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Influence of the seeding rate on the formation of anatomical features of the monoecious hemp stems of Diana breed

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Abstract. The article considers the research results on the influence of the seeding rate on formation of anatomical features of the monoecious helm stems of the Diana breed. According to the experiment scheme, the seeding rate is from 0.1 to 2.7 million pieces of germinating seeds per hectare. The size of each plot is 10 × 10 m (100 m2). The tier is 3-fold. Nature of the change in the thickness of the bast-fibered layer depending on the seeding rates was studied. The results of the research showed that the thickest bast-fibered layer (530.5-636.4 μm) is formed due to the seeding rates of 1.8–2.7 million pieces / ha. Thus, there is a reason to assume that the increased seed rates allow achieving the best yields indicators of the bast-fibered substances. It is noteworthy that each seeding rate is characterized by a certain amount of elementary fibers in the stems: stems from crops with the seeding rate of 0.1–0.6 million pieces / ha have the smallest number of primary and secondary fibers. The largest cells of primary and secondary fibers are found in the stems from crops with the seeding rate of 0.1–0.6 million pieces / ha, the smallest - due to the seeding rate of 1.8–2.7 million pieces / ha. Consequently, the size of both primary and secondary fibers decreases when the seeding rate is increased. The data of the research conclusively prove that the size of the inner lumen of the elementary fibers decreases both lengthwise and edgewise when the seeding rate is increased. Stems that are grown on the plots with the seeding rate of 1.8 -2.7 million pieces / ha have a thick bast-fibered layer (530.5–636.4 μm) with the largest amount of primary and secondary fibers (6918 , 4-8302.6 cm) of a regular multi-faceted shape with a small internal lumen lengthwise and edgewise (2.9–4.2 μm and 2.2–2.7 μm).

1. Introduction

Nowadays, one of the most urgent tasks of agriculture is to further increase the production of grain, industrial, fodder and other agricultural crops. It is also important that among the industrial crops helm takes a special position. Production of it is of significant importance. This culture is considered to be a source of 25 000 types of products for medical, food, textile, consumer goods, paper, construction, aviation, fuel and energy and other industries [1–4].

According to the literature data, the stems of helm contain more than 15% of fiber which is used for the production of ropes, a special cord, harvest twine, tarpaulin and fire hoses. Products made of hemp fiber are different in solidity and slowly decay. Woody core of stems, which is called hards, is used for making construction materials, thin and cigarette paper, shell of sausage products and ethyl alcohol [5–8].

Therefore, the seeding rate is very important when solving the problems aimed at increasing the yield of helm and improving quality of products.

It is known that the anatomical features of stems, yield indicators and fiber quality are always interrelated [9, 10]. Therefore, this research will help to establish the optimal seeding rate, as well as to scientifically justify the possibility of getting high yield of good quality fiber.

The purpose of the research is to identify the influence of the seeding rate on the formation of anatomical features of the stems of monoecious hemp of the breed Diana.

2. Experimental research

Field experiments were made after fall plowing of a plot to a depth of 23–24 cm with the help of plows PLN-4-35. Alfalfa, a perennial grass, was grown for 5 years on this plot. In early spring the field was harrowed, and then cultivated in two tracks to a depth of 6–8 cm with simultaneous harrowing (aggregate KPS-4 + BZSS = 1). Mineral fertilizers were applied for cultivation at a rate of N_{120} $P_{90}K_{90}$ kg of active material per 1 hectare. The sowing was carried out simultaneously on all experimental plots with the help of a manual marker. The method of sowing is wide-row with a planting distance of 60 cm. The depth of seeding is 3–4 cm. The seeding rate according to the experiment scheme is from 0.1 to 2.7 million pieces of germinable seeds per 1 hectare.

The scheme of the experiment:

- Sowing with the seeding rate of 0.1 million pieces per 1 ha,
- Sowing with the seeding rate of 0.3 million pieces per 1 ha,
- Sowing with the seeding rate of 0.6 million pieces per 1 ha,
- Sowing with the seeding rate of 0.9 million pieces per 1 ha,
- Sowing with the seeding rate of 1.2 million pieces per 1 ha,
- Sowing with the seeding rate of 1.5 million pieces per 1 ha,
- Sowing with the seeding rate of 1.8 million pieces per 1 ha,
- Sowing with the seeding rate of 2.1 million pieces per 1 ha,
- Sowing with the seeding rate of 2.4 million pieces per 1 ha,
- Sowing with the seeding rate of 2.7 million pieces per 1 ha.

The size of each plot – 10×10 m (100 m^2). The tier is 3-fold.

One of the most important conditions for the methodology of anatomical studies is the proper selection of an average sample. 30 plants were selected from the trial sheaves for this purpose. After determining the average height and diameter of the stem, one plant was selected for each variant of the experiment in which the height and diameter of the stem exactly corresponded to the average data of 30 plants. Then, the samples were subjected to anatomical studies. In the middle of the stem, the segments with the length of 2 cm were cut out. They were fixed in a glass jar in a mixture of ethyl alcohol, glycerin and distilled water for 7 days. Then, slices were made with the help of a microtome and were stained with a dilute solution of chlor zinc iodine. During microscopic examination the following characteristics were determined: the radius of the barque and the woody core, location of the cells in the bundle, structure and shape of the cells of the elementary fiber, the number of cells on a cross section. The thickness of the cells of the elementary fibers and lumens were measured with the help of the ocular micrometer. Microphotographs were made by the camera "Zenith TTL" with a magnification of 280 times.

The experiment was made on a selective hashish-free breed of the monoecious hemp of the Central Russian type Diana, which was included into the State Register in 1994 and recommended for practical use in the majority of the hemp regions of the Russian Federation (Copyright Certificate No. 6456 dated 11.04.1994).

