INVESTIGATION OF HEMP (*CANNABIS SATIVA* L.) MORPHOLOGICAL PARAMETERS AS INFLUENCED BY SEED RATE AND GENOTYPE

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Abstract. Recently the interest in industrial hemp (*Cannabis sativa* L.) as a multipurpose plant is growing up over Europe as well as in Lithuania and Latvia. Close to 50 thousand various products can be made from different parts (seed, leaves, panicles, stems, even roots) of this plant. More than 50 varieties of industrial hemp are allowed to be grown in the European Union, just the proper variety should be chosen depending on the country and growing purposes. Nevertheless, the yielding capacities of hemp depend on many factors such as the genotype, seed rate, growing technology, pedoclimatic conditions, etc. The investigation of hemp plant morphological parameters was carried out at the Upytė Experimental Station of the Lithuanian Research Centre for Agriculture and Forestry in 2014. The data showed that both factors did not have significant influence on the total stem length, technical stem length and stem diameter of the tested varieties. Seed rate had a significant influence on the length of the flowering part of the plant (panicle) as well as on the ratio between the technical stem part and the stem diameter – very important index for fibre quantity and quality. In the plots sown at higher seed rate (70 kg·ha^{-1}) the panicle was (0.29 m) significantly shorter than that (0.39 m) in the plots sown at lower seed rate (45 kg·ha^{-1}). The plants sown at higher seed rate (70 kg·ha^{-1}) had a higher (376.8) ratio between the technical stem length and stem diameter than that (319.7) sown at lower seed rate (45 kg·ha^{-1}).

Keywords: diameter, panicle stem length.

Introduction

Recently the interest in industrial hemp (*Cannabis sativa* L.) as a multipurpose plant is growing up over Europe as well as in Lithuania and Latvia [1-6].

Close to 50 thousand various products can be made from different parts of this plant (seed, leaves, panicles, stems). Even roots are useful for enriching soil and improving its quality. But the main and the oldest production of this plant is fiber, as the hemp is a bast fibre plant. Hemp fiber could be widely used in paper, textiles, composites, agriculture, automotive, construction, isolation, medicine, etc. [7-8]. Recently the application of hemp fibers is rather wide, and each application needs a different quality of fibers.

The EC common catalogue of varieties of agricultural plant species in 2015 contained the list of 51 hemp varieties [9], just the proper variety should be chosen depending on the country and growing purposes. Nevertheless, the yielding capacities of hemp and the fibre quality depend on many factors such as the genotype, seed rate, growing technology and hemp morphology, pedoclimatic conditions, etc. [10-12].

No doubts, production of the crop depends on the sowing rate. Different range of seed rates for hemp is reported when growing it for different purposes. For textile purposes the suggested seed rate varies from 40 to 80 kg·ha^{-1} [10; 13-16].

Only rare literature sources report about hemp stem morphology [11; 21]. The aim of the investigation was to evaluate how the choice of hemp variety and the sowing rate influence on hemp morphological indices; which of them are generally dependant on the tested factors and should be taken into account of hemp growers.

Materials and methods

The investigation of hemp plant morphological parameters was carried out at the Upytė Experimental Station of the Lithuanian Research Centre for Agriculture and Forestry in 2014. The soil – Eutri-Endohypogleyic Cambisol, CMg-n-w-eu [17].

Bi-factorial trial was carried out: Factor A – variety (USO 31 and Bialobrzeskie); Factor B – sowing rate (45 kg·ha^{-1} and 70 kg·ha^{-1}). Both selected varieties are monoecious.

Hemp was sown on the 7th of May in 15 cm inter-row spacing by a single-row sowing machine. The size of the trial plots was 2 × 5 = 10 m^2, the size of the record plots – 2 × 4 = 8 m^2 (trial was sown

in tree replications). Randomized plot design was used. At both sides of the trial the protective plots of the same size as the record plots were sown.

