Breeding and cultivation of industrial hemp in Poland

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S u m m a r y

In recent years we are witnesses of the growth of interest in agriculture, industry and environmental movements in reproducible plant materials, including fibrous hemp – a plant attractive both to the agriculture and many industries. In addition to traditional textile use, the use of hemp found, inter alia, in the paper industry, construction materials, automotive, energy, cosmetics, pharmaceutical and chemical industries. Also in Poland, after the crisis, the growth of interest in hemp is demonstrated by the increase in area from 100 ha in 2003 to more than 1,600 ha in 2008.
In Poland, work with hemp breeding started in 1946. At that time, the content of crude fiber in straw was only 14.3%. As a result of the multi-breeding work out this contents grew to 25–30%. The first the Polish monoecious hemp variety, entered in 1968 in the Register of Varieties is Białobrzeskie. This variety of high economic value has successfully grown to this days not only in Poland, but also in the European Union.
At present, in the National Register of COBORU there are five varieties of monoecious hemp grown in INF&MP: Białobrzeskie, Beniko, Silesia, Tygra and Wielkopolskie. These are varieties adapted to Polish climate and soil conditions. When applied for proper growing conditions, they ensure high and stable yields. In accordance with the requirements of the Drugs Act of 29 July 2005, which regulates the cultivation of hemp in Poland, all Polish varieties and breeding prospective families contain less than 0.2% of hallucinogens.
Growing hemp does not require, as a rule, use of plant chemical protection, provides high yields, leaving the soil in a very good structure. The new varieties, technologies and cultivation of cannabis harvest to total mechanization and obtain the raw material for specific technological parameters, caused the hemp plant has become attractive for both agriculture and industry.

Key words: *natural fibres, hemp, hemp breeding, dioecious hemp, monoecious hemp, hemp agrotechnology*

INTRODUCTION

Poland is one of the countries with long tradition in the hemp cultivation and processing. The first studies on the technology of cultivation, production of raw fiber technology and processing was conducted before World War II. In 1928 hemp was grown in the area of 29 300 ha. In the sixties, the area of hemp cultivation in Poland reached its highest at 30 000 ha.

The transformation of the Polish economy in the early nineties and lack of business support led to the fall of retteries, spinning mills and weaving mills. In these period there was no recipient of hemp straw in Poland. The Institute of Natural Fibres decided to suspend the creative programs of breeding hemp and to support the limited extent of conservative breeding.

In recent years, the evidences of the growing interest in renewable plant materials, including fibrous hemp, a plant attractive to both the agriculture and many industries, is visible. In addition to traditional textile use, hemp can be applied for example in the paper industry, construction materials, automotive, energy, cosmetics, pharmaceutical and chemical industries.

Also in Poland, after the crisis, the growth of interest in hemp is demonstrated by the increase in area from 100 ha in 2003 to more than 1,600 ha in 2008, mainly for the purpose of building materials, automotive, composite and recently for energy. Unfortunately, the anti-drug law in Poland [1] does not allow the hemp cultivation for energy.

POLISH HEMP CULTIVARS

The investigations on hemp breeding in Poland started in 1946, when the content of crude fiber in the straw was only 14.3%. As a result of many years of breeding this content grew to 25–30%.

The first Polish cultivars of dioecious hemp were of Central Europe type. Among these cultivars LKCSD, giving high and reliable seed (3–4 q/ha), straw (7 t/ha) and fiber yields (20%), competing with leading cultivars of dioecious hemp of South type, was introduced in Poland.

The main flaw of dioecious hemp cultivars is a different maturation term of male and female individual, hindering the harvest and processing. Therefore, in 1956 in the Institute a breeding program started in order to obtain the same aging process in plants that are monoecious with male and female flowers on one stalk [2].

The first Polish monoecious hemp variety listed in 1968 in the Register of Varieties was Białobrzeskie. This variety of a high economic value (tab. 1), has been successfully grown to this day not only in Poland but also in the other countries of the European Union.

