

BREEDING OF BULGARIAN COTTON VARIETIES WITH IMPROVED FIBER QUALITY

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In recent years, considerable progress has been made in Bulgarian cotton breeding for earliness and fiber quality. Its results are the new varieties Colorit, Darmi and Natalia. They have been obtained from crosses of *G. hirsutum* L. and bred lines of *G. hirsutum* L. × *G. barbadense* L. origin. Their earliness and productivity are comparable to the variety Chirpan-539 (standard for earliness and productivity) and fiber length, to the variety Avangard-264 (standard for fiber quality). Natalia and Darmi are distinguished for their lint percentage, greater than in Avangard-264. Hierarchical cluster analysis based on six agronomic traits shows that Natalia is very similar to the standard variety Avangard-264, whilst Darmi is genetically more distant. All the genotypes are stable for different agronomic traits, which is valuable for further breeding.

Key words: cotton, *G. hirsutum*, varieties, fiber length, yield, cluster analysis, phenotypic stability.

Introduction

The cotton breeding programs in Bulgaria are focused on the development of cultivars with high genetic potential for yield over 4500–5000 kg/ha as well as on the creation of cultivars with improved fiber qualities, especially in terms of length. In 1996, the cultivars Chirpan-539, Chirpan-603 (early and high yielding) and Avangard-264 (fiber 3 mm longer than the standard variety Beli izvor) were created and introduced in the production (Bozhinov *et al.*, 1996; Koynov, Stoilova, 1996). Other achievements in the breeding for earliness and productivity were the cultivars Beli Iskar and Beli Lom (Bozhinov M., Bozhinov B., 2004), while the cultivars Perla-267 and Vega were the results of breeding for fiber quality (Stoilova, Saldzhiev, 2000, 2005). Three new cotton varieties resulting from the breeding of fiber quality, Colorit, Darmi and Natalia, were recognized by IASAS (Executive Agency for Variety Testing, Approbation and Seed Control) in 2007–2008 (Report of IASAS, 2007, 2008).

The aim of this study was to determine the productive potential and fiber quality indices of new cotton varieties in comparison with the standard cultivars, as well as the combination of other valuable properties.

Material and Methods

Three new cotton varieties were obtained by crosses of *G. hirsutum* L. and bred lines of *G. hirsutum* L. × *G. barbadense* L. origin: Natalia (line 65 × T-073), Darmi (line 268 × C-9070), and Colorit (line 266 × Balkan). In 2002–2006, they were included in competitive cultivar trials, set up by the standard method, in four replications, with harvesting plots of 30,6 m² (2002–2005) and 20 m² (2006), and planting density of 60 × 10 × 1. The varieties were evaluated on the base of obtained data for the most important agronomic traits: September and total yields, boll weight, length and lint percentage. Fiber length was determined by the butterfly method. Ten plants from each replication were analyzed. Two standards were used: the cultivar Chirpan-539 for earliness and productivity and the cultivar Avangard-264 for fiber quality. Statistical program ANOVA was applied for data evaluation. Hierarchical cluster analysis based on the agronomic traits was also applied. The varieties were clustered using the Ward method (Ward, 1963). Program STABLE (Kang, Magari, 1995) was used to estimate genotype × environment interaction and stability parameters σ_i^2 , S_i^2 (Shukla, 1972), and Kang's YS_i (Kang, 1993).

The variety Colorit was included in the state cultivar testing in 2001–2003; Darmi, in 2002–2004; and Natalia, in 2004–2007.

The period of study (2001–2007) included years of various temperature and rainfall supply: 2001 (warm and very dry) was exceptionally unfavorable in regard to the rainfall supply; 2002 and 2003 (warm and moderately wet) were very favorable for cotton; 2004 was cool and wet; 2005 – moderately cool and wet; 2006 – moderately warm and moderately dry and 2007 – very hot and moderately wet.

Results and Discussion

The results of the competitive cultivar testing of new varieties averaged over the period 2002–2006 are shown in Table 1. In the average over the five-year period, the new varieties Natalia, Darmi and Colorit and both standards – Chirpan-539 and Avangard-264 did not differ in total yield of seed cotton. In terms of September yield, which is used as a criterion of earliness, Natalia and Darmi were inferior to Chirpan-539 by 7,0–7,2 % (standard for earliness and productivity), but the differences were statistically insignificant.

