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Fiber Length in Broomcorn as Affected by Stand Density

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Abstract: Broomcorn fiber length is determined by measuring the distance between the point at which the fibers start to branch out and the tip of at least two thirds of all the fibers present in a given panicle. This is a very important morphological trait, as it determines the success of the panicle harvest. A two-year investigation was carried out in order to determine the influence of different stand densities on fiber length levels in two broomcorn genotypes. Two row-to-row spacings (50 and 70 cm) and six plant-to-plant ones (5, 9, 13, 17, 21, and 25 cm) were studied. Fiber length was the smallest (42.6 and 45.2 cm) with the highest stand densities, and it increased with increasing plant growing space (63.7 cm and 71.0 cm).

Key words: broomcorn, fiber length, row-to-row spacing, plant-to-plant spacing.

Introduction

Broomcorn - *Sorghum bicolor* (L.) Moench, has a wide variety of uses due to its variability. In many developing countries, sorghum grain is utilized in the human diet, and this crop is also used as the high-protein component of animal feed. Sorghum is used to produce glucose, syrup, starch, gluten, oil, alcohol, cellulose, and paper, its fresh weight is used to produce silage or haylage, the panicles are used by broom manufacturers, while broomcorn biomass is used for the obtainment of bioenergy. Agronomically, sorghums (*Sorghum bicolor* (L.) Moench) are divided into

broomcorn, grain sorghum, sweet (silage) sorghum, and Sudan grass (Berenji and Dahlberg 2004). According to this agronomic classification, which is based on the method of use, broomcorn is an industrial crop, while all the other sorghums are classified as forage crops (Berenji and Mijavec 1992). In Serbia, broomcorn is grown on about 2,000 hectares. Broomcorn has modest environmental requirements and its production is stable and economical thanks to a steady demand for this crop (Berenji and Sikora 2006).

Fiber length and peduncle length make up panicle length. This trait is of great importance in broomcorn growing, since panicle length determines the usability of the panicles. Broom manufacturers value medium long (40-50 cm) and long (50-65 cm) panicles the most. Panicles shorter than that cannot be used to make large brooms, while very long panicles have the disadvantage of leaving too much waste during the process of broom making.

Mijavec and Kisgeci (1971) carried out a three-year trial to study how broomcorn panicle length is affected by row-to-row spacings of 42 52.5 and 63 cm and plant-to-plant spacings of 5, 10, 15 and 20 cm. They found that panicle length increased with increasing row-to-row and plant-to-plant spacings. In the study, only the highest row-to-row spacing and the largest spacing between the plants reduced panicle length.

The development of short broomcorn varieties as opposed to tall ones that had been grown earlier has resulted in reduced stem height (from 195 to 60 cm) and fibre elongation (from 51 to 73 cm), leading to an increase of weight (from 16 to 24.8 g) and yield of threshed panicle and a decrease of seed yield per panicle (from 39.1 to 31.0 g), whereby the percentage utilization of the plant has been increased from 29.1 to 45% (Berenji 1996).

Environmental conditions affect most morphological traits in broomcorn. Among other things, plant vegetative space has a great effect on the aforementioned traits, and, hence, the objective of this paper was to determine the effect of the plant vegetative space on fiber length in two broomcorn genotypes developed at the Novi Sad institute.

Materials and Methods

In order to study the effects of stand density on broomcorn fiber length, a trial was carried out during 2002 and 2003 on a piece of private property at Sajkas. The trial used a split-plot design with four replications and included large plots, which represented the different varieties, and smaller ones, which had row-to-row spacings of 50 or 70 cm and were divided into smaller subplots with six different plant-to-plant spacings (5, 9, 13, 17, 21 and 25 cm). The trial studied two broomcorn genotypes developed at the Institute of Field and Vegetable Crops in Novi Sad – Neoplanta Plus and Line N^o 5. The basic plot was 10 meters long and comprised two rows of broomcorn plants with a spacing of either 50 or 70 cm between the rows. In total, there were 96 basic plots in the trial (12 treatments with four replications times two (one for each variety)). In both study years, the standard cultural practice was used, namely basic tillage in the autumn down to 25 cm soil depth, seedbed preparation in the spring, interrow tillage, hoeing, and weeding.

The planting was done in strips using a hand seeder on a pre-marked plot. After emergence, the stand was thinned to a desired density. Samples of plant material to be used for morphological analyses were taken at technological maturity. Fifteen plants were taken from each basic plot (1,440 plants in total). Fiber length was measured and analysis was conducted of the effects of stand density on fiber length. The results were processed statistically by two-factor analysis of variance. The significance of differences was tested by the LSD test and the results were presented graphically and tabularly.

