 kg.ha^{-1} (119 g.kg^{-1}). The varieties Avangard-264 and Veno were inferior to Chirpan-539 by 141 - 230 g.kg^{-1}. Other varieties, including Macedonian 5140, were equal with it.

The varieties Colorit and 5140 had the biggest boll weight in the region of Chirpan, the varieties Trakia and 5140 – in the region of Strumica. In Strumica all varieties have formed bigger boll weight. On the average of all genotypes, the boll weight in Strumica was significantly bigger than in Chirpan, 6.6 g and 5.2 g, respectively. The boll weight in both regions was bigger in 2008. In this year the biggest boll weight in Chirpan was found for the varieties Colorit and Vega (5.7 g), in Strumica – for the varieties 5140, Trakia (7.4 g) and Perla-267 (7.2 g). In the same year, in the region of Strumica, the variety Perla-267 surpassed the standard, while in the region of Chirpan stood behind it.

Average for the two regions, the biggest boll weight was found for the variety 5140 (6.4 g), followed by Trakia, Perla-267, Colorit, Natalia and Vega (6.0- 6.2 g), by 0.3-0.7 g over the standard. The varieties Veno and Avangard-264 (5.6-5.8 g) were equal with Chirpan-539, Darmi (5.5 g) significantly was inferior to it by 0.2 g.

The varieties Chirpan-539, Veno, Trakia and Helius had fiber length 25.5-26.3 mm and lint percentage 39.6-40.9 % (average for the two years and the two regions). The other varieties showed longer fiber - 26.7-27.8 mm and lower lint percentage - 38.0-39.1 % (Table 4). The longest fiber was found for the variety Natalia and the highest lint percentage – for the variety Chirpan-539. The Macedonian variety 5140 in fiber length (26.4 mm) referred to the varieties with short fiber, in lint percentage (39.1 %) - to these with lower one.

Fiber length in Strumica was bigger (27.0 mm) than in Chirpan (26.5 mm) (average for the two years). In Strumica the longest fiber was found for the variety Natalia - 28.2 mm, in Chirpan – for the variety Darmi - 27.8 mm, followed by Avangard-264 - 27.6 mm. In Strumica the fiber length was the same in both years, while in Chirpan the fiber was longer by 1.0 mm in 2008 compared to 2009 caused by the shortened vegetation period.

Soil and air humidity is of great importance for the formation of this feature. Although the two years were dry (2008 – middle dry, 2009 – dry) and this reflected unfavorably on the fiber length, especially of the more qualitative varieties, the last formed longer fiber in both years. The longest fiber in 2008 was found for Natalia, in 2009 – for Darmi and Natalia varieties.

The fiber lint percentage was also higher in Srtumica – 39.4%, while in Chirpan was 39.0 % (average for the two years). In Strumica the varieties Chirpan-539, Veno and Helius had high and close values for this trait (40.1-40.7%), in Chirpan the highest lint percentage was found for Chirpan-539 (41.2%), followed by Veno (40%). In Strumica the fiber lint percentage was higher in 2008 (the highest for Veno variety – 41.6%), in Chirpan it was higher in 2009 (the highest for Chirpan-539 variety – 41.5%).

The analysis of results confirms the significance of regions for developing of seed cotton yield and boll weight, while fiber length and lint percentage depended mainly on the genotypes. The varieties performed better in Strumica than in Chirpan (especially in seed cotton yield). In the region of Strumica the varieties differed more strongly in yield and lint percentage and more weekly in fiber length.

The longer growing season for cotton in Strumica than in Bulgaria has allowed usage of rainfall in August and early September as well as to accumulate and mature more bolls, which reflected favorably on yield. The Mediterranean climate ascendancy also advantaged growth and development of cotton.

In years with insufficient rainfall supply, such as 2008 and 2009 were, the qualitative varieties cannot realize their longer fiber. Under conditions of Bulgaria, critical period for fiber length depending on rainfall and temperature sum was found to be July 11-August 10 and July 11-August 20 for the varieties, which mature later as Avangard-264 (Stoilova, 2012). This is the period during fiber length is formed and rainfall are most important for fiber increasee and to reach its maximum length.

