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The Effect of Some Agronomic Factors on the Amount and Quality of Homomorphic Fibre

Abstract
Due to overproduction of food in the agriculture sector, the cultivation of plants which can yield renewable raw materials for industry is increasing in importance. One such plant is hemp, which can be a source of raw material for different branches of industry such as textile, pulp and paper, composite materials, building, the production of renewable energy, etc. It has therefore been found necessary to conduct research on the effect of different agronomic factors on the quality and quantity of raw materials obtained from hemp, namely straw (biomass) and homomorphic fibre, depending on direction of use.

Key words: *homomorphic fibres, hemp, agronomic factors, quality, crop quantity.*

RESEARCH AND DEVELOPMENT

Introduction

The interest of agriculture and industry in the production and utilisation of renewable raw materials has increased recently. This situation is, on one hand, a result of the overproduction of food and limited resources, and on the other, problems connected with the production and neutralisation of considerable amounts of synthetic wastes. An increasing pro-environmental cautiousness, seeking solutions for agriculture and annually renewable raw materials for industry has caused hemp to be rediscovered.

Currently, the interest in this plant is focused on its use as a raw material for the production of environmentally friendly clothes based on blends with cotton and chemical fibres, as well as long fibrous pulp and composite materials. The main reasons why interest in hemp is resurgent are as follows:

- increasing interest in developed countries in healthy clothes made of hemp fibre or blends containing hemp. The main reason for this interest is the specific properties of hemp fibre, namely its aseptic properties, high absorbency and hygroscopicity, good thermal and electrostatic properties, protection against UV radiation and lack of any allergenic effect. Clothes with even low addition of hemp fibres show significantly higher surface resistance, and increased sorption heat which allows the human body to adapt to changing environmental conditions. The properties of inhibiting bacterial and fungal development have practical importance in the production of socks. When all the properties mentioned above are combined with improvements in spinning, knitting and finishing techniques, this makes many applications of hemp fibre in clothes possible [1,2].
- the creation of new, economical hemp processing technologies has opened the way to utilising hemp as an alternative raw material for wood in the production of long fibre pulps and quality papers. The consumption of paper is growing world-wide and forest resources are decreasing proportionally. Hemp, due to its high yield of dry matter of about 10 tons per ha, and high fibre content (about 75%), is a good raw material for replacing wood in the production of pulp [3,4].
- the production of composite materials using hemp fibre and thermoplastic materials, especially polypropylene, for the automotive industry. Utilising hemp's excellent strength properties at a considerably lower specific weight and good processing techniques result in a gradual forcing-out of those materials traditionally used in car manufacture such as glass, carbon and similar fibres by the hemp fibre. Decreasing the car weight allows for a reduction in fuel consumption - ecology and economy in one.

The cultivation of hemp offers the possibility of running alternative agricultural production, leading to an improvement of the economical activity conditions in countries facing overproduction of food, as well as the start of production of annually renewable, environmentally friendly raw materials for different industries [5]. The cultivation and processing of fibre plants may constitute a chance for Poland among other countries to find a niche production and place in the international division of labour within the EU.

The traditionally-used technology for producing hemp fibre aimed at as high an efficiency of long fibre as possible, with the short fibre being only a by-product. The technology of cultivation and studies conducted was thus focused on this crop [6,7]. Currently, work is under way to obtain the homomorphic fibre, allowing processing costs to decrease. Processing the straw by the homomorphic method, a fibre is obtained that is more homogeneous and with a structure similar to a high-quality motted tow. Further mechanical, chemical and enzymatic processing will allow the fibre to be used for the production of yarns blended with cotton, wool, chemical fibres, and high-quality pulps and composite materials. As there is a potential for implementing new technology, it is necessary to learn the effect of different factors, including agronomic ones, on the amount and quality of homomorphic fibre to be utilised in different industries [7,8,9].

Methodology and Scope of Research

The thesis mentioned above is based on plot experiments and qualitative analysis of obtained homomorphic fibre. The experiments were carried out in 1999-2001 in the INF Experimental Station in Sielec Stary.

The experiments were set as split-plot experiments with three replications. The tested factors were as follows:

- three sowing densities: 60, 90 and 120 kg/ha,
- three levels of nitrogen doses: 80, 120 and 160 kg N/ha,
- three harvest times: beginning of flowering, end of flowering and beginning of seed maturity in the middle part of the panicle.