Results and Discussion

The present paper analyzes the effects of stand density on fiber length in two broomcorn varieties, Neoplanta Plus and Line № 5. Broomcorn fiber length is determined by measuring the distance between the point at which the fibers start to branch out and the tip of at least two thirds of all the fibers present in a given panicle.

Fiber length is of great importance not only as a yield component but as a determinant of panicle quality as well (Berenji and Sikora 2006).

A positive correlation between row-to-row spacing and fiber length has been reported by Mijavec *et al.* (1980), who studied the influence of stand thinning on panicle length and determined that a row-to-row spacing of 50 cm and a plant-to-plant spacing of 10–15 cm are most suitable for broomcorn production both in terms of yield levels and in terms of panicle quality. Reduced plant living space decreased panicle length, and vice versa.

In Serbia, the problem of determining optimum plant vegetative space that would ensure high yields of high-quality broomcorn panicles has been mostly tackled by the Department of Hops, Sorghums, and Medicinal Plants of the Institute of Field and Vegetable Crops in Novi Sad. Based on his findings, Husar (1963) recommended a row-to-row spacing of 40 cm and a plant-to-plant spacing of 15–20 cm. On the basis of perennial trials, Berenji (1990) concluded that the environment and hence the method of growing play a major role in the variation of economically important broomcorn traits.

Melton (1958) found that differences in broomcorn panicle yields stem not only from the genotype but from the year and stand density as well. The same author also reported significant effects of the environment on panicle mass, panicle length, peduncle diameter, fiber fineness, stem diameter, and leaf width and length.

In 2002 in the present study, there were on average no significant differences in fiber length between the row-to-row spacings of 50 and 70 cm in the variety Neoplanta Plus (65.83 cm at 50 cm and 66.95 cm at 70 cm). In 2003, the difference between the two treatments was highly significant (52.50 cm at 50 cm and 56.61 cm at 70 cm). In both study years, greater fiber length was obtained with the interrow spacing of 70 cm (Tab. 1.).

In 2002, highly significant differences in fiber length were found between the plant-to-plant spacings of 5 and 9 cm (52.28 and 65.19 cm) on the one hand and the rest of the spacings on the other. In 2003, the situation was the same (36.51 cm at 5 cm and 50.88 cm at 9 cm). When comparing the effects of different row-to-row

spacings with the plant-to-plant spacing being the same, no significant differences were observed in 2002, whereas in 2003 greater fiber length was obtained with 70 cm between the rows when the plant-to-plant spacing was 5 and 9 cm.

Table. 1. Fibre length (cm) of variety Neoplanta Plus

	Row-to-row spacing (cm) (A)	Plant-to-plant spacing (cm) (B)						Mean (A)
		5	9	13	17	21	25	
2002	50	52.90	63.85	68.60	69.18	71.13	69.35	65.83
	70	51.65	66.53	72.28	71.73	72.58	66.98	66.95
	Mean (B)	52.28	65.19	70.44	70.45	71.85	68.16	-
2003	50	32.28	45.60	58.65	57.15	59.10	62.23	52.50
	70	40.75	56.15	60.75	60.20	61.35	60.45	56.61
	Mean (B)	36.51	50.88	59.70	58.68	60.23	61.34	-
		2002		2003				
		LSD _{0.05}	LSD _{0.01}	LSD _{0.05}	LSD _{0.01}			
A		1.54	2.83	1.96	3.59			
B		2.93	3.95	2.30	3.10			
BxA		3.99	5.56	3.36	4.88			
AxB		4.15	5.58	3.25	4.38			

The differences in fiber length means between the row-to-row spacings of 50 and 70 cm that were found in Line № 5 in 2002 (70.13 and 72.80 cm) and 2003 (62.20 and 64.06 cm) were not statistically significant (Tab. 2).

The average values of fiber length found for the plant-to-plant spacings of 5 and 9 cm were 48.99 and 69.69 cm in 2002 and 46.04 and 59.51 cm in 2003. These values were significantly lower than those found for the other plant-to-plant spacings. The greatest fiber length in 2002 was obtained with a plant-to-plant spacing of 21 cm (79.06 cm), with the difference being statistically highly significant relative to the spacings of 5, 9 and 25 cm. In 2003, the greatest fiber length was observed with a plant-to-plant spacing of 25 cm (70.03 cm). The difference was highly significant compared with the spacings of 5 and 9 cm and significant relative to the spacing of 13 cm. In 2003, there was a tendency towards increasing fiber length with decreasing stand density.

Looking at the different interrow spacings with the plant-to-plant distance being the same, a highly significant difference was observed only in the case of the spacing of 9 cm, where a greater fiber length was obtained with the interrow spacing of 70 cm compared with the 50 cm one in 2002 and there were statistically significant differences in 2003 as well.

