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APPLICATION OF CLUSTER ANALYSIS FOR EVALUATION OF NEW BULGARIAN AND MACEDONIAN COTTON VARIETIES AND LINES

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Abstract

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The aim of this study was to assess the genetic distance between eleven Bulgarian and four Macedonian cotton varieties by applying the method of cluster analysis. The trial was carried out in 2008 and 2009. The cluster analysis based on the varieties agronomic and fiber technological properties confirmed the genetic differences between them. The varieties grouped into two basic groups depending on the breeding directions and breeding methods. Some varieties were genetically very similar and they could be included in one breeding program for rapid breeding effect. The Macedonian varieties and lines were genetically distant from some Bulgarian varieties and their including in one breeding program can has a good effect. The year conditions had influence on genetic similarity and genetic remoteness as a result of predetermination of genetic formulas controlling the traits. In Strumica the varieties differentiated stronger in yield and lint percentage and weaker in fiber length.

Key words: G. hirsutum L., breeding, productivity, fiber length, lint percentage

Introduction

Cluster analysis is applied widely for assessment of genetic distance, respectively genetic remoteness of definite set of genotypes. In the recombinatory breeding the most remoteness genotypes are included in crosses for strengthening of the heterosis manifestation, segregation processes and variability in the next generations. Cluster analysis gives a very visual picture for grouping of varieties by single trait or complex of traits, which could be facilitated to a great degree their effective usage in the cotton breeding programs.

In cotton this analysis is used very limited (Brown, 1991; Kalsy et al., 1995; Tatineni et al., 1996; Patil et al., 1999; Valkova and Dechev, 2003; Stoilova and Dechev, 2003; Dimitrova et al., 2004 a,b,c; Stoilova et al., 2005).

The aim of this study was by applying of cluster analysis to assess the genetic remoteness of modern Bulgarian and Macedonian cotton cultivars and lines through the phenotype of the most important agronomic traits.

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Materials and Methods

In the experiment were included new Bulgarian and Macedonian cotton varieties and lines: Chirpan-539 (standard for productivity), Beli Iskar, Veno, Trakia, Helius, Avangard-264 (standard for fiber quality), Perla, Vega, Colorit, Natalia and Darmi (Bulgarian); Strumica-105, 5136, 5138, 5140 and 5141 (Macedonian). In the experimental field of Agrarian faculty in Strumica to Goce Delchev University in Stip a trial set up by the block design method in two replications and harvest plot of 10 m^2 and 15 m^2 in 2008 and 2009, respectively was carried out. The trial was set on alluvial type soil, which distinguishes with low content of humus, nitrogen and phosphorus and good security of active potassium. Wheat was predecessor in the two years of study.

The seed cotton yield, boll weight, length and lint percentage of fiber were evaluated.

Hierarchical cluster analysis was applied for the genotypes grouping (Ward, 1963). As a measure for divergence

the Euclidean distance between them was used. The data were standardized preliminary.

The Strumica valley is situated on 200-300 m altitude and it is under the influence of the Sub-Mediterranean and Eastern-continental climate. Rainfall distinguished with Mediterranean regime with maximum in November and minimum in summer months (July or August).

The years of the investigation were characterized the following way: 2008 was very dry by 70 mm less rainfall in May and September and by 87.8 mm less in simmer months; in 2009 during the vegetation period rainfall were by 11.5% more than the norm and promoted for developing of high yields.

The temperature sum in both years was in limits of average value or little above for a long term period.

Results and Discussion

In 2008 the varieties Helius and Natalia showed the highest yield - 5714 kg/ha (equal for both varieties) and exceeded the standard Chirpan-539 by 24.6% (Table 1).

High yield was obtained from Vega - 5429 kg/ha, 18.4% over Chirpan-539. The Macedonian variety Strumica-105 was equal to the standard variety the others were strongly inferior to it. The biggest bolls were found for the Macedonian varieties 5140 (8.4 g), Strumica-105 (7.8 g), 5138 (7.1 g) and Bulgarian varieties Trakia (7.7 g), and Perla (7.6 g). The longest fiber was found for the Bulgarian varieties Natalia (29.2 mm) and Colorit (28.3 mm) whilst the shortest fiber was found for Trakia (25.0 mm), 5138 (25.5 mm) and Perla (25.7 mm). As for the fiber lint percentage the varieties Chirpan-539, Veno and Strumica-105 had the highest values – 41.0-41.3%.