Currently, there are five cultivars of monoecious hemp grown in INF&MP (The

Institute of Natural Fibres and Medicinal Plants): Białobrzeskie, Beniko, Silesia, Tygra and Wielkopolskie listed in the National Register of Research Centre for Cultivar Testing (COBORU) in Słupia Wielka, Poland. These are cultivars adapted to Polish climate and soil conditions. When applied in proper growing conditions, they ensure high and stable yields (tab. 1). In accordance to the requirements of the Drugs Act of 29 July 2005, which regulates the cultivation of hemp in Poland, all Polish cultivars and breeding prospective families contain less than 0.2% of Δ-9 THC.

Table 1.

The comparison of the cultivars of National Register COBORU – the average of 2004–2008 (Białobrzeskie, Beniko, Silesia) and 2007–2008 (Tygra, Wielkopolskie)

variety	stem yield [dt/ha]	seed yield [dt/ha]	raw fiber content [%]	total fiber yield [dt/ha]	cellulose content [%]	cellulose yield [dt/ha]	fatty acids content [%]	total height [cm]	1000 seed mass [g]	THC content [%]
Białobrzeskie	140	10.8	26.9	35.1	50.7	72	36.6	213	13.7	0.031
Beniko	135	8.5	30.2	38.6	51.7	71	34.7	214	14.8	0.023
Silesia	140	11.3	26.3	34.2	50.9	72	35.3	212	14.2	0.061
Tygra	158	9.8	28.2	40.4	46.5	73	35.3	225	14.0	0.041
Wielkoplolskie	171	9.8	24.5	37.5	45.6	78	34.7	228	16.0	0.020

The changing directions of the use of hemp raw material resulted in modification of long-term breeding program for monoecious hemp. Currently, several programs have been introduced the growing variety of far under 0.2% Δ-9 THC and to guarantee a high yield of biomass, fiber, pulp and seed per hectare. Large emphasis is placed on the breeding of early cultivars, allowing the harvest in more favorable weather conditions and obtaining a higher yield of healthy seed [4].

Table 2 presents the results of comparative breeding survey in which the economic value of the prospective families, cultivars in the national register COBORU and two French cultivars Santhica and Epsylon 68 were assessed.

Integral parts of the creative breeding of hemp in INF&MP are *in vitro* cultures. In Department of Biotechnology and Molecular Biology of INF&MP a research on effective methods of obtaining hemp in the regenerating cultures *in vitro* is conducted. An efficient system of regeneration in tissue cultures is a good basis to start work on obtaining transgenic plants with altered selected characteristics such as resistance to pests and diseases, high fiber yield, high seed and oil content and low tetrahydrocannabinol (Δ9-THC) level [5]. Monoecious hemp breeding is difficult. In spite of that, traditional farming methods supported with genetic engineering methods will accelerate the acquisition of the expected variety of technological parameters.

Table 2.

Comparison of hemp cultivars and breeding lines – Pętkowo 2007

variety/breeding line	total yield [dt/ha]	straw field (deseeded) [dt/ha]	raw fiber content [%]	total fiber yield [dt/ha]	cellulose content [%]	cellulose yield [dt/ha]	seed yield [dt/ha]
Epsylon 68	152	134	21,1	28	45,8	61	4,4
Santhica	143	132	27,2	36	46	61	2,5
Białobrzeskie	157	142	27,3	39	47,5	67	4,9
Beniko	134	123	36,0	44	51,1	63	1,9
Silesia	164	147	25,5	37	46,1	68	5,9
Tygra	166	150	26,8	40	45,7	68	6,1
Line G-2	203	176	19,8	35	43,9	77	6,4
Line 4	192	162	25,7	42	47,9	77	8,4

BIOLOGICAL REQUIREMENTS

Water requirements

It is estimated that during growing process hemp need at least 250–300 mm of precipitation. However, for the proper development of hemp not only total precipitation but also the distribution of rainfall during the growing season is important. Water consumption is correlated with the intensity of plant growth – the highest in June and July. The roots of hemp extend to a depth of 2–3 m which allows them to collect water from the deeper layers of the soil and survive periods of drought.