The plot area for biometric measurements was 24 m^2.

During the vegetation period the observations of the plant development stages were carried out. The plant density was determined twice, after germination of hemp plants and before the harvest. Hemp was harvested by a single cutterbar mower and ginned manually using ginning combs. The ginned straw was distributed on the plots again and left for dew retting. The optimally retted straw was collected by hand from the plots and dried in the field. The straw was processed in the Experimental Retting Plant of the Institute of Natural Fibres in Stęszew using a tow producing unit consisting of sequentially arranged devices, a straw bottom shaker, a breaker and a scutcher. The PMG-1 hemp straw breaker was mounted in front of the tow-producing unit to secure preliminary breaking of the straw. Before processing, the straw was cut into three sections of 700-800 mm in length by a set of circular saws. When the processing of straw was complete, the efficiency of the homomorphic fibre in relation to the straw was determined and calculated to 12% of moisture content. The qualitative assessment of homomorphic fibre was carried out in the Metrological Laboratory of the Institute of Natural Fibres in Poznań.

The following parameters were tested:
- the degree of straw retting, according to Standard PN-80/P-0468013,
- the moisture content in the homomorphic fibre, according to Standard PN-91/P-04601,
- impurities content in the homomorphic fibre, according to Standard PN-79/P-04678,
- divisibility of the homomorphic fibre, according to Standard PN-86/P-04677,
- strength of the homomorphic fibre, according to Standard PN-86/P-04676.

The samples for the above tests were collected according to the methodology given in Standard PN-92/P-04603. Since there are no standards specifying the quality assessment of homomorphic fibre, this was performed according to the standards for short hemp fibre, BN-76/7522-04.

The results obtained were analysed statistically using the variance analysis for split-plot experiments. The perennial synthesis was carried out based on analysis of variance for orthogonal experiments; the significance of the differences obtained was determined at the confidence interval on a level of 0.05.

Conditions of the Experiment

Soil conditions

The experiment was set on grey brown podzolic soil developed on light loamy sand and clay. The field had a drainage system, and the subsoil water level was below the reach of the hemp root system. The plough layer was about 30 cm deep. The content of the nutritive compound in the soil and soil classes are shown in Table 1.

Agronomic conditions

In all three years the hemp was cultivated after sugar beet. The forecrop for the sugar beet was winter wheat. Phosphorus and potassium fertilisers were applied, in the amounts of 50 kg of P_2O_5/ha as a superphosphate and 120 kg K_2O/ha as a potassium salt. Nitrogen, in the form of 46% urea, was applied according to the scheme of the experiment. The parameters of the sowing material are given in Table 2.

The pre-basic seeds of the Białobrzeskie hemp cultivar were sown in the amount specified in the scheme of the experiment; the row spacing was 12.5 cm, the depth of sowing 2-3 cm. The time of sowing is shown in Table 3.

The weed control was performed using Afalon (1.3 kg/ha) right after sowing. The harvest took place according to the scheme of the experiment (Table 3) and was performed by the single cutterbar mower.

Observations of development stages

The history of the development stages is presented in Table 3. The plants began to germinate and flower within 6 to 7 and 57 to 62 days after sowing, respectively, except for the year 1999 when flowering began after only 47 days. The whole vegetation period from sowing till seed formation in the middle of the panicle lasted from 126 days in 2001 to 139 days in 2000.

Meteorological conditions

The distribution of precipitation and temperature in the INF Experimental Station in Sielec Stary, for the period of 1999-2001, is shown in Table 4.

In 1999 climatic conditions were varied. At the beginning, conditions were favourable for the development of plants; however, at the beginning of August they became very dry and caused the plants to die off. Harvest times I and II took place during the time of drought.

The year 2000 was characterised by favourable conditions for growth and development of hemp. The plants grew and developed correctly. June was dry but had no significant negative effect on the plants' development.