The varieties and standards were clustered by four traits on the base of data in Table 2. The dendrogram presented on Figure 1 showed that the genotypes divided into two basic clusters. The first cluster included Bulgarian varieties which subdivided into two smaller clusters indicating some genetic differences. The second cluster included all Macedonian varieties and three Bulgarian ones – Trakia, Perla and Vega. The Macedonian varieties formed separate subgroup that means they were genetically similar with the exception of line 5138. Of the Bulgarian varieties genetically very similar were Colorit and Natalia, Darmi and Veno, and of the Macedonian ones – Strumica-105 and 5140. Genetic similarity was observed for some Bulgarian and Macedonian varieties as Perla and line 5138, Vega and line 5136.

Clustering by three traits – seed cotton yield, fiber length and lint percentage, showed that the Macedonian line 5138 was in one cluster together with the Bulgarian varieties whilst the Bulgarian variety Vega was in one cluster together with

Table 1
Agronomic properties of varieties tested in Strumica in 2008

Variety Line №	Seed cotton yield, kg/ha	In % to Chirpan-539	Boll weight, g	Fiber length, mm	Lint percentage, %
Chirpan-539	4586	100.0	6.0	26.5	41.0
Veno	5143	112.1^{+}	5.7	26.5	41.6
Trakia	4000	87.2^{0}	7.7^{+++}	25.0°°	40.0
Helius	5714	124.6^{+++}	5.8	26.4	40.2
Avangard-264	2871	626.°°°	6.7^{+}	27.3^{+}	38.5^{0}
Perla	3857	84.4°°	7.6^{+++}	25.7^{0}	38.3°°
Natalia	5714	124.6^{+++}	7.0^{++}	29.2^{+++}	39.5
Darmi	4000	87.2^{0}	5.4°	27.0	38.6^{0}
Colorit	3943	86.0^{0}	6.9^{++}	28.3^{+++}	40.3
Vega	5429	118.4^{++}	6.4	27.5^{+}	39.0^{0}
Strumica-105	4613	100.6	7.8^{+++}	27.9^{++}	41.3
5140	4000	87.2^{0}	8.4^{+++}	27.0	40.7
5141	3643	79.4°°	5.5°	26.5	39.0^{0}
5136	3928	85.6^{0}	6.3	27.5^{+}	40.4
5138	3500	76.3°°	7.1^{++}	25.5^{0}	40.7
GD 5 %	495.2	10.8	0.5	0.8	1.9
GD 1%	698.7	15.2	0.8	1.1	2.6
GD 0.1 %	998.2	21.8	1.1	1.6	3.7

Table 2
Agronomic propreties of varieties tested in Strumica in 2009

Variety Line №	Seed cotton yield, kg/ha	In % to Chirpan-539	Boll weight, g	Fiber length, mm	Lint percentage, %
Chirpan-539	4210	100.0	6.5	27.0	40.0
Veno	1150	27.3°°°	6.2	27.5	40.0
Trakia	5000	118.8+++	7.0	26.5	39.4
Helius	5520	131.1+++	6.7	26.9	40.2
Avangard-264	4200	99.8	6.4	26.8	39.4
Perla	4930	117.1+++	6.6	27.0	37.0°°
Natalia	5060	120.2+++	6.7	27.3	37.2°°
Darmi	4650	110.5+++	6.1	27.3	39.7
Colorit	4800	114.0+++	6.6	26.7	37.5°°
Vega	5010	119.0+++	7.0	27.5	38.5
5140	4850	115.2+++	6.2	26.7	38.8
5136	5090	120.9+++	7.0	26.6	38.2
GD 5 %	117	2.8	0.6	1.1	1.6
GD 1%	165	3.9	0.8	1.5	2.2
GD 0.1 %	236	5.6	1.2	2.2	3.2

the Macedonian varieties (Figure 2). The Macedonian varieties together with Avangard-264, Vega, Trakia and Perla (Bulgarian) formed one basic cluster when they were clustered by fiber length and lint percentage (Figure 3).