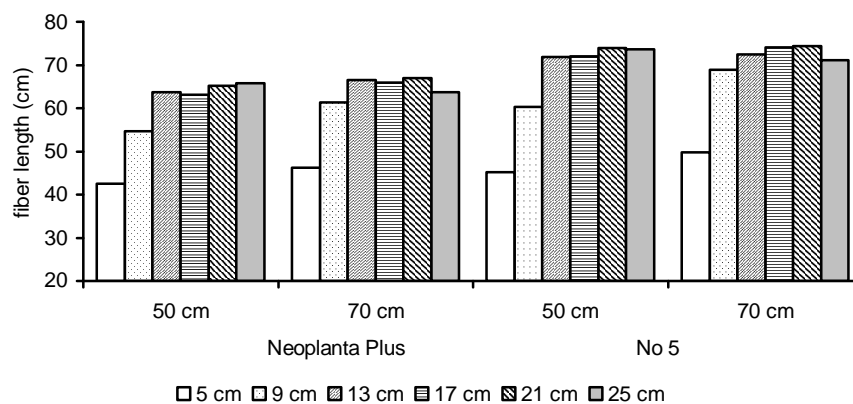
In general, the trend in both years was one of decreasing fiber length with increasing plant number per hectare for both varieties studied.

Table. 2. Fiber length (cm) of Line № 5

	Row-to-row spacing (cm) (A)	Plant-to-plant spacing (cm) (B)					Mean (A)	
		5	9	13	17	21		25
2002	50	46.78	64.15	78.55	76.25	79.05	76.03	70.13
	70	51.20	75.23	78.88	79.23	79.08	73.22	72.80
	Mean (B)	48.99	69.69	78.71	77.74	79.06	74.63	-
2003	50	43.65	56.48	65.26	67.73	68.93	71.20	62.20
	70	48.43	62.55	65.92	69.02	69.60	68.85	64.06
	Mean (B)	46.04	59.51	65.58	68.38	69.26	70.03	-
		2002		2003				
		LSD _{0.05}	LSD _{0.01}	LSD _{0.05}	LSD _{0.01}			
A		5.55	10.19	3.19	5.85			
B		3.23	4.36	3.39	4.56			
BxA		6.02	9.68	5.07	7.45			
AxB		4.57	6.16	4.79	6.45			

As regards the average values for both study years, both varieties, and both row-to-row spacings, the tendency was towards increasing fiber length with increasing vegetative space (Fig. 1.).

Figure 1. Fiber length means in the two study years



Conclusion

Stand density has a large influence on most morphological traits of broom-corn plants and panicles.

Fiber length increases with increasing plant living space. With vegetative spaces of 350 cm² or less, fiber length decreases while peduncle length increases.

Vegetative spaces of 630 and 650 cm² (70x9 and 50x13 cm) produced the most regular shape of the panicle in both genotypes studied. Increasing vegetative space increased the level of panicle deformation in which the fibers become pipe-shaped. Decreasing vegetative space increased the proportion of toothpick-like panicles.

By varying the stand density, some broomcorn morphological traits as well as panicle quality can be made more suitable for the needs of the processing industry. The results of the present study suggest that row-to-row spacings of 50 and 70 cm are both acceptable in broomcorn growing provided an optimum stand density is achieved. To achieve such density, the interrow spacing of 50 cm should be paired up with a plant-to-plant spacing of 13 cm and 70 cm between the rows are best when accompanied by a plant-to-plant spacing of 9 cm. These combinations are most suitable both in terms of panicle yield per unit area and in terms of panicle quality. These densities produce stands of 153,800 and 158,700 plants per hectare, which are the recommended plant populations for the actual growing practice in this crop.

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DUŽINA PETELJKI SIRKA METLAŠA PRI RAZLIČITOM SKLOPU BILJAKA

- originalni naučni rad -

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Rezime

Dužina peteljki sirkovih metlica predstavlja rastojanje između tačke grananja peteljki i mesta gde se nalazi vrh najmanje $\frac{2}{3}$ od ukupnog broja peteljki.

Ovo je veoma bitna morfološka osobina biljaka sirka metlaša, od koje zavisi uspešnost žetve sirkovih metlica. U cilju sagledavanja promene dužine peteljki sirkovih metlica u zavisnosti od različitog sklopa biljaka, izvršena su dvogodišnja istraživanja sa dva genotipa sirka metlaša. Ispitivana su dva međuredna razmaka od 50 i 70 cm i šest različitih razmaka biljaka u redu, (5, 9, 13, 17, 21 i 25 cm). Dužina peteljki bila je najmanja pri najgušćim sklopovima 42,59 i 45,22 cm, dok je sa povećanjem vegetacionog prostora dužina peteljki bila sve veća - 63,72 i 71,04 cm.