The year 2001 was characterised by high precipitation, although at the beginning of June, dry conditions appeared. Furthermore, in April and especially in May precipitation was deficient as compared to the perennial average, reaching only 35.5

Table 1. *The content of nutrients in the soil and soil classes in the following years of the experiment in mg/100 g of soil.*

Year	Contents of nutrients, mg/100 g of soil				Soil class
	P_2O_5	K_2O	Mg	pH	
1999	12.2	9.5	9.1	5.7	IIIa
2000	41.5	13.5	3.9	7.1	IVb
2001	27.0	36.5	6.6	6.2	IIIb

Table 2. *Characteristics of sowing material.*

Year	Qualification degree	1000 seed weight, g	Germination capacity, %
1999	pre-basic	14.0	84.7
2000	pre-basic	14.0	94.7
2001	pre-basic	14.1	90.0

Table 3. *Sowing dates and development stage observations of hemp.*

Observation	Years		
	1999	2000	2001
Date of sowing	30.04	27.04	04.05
Beginning of germination	06.05	02.05	10.05
Full germination	10.05	09.05	14.05
Beginning of flowering	16.07	28.07	31.07
End of flowering	02.08	11.08	13.08
Harvest time I	16.07	28.07	31.07
Harvest time II	02.08	11.08	13.08
Harvest time III	08.09	07.09	07.09
Duration of the vegetation period (sowing-seed matured in the middle of the panicle	131 days	139 days	126 days

*Table 4. Precipitation and temperature in the INF Experimental Station in Sielec Stary (*perennial average for the period 1881-1930 in the Rawicz district).*

Month	Average temperatures, °C				Sum of precipitation, mm			
	1999	2000	2001	Years average*	1999	2000	2001	Years average*
I	4.6	0.6	0.9	-1.7	21.5	31.1	13.0	32.0
II	-0.4	3.8	1.7	-1.0	33.5	27.4	21.9	26.0
III	5.4	4.7	3.6	2.5	58.2	92.6	60.2	32.0
IV	9.1	10.8	8.0	7.3	48.3	13.7	35.7	37.0
V	12.9	14.6	14.6	12.7	75.9	55.1	25.5	61.0
VI	15.4	16.6	14.6	15.6	64.7	56.7	72.0	53.0
VII	19.4	15.5	18.9	17.4	35.0	96.1	190.3	78.0
VIII	16.9	17.5	18.7	16.0	37.5	134.5	50.4	60.0

Table 5. The effect of sowing density, nitrogen fertilisation and time of harvest on the yield of raw defoliated and ginned straw in dt/ha; LSD - the Lowest Significant Difference (in all tables).

Sowing density, kg/ha	Nitrogen, kg/ha	Yields, dt/ha			
		Time of harvest			Mean
		I	II	III	
60	80	77.79	85.95	80.72	81.49
	120	79.53	92.97	99.56	90.69
	160	75.01	80.65	86.32	80.66
	Mean	77.44	86.52	88.87	84.28
90	80	82.26	98.60	95.55	92.14
	120	87.73	98.81	92.51	93.02
	160	76.12	93.66	92.82	87.53
	Mean	82.04	97.02	93.63	90.90
120	80	96.31	110.12	116.44	107.62
	120	97.59	107.46	107.54	104.19
	160	82.24	100.07	104.15	95.49
	Mean	92.04	105.88	109.38	102.44
Mean	80	85.45	98.22	97.57	93.75
	120	88.28	99.74	99.87	95.97
	160	77.79	91.74	99.87	95.97
	Mean	83.84	96.48	97.29	92.54

LSD for sowing density = 8.77
LSD for nitrogen fertilisation = 3.38
LSD for harvest time = 3.30
LSD_I for interaction = 9.89
LSD_{II} for interaction = 9.97
LSD_{III} for interaction = 12.02

Table 6. Dew-retted straw yield in dt/ha depending on sowing density, nitrogen dose and harvest time.

Sowing density, kg/ha	Nitrogen, kg/ha	Yields, dt/ha			
		Time of harvest			Mean
		I	II	III	
60	80	58.34	64.46	60.54	61.12
	120	59.65	69.73	74.67	68.02
	160	56.26	60.49	64.74	60.50
	Mean	58.08	64.89	66.65	63.21
90	80	61.69	73.95	71.66	69.11
	120	65.79	74.11	69.38	69.77
	160	57.09	70.25	69.62	65.64
	Mean	61.53	72.76	70.22	68.18
120	80	72.23	82.59	87.33	80.72
	120	73.19	80.60	80.66	78.14
	160	61.68	75.05	78.11	71.62
	Mean	69.03	79.41	82.04	76.83
Mean	80	64.09	73.67	73.18	70.31
	120	66.21	74.81	74.90	72.00
	160	58.34	68.60	70.82	65.92
	Mean	62.88	72.36	72.97	69.41

LSD for sowing density = 9.30
LSD for nitrogen fertilisation = 2.20
LSD for harvest time = 2.87
LSD_I for interaction = 8.41
LSD_{II} for interaction = 7.68
LSD_{III} for interaction = 9.74

mm. In July, especially in third decade, rains exceeded the perennial average by as much as 112.3 mm. This caused poor development of the hemp.