On the base of results from the cluster analyses we can conclude that the line 5138 was genetically more distant from the other Macedonian varieties. This line was at a short distance to the Bulgarian varieties. Of the last the variety Vega was the most distant and genetically nearest to the Macedonian varieties.

In 2009 the variety Helius showed the highest yield of 5520 kg/ha and exceeded the standard Chirpan-539 by 31.1% (Table 2).

Very high yields of 5010-5090 kg/ha or by 18.8-20.9% over the standard were obtained from Macedonian line 5136

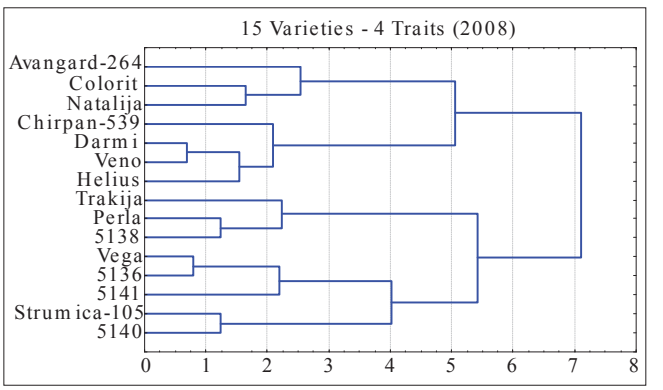

Fig. 1. Dendrogram of cluster analysis of 15 cotton varieties by 4 traits (seed cotton yield, boll weight, fiber length and lint percentage) based on data in 2008

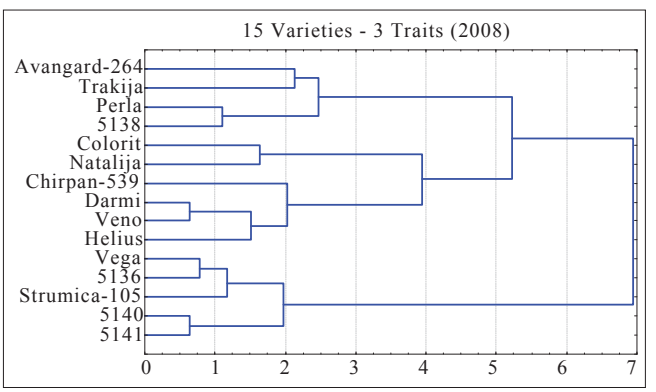

Fig. 2. Dendrogram of cluster analysis of 15 cotton varieties by 3 traits (seed cotton yield, fiber length and lint percentage) based on the data in 2008

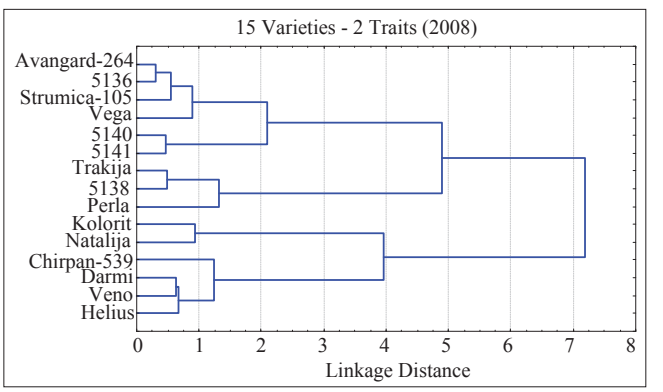

Fig. 3. Dendrogram of cluster analysis of 15 cotton varieties by 2 technological traits fiber length and lint percentage) based on data in 2008

and Bulgarian varieties Natalia, Vega and Trakia. The varieties Perla, Darmi, Colorit and line 5140 surpassed Chirpan-539 by 10.5 to 17.1%, whilst Avangard-264 was equal to it. The varieties Trakia, Vega and line 5136 had the biggest bolls – 7.0 g at 6.1-6.7 g for the others. The varieties Veno and Vega showed by 0.5 mm longer fiber than that of the standard, whilst for the variety Trakia it was shorter. This year was unfavorable for the fiber length formation and the varieties differentiated weakly by this trait. As for the fiber lint percentage the varieties Chirpan-539, Veno and Helius showed the highest indices - 40-40.2%. The varieties Perla, Natalia and Colorit had the lowest lint percentage - 37.0-37.5%.

