

A new cotton variety Aida

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Citation

Dimitrova, V. (2022). A new cotton variety Aida. *Rastenievadni nauki*, 59(1) 43-50

Abstract

The aim of this research was to study the productive potential and to evaluate the fiber quality characteristics of the new cotton Aida variety. The variety was studied in competitive variety trials conducted in 2014-2017 in the experimental field of the Field Crops Institute in town of Chirpan. In the system of the IASAS (Exclusive Agency for Variety Testing, Approbation and Seed Control) the Aida variety was tested in 2017-2018. It was approved as a new cotton variety in 2019 and was certified in 2020. It was obtained by remote hybridization and backcross technology. Aida variety showed high and stable productivity during the years of testing. According to the IASAS data, in the seed cotton yield of 2380 kg/ha, on average over two years, it exceeded the two standards - Chirpan-539 and Avangard-264, respectively by 11.3% and 14.7%, the average standard - by 13.0%. It outperformed the standards in September harvest and in fiber (lint) yield. The Aida variety was distinguished by its high fiber quality, and in some fiber properties it was superior to both standards or equalized with Avangard-264 variety - standard for fiber quality. Compared to the standard varieties, the Aida variety had a better fiber consistency (SCI) Index, greater Upper Half Mean Length (UHML), better uniformity in fiber length and a better spectroscopy with a reflection of the RD difference. The content of short fibers was very low. The results obtained identified the Aida variety as a very good combination of earliness, productivity and fiber quality. This outlined it as a very valuable for the cotton production and for the cotton breeding programs.

Key words: cotton; *G. hirsutum* L.; variety; productivity; fiber properties

INTRODUCTION

Main task of the plant breeding is constantly to improve the existing varieties. Cotton breeding programs in Bulgaria are mainly aimed at improving the earliness, productivity and fiber quality of the modern varieties. Priority is given to earliness due to the short growing season.

Cotton varieties grown in Bulgaria have to be early, with high and stable yields, and high fiber quality to meet the requirements of the cotton production and textile industry.

In the selection of cotton in Bulgaria the most widely used breeding method is intraspecific hybridization. As a result of successful breeding work by this method, a number of varieties have been created and implemented in the cotton production, of which the Beli izvor (No. 432), Garant (No. 996), Ogosta (No. 644), Chirpan-603, Chirpan-539 (Bo-

zhinov & Dimitrova, 1981a, 1981b, 1986, 1989; Bozhinov et al., 1996) were particularly valuable.

The variety Beli izvor possessed a complex of qualities and has remained in production for the longest time, being from 1981 to 2003 the main variety for the country. Chirpan-603 and Chirpan-539 varieties were newer, earlier and more productive than Beli Izvor, they had better fiber quality, higher lint percentage, and better harvested with machines.

Newer and newest varieties - Beli Iskar, Beli Lom, IPTP Veno, Boyana, Denitsa and Philipopolis, also obtained through intraspecific hybridization, were a step forward in the selection for increasing the productivity, fiber quality and its lint percentage (Bozhinov & Bozhinov, 2004; 2008; Valkova & Bozhinov, 2010; Valkova, 2014a, 2014b).

Through the use of experimental mutagenesis in Bulgaria the varieties Trakia, Helius, Sirius and Tsvetelina were obtained. These varieties combined

high productivity and a number of other valuable economic and technological qualities (Valkova, 2009, 2017; Koleva & Valkova, 2019).

The main method for improving the fiber quality was the interspecific hybridization of the species *G. hirsutum* L. × *G. barbadense* L. Avangard-264 variety, registered in 1994, by 3 mm longer fiber than the standard variety Beli izvor was obtained (Koynov & Stoilova, 1996).

More recent achievements in the selection for quality were Pearl-267, Vega, Colorit, Darmi and Natalia varieties (Stoilova & Saldzhiev, 2000, 2005a, 2005b, 2008a, 2008b, 2010), obtained from the combination of interspecific *G. hirsutum* L. × *G. barbadense* L. hybridization with intraspecific hybridization.

The aim of this research was to study the productive potential and to evaluate the technological fiber properties of the new cotton Aida variety, compared to the standard varieties.

