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THE FIBER CONTENT IN FIBROUS HEMP DEPENDING ON SELECTED AGROTECHNICAL FACTORS

ABSTRACT

Relationship between genotypes represented by two fibrous hemp varieties and some agrotechnical factors was investigated in the study. The aim of it was finding how selected factors (three sowing dates, two sowing densities and five harvest dates) influence on total fiber content using osmotic degumming of fibrous plants method for fiber content determination.

Results showed 34% higher fiber content for Beniko in comparison to Tygra. It was also shown that fiber content in plants was stronger correlated with harvest date than date of sowing and its density.

Key words: *Cannabis sativa* L., fiber content, fineness determination, harvest time, sowing time, sowing density

INTRODUCTION

The chemical composition, antibacterial properties and economic value of hemp make it find really versatile use for. The plant can become the material not only in food industry (Cassano, 2013; Nissen, 2010; Yuan-Yuan of Notchboards, 2013), for construction materials (Awwad, 2012) and textiles, but also in energy production (Prade, 2011; Prade, 2012; Kreuger, 2011; Stankiewicz, 2012) and pharmacology (Alexander, 2009).

The content of the fibre is one of more important features of fibrous varieties of hemp. The process of fibre formation in the stem depends on a large extent weather conditions and the applied agricultural treatments (Jaranowska 1962).

In order to determine the quantity of the fibre in fibrous plants numerous methods were developed, where the test conditions were applied to achieve repeatable results. Conventional technics, dependingly on the way of extracting the fibre, include the three methods: biological, chemical (Kozłowski 2006) and mechanical (Keller, 2001). Another method of determining the content of the fibre is the use near-infrared spectroscopy (LSDS) (Barton, 2002; Sharma 2005).

Use of a method based on osmosis deserves for a special attention (Konczewicz 2007). The method uses physical phenomena, mainly osmosis, occurring in contact with water inside fibrous plants what makes possible to extract fibres from plants without affecting natural properties of fibre. The fibre obtained with this method implementation characterizes with softness, fineness and colour strictly adequate to the used raw material.

The aim of presented studies is comparing the fiber content is bred cultivars according to different agrotechnological factors: time of sowing, sowing density and time of harvest and prove the most important factor affecting fiber quality.

MATERIALS AND METHODS

Two Polish cultivars – Beniko and Tygra were studied. These fibrous hemp varieties are accepted to The Polish National List of Agricultural Plants of Research Centre for Cultivar Testing (COBORU) and the EU Catalogue of Crop Varieties. They are monoecious fibrous cultivars and contain less than 0.2% of hallucinogenic substances. They belong to Central European type of hemp and their vegetation period is adapted to Polish weather and soil conditions (Grabowska 2008). They do not require application of plant protection treatments and can be cultivated on polluted areas contributing their reclamation (Majtkowski 2011).

The following factors were considered: genotypes (selected registered varieties of hemp), sowing dates (three), sowing densities (two) and dates of harvest (five). The research was conducted within the years 2010-2011. In the first year of the experiment the sowing dates were between the first and second decades of May and the first decade of June respectively. However, in the second year the sowing of seeds took place in the last decade of April and between the second and third decades of May respectively. There were considered five harvest dates in order to determine the fibre content in the plants at different levels of maturity.

In 2010 the harvest of plants lasted from 4th August to 9th September, at seven-day-intervals. In the second year of the study harvest was being done from 7th July to 10th August, every seven days. The influence of different sowing densities (i.e. 10 and 50 kg × ha⁻¹ was also the subject of comparison

The fibre formation was determined on the basis of their content in whole stems collected in five harvesting dates mentioned above and two sowing densities in the range of field-experiments conducted for two years in the Pilot Plant of the Institute of Natural Fibres and Medicinal Plants in Pętkowo, located near Środa Wielkopolska.

Hemp plants (3 kg batches) were harvested from the experimental plots with the same method, in the determined stage of development and maturities of the plant (Fig. 1). After drying the plant material was divided, segregated, and connected into samples of 100g each and analysed for the fibre content according to the method of degumming of fibrous plants, elaborated at the chemical laboratory of IW LSDZ in Poznań.

Fig. 1. The mature hemp branch of Tygra cultivar

In order to determine the fiber content and fiber formation depending on the degree of the maturity of the plant there was applied the osmotic degumming method developed at the Institute of Natural Fibres and Medicinal Plants (Konczewicz 2007).