Clustering of the varieties based on data in Table 2 (by four traits) is presented on Figure 4. The varieties were divided into two basic clusters. The first cluster included Chirpan-539, Avangard-264, 5140 (Macedonian), Helius, Darmi and Veno. The standard variety Chirpan-539 and Avangard-264 showed high similarity. The variety Veno formed separate group because of its low yield. The other cluster included Trakia, 5136 (Macedonian), Perla, Natalia, Colorit and Vega. The last four varieties formed one subgroup. The varieties Perla and Natalia were very similar. In Strumica in this year the varieties differentiated better in yield and lint percentage and weaker in fiber length. As a result some varieties changed their basic cluster. The Macedonian varieties 5136 and 5140 which were in one basic cluster in 2008 referred to different clusters in 2009.

The highest yield of 5619 kg/ha average for two years was found for the variety Helius which exceeded the standard Chirpan-539 by 22.7% and the Macedonian lines 5140 and 5136 by 27.0% and 24.6%**,** respectively (Table 3). High yields of 5390 kg/ha and 5222 kg/ha by 22.5% and 18.6% over Chirpan-539 were obtained from Natalia and Vega. The variety Natalia surpassed the Macedonian lines by 19.5-21.8%, Vega - by 15.8-18.0%. The biggest bolls were found for Trakia, Perla and 5140 – 7.1-7.4 g, the smallest – for Darmi – 5.7 g, the other varieties had boll weight of 6.0-6.9 g. The longest fiber of 28.3 mm, by 1.6 mm over Chirpan-539 and by 1.2-1.4 mm over the Macedonian lines, was found for the variety Natalia. The varieties Colorit and Vega had by 0.8 mm longer fiber than that of Chirpan and by 0.4-0.6 mm longer than that of the Macedonian lines. The shortest fiber was found for the variety Trakia. The varieties Chirpan-539, Veno and Helius had the highest lint percentage of 40.2-40.5%. Macedonian lines had lower lint percentage about 39.5-39.7%. The lowest lint percentage of 37.7% was found for Perla.

Clustering of varieties based on the data in Table 3 (by 4 traits) is presented on Figure 5. The varieties divided into two basic clusters. The first cluster included Chirpan-539, Helius, Darmi and Veno. The varieties Chirpan-539 and Helius showed high similarity. They differed in yield but had the same boll weight, fiber length and lint percentage. Large genetic diversity is observed in the second cluster.

Table 3
Agonomic properties of varieties of tested in Agrarian faculty, Strumica in 2008-2009 (average for two jears)

Variety Line №	Seed cotton yield, *kg/ha*	In *%* to Chirpan-539	Boll weight, *g*	Fiber length, *mm*	Lint percentage, *%*
Chirpan-539	4401	100.0	6.3	26.7	40.5
Veno	3146	71.5°°°	6.0	27.0	40.8
Trakia	4500	102.2	7.4^{+++}	25.7°°	39.7
Helius	5619	127.7^{+++}	6.3	26.7	40.2
Avangard-264	3536	80.3°°°	6.6	27.1	39.0^{0}
Perla	4396	99.9	7.1^{+++}	26.4	37.7°°°
Natalia	5390	122.5^{+++}	6.9^{++}	28.3^{+++}	38.3°°°
Darmi	4327	98.3	5.7°°	27.2	39.1^{0}
Colorit	4374	99.4	6.8^{+}	27.5^{++}	38.9°°
Vega	5222	118.6^{+++}	6.7^{+}	27.5^{++}	38.7°°
5140	4425	100.5	7.3^{+++}	26.9	39.7
5136	4510	102.5	6.7^{+}	27.1	39.5
GD 5 *%*	281	6.4	0.4	0.6	1.2
GD 1*%*	381	8.6	0.6	0.8	1.6
GD 0.1 *%*	511	11.6	0.8	1.1	2.1