Results

Yield of straw

The joint effect of sowing density, nitrogen fertilisation and time of harvest on the yield of raw defoliated and ginned straw is shown in Table 5. The highest yield was harvested when 120 kg of seeds were sown and plants were harvested at harvest times II and III, regardless of the nitrogen fertilisation. Since the highest yield was obtained at the lowest nitrogen dose (80 kg/ha), and the remaining doses (120 and 160 kg/ha) caused no significant changes in the raw ginned and defoliated straw yield, it should be concluded that the optimal dose of nitrogen for the yield mentioned above was the lowest one, 80 kg N/ha. Summing up, the optimal variant for the yield of the raw, ginned and defoliated straw proved to be the following: the sowing density of 120 kg of seeds per ha, nitrogen dose of 80 kg N/ha and harvest time II or III, i.e. from the end of flowering till the beginning of seed maturity in the middle of the panicle (Table 5).

The yield of dew-retted straw also depended on the triple interaction of sowing density, nitrogen dose and harvest time. The yield of dew-retted hemp straw depended on joint effect of all three experimental factors. The highest yield of dew-retted straw was obtained at the sowing density of 120 kg/ha, the lowest nitrogen dose of 80 kg N/ha and harvesting the plants in harvest times II and III. Then, the obtained yields of dew-retted straw were 82.59 dt/ha and 87.30 dt/ha, respectively (Table 6).

Yield of homomorphic fibre

Hemp is grown mainly for fibre used in spinning, and more recently for non-textile applications also such as the production of pulp and paper, composite materials, insulation materials, structure materials, etc. Therefore, it is very important to ensure a proper amount and quality of the fibre, which is of great importance for this crop's economics. The yield of homomorphic fibre depended on the joint effect of sowing density, nitrogen dose and harvest time.

The highest yield of hemp homomorphic fibre (29.3 dt/ha) was obtained when applying the sowing density of 120 kg seeds/

Table 7. The effect of sowing density, nitrogen dose and harvest time on the yield of hemp homomorphic fibre.

Sowing density, kg/ha	Yield of homomorphic fibre, dt/ha at:			
	Nitrogen dose, kg/ha			Mean
	80	120	160	
60	21.9	25.3	21.4	22.9
90	26.1	27.0	24.6	25.9
120	29.3	27.4	27.3	28.0
Mean	25.8	26.6	24.4	25.6

LSD for sowing density = 2.3 LSD for nitrogen fertilisation = 1.0
LSD_I for interaction = 1.8 LSD_{II} for interaction = 2.7

Table 8. The effect of nitrogen fertilisation and harvest times on the yields of hemp homomorphic fibre in dt/ha.

Nitrogen fertilisation, kg/ha	Yield of homomorphic fibre, dt/ha at:			
	Harvest time			Mean
	I	II	III	
80	22.0	27.4	27.9	25.8
120	22.0	29.1	28.6	26.6
160	18.2	27.1	28.0	24.4
Mean	20.7	28.2	28.2	25.6

LSD for nitrogen fertilisation = 1.0 LSD for harvest time = 1.1
LSD_I for interaction = 1.7 LSD_{II} for interaction = 1.9

Table 9. The effect of nitrogen dose and harvest time on the output of homomorphic fibre in percent of straw.

Nitrogen fertilisation, kg/ha	Output, % at:		
	Harvest time		
	I	II	III
80	33.3	34.1	34.0
120	33.0	35.1	33.2
160	32.3	34.3	35.5
Mean	32.9	34.5	34.2

LSD for harvest time = 0.9 LSD_{II} for interaction = 1.5
LSD_I for interaction = 1.5

Table 10. The effect of sowing density and nitrogen fertilisation on impurities content in homomorphic fibre.