Hemp was harvested when the first matured seed appeared (26th of August). The morphological indices of hemp stems have been measured (total stem length (the distance from the stem footer part at the place of cotyledons till the top), technical stem length (the distance from the stem footer part at cotyledons place up till the panicle), stem diameter in the middle distance between the footer and upper parts of the stem), the length of panicle (as a difference between the stem total and technical length) [11; 18]. A very important index for fibre quantity and quality was calculated as the ratio between the technical stem length and the stem diameter [11; 19]. Mainly this index is evaluated in Russia and Ukraine, but it has not been evaluated in Lithuania and Latvia before.

For statistical data evaluation statistical software developed in the Lithuanian Institute of Agriculture was used, ANOVA method was applied [20].

Mean air temperature and the amount of precipitation were assessed during the hemp growing period (Table 1). Hemp germinated approximately in two weeks after sowing. It was warm and rainy in the middle of May (the amount of precipitation was twice more than the long-term average for the second ten-day period of May). June was slightly cooler than the long-term average but abundant in precipitation. It was warm in July and August, but the amount of precipitation was again huge, and even oversupply as water for some time was flooding some surfaces on the trial field.

Table 1

Mean weather temperature and precipitation during hemp growing period

Month	Ten-day period	Mean weather temperature, ºC		Rainfall, mm	
		2014	Long-term average	2014	Long-term average
May	I	8.2	11.0	23.5	16.0
	II	13.8	12.6	34.0	16.0
	III	16.8	13.5	7.5	18.0
	Aver./total	**12.9**	**12.4**	**65.0**	**50.0**
June	I	17.0	14.4	12.0	22.0
	II	13.2	15.3	27.0	23.0
	III	12.6	16.2	71.0	24.0
	Aver./total	**14.3**	**15.3**	**110.0**	**69.0**
July	I	19.0	17.2	49.5	25.0
	II	18.8	18.0	20.0	25.0
	III	21.9	18.0	23.0	26.0
	Aver./total	**19.9**	**17.7**	**92.5**	**76.0**
August	I	22.4	17.2	58.0	28.0
	II	17.0	16.1	35.5	29.0
	III	13.2	15.0	79.5	28.0
	Aver./total	**17.4**	**16.1**	**173.0**	**85.0**

Results and discussion

Hemp stem length is the most important morphological index influencing fibre productivity: fibre content is higher in taller stems [11].

In 2014, the total hemp stem length in the treatments was quite similar – 1.81-1.92 m. The plants of variety USO 31 (1.87 m) were slightly taller than that of variety Bialobrzeskie (1.84 m), just the differences were insignificant (Table 2). In the earliest trials, carried out in 2006-2007, significant differences in plant height between Beniko and Bialobrzeskie were not noticed also, nevertheless, the plants were taller in thin crop and lower – in thick crop [21].

The technical stem length of both varieties was quite similar – 1.50-1.53 m. The plants sown at higher seed rate (70 kg·ha^{-1}) had longer technical part of the stem (1.56 m), but the statistical analysis

did not show significant differences between the tested seed rates as well as between different varieties (Table 3).

The plants of variety USO 31 had a longer panicle (in average, 0.37 m), but the difference between the tested varieties was insignificant (Table 4). Seed rate had a significant influence on the length of the panicle – in the plots sown at higher seed rate (70 kg·ha^{-1}) the panicle was significantly shorter (0.29 m) than that (0.39 m) in the plots sown at lower seed rate (45 kg·ha^{-1}).

Table 2

Influence of genotype and seed rate on total stem length (m)

Variety (Factor A)	Seed rate (Factor B)		Mean for Factor A
	45 kg·ha^{-1}	70 kg·ha^{-1}	
USO 31	1.92	1.82	1.87
Bialobrzeskie	1.81	1.88	1.84
Mean for Factor B	1.86	1.85	-
R_{05} (variety) = 0. 086 R_{05} (seed rate) = 0.086 R_{05} (variety x seed rate) = 0.149			

Table 3

Influence of genotype and seed rate on technical stem length (m)