Heat requirements

Hemp heat demand is relatively high, in latitude between 51° and 58°, heat sum during the growing season vary from 2000°C to 3000°C. However, for the proper development of hemp is very important sufficient heat during the intense development in June and July. Last observations have shown that low temperature and lack of rainfall during this period results in inhibition of growth and affects adversely the amount of straw yield, fiber and seed. Hemp seed germination occurs at a temperature of 8–10°C within 8–12 days. Young plants survive frost up to –6°C. This allows relatively early sowing, thus reaching biological maturity no later than in mid-September. In Polish climate it is important for obtaining dry straw and seed.

Soil requirements

Hemp, compared with other plants, grows very quickly. Type of soil and its abundance in nutrients determine the amount of yield and particularly the efficiency and quality of fiber. Hemp plants are regarded as river valleys and plains resident. Fertile soils, rich in humus, nitrogen and calcium, as well as neutral or slightly alkaline conditions are the most appropriate for hemp. Sandy light soils and heavy clay as well as the constantly wet are soils are unfavorable for growing hemp [7, 8].

CULTIVATION

The position of the crop rotation

In determining the proper position in the rotation one should be aware of the positive characteristics of hemp regarding the biological properties of this plant. Due to large biomass production hemp can be considered as an anti-weed treatment. Hemp is distinguished as a monoculture resistant in good soil conditions and adequate fertilizing and can be practiced repeatedly on the same field with no loss. However, monoculture leads to the spread of fungal diseases and the emergence of insects [2, 8].

Well nourished hemp produces a large quantity of biomass, which perfectly shadows soil during the growing season. Well-developed root system decomposes after the harvest. This makes hemp ensuring good ventilation of the soil and the supply of caries humus in soil structure. Hemp is ideal predecessor for cereals and therefore monoculture cultivation of hemp is considered pointless.

Fertilization

The effects of fertilization depend on the culture and soil fertility, natural humidity conditions and the weather. Hemp uses well the residue of recent fertilizers and act usually positively to high doses of mineral fertilizers.

The recommended doses are:

- 90–120 kg/ha N,
- 70–100 kg/ha P_2O_5,
- 150–180 kg/ha K_2O

On acid soil liming is recommended from 15 (lighter soil) to 20 (heavier soils) q/ha before winter tillage. At pH<5 liming is necessary, pH 5.1–6.0 is advisable.

Similarly to the formation of biomass in other plants, nitrogen plays a crucial role in the formation of a straw and fiber yield. However, excessive nitrogen application extends the growing of hemp, promotes overgrowth of plants, and reduces the content and quality of fiber in stems.

Date of sowing

Proper sowing is largely determined by the weather in spring, and is essential for the cultivation of hemp. Sowing hemp in cold weather causes long seed germination and increase of plant loss. On the other hand, excessive delay in sowing reduces the period of rapid plant growth, reducing the amount and quality of yield.

The density of sowing

The optimum density of sowing hemp depends mainly on climate and soil conditions, type, direction and purpose of cultivation:

- 10–20 kg/ha, spacing rows 50–60 cm – seed production
- 60–70 kg/ha, about 10 cm – the textile use
- 30–50 kg/ha, about 10 cm – for the cellulose, biocomposite

The number of plants per unit area is a fundamental issue for the efficiency and quality of fiber.

Date of harvest is one of the most important factors determining the size and quality of yield [9, 10]. It depends, above all, on the variety characteristics and direction of cultivation:

- in full biological maturity – when the seeds ripen in the middle of the panicle it is the time for harvest at seed plantations. The delay causes loss of seed due to birds feeding on the seeds, seed scattering and reduces the quality of seed. For industrial plantations, within that period, a high yield of fiber and second quality seeds were obtained, which are a material for processing (such as for oil or food for birds, or fish);
- 1–2 weeks after blooming a high yield of strong fibers was obtained;
- when collecting about 2 weeks earlier fi,ber good for weaving was obtained.

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HODOWLA I UPRAWA KONOPI WŁÓKNISTYCH W POLSCE

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Streszczenie

W ostatnich latach jesteśmy świadkami