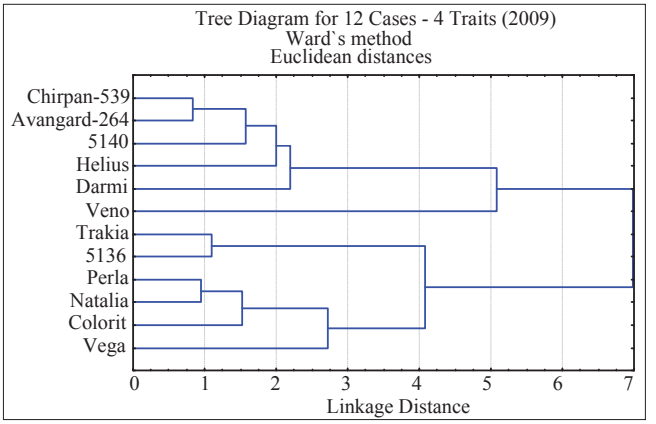

Fig. 4. Dendrogram of cluster analysis of 12 cotton varieties by 4 traits (seed cotton yield, boll weight, fiber length and lint percentage) based on the data in 2009

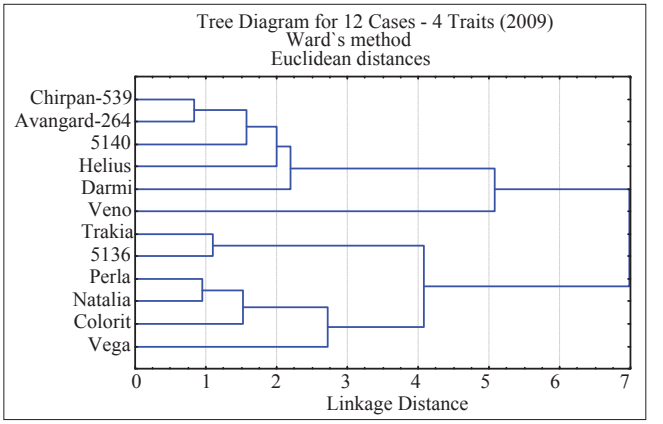

Fig. 5. Dendrogram of cluster analysis of 12 cotton varieties by 4 traits (seed cotton yield, boll weight, fiber length and lint percentage) based on the average data for 2008-2009

The varieties Natalia and Vega were very similar and separated into single group. The variety Trakia and Perla formed other single group. The variety Perla is characterized by longer fiber than realized in Strumica. The Macedonian varieties were in one subclusters together with Avangard-264 and Colorit.

The Bulgarian cotton varieties have been created from two differently purposeful breeding programs. The varieties Chirpan-539, Beli Iskar and Veno have been obtained through intraspecific hybridization, Trakia and Helius by applying of experimental mutagenesis. These varieties possess earliness, high genetic potential for yield and high lint percentage. The varieties Avangard-264, Perla, Vega, Colorit, Darmi and Natalia possess germplasm from the *G. barbadense L.* species and distinguish by longer fiber, which realized in suitable conditions. The cluster analyses showed that the Macedonian lines were closer to the varieties from the second group. Lines 5136 and 5140 were at a short distance with Avangard-264 and Colorit. Because of that it is better the Macedonian lines to be included in crosses with the varieties of the first group.

The varieties Helius, Natalia and Vega proved to be the best for the Strumica region. The variety Helius was genetically distant from the other two. These three varieties are high achievement in the Bulgarian cotton breedeng – Helius in breeding for productivity, Natalia and Vega – in breeding for fiber quality.

Clustering based on average data included the phenotype stability of traits and gave more reliable information for genetic remoteness of genotypes.

Conclusion

By the Bulgarian cotton breeding large variety diversity has been created which is a good precondition for the cotton breeding development in our country.

The cluster analysis confirmed the genetic differences between the varieties and showed visually their genetic remoteness. The varieties grouped into two basic groups depending on the breeding directions, breeding methods and preliminary selection by the traits.

Some varieties were genetically very similar by the studied traits and they could be included in one breeding program for rapid breeding effect.

The Macedonian varieties and lines were genetically distant from some Bulgarian varieties and their including in one breeding program can has a good effect.

The year conditions had influence on genetic similarity and genetic remoteness as a result of predetermination of genetic formulas controlling the traits.

In Strumica the varieties differentiated stronger in yield and lint percentage and weaker in fiber length.

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