Based on the average data for the two years and two regions (Table 3 and Table 4) the varieties were clustered by four traits (seed cotton yield, boll weight, length and lint percentage of fiber) (Figure 2). The genotypes divided into two basic clusters. The varieties Chirpan-539 and Veno, also Trakia and Helius, proved to be very similar and formed one cluster. They had short fiber and high lint percentage. Chirpan-539 and Veno varieties were created by intraspecific hybridization, Trakia and Helius – by experimental mutagenesis. The other Bulgarian varieties and Macedonian variety 5140 referred to the second cluster. These varieties had longer fiber (with the exception of 5140) and lower lint percentage. The Bulgarian varieties in this cluster were created by interspecific hybridization of the species *G. hirsutum* L. × *G. barbadense* L. (Avangard-264) and hybridization of stabilized lines (*G. hirsutum* L. × *G. barbadense* L.) with promising varieties of the *G. hirsutum* L. spesies. The varieties Avangard-264 and Darmi, also Natalia and Vega proved to be very similar, 5140 was similar to Colorit.

The cluster analysis based on the economic and fiber technological properties confirmed the genetics differences between the Bulgarian varieties resulted from two differently purposeful cotton-breeding programs: Chirpan-539, Veno, Trakia and Helius varieties - from breeding of high productivity; the others – from breeding of fiber quality. The varieties differed mainly in fiber length and lint percentage.

Concerning grouping of the varieties and their similarity depending on the breeding programs, the clustering based

Table 4
Economic traits of varieties tested in Chirpan (Bulgaria) and Strumica (Macedonia) in 2008 and 2009

Variety	Bulgaria			Macedonia			Average
	2008	2009	Average	2008	2009	Average	
Fiber length, *mm*							
Chirpan-539	27.0	24.9	25.9	26.5	27.0	26.8	26.3
Veno	26.1	24.6	25.3	26.5	27.5	27.1	26.2
Trakia	25.4	24.9	25.2	25.0	26.5	25.8	25.5
Helius	25.6	25.0	25.2	26.4	26.9	26.7	26.0
Avangard-264	28.3	26.9	27.6	27.3	26.8	27.0	27.3
Perla-267	27.3	26.6	26.9	25.7	27.0	26.4	26.7
Natalia	27.3	27.3	27.3	29.2	27.3	28.2	27.8
Darmi	28.1	27.3	27.8	27.0	27.3	27.2	27.4
Colorit	27.3	26.1	26.7	28.3	26.7	27.5	27.1
Vega	27.9	26.7	27.3	27.5	27.5	27.5	27.4
5140 (Macedonia)	26.4	25.4	25.9	27.0	26.7	26.9	26.4
Average - years	27.0	26.0	-	26.9	27.0	-	26.7
Average - regions	-	-	26.5	-	-	27.0	26.7
Lint Percentage, %							
Chirpan-539	40.9	41.5	41.2	41.0	40.0	40.4	40.9
Veno	40.5	39.6	40.0	41.6	40.0	40.7	40.4
Trakia	39.4	39.7	39.5	40.0	39.4	39.8	39.6
Helius	39.4	40.1	39.7	40.2	40.2	40.1	40.0
Avangard-264	35.7	38.3	36.9	38.5	39.4	39.0	38.0
Perla-267	37.8	38.8	38.3	38.3	37.0	37.7	38.0
Natalia	38.8	39.0	38.9	39.5	37.2	38.4	38.6
Darmi	38.3	39.7	38.9	38.6	39.7	39.2	39.1
Colorit	37.7	39.3	38.5	40.3	37.5	38.9	38.7
Vega	37.1	39.8	38.4	39.0	38.5	38.7	38.6
5140 (Macedonia)	38.5	38.3	38.4	40.7	38.8	39.8	39.1
Average - years	38.5	39.4	-	39.8	38.9	-	39.2
Average - regions	-	-	39.0	-	-	39.4	39.2