The degumming process of fibrous hemp was carried out in the laboratory-scale, under constant conditions: the temperature at 30°C, time 168 h, at constant regulated water flow to maintain 7 pH. Laboratory-tests were run on 100 g of the raw material each time. The mechanical processing of the degummed straw was done with a laboratory scutching and shaking de-

vices. The study comprised 120 tests and the analysis was done in two repetitions.

The fibre content (WL) in fibrous hemp plants was calculated according to the formula below:

$$WL = \frac{n_2}{n_1} \times 100\%$$

where:

n_1 – the dry matter of the straw in g, n_2 – the dry matter of the fibre in g.

The obtained findings of the fibre content in entire hemp stems were analysed statistically.

Determination of the linear mass of the bast fibre (fibre fineness) was done according to the PN-P-04677:1973 standard, also known as gravimetric method, titled: The methods of testing fibre materials - flax and hemp fibre - determination of fineness (Fig. 2). The method involves weighing 100-fibre bundles of the same length (10 mm).

Fig. 2. The fibre of the Beniko cultivar before fineness testing

RESULTS

The presented studies indicate clear advantage of Beniko cultivar in terms of fiber content, which is 34% higher than in the case of Tygra (Table 1). Differences of the content of the fibre in investigated cultivars, in years and correlation of factors: cultivar and years, are insignificant. Moreover, results show lower fiber content in Tygra resulting from the delay in the sowing time. However, delay of the sowing date in the Beniko does not influence the fiber content (Table 2). The correlation between both examined factors: the cultivar and sowing date is significant.

Table 1

The fibre content depending on the cultivar.

Cultivar	2010	2011	Average
Beniko	34.96	33.80	34.38
Tygra	26.58	25.71	26.15
LSD (0,05)			
For cultivars	2,9406		
For year	1,9572		
For correlation	4,1586		

Table 2

The fibre content depending on the cultivar and the sowing date.

Cultivars	Sowing date	2010	2011	Average
Beniko	I	33.62	33.60	33.61
	II	36.42	33.15	34.79
	III	34.86	34.64	34.75
Tygra	I	31.07	25.17	28.12
	II	25.31	27.20	26.26
	III	23.36	24.76	24.06
LSD (0,05)				
for correlation (cultivars × sowing time)		3,7451		
for years		2,9547		

The fibre content of Beniko increases by 20% with the delay of harvesting, while in case of Tygra such relation was not observed between the growth in the fibre content and the delay in harvesting (Table 3). On the other hand, the fiber content in Tygra cultivar is lowering with the delay of sowing dates. In case of Beniko this factor remains at constant level (Table 4).

Table 3

The fibre content depending on the cultivar and harvesting date

Cultivars	Harvest time	2010	2011	Average
Beniko	I	33,47	29,16	31,32
	II	35,81	33,27	34,54
	III	32,72	32,96	32,84
	IV	32,96	35,97	34,47
	V	39,87	37,64	38,76
Tygra	I	27,69	22,60	25,15
	II	26,71	27,75	27,23
	III	25,23	23,26	24,25
	IV	26,74	27,67	27,21
	V	26,50	27,24	26,85
LSD (0,05)				
for correl. (cultivars × harvesting dates)		4.8617		
for years		4.4421		

Table 4

The fibre content depending on the sowing date and the cultivar

Sowing dates	Cultivars	2010	2011	Average
I	Beniko	33.62	33.60	33.61
	Tygra	31.07	25.17	28.12
II	Beniko	36.42	33.15	34.79
	Tygra	25.31	27.20	26.26
III	Beniko	34.87	34.64	34.76
	Tygra	23.36	24.76	24.06
LSD (0,05)				
for correlation (sowing date × cultivar)		3.8609		
for years		2.7182		

The tendency to increase in the fiber content was found only for Beniko cultivar, for later harvest. The fiber content of Tygra was shown to be at similar levels (Table 5). The correlation of the above-mentioned factors is insignificant.

Furthermore, the properties of the fiber obtained from the two hemp cultivars were tested. Breaking tenacity (specific strength), elongation, breaking force and linear mass of fiber were determined. The fiber extracted from Beniko had lower linear mass i.e. between 2,60 and 2,94 tex, sufficient for clothing products. However, fiber from Tygra hemp, owing to its higher linear mass at 3,28 - 4,14 tex, can be used for technical applications. All the other tested parameters did not give clear results.