Sowing density, kg/ha	Impurities content, % at:		
	Nitrogen fertilisation, kg/ha		
	80	120	160
60	7.4	7.7	7.6
90	7.4	7.8	7.5
120	7.6	7.1	7.5

LSD for sowing density = 0.3 LSD_{II} for nitrogen fertilisation = 0.2
LSD_I for interaction =0.4 LSD_{II} for interaction = 0.5

ha and the lowest nitrogen dose (80 kg N/ha) (Table 4). Increasing the nitrogen doses to 120 and 160 kg N/ha caused the yield of homomorphic fibre to decrease by 2 dt/ha as compared to the highest one. Also, when 90 kg of seeds was sown per ha, the highest yield of homomorphic fibre was higher by 2 dt/ha as compared to the highest one. On the other hand, when the lowest sowing density was applied (60 kg of seeds per ha), the highest yield was lower by 4 dt/ha, as compared to the highest yield obtained at the highest sowing density (20 kg of seeds /ha) and the lowest nitrogen dose (80 kg/ha). On average, the highest yield of homomorphic fibre was obtained at a nitrogen dose of 120 kg N/ha. The effect of nitrogen fertilisation and harvest times on the yields of hemp homomorphic fibre is presented in Table 8.

At harvest time I, the highest yield of homomorphic fibre was obtained at lower nitrogen doses, 80 and 120 kg N/ha. At harvest time II, the most optimal nitrogen dose was 120 kg N/ha. It was also the highest yield of homomorphic fibre obtained under the joint effect of nitrogen doses and harvest times (Table 8). When the harvest time was delayed (harvest time III), the highest yield of homomorphic fibre could be obtained at higher doses of nitrogen, 120 and 160 kg N/ha. The yield was also significantly higher (by 6 dt/ha) from that obtained from the best combinations in harvest time I. On average, the most effective harvest time for the yield of homomorphic fibre proved to be harvest time III.

Output of homomorphic fibre

The output of homomorphic fibre depended on joint effect nitrogen dose and harvest time (Table 9). At harvest time I, the increase of nitrogen doses caused the reduction in homomorphic fibre, especially considering doses 120 and 160 kg N/ha, by 0.7%. Delaying the harvesting (harvest time II) proved to have a positive effect on the output of homomorphic fibre at the lowest nitrogen dose (80 kg N/ha), increasing by 0.9%. At the nitrogen dose 120 kg N/ha, the output of homomorphic fibre increased by 2.1%, and by 2.0% at the dose of 160 kg N/ha. A further delay of harvest (harvest time III) caused no increase in homomorphic fibre output at 80 and 120 kg N/ha nitrogen doses. The output of homomorphic fibre at 160 kg N/ha dose between harvest times II and III increased by an additional 1.1%.

Impurities in homomorphic fibre

The content of impurities in homomorphic fibre depending on sowing density and nitrogen fertilisation is shown in Table 10.

The impurities content in the fibre ranged from 7.1 to 7.8% (Table 10). The increase in nitrogen fertilisation from 80 to 120 kg N/ha, at the lowest sowing densities (60 and 90 kg of seeds/ha) showed a significant effect on the content of impurities in the homomorphic fibre. Further increase nitrogen doses caused no differences in respect to this feature. The increase in nitrogen at the highest sowing density (120 kg of seeds/ha) showed no clear tendency regarding the impurities content in the homomorphic fibre.

The content of impurities in the ho-

Table 11. Impurities of homomorphic fibre depending on the harvest time.

Harvest time	Impurities content, %
I	7.2
II	7.6
III	7.8
LSD	0.3

Table 12. The effect of sowing density and nitrogen fertilisation on degree of retting of the homomorphic fibre, %.

Sowing density, kg/ha	Degree of retting, %		
	Nitrogen fertilisation, kg/ha		
	80	120	160
60	97.4	96.7	98.1
90	98.8	98.4	96.7
120	98.0	97.0	98.1
Mean	98.1	97.4	97.6

LSD for sowing density = 0.6 LSD for nitrogen fertilisation = 0.6

LSD_I for interaction = 1.0 LSD_{II} for interaction = 1.0

Table 15. The effect of sowing density and nitrogen fertilisation on the divisibility of homomorphic fibre.