As for boll weight, Darmi was equal to Chirpan-539, while Natalia, Colorit and Avangard-264 had higher boll weights by 0,2 g. The average fiber length for the five-year period was insignificantly (0,3–0,5 mm) longer than that of Avangard-

264 (standard for fiber quality). In fiber length (28,7–28,9 mm) they surpassed Chirpan-539 by 2,2–2,4 mm. In terms of lint percentage Natalia and Darmi surpassed Avangard-264 by 1,7–1,9 %, but by this property they were behind Chirpan-539 by 1,4–1,6 %. Colorit had lower lint percentage and was approximately equal to Avangard-264, and considerably inferior (by 2,9 %) to Chirpan-539. The longer fiber of this variety was combined with a higher set of the first fruit branch: 21,0 cm at 18,9 cm for Chirpan-539 and 18,5 cm for Avangard-264 which makes it very suitable for machine picking of cotton.

Cluster analysis based on the data in Table 1 shows that the new varieties and the standard cultivar Avangard-264 are in one basic cluster. The cultivar Chirpan-539 is separated from them because of its shorter fiber and higher lint percentage (Fig. 1). The new varieties at a lower level of division show some genetic differences. Natalia is very similar to Avangard-264.

Two factor analysis of variance of the traits under study (Table 2) showed that the effect of genotypes was insignificant for total and September yields. Genotypes may differ in stability at insignificant mean values. The effect of years was significant for all traits. The genotype × environment interaction was significant for both the total yield and September yield as well as for the fiber length and lint percentage. A significant heterogeneity was detected only for fiber length.

Table 1
Agronomic indices of Natalia, Darmi and Colorit for a five-year period (2002–2006)

Cultivars	Seed cotton yield, kg/ha	In % to Chirpan-539	September yield, kg/ha	In % to Chirpan-539	Boll weight, g	Lint percentage, %	Fiber length, mm	Height of first fruit branch, cm
Chirpan-539 (St.)	2355	100,0	1740	100,0	5,6	40,1	26,5	18,9
Avangard-264 (St.)	2350	99,8	1784	102,5	5,8 ⁺	36,8 ⁰⁰⁰	28,4 ⁺⁺⁺	18,5
Natalia	2353	99,9	1619	93,0	5,8 ⁺	38,7 ⁰⁰	28,9 ⁺⁺⁺	19,1
Darmi	2300	97,7	1615	92,8	5,6	38,5 ⁰⁰	28,7 ⁺⁺⁺	19,8
Colorit	2330	98,9	1715	98,6	5,8 ⁺	37,2 ⁰⁰⁰	28,8 ⁺⁺⁺	21,0 ⁺⁺
GD 5 %	245	10,4	214	12,3	0,2	1,0	0,8	1,4
GD 1 %	337	14,3	295	16,9	0,3	1,4	1,1	2,0
GD 0,1 %	464	19,7	406	23,3	0,5	1,9	1,5	2,8
Average for trial	2338		1695		5,7	38,2	28,2	19,4

Table 2

Analysis of phenotypic variance of studied characters for stability

Sources of variation	Degree of freedom	Mean squares			
		Seed cotton yield	September yield	Lint percentage, %	Fiber length, mm
Genotypes	4	10775 ^{ns}	112456 ^{ns}	35,87 ⁺⁺	20,42 ⁺⁺
Environments	4	12089680 ⁺⁺	6174913 ⁺⁺	23,53 ⁺⁺	3,56 ⁺⁺
Interaction	16	133047 ⁺⁺	102192 ⁺⁺	2,27 ⁺⁺	1,30 ⁺⁺
Heterogeneity	4	19557 ^{ns}	156950 ^{ns}	3,87 ^{ns}	2,74 ⁺
Residual	12	170877 ⁺⁺	83940 ⁺⁺	1,74 ⁺⁺	0,82 ⁺⁺
Pooled error	60	33360	25548	0,57	0,33

Notes. +, ++ – significant at the 0,05 and 0,01 probability level, respectively; ns – non-significant.

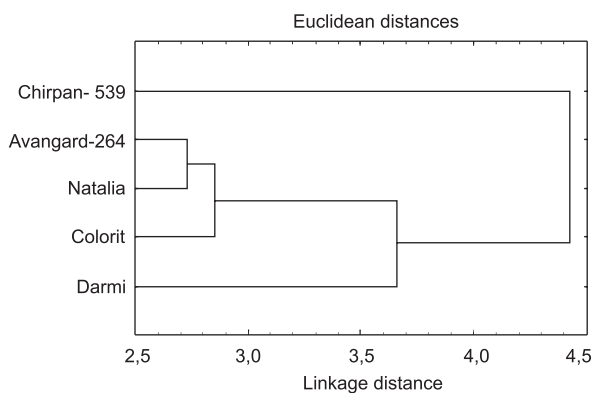


Fig. 1. Cluster analysis of 5 cotton varieties by 6 traits, Ward's method.