Variety (Factor A)	Seed rate (Factor B)		Mean for Factor A
	45 kg·ha^{-1}	70 kg·ha^{-1}	
USO 31	1.48	1.53	1.50
Bialobrzeskie	1.47	1.60	1.53
Mean for Factor B	1.47	1.56	-
R_{05} (variety) = 0.069 R_{05} (seed rate) = 0.069 R_{05} (variety x seed rate) = 0.119			

Table 4

Influence of genotype and seed rate on length of panicle (m)

Variety (Factor A)	Seed rate (Factor B)		Mean for Factor A
	45 kg·ha^{-1}	70 kg·ha^{-1}	
USO 31	0.44	0.30	0.37
Bialobrzeskie	0.34	0.28	0.31
Mean for Factor B	0.39*	0.29*	-
R_{05} (variety) = 0.048 R_{05} (seed rate) = 0.048 R_{05} (variety x seed rate) = 0.084			

* – significant at 0.05 probability level;

The stems of the hemp plants in the trial were rather thin (3.98-4.89 mm) (Table 5). The stem diameter was found to be quite similar (4.37-4.44 cm) for both tested varieties.

Literature sources report about thinner hemp stems grown at higher seed rate [10-11]. The measurements showed that the plants sown at seed rate of 70 kg·ha^{-1} had smaller stem diameter (4.17 mm) than that in the plots sown at lower seed rate (45 kg·ha^{-1}) (4.63 mm), but the statistical analysis did not show any significant differences.

In the previous trials, carried out in 2006-2007, the stem diameter of Beniko plants was significantly higher than that of Bialobrzeskie, but we did not find significant differences when sowing different seed amounts (only tendencies of thicker plants in thin crop could be noticed) [21].

L. Grabowska and W. Koziara [14] report that increase of the seed rate caused decrease of the plant length and diameter. Practically similar results were obtained by T. Schäfer in Germany [22]. We also noted the same tendencies; just the differences in 2014 were not significant.

Relational index of distribution of fibres in the stem is the ratio between the technical stem length and the stem diameter – the higher is the ratio, the better is the fibre quality [11; 19; 23]. The results of our investigation show that this index was significantly influenced by seed rate. The plants sown at higher seed rate (70 kg·ha^{-1}) had a higher ratio between the technical stem length and the stem diameter (376.8) than that sown at lower seed rate (45 kg·ha^{-1}) (319.7) (Table 6).

Table 5

Influence of genotype and seed rate on stem diameter (mm)

Variety (Factor A)	Seed rate (Factor B)		Mean for Factor A
	45 kg·ha^{-1}	70 kg·ha^{-1}	
USO 31	4.89	3.98	4.44
Bialobrzeskie	4.37	4.36	4.37
Mean for Factor B	4.63	4.17	-
R_{05} (variety) = 0. 0.298 R_{05} (seed rate) = 0.298 R_{05} (variety x seed rate) = 0.517			

Table 6

Influence of genotype and seed rate on ratio between technical stem length and stem diameter

Variety (Factor A)	Seed rate (Factor B)		Mean for Factor A
	45 kg·ha^{-1}	70 kg·ha^{-1}	
USO 31	303.8	386.4	345.1
Bialobrzeskie	335.6	367.3	351.4
Mean for Factor B	319.7	376.8	-
R_{05} (variety) = 21.86 R_{05} (seed rate) = 21.86 R_{05} (variety x seed rate) = 37.86			

A variety, as a Factor, did not have the influence on this index. In the investigation of Ukrainian scientists, the ratio between the technical stem length and the stem diameter for variety USO 31 was 279.3 [11].

Conclusions

1. In 2014, a variety, as a Factor, did not have a significant influence on the tested morphological parameters.
2. The seed rate, as a Factor, had a significant influence on the length of the panicle and on the ratio between the technical stem length and the stem diameter.
3. In the plots sown at higher seed rate (70 kg·ha^{-1}) the panicle was (0.29 m) significantly shorter than that (0.39 m) in the plots sown at lower seed rate (45 kg·ha^{-1}).
4. The plants sown at higher seed rate (70 kg·ha^{-1}) had a higher (376.8) ratio between the technical stem length and the stem diameter than that (319.7) sown at lower seed rate (45 kg·ha^{-1}).

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