Sowing density, kg/ha	Divisibility, tex at:			
	Nitrogen fertilisation, kg/ha			Mean
	80	120	160	
60	11.4	11.4	12.1	11.6
90	10.4	11.4	10.9	11.1
120	11.0	11.8	11.4	11.4
Mean	11.1	11.5	11.4	11.3

LSD for sowing density = 0.2 LSD for nitrogen fertilisation = 0.2

LSD_I for interaction = 0.4 LSD_{II} for interaction = 0.4

Table 16. The effect of nitrogen fertilisation and harvest time on the divisibility of homomorphic fibre.

Nitrogen fertilisation, kg/ha	Divisibility, tex at:			
	Harvest time			Mean
	I	II	III	
80	8.8	11.5	13.0	11.1
120	9.3	11.5	13.7	11.5
160	9.5	11.7	13.2	11.5
Mean	9.2	11.6	13.3	11.4

LSD for nitrogen fertilisation = 0.2 LSD for harvest time = 0.2

LSD_I for interaction = 0.4 LSD_{II} for interaction = 0.4

Table 17. The strength of homomorphic fibre, cN/tex, depending on effect of sowing density and nitrogen fertilisation.

Sowing density, kg/ha	Strength, cN/tex at:		
	Nitrogen fertilisation, kg/ha		
	80	120	160
60	33.8	31.4	31.8
90	32.9	33.3	29.6
120	30.6	31.6	31.4
Mean	32.4	32.1	30.9

LSD for sowing density = 1.4 LSD for nitrogen fertilisation =1.0

LSD_I for interaction = 1.8 LSD_{II} for interaction = 2.0

Table 18. Strength of homomorphic fibre, cN/tex, depending on the effect of sowing density and harvest time.

Sowing density, kg/ha	Strength, cN/tex at:		
	Harvest time		
	I	II	III
60	30.3	33.6	33.1
90	32.2	34.2	29.4
120	32.2	31.7	29.7
Mean	31.6	33.2	30.7

LSD for sowing density = 1.4 LSD for harvest time = 1.3

LSD_I for interaction = 2.2 LSD_{II} for interaction = 2.2

Table 13. The degree of correct retting of homomorphic fibre, %, depending on harvest time.

Harvest time	Degree of correct retting, %
I	98.3
II	99.3
III	95.5
LSD	98.3

Table 14. The effect of harvest time on staple of homomorphic fibre.

Harvest time	Staple, mm
I	361
II	465
III	432
LSD	82

momorphic fibre increased as a result of harvest delay from 7.2% at harvest time I to 7.8% at harvest time III. The increase was clearly directed from harvest time I to II and from harvest time II to III (Table 11).

Degree of retting of the homomorphic fibre

The correct degree of retting of the homomorphic fibre as the effect of sowing density and nitrogen fertilisation is presented in Table 12.

The correct degree of retting of homomorphic fibre obtained differed from 96.7% to 98.8%, and depended on the joint effect of sowing density and nitrogen doses. The degree of correct retting at the lowest nitrogen dose (60 kg N/ha) showed no tendency to change. The nitrogen doses of 80 and 120 kg N/ha yielded a higher content of well-retted fibre than the highest nitrogen dose, 160 kg N/ha. No significant differences in the correct retting degree of fibre under applied nitrogen doses were observed using a sowing density of 120 kg seeds/ha (Table 9).

The correct degree of retting has a very strong effect on the quality of fibre, namely on the homogeneity and uniformity of fibre parameters.The correct degree of retting ensures the required and uniform thinness of fibres, better behaviour in spinning, and allows for obtaining thinner and better quality yarns.

The harvest time showed an independent effect on the degree of correct retting. As shown in Table 13, the highest content of well-retted fibres was obtained at harvest time I and II. The content of well-retted fibres at n harvest time III was significantly lower.

The staple of homomorphic fibre

The effect of harvest time on the staple (content of fibres from particular length intervals) of homomorphic fibre is shown in Table 14.

The time of harvest showed no effect on the staple of homomorphic fibre (Table 14). At harvest time I (the earliest) the average length of homomorphic fibre was the lowest, 361 mm. When delaying the harvest till the end of flowering (harvest time II), the average length of fibre increased by 28.8%. Further delaying the harvest time (harvest time III) caused the worsening of this parameter by 7%, but it was still higher than in the beginning of flowering by 19.7%.