In terms of seed cotton yield the variance stability indices (σ_i^2 and S_i^2) determined as stable the varieties Avangard-264, Darmi, and Colorit (Table 3).

The YS_i index, which enables the simultaneous estimation for yield and stability, showed the highest breeding value for the standard variety Avangard-264. The varieties Avangard-264 and Colorit were stable also in September yield according to variance stability indices (σ_i^2 and S_i^2). According to the YS_i index, Avangard-264 was the most stable, and Colorit ranked second. As for breeding for lint percentage, useful stability based on the σ_i^2 and S_i^2 values was found for Avangard, Darmi and Colorit. According to the YS_i index, Darmi was the most valuable. In fiber length, the variance stability indices (σ_i^2 and S_i^2) showed that both standards, Chirpan-539 and Avangard-264, were stable. Avangard-264 was the most valuable according to the YS_i index.

Table 3

Stability parameters by Shukla (σ_i^2 and S_i^2) (1972) and Kang (YS_i) (1993) for four traits of 5 genotypes

Cultivars	σ_i^2	S_i^2	YS_i
Seed cotton yield			
Chirpan-539 (St.)	1394,033 ⁺⁺	1733,498 ⁺⁺	0
Avangard-264 (St.)	-12,811 ^{ns}	-0,988 ^{ns}	6+
Natalia	4966,800 ⁺⁺	6460,990 ⁺⁺	-1
Darmi	-89,706 ^{ns}	-121,740 ^{ns}	-2
Colorit	394,180 ^{ns}	472,076 ^{ns}	-3
September yield			
Chirpan-539 (St.)	1094,928 ⁺⁺	992,177 ⁺	-1+
Avangard-264 (St.)	349,822 ^{ns}	601,599 ^{ns}	6+
Natalia	1722,301 ⁺⁺	1575,065 ⁺⁺	-9
Darmi	1632,465 ⁺⁺	1211,426 ⁺⁺	-10
Colorit	310,363 ^{ns}	-183,280 ^{ns}	4+
Lint percentage			
Chirpan-539 (St.)	6,736 ⁺⁺	5,259 ⁺⁺	0
Avangard-264 (St.)	-0,114 ^{ns}	0,154 ^{ns}	-2
Natalia	5,249 ⁺⁺	3,177 ⁺⁺	-1
Darmi	-0,187 ^{ns}	0,137 ^{ns}	6+
Colorit	-0,347 ^{ns}	-0,048 ^{ns}	-1
Fiber length			
Chirpan-539 (St.)	0,070 ^{ns}	0,361 ^{ns}	-2
Avangard-264 (St.)	0,001 ^{ns}	0,260 ^{ns}	5+
Natalia	1,912 ⁺⁺	2,194 ⁺⁺	0
Darmi	2,720 ⁺⁺	0,593 ^{ns}	-2
Colorit	1,804 ⁺⁺	0,705 ^{ns}	-1

Within the state cultivar testing of cv. Colorit in 2001–2003, a total yield of 2260 kg/ha was obtained as the average for all stations included, 4,1 % higher than Avangard-264 (standard for fiber quality), and it did not differ from Chirpan-539. In lint yield, it also surpassed Avangard-264 by 4,6 %, but was inferior to Chirpan-539 by 3.6 %. In modal and staple length (29,0–31,3 mm), the gain over Avangard-264 was 1,2 and 0,6 mm, and Colorit showed a higher uniformity. The total yield of cv. Darmi averaged over three years (2002–2004) was 2500 kg/ha, 6,8 % higher than Avangard-264 and 2,0 % higher than Chirpan-539. In lint yield, it surpassed Avangard-264 by 7,4 % and was about equal to Chirpan-539. The variety Natalia yielded 2330 kg/ha as the average for 2004–2007 and exceeded both standards (Avangard-264 by 4,5 % and Chirpan by 3,5 %), in lint yield surpassed Avangard-264 by 7,1 % and was inferior to Chirpan-539 by 2,4 % (IASAS, 2007–2008).

Conclusions

The varieties Natalia, Darmi and Colorit are the result of progress in breeding for fiber quality. Their fiber is 0.6 mm longer. It is combined with other advantages: higher lint percentage in Natalia and Darmi than in Avangard-264 and higher first fruit branch in Colorit.

These varieties had higher productivity than Avangard-264 in the state cultivar testing. Darmi and Natalia also overpowered Chirpan-539 in seed cotton yield by 2,0–3,5 %.

The new varieties and the standard cultivar Avangard-264 belonged to one basic cluster, and

it is preferable to use them in breeding programs with varieties further apart.

The cultivar Avangard-264 had superior combinations of yield and stability simultaneously as well as of fiber length and stability, and the new variety Darmi, of fiber lint percentage and stability.

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