Significance	Factors:						
	A-Varieties	B-Regions	C- Years	A × B	A × C	B × C	A×B×C
Fiber length, *mm*							
P=5.0 %	0.4	0.2	0.2	0.5	0.5	0.2	0.7
P=1%	0.5	0.2	0.2	0.7	0.7	0.3	1.0
P=0.1 %	0.7	0.3	0.3	0.9	0.9	0.4	1.3
Lint percentage, %							
P=5.0 %	0.7	0.3	0.3	1.0	1.0	0.4	1.4
P=1%	0.9	0.4	0.4	1.3	1.3	0.5	1.8
P=0.1 %	1.2	0.5	0.5	1.7	1.7	0.7	2.4

on the fiber length and lint percentage was more demonstrative (Figure 3). Genotypes, with short fiber and high lint percentage, obtained by intraspecific hybridization and experimental mutagenesis, and those, with longer fiber and lower lint percentage, obtained after interspecific hybridization, differentiated into two basic clusters. Differentiation

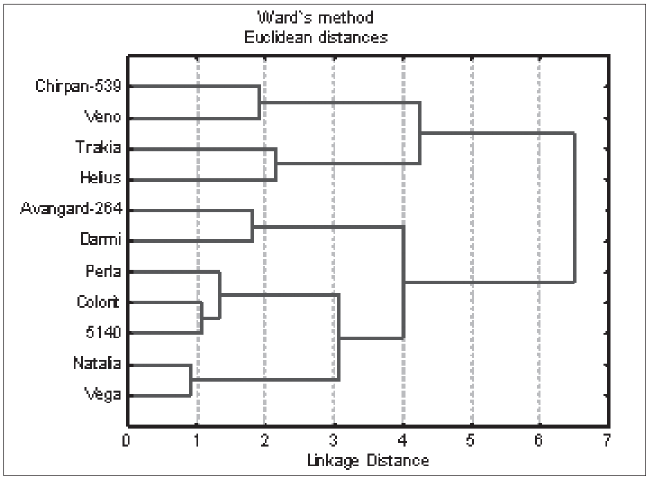

Fig. 2. Dendrogram of 11 cotton varieties by four traits based on the average data for the two regions Chirpan and Strumica (2008-2009)

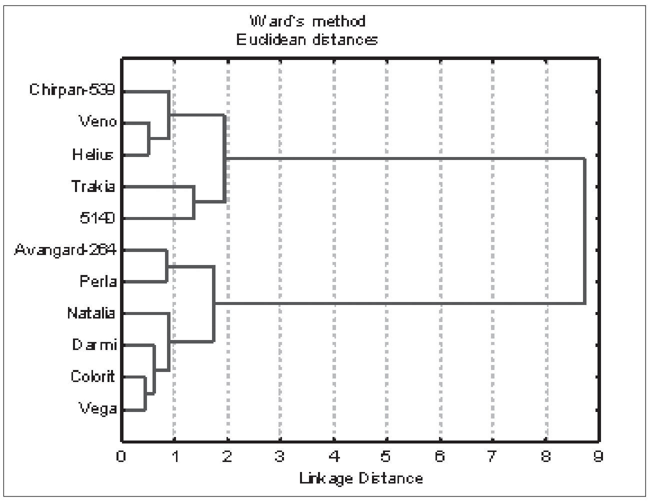

Fig. 3. Dendrogram of 11 cotton varieties by 2 traits (fiber length and lint percentage) based on the average data for the two regions Chirpan and Strumica (2008-2009)

of the varieties was almost entirely caused by the inclusion of genotypes with *G. barbadense* germplasm determining longer fiber and lower lint percentage under different growing conditions.