According to the experiments, the breed is characterized by the absence of connnabinoid compounds in the inflorescences. The fat content in seeds is 33.5%, fibers content in stems is 24.4%, the content of cellulose in the woody core is 49.7%, and the content of ethyl alcohol in the woody core is 16.8%. The yield of stems is 85.1 c / ha, the yield of seed is 11.2, the yield of fiber is 20.8, the yield of oil is 3.4, the yield of cellulose is 31.7. The yield of ethyl alcohol is 107.2 dl / ha.

The breed Diana has good indicators of fiber quality: the metric number is 21.3 tex, solidity is 26.6 kgs, flexibility is 24.0 mm. Vegetation period lasts for 108 days.

3. Results and considerations

As the bast-fibered layer is the source of fiber, change in thickness of the bast-fibered layer depending on the seeding rate was studied first (table 1).

Table 1. Influence of the seeding rate on formation of thickness of the bast-fibered layer in hemp (for 2011–2013).

Seeding rate, million pieces per 1 ha	Thickness of bast-fibered layer, micron		
	Total amount	including	
		primary fibers	secondary fibers
2.7	636.4	543.6	92.8
2.4	609.9	521.0	88.9
2.1	556.8	475.6	81.2
1.8	530.5	453.0	77.3
1.5	503.8	430.3	73.5
1.2	477.3	407.7	69.6
0.9	424.3	362.4	61.9
0.6	371.2	317.1	54.1
0.3	344.7	294.4	50.3
0.1	318.2	271.8	46.4

Due to the data in the table 2, the thickest bast-fibered layer (530.5-636.4 μm) is formed due to the seeding rate of 1.8–2.7 million pieces / ha. Thus, there is reason to assume that increased seeding rates allow achieving the best yield indicators of the bast-fibered substances.

Table 2. The amount of elementary fibers in the hemp stems depending on the seeding rate (for 2011-2013).

Seeding rate, million pieces per 1 ha	Number of elementary fibers, pieces		
	Total amount	including	
		primary fibers	secondary fibers
2.7	8302.6	7901.8	1210.8
2.4	7956.8	6796.9	1159.9
2.1	7264.1	6204,7	1059.4
1.8	6918.4	5909.8	1008.6
1.5	6572.6	5613.7	958.9
1.2	6226.9	5318.8	908.1
0.9	5535.5	4727.9	807.6
0.6	4842.7	4136.9	705.8
0.3	4497.0	3840.1	656.3
0.1	4151.3	3545.9	605.4

It is noteworthy that each seeding rate is characterized by a certain amount of elementary fibers in the stems: stems from crops with a seeding rate of 0.1-0.6 million pieces / ha have the smallest number of primary and secondary fibers (table 2).

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It is established that the shape of the cell is determined by its size lengthwise and edgewise: hemp can have cells of regular, polygonal, oval, round, irregular, plain, elongated, zigzag shape with salient angles and rounded edges.

Table 3. Size of primary and secondary elementary cells in the hemp stems depending on the seeding rate (for 2011–2013).

Seeding rate, million pieces per ha	Size of elementary fibers, micron			
	primary		secondary	
	in tangential direction	in radial direction	in tangential direction	in radial direction
2.7	21.1	17.2	11.8	9.3
2.4	22.5	18.1	12.1	9.6
2.1	23.9	19.0	12.4	9.9
1.8	25.3	19.9	12.8	10.2
1.5	26.7	20.8	13.1	10.5
1.2	28.1	21.7	13.5	10.8
0.9	29.5	22.6	13.9	11.2
0,6	30.9	23.5	14.3	11.6
0.3	32.3	24.4	14.7	12.0
0.1	33.5	25.4	15.2	12.8

The results of the research showed that primary and secondary fibers have the largest cells due to the seeding rate of 0.1–0.6 million pieces / ha, the smallest - due to the seeding rate of 1.8–2.7 million pieces / ha.

Consequently, as the seeding rate increases, the size of both primary and secondary fibers decreases.

The question about the change in the size of the inner lumen of primary and secondary elementary fibers depending on the seeding rate is also interesting (table 4).

Table 4. Influence of the seeding rate on the size of the inner lumen of primary and secondary elementary fibers of the hemp (for 2011–2013).

Seeding rate, million pieces per 1 ha	Size of the inner lumen of the elementary fibers , micron			
	primary		secondary	
	in tangential direction	in radial direction	in tangential direction	in radial direction
2.7	2.9	2.2	1.3	0.9
2.4	3.3	2.3	1.3	0.9
2.1	3.7	2.5	1.4	1.0
1.8	4.2	2.7	1.6	1.1
1.5	4.6	2.8	1.6	1.1
1.2	5.0	3.0	1.7	1.2
0.9	5.4	3.2	1.8	1.3
0.6	5.8	3.3	1.9	1.4
0.3	6.2	3.3	2.0	1.5
0.1	6.7	3.6	2.0	1.5

Due to the data in the table, it is seen that as the seeding rate increases, the size of the inner lumen of the fibers decreases both lengthwise and edgewise. Stems that were grown on the plots with the seeding rates of 1.8–2.7 million pieces / ha have a thick bast-fibered layer (530.5–636.4 microns) with the largest number of primary and secondary elementary fibers (6918.4–8302.6 cm) of regular multi-faceted shape with a small internal lumen lengthwise and edgewise (2.9–4.2 microns and 2.2–2.7 microns).

4. Conclusion
Thus, the obtained experimental material allows assuming that crops with the seeding rate of 1.8-2.7 million pieces / ha can fully provide high yield of fibers (25.9–29.5%) with good technological properties. It is provided by the largest thickness of the fibrous layer, the largest number of elementary fibers and the smallest size of the internal lumen of the elementary fibers.

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