Table 5

The fibre content depending on the harvesting date and the cultivar				
Harvest time	Cultivars	2010	2011	Average
I	Tygra	27.69	22.60	25.14
	Beniko	33.46	29.15	31.3
II	Tygra	26.71	27.74	27.22
	Beniko	35.81	33.26	34.53
III	Tygra	25.23	23.26	24.24
	Beniko	32.72	32.95	32.83
IV	Tygra	26.74	27.67	27.2
	Beniko	32.96	35.97	34.46
V	Tygra	26.50	27.23	26.86
	Beniko	39.87	37.63	38.75
LSD (0,05)				
for the correl. (harvesting date × cultivar)		6.4321		
for years		4.4306		
for varieties		2.0340		

Table 6

The fibre content of both cultivars depending on sowing date and harvesting dates				
Sowing date	Harvest time	2010	2011	Average
I	I	33.56	27.15	30.36
	II	33.98	27.40	30.69
	III	29.35	27.69	28.52
	IV	28.51	30.70	29.61
	V	36.31	33.99	35.15
II	I	31.34	27.29	29.32
	II	29.67	30.52	30.10
	III	29.34	28.51	28.92
	IV	32.56	32.62	32.59
	V	31.42	31.92	31.67
III	I	26.85	23.20	25.03
	II	30.14	33.60	31.87
	III	28.24	28.15	28.20
	IV	28.49	32.15	30.32
	V	31.84	31.40	31.62
LSD (0.05)				
for correlation (harvest time × cultivar)		5.7770		
for harvesting time		2.3585		
for years		1.1926		

In general, results for both varieties clearly indicated the tendency of the fibre content increasing with delay in harvesting but only for early and late sowing dates (Table 6). On the other hand, harvesting time of Beniko and Tygra is linked with the increase in the fiber content (Table 7). A considerable growth in the fibre content can be observed in the fifth date of the harvesting, when the plants contained about 20% more fibre than in the first date. Furthermore, in 2011 the increase of the fibre content was higher than in 2010. The correlation of the investigated factors is significant.

Table 7

The fibre content of both cultivars depending on the harvesting dates

Harvest time	2010	2011	Average
I	30,58	25,88	28,23
II	31,26	30,51	30,88
III	28,98	28,11	28,55
IV	29,85	31,82	30,84
V	33,78	32,44	33,11
LSD (0,05)			
for harvesting date		2,7008	
for years		0,3811	
for correlation (harvesting date × years)		3,8195	

DISCUSSION

The two-year study confirmed the hypothesis that agrotechnical factors, most of all the selection of a variety and harvesting time, have significant effect on the fiber content in hemp. So far the dependencies between hemp varieties and sowing density and between sowing density, harvesting time and the fiber content in Białobrzskie cultivar were studied (Grabowska and Koziara 2005). However, the fibre quality was not included. The most important factors determining the quality and quantity of hemp yield were also presented. It was showed that the harvest time is one of the most significant factor for hemp cultivation (Grabowska and Koziara 2005, Burczyk *et al.*, 2009). Therefore it can be stated that the fiber content depends first of all on the cultivar, harvesting date and to a lesser extent on sowing dates and density. These conclusions are of high practical value for selecting the intended applications of cultivated hemp. Moreover, the study allowed for comparison of the two cultivars in terms of fiber content and its possible applications.

CONCLUSIONS

- Significant dependence between the fiber content and the cultivar was proved. The results clearly showed that Beniko possesses 34% more fibre than Tygra.
- The fibre content is linked much more with the harvesting date than the sowing date. The delay in sowing time in case of Tygra leads to reduction of the fibre content. The fiber content of Beniko increases with the delay in harvesting. However, for Tygra later sowing is associated with lower fibre content in the straw.
- There is correlation between higher fiber content and delayed harvesting but only for early and late sowing dates.
- In cultivation of hemp for fiber as the main yield, strict observation of recommended sowing and harvesting dates and the selection of varieties are crucial.
- With the delay in harvesting time the fiber content rises regardless of the tested factors. In particular, the plants harvested in the fifth date had about 20% higher fiber content than those harvested in the first date.

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