Conclusion

The region of Strumica (for a long period) was characterized by a higher temperature sum during the cotton-growing season than that of Chirpan, while rainfall amount was slightly higher in Chirpan. During the two years of study in Bulgaria and in Macedonia, there was sufficient temperature security and rainfall deficiency for cotton. The region of Strumica was comparatively arid than of Chirpan, but the longer cotton growing season allowed the effective usage of rainfall during August-September and yields were almost twice higher. In Chirpan rainfall in September can not compensate deficiency of moisture during the summer months (July and August) because of short growing season for cotton. Of the studied factors (varieties, years and regions) the regions had the biggest share in the total variation of seed cotton yield (73.2%) and boll weight, the varieties – in the total variation of fiber length and lint percentage (44.5% and 44.4%). The effect of years was significant only for boll weight and fiber length. In Strumica the varieties differentiated more strongly in seed cotton yield and fiber lint percentage and more slightly in fiber length. Under the conditions of Bulgaria, the varieties Darmi, Helius and Natalia proved to be the best. The variety Darmi in seed cotton yield (2233 kg/ha^{-1}) exceeded the standard variety Chirpan-539 by 62 g.kg^{-1}, Helius exceeded it by 32 g.kg^{-1}, Natalia – by 16 g.kg^{-1}. Darmi and Natalia surpassed the standard in fiber length by 1.9 mm and 1.1 mm, respectively, both varieties were inferior to it in lint percentage. The Macedonian variety 5140 under the conditions of Chirpan was inferior to the standard in seed cotton yield by 48 g.kg^{-1} and in lint percentage by 2.6%. At the conditions of Strumica (Macedonia), the Bulgarian cotton varieties Helius, Natalia and Vega were found to be the best. The variety Helius in seed cotton yield significantly exceeded (by 277 g.kg^{-1}) the standard Chirpan-539 and the Macedonian variety 5140. The varieties Natalia and Vega in seed cotton yield also exceeded the standard (by 225 g.kg^{-1} and 186 g.kg^{-1}) and the Macedonian variety. Higher productivity of these varieties was combined with longer fiber. Average for the two regions the highest yield was found for the variety Helius - 3895 kg/ha^{-1}, an increase of 198 g.kg^{-1} over the standard variety Chirpan-539, followed by Natalia - 3762 kg/ha^{-1} and Vega – 3639 kg/ha^{-1}, or 154 g.kg^{-1} and 119 g.kg^{-1} above the standard. The variety Natalia outlined by the longest fiber, Chirpan-539 – by the highest lint percentage. The varieties Helius and Natalia had the best ecological and genetic organization of complex quantitative characters such as productivity, quality and drought stress tolerance. Natalia was found to be the variety with the longest fiber and Chirpan-539 was found to be the variety with the highest lint percentage. The cluster analysis based on the economic traits average data from the two regions confirmed the genetic differences between the Bulgarian varieties resulted from two differently purposeful breeding programs – for high productivity and for fiber quality.

Acknowledgements

This study was sponsored by the Fund "Scientific Researches" to Ministry of Education, Youth and Science, Republic of Bulgaria and Ministry of Education, Republic of Macedonia.

References

Bojinov, M. B. Bojinov and L. Dimitrova, 2000. Performance of Mediterranean cotton varieties in Bulgaria. In: O. Gencer, M. Rifat Derici, F. Goktepe (Editorial Board), Proceedings, the Inter-Regional Cooperative Research Network on Cotton (Proceedings of a Joint Workshop and Meeting of the All Working Groups, 20-24 September 2000, Adana-Turkey) Cukurova University Press 2001, Adana, Turkey, pp. 79-81.

Borrero, A., 1996. Report of variety trials. Proceedings of Consultation, CIRAD, Montpelier, France, pp. 37-38.

Dragavcev, B. A., 1994. Algoritms of Ecologic-genetic Gene Pool Inventory and Construction Methods of Agricultural Plants by Yield, Resistance and Quality. Recommendation of Methods (New Approaches), Sankt Peterburg (Ru).

Spasova, D., D. Spasov, L. Mihaylov, A. Stoilova and N. Valkova, 2010. Performance of new Bulgarian cotton varieties in Strumica, Macedonia. *Field Crops Studies*, **6** (3): 387-393 (Bg).

Stoilova, A. and M. Bozhinov, 2004. Performance of Mediterranean cotton varieties in Bulgaria in 2001-2003. U. Kechagia and F. Hanthopoulos (Editors), Proceedings of Plenary Meeting of Inter-Regional Cooperative Research Network on Cotton, 29 September-1 October 2004, Tessaloniki, Greece, Cotton and Industrial Plants Institute, Tessaloniki, Greece, pp. 47-52.

Stoilova, A. and N. Valkova, 2010**.** Assessment of new Bulgarian and foreign cotton varieties by applying of cluster analysis. *Journal of International Scientific Publication: Materials, Methods & Technologies*, **4** (1): 49-64 (Bg).

Stoilova, A., 2012. Effect of main agrometeorological factors on lintpercentage and length of cotton fiber. *Field Crops Studies*, **8** (3): 323-333 (Bg).

Ward, J. H., 1963. Hierarchical grouping to optimize an objective function. *Journal of American Statistical Association*, **58**: 236-244.