MATERIAL AND METHODS

The Aida variety was created by remote hybridization, by the crossing of the allotetraploid *Gossypium thurberi* Tod. × *G. raimondii* Ulbr. with the variety Darmi - *G. hirsutum* L. and backcrossing of the triple hybrid (*G. thurberi* Tod. × *G. raimondii* Ulbr.) × Darmi with the variety Darmi. The Darmi variety was obtained by combining the interspecific of *Gossypium hirsutum* L. × *G. barbadense* L. hybridization with intraspecific. This variety is characterized by a high productive potential, which was well realized in favourable for cotton years, with sufficient temperature security and rainfall. In dry years the yield of the Darmi variety was lower. The Darmi variety is distinguished by its large bolls, longer fiber than that of the standard *G. hirsutum* L. varieties, but has a lower lint percentage inherited from the *G. barbadense* L. species.

The initial plant was selected in F_3BC_1 and repeating negative selection was performed in the progeny by the economically most important traits. In 2010, as breeding line No. 457, it was included in the control testing. In 2011, line No. 457 was in preliminary variety testing and since 2012 it was included in competitive variety trials.

The trials were conducted in the experimental field of the Field Crops Institute in town of Chirpan

on leached vertisols type and were plotted by the block method, in 4 replications, and a 20 m² harvest plot. The Chirpan-539 variety was used as standard. This variety is very early maturing, high yielding and outlines with high lint percentage, very good ecological plasticity and stability. Standard cotton growing technology was applied. 10 plants of each replicate were observed. To evaluate the economic qualities the following were taken into account: seed cotton yield (kg/ha); boll weight (g); lint percentage (%) and fiber length measured by the “butterfly” method (mm). A two-factor analysis of variance was performed on the results (Lidansky, 1998). The ANOVA 123 program was used.

Variety Aida was included for testing in the IASAS system (Exclusive Agency for Variety Testing, Approbation and Control) in 2017-2018. In 2017, it was tested in two locations - Radnevo and Burgas experimental stations of variety testing at the IASAS. In the next 2018, it was tested only in Radnevo experimental station, typical in climatic and soil conditions for cotton cultivation in southern Bulgaria. The main cotton areas are located in this region. The standards were Chirpan-539 for earliness and productivity and Avangard-264 for fiber quality. In the state variety testing, the new cotton varieties were also compared to the average standard - the average of the two standards.

The years of the study were characterized as follows: in terms of temperature security, 2015, 2016, 2017 and 2018 were warm ($P=14.3-17.2\%$), 2014 was medium to moderately cool ($P=66.7\%$); in terms of rainfall availability, 2015 and 2017 were moderately wet ($P=28.6-33.3\%$), 2014 and 2018 were wet ($P=12.9-14.8\%$) and 2016 was dry ($P=93.1\%$). The variability of years in terms of the rainfall supply was greater compared to their temperature security. $P\%$ is the coverage factor (coefficient of security) for the temperature sum in May-September and the precipitation sum in May-August, respectively. The years of the study were compared with the multi-year averages over a 30-year baseline period of the last 30 years (1989-2018). This period was taken as a climatic norm (Alexandrov et al., 2010).

RESULTS AND DISCUSSION

The Aida variety has a medium high with a conical shape shrub. The stem is erect, green, with

medium hairiness at the upper part and medium anthocyan colour at maturity. The leaf mass is of medium density. The leaves are medium-sized, palm-shaped, 3-5 lobed, with medium hair on the underside and grassy-green colour. The fruiting branches are medium-long, with medium-long internodes. The variety sets the 1st fruiting branch at an average height of 15.7 cm, by 1.0 cm lower than the standard variety, but the variety is suitable for mechanical harvesting. The flowers are cream, without anthocyanin spot at the base of the petals. The bolls are medium sized, 4-5 lobes, oval-ovate in shape and have a well-shaped protrusion on the tip. The degree of the bolls opening at full maturity is medium to strong. The seeds are medium-sized, covered with a medium thick, whitish fuzz. The fibre of the Aida variety is white, with a relatively high lint percentage, medium-long, medium-fineness, of good strength and uniformity in length. In fiber lint percentage, 37% on average, it has close to the high-lint percentage standard Chirpan-539 variety.