Divisibility of homomorphic fibre

The divisibility of homomorphic fibre expressed in tex remained constant at the lowest sowing density (60 kg of seeds/ha) and at the two lowest nitrogen doses (80 and 120 kg N/ha) (Table 15). The application of a higher nitrogen dose (160 kg N/ha) worsened the divisibility of homomorphic fibre by 6.1%. The divisibility of homomorphic fibre at the sowing density of 90 kg of seeds per ha showed no clear tendency under the effect of nitrogen fertilisation. The best results were obtained when the lowest and the highest nitrogen dose was applied. At the highest sowing density (120 kg of seeds/ha) the fibre showed the best divisibility at the lowest nitrogen dose, 80 kg N/ha.

The divisibility of fibre reflects its ability to divide into smaller aggregates of technical fibres in subsequent processes during yarn production. The divisibility of homomorphic fibre depended on the joint effect of nitrogen fertilisation and harvest time of hemp (Table 16). The highest divisibility of fibre (8.8 tex) was obtained at the lowest dose of nitrogen (80 kg N/ha) and harvesting at harvest time I. This was also the best harvest time for this feature at higher nitrogen doses, 120 and 160 kg N/ha. Delaying the harvesting at each nitrogen dose to harvest time II, and especially to harvest time III, caused a worsening of homomorphic fibre divisibility (Table 16).

Strength of homomorphic fibre

The strength of homomorphic fibre, expressed in CN/tex, depended on the joint effect of sowing density and nitrogen fertilisation.

The highest strength of homomorphic fibre (33.8 CN/tex) was obtained at the lowest sowing density, 60 kg of seeds per ha. When increasing the nitrogen fertilisation at the lowest sowing density (60 kg of seeds per ha), the strength of the homomorphic fibre decreased. The highest strength at sowing density of 90 kg/ha (33.3 CN/tex) was obtained when 120 kg of N per ha was applied. The weakest fibre was obtained at the higher nitrogen dose, 160 kg N/ha. When applying the highest sowing density (120 kg of seeds per ha) the strongest fibre was obtained at 120 and 160 kg N/ha. On average, the best strength parameters of homomorphic fibre were obtained at the lowest nitrogen dose, 80 kg N/ha (Table 17). In addition, the joint effect of sowing density and harvest time of hemp was significant on the strength homomorphic fibre.

As shown in Table 18, the highest strength of homomorphic fibre (34.2 CN/tex) was obtained at 90 kg of seeds sown and crop harvested at harvest time II. The weakest fibre was obtained from plants sown at higher densities (90 and 120 kg of seeds/ha) and harvested at harvest time III. On average, the best strength of fibre was obtained from plants harvested at harvest time II.

Conclusions

- The optimal nitrogen dose for obtaining the highest yields of raw dew-retted straw and homomorphic fibre was 80 kh/ha. The increased doses of nitrogen were associated with higher total and technical length of hemp stems and stem diameter, but also resulted in worse quality parameters of homomorphic fibre, as expressed by the amount of impurities, divisibility and strength.
- The sowing density of 120 kg of seeds per hectare allowed the highest yields of raw straw, dew-retted straw and homomorphic fibre to be obtained. However, the quality of the homomorphic fibre as expressed by such parameters as divisibility and strength could not be maintained at the optimal level.
- The best quality of homomorphic fibre as a raw material for textile industry was obtained at the average sowing density of 90 kg/ha, the lowest nitrogen dose of 80 kg/ha, and harvesting at harvest time I, i.e. at the beginning of flowering of hemp.
- Delaying the harvest until the stage when seeds are mature in the middle part of the panicle (harvest time III), allows the highest yield of raw and dew-retted straw to be obtained, likewise the homomorphic fibre and its output.
- The best qualitative parameters of homomorphic fibre expressed by the divisibility, strength, impurities content and degree of correct retting were achieved when the hemp was harvested at the beginning of flowering.
- Delaying the harvest until the end of flowering causes an increase of about 10% in the morphological parameters of plants as expressed by the total length, technical length, length of panicles and stem diameters.
- The results obtained justify the conclusion that applying proper agricultural technology treatments such as nitrogen fertilisation, sowing density and harvest time to hemp cultivation makes it possible to obtain a homomorphic fibre, which depending on its further application, can be modified by using these treatments.
- The best quality of homomorphic fibre as a raw material for textile industry can be obtained using the medium sowing density of 90 kg of seeds per hectare, the lowest nitrogen dose, and by harvesting the hemp at the beginning of flowering (harvest time I).

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