The Aida variety is a highly productive for the conditions of our country, with insufficient temperature and rainfall security for cotton. Cotton is grown under non-irrigated conditions. The results of the test of the variety in the Field Crops Insti-

tute in Chirpan showed that the seed cotton yields in individual years varied from 1549 kg/ha in 2015 to 2102 kg/ha in 2014, which was respectively by 1.4% to 13.3% above the standard Chirpan-539 variety (Table 1). Excluding 2015, when emergence problems were observed as a result of poor quality sowing, the excess of seed cotton yield by individual years remained relatively stable - 10.9-13.3%. The average seed cotton yield over four years (2014-2017) of the standard variety was 1615 kg/ha, of the Aida variety - 1771 kg/ha, which was 9.7% more. The results for the average seed cotton yields characterized the Aida variety as high yielding and stable over the years. The Aida variety had significant smaller boll weight by 0.3 g than that of the standard variety - Chirpan-539 (Table 2). Its fibre was by 0.5 mm longer than that of the standard variety, but the lint percentage was lower by 0.5%. The Aida variety outperformed the standard variety in fibre yield (lint yield) by 5.7% due to the higher seed cotton yield.

The results obtained from the state variety testing (IASAS data) are presented in Table 3. The September harvest, the cotton harvested by 30 September, was used as the main criterion for determining the earliness of varieties. In 2017, on an average of the two locations, the Aida variety in September

Table 1. Seed cotton yield resulting from the Aida variety included in variety trial, plotted at the Field Crops Institute in Chirpan during 2014-2017

| Variety | Seed cotton yield, kg/ha | | | | | In % to Chirpan-539 |
|-------------|--------------------------|------|------|------|---------|----------------------|
| | 2014 | 2015 | 2016 | 2017 | Average | |
| Chirpan-539 | 1855 | 1527 | 1643 | 1437 | 1615 | 100.0 |
| Aida | 2102 | 1549 | 1822 | 1610 | 1771 | 109.7 ⁺⁺⁺ |
| GD 5% | 153 | 126 | 117 | 57 | 81 | 5.0 |
| GD 1% | 202 | 168 | 158 | 76 | 107 | 6.6 |
| GD 0.1% | 257 | 220 | 211 | 98 | 138 | 8.5 |

Table 2. Economic traits of the variety Aida included in variety trial, plotted at the Field Crops Institute in Chirpan during 2014-2017

| Variety | Lint yield, kg/ha | Boll weight, g | Fiber length, mm | Lint percentage, % |
|-------------|-------------------|-------------------|--------------------|---------------------|
| Chirpan-539 | 662.0 | 5.2 | 25.9 | 41.0 |
| Aida | 669.5 | 4.9 ⁰⁰ | 26.4 ⁺⁺ | 39.5 ⁰⁰⁰ |
| GD 5% | - | 0.2 | 0.3 | 0.5 |
| GD 1% | - | 0.3 | 0.5 | 0.7 |
| GD 0.1% | - | 0.4 | 0.6 | 0.9 |

harvest of 1683 kg/ha very slightly outperformed both standards. In 2018, in the Radnevo experimental station, the Aida variety by September harvest of 2285 kg/ha strongly outperformed both standards and exceeded the average standard by 29.5%. As a result of the high September harvest realized in 2018, on average over the two years - 2017-2018, the Aida variety by this trait significantly surpassed both standards and the average standard - by 10.3% (data not shown here).

On average over the two years, from the two variety testing experimental stations, the September yield harvested of the Aida variety was 1984 kg/ha, which was 16.0% above the average standard, 13.2% above Chirpan-539 variety and 18.8% above Avngard-264 variety.

In the experimental station for variety testing in Radnevo, average for the two years, from the standard varieties Chirpan-539 and Avangard-264, seed cotton yields of 2269 kg/ha and 2215 kg/ha, respectively, were obtained, average of the two standards - 2242 kg/ha (average standard). The Aida variety in seed cotton yield of 2454 kg/ha exceeded both standards, Chirpan-539 - by 8.1%, Avangard-264 - by 10.8%, the average standard - by 9.5 %. In the

experimental station for variety testing in Burgas the yields were lower, this region is less suitable for cotton growing (data not given here). The standard varieties in 2017 yielded 1653 kg/ha and 1714 kg/ha, with an average of 1683 kg/ha from the two standards. The Aida variety in terms of seed cotton yield - 1818 kg/ha was superior to both standards, Chirpan-539 - by 6.1%, Avangard-264 – by 10.0%, the average standard – by 8.0%. In 2018, the Aida variety yielded 2581 kg/ha of seed cotton yield, 24.5% above the average standard.

On average over the two years, from the two locations, Aida variety achieved seed cotton yield of 2328 kg/ha, which was 11.3% above Chirpan-539, 14.7% above Avangard-264 and 13.0% above the average standard. The Aida variety proved to be more productive than both standards, in both stations and in both years, i.e. this variety retained its high productivity under different environmental conditions, which confirmed the results of the competitive variety testing of the variety in the Field Crops Institute in Chirpan.

The Aida variety in terms of fiber yield (lint yield) of 787 kg/ha in 2017, was slightly inferior by 1.4% to Chirpan-539, superior by 3.7% to Avangard-

Table 3. Test results obtained from Aida variety in the IASAS system (state variety testing) in 2017-2018

| Variety | 2017 | 2018 | Average | In % to average standard |
|--------------------------|------|------|---------|--------------------------|
| September harvest, kg/ha | | | | |
| Average standard | 1657 | 1765 | 1711 | 100.0 |
| Chirpan-539 | 1669 | 1835 | 1752 | 102.4 |
| Avangard-264 | 1645 | 1695 | 1670 | 97.6 |
| Aida | 1683 | 2285 | 1984 | 116.0 |
| Seed cotton yield, kg/ha | | | | |
| Average standard | 2047 | 2073 | 2060 | 100.0 |
| Chirpan-539 | 2070 | 2111 | 2091 | 101.5 |
| Avangard-264 | 2024 | 2034 | 2029 | 98.5 |
| Aida | 2070 | 2586 | 2328 | 113.0 |
| Lint yield, kg/ha | | | | |
| Average standard | 778 | 740 | 759 | 100.0 |
| Chirpan-539 | 798 | 779 | 789 | 103.9 |
| Avangard-264 | 759 | 702 | 731 | 96.3 |
| Aida | 787 | 931 | 859 | 113.2 |
| Lint percentage, % | | | | |
| Average standard | 37.9 | 35.7 | 36.8 | 100.0 |
| Chirpan-539 | 38.4 | 36.9 | 37.7 | 102.4 |
| Avangard-264 | 37.3 | 34.5 | 35.9 | 97.5 |
| Aida | 38.0 | 36.0 | 37.0 | 100.5 |

264, resulting in slightly exceeded by 1.1% the average standard. In 2018, in the Radnevo experimental station, the Aida variety showed a higher fiber yield (lint yield) of 931 kg/ha, significantly exceeding both standards, Chirpan-539 by 19.5%, Avangard-264 by 32.6%, the average standard by 25.8%. Its high fiber yield was due to the high total seed cotton yield in this year. This trend was maintained in the fiber (lint) yield realized over the two years from the two locations. On average for the two years, from the two experimental stations, the fiber yield of the Aida variety was 859 kg/ha, surpassing both standards, Chirpan-539 - by 9.0%, Avangard-264 - by 17.7%, the average standard - by 13.2%.

In 2017, the lint percentage of Aida variety was 38.0% and it was inferior to Chirpan-539 by 0.4% and surpassed Avangard-264 by 0.7% (Table 3). In 2018, this trend persisted, but the differences were more pronounced, it was inferior to Chirpan-539 by 0.9%, outperforming Avangard-264 by 1.5%. Based on the average data for the two years, from the two locations, the Aida variety in terms of lint percentage of 37.0% was inferior to Chirpan-539 by 0.7%, surpassed Avangard-264 by 1.1%, approaching the average standard.

In the state variety testing, the growing season for Aida variety was 119 days, with 120 days for Chirpan-539 and 119 days for Avangard-264. The height of the 1st fruiting branch for the standard varieties was 16.5 cm, for the new variety it was 15.5 cm, 1 cm lower (data not given here).

The results for the fiber technological properties are presented in Table 4. Compared to the two standards (Chirpan-539 for productivity and Avangard-264 for fibre quality), the Aida variety was distinguished by a better consistency (SCI) Index of the fiber in both years of the study, indicating that this quality was not affected by environmental conditions. This quality is related to fiber spinning. On average for the two years this, (SCI) Index for Aida variety was 126, for standard varieties it was much lower, for Chirpan-539 variety - 114, for Avangard-264 variety - 118, for the average standard - 117.

The Aida variety showed better spectroscopy with a reflection of RD difference by individual years and the average for the two years. The Rd index was 82.7 vs. 81.1 for Chirpan-539 and 81.5 for Avangard-264. As for the yellowness (+b) – 8.5 the new variety was leveled with the standard varieties.

During the two years of the study, the Aida variety had slightly higher (in 2017) or slightly lower (in 2018) micronaire value of the fiber than Avangard-264 variety. The micronaire value determines the fineness of the fiber. A lower microner means a finer fiber. Avangard-264 variety had a finer fiber than the Chirpan-539 variety. On average over the two years, Aida variety according to the micronaire value of the fiber - 4.61 mic was equalized with Avangard-264 - 4.62 mic. The new variety possessed a finer fiber than that of Chirpan-539 variety in both years of the study.

Aida variety in fiber length of 25.67 mm in 2017 slightly exceeded both standards, while in 2018 it had a longer fiber of 27.39 mm and exceeded Chirpan-539 by 1.48 mm, Avangard-264 by 0.56 mm. In 2018, compared to 2017, it had a slightly shorter fiber and exceeded the standards by 0.49 mm. On average for both years, the Aida variety had fiber length (UHML) of 26.53 mm and exceeded both standards, Chirpan-539 by 1.01 mm, Avangard-264 by 0.35 mm, the average of the two standards by 0.68 mm.

The new variety showed better uniformity in fiber length than the two standards over the two years of the study, average 83.2% compared to 81.9% for the standard varieties. In terms of fibre strength – average of 27.7 g/tex and fiber elongation Aida variety was levelled with the standard varieties. This variety had a low short fibre content of 8.1%, as in the standard varieties - 9.0 % and 8.5 %, respectively.

Summarized results of the analysis showed that Aida variety had high and stable productivity by individual years. In terms of seed cotton yield and fibre (lint) yield it was superior to both standards. The boll weight was smaller than that of the standard varieties and its high productivity was due to the greater fertility of the variety, accumulating and retaining a larger number of bolls. The higher fiber (lint) yield per hectare was the result of the higher total seed cotton yield.

The new variety possessed high fiber quality, as in some fiber properties surpassed both standards or equalized with Avangard-264, the standard for fiber quality.

Compared to the standard varieties, Aida variety had a better fiber consistency (SCI) Index, which means better spinning, greater Upper Half Mean length and better uniformity in length and it was

characterized by better spectroscopy with reflectance of the RD difference.

There was no development of verticillium wilt and bacteriosis on a natural infectious background. On an artificial infectious background,

the variety was susceptible to the causative agents of verticillium wilt as the standard varieties were.

This variety confirmed its qualities in the state variety testing and due to this it was approved by

Table 4. Technological fibre qualities according to IACAS data, 2017-2018

| Year | Average standard | Chirpan-539 | Avangard-264 | Aida |
|--|------------------|-------------|--------------|-------|
| Spinning, consistency (SCI), Index | | | | |
| 2017 | 115 | 114 | 117 | 121 |
| 2018 | 117 | 114 | 119 | 131 |
| Average 2017-2018 | 116 | 114 | 118 | 126 |
| Deviation | | -2 | +2 | +10 |
| Micronaire (Mic) | | | | |
| 2017 | 4.57 | 4.74 | 4.41 | 4.48 |
| 2018 | 4.92 | 5.00 | 4.83 | 4.73 |
| Average 2017-2018 | 4.75 | 4.87 | 4.62 | 4.61 |
| Deviation | | +0.12 | -0.13 | -0.14 |
| Maturity(Mat) Index | | | | |
| 2017 | 0.86 | 0.87 | 0.86 | 0.86 |
| 2018 | 0.87 | 0.87 | 0.87 | 0.87 |
| Average 2017-2018 | 0.87 | 0.87 | 0.87 | 0.87 |
| Deviation | | 0 | 0 | 0 |
| Fiber mean length (UHML - Upper Half Mean Length), mm | | | | |
| 2017 | 25.33 | 25.13 | 25.54 | 25.67 |
| 2018 | 26.37 | 25.91 | 26.83 | 27.39 |
| Average 2017-2018 | 25.85 | 25.52 | 26.18 | 26.53 |
| Deviation | | -0.33 | +0.33 | +0.68 |
| Uniformity (UL) % | | | | |
| 2017 | 81.5 | 81.6 | 81.3 | 82.2 |
| 2018 | 82.4 | 82.3 | 82.5 | 84.1 |
| Average 2017-2018 | 82.0 | 81.9 | 81.9 | 83.2 |
| Deviation | | -0.1 | -0.1 | +1.2 |
| Short fibers (SFL), 12.7 mm | | | | |
| 2017 | 9.2 | 9.4 | 9.0 | 8.8 |
| 2018 | 8.4 | 8.6 | 8.1 | 7.5 |
| Average 2017-2018 | 8.8 | 9.0 | 8.5 | 8.1 |
| Deviation | | +0.2 | -0.3 | -0.7 |
| Strength (Str), g/tex | | | | |
| 2017 | 28.3 | 28.4 | 28.2 | 28.2 |
| 2018 | 27.5 | 27.3 | 27.7 | 27.9 |
| Average 2017-2018 | 27.9 | 27.8 | 27.9 | 27.7 |
| Deviation | | -0.1 | 0.0 | -0.2 |
| Elongation (Elg), % | | | | |
| 2017 | 7.1 | 7.1 | 7.2 | 7.1 |
| 2018 | 7.1 | 7.3 | 6.9 | 6.9 |
| Average 2017-2018 | 7.1 | 7.2 | 7.1 | 7.0 |
| Deviation | | +0.1 | 0.0 | -0.1 |

| | | | | | |
|--|---------|------|------|------|------|
| Spectroscopy with reflectance of the difference RD | | | | | |
| 2017 | | 81.1 | 80.4 | 81.9 | 82.6 |
| 2018 | | 81.5 | 81.9 | 81.0 | 82.9 |
| Average 2017-2018 | | 81.3 | 81.2 | 81.5 | 82.7 |
| Deviation | | | -0.1 | +0.2 | +1.4 |
| Yellowness (+b) | | | | | |
| 2017 | | 8.9 | 8.9 | 8.9 | 8.9 |
| 2018 | | 8.2 | 8.3 | 8.0 | 8.2 |
| Average 2017-2018 | | 8.5 | 8.6 | 8.5 | 8.5 |
| Deviation | | | +0.1 | 0.0 | 0.0 |
| Color Grade (C Grad) Upland | | | | | |
| 2017 | Radnevo | - | 21-1 | 11-1 | 11-1 |
| | Burgas | - | 11-2 | 11-2 | 11-1 |
| 2018 | Radnevo | - | 21-1 | 21-1 | 11-1 |

the IASAS as a new cotton variety Aida in 2019 and certified in 2020 (Sertificate No. 11199).

CONCLUSIONS

The Aida variety combined high and stable productivity over the years and high fibre quality, making it a new achievement in the cotton breeding. In terms of average seed cotton yields of 2380 kg/ha it exceeded the two standard varieties Chirpan-539 and Avangard-264 by 11.3% and 14.7%, respectively, the average standard by 13.0%. It surpassed them in September harvest and in fiber yield (lint yield) by 9.0% and 17.7%.

The new variety had the advantage for some technological fiber properties, exceeding both standards - Chirpan-539 and Avangard-264 – the standard for fiber quality. Its fiber differed with a better spinning consistency, greater Upper Half Mean Length, better uniformity in fiber length and better spectroscopy. The content of short fibers was very low.

The Aida variety had a finer fiber than that of Chirpan-539, equalizing with Avangard-264. In terms of fiber strength and fiber elongation, it was leveled with the standard varieties.

The Aida variety has confirmed its qualities in the state variety testing and it has been approved as a new cotton variety in 2019 and certified in 2020.

The Aida variety possesses fiber qualities that are highly valued by the textile industry. This va-

riety is also very valuable for cotton breeding, for inclusion in crosses to further improve the productivity and fiber quality of modern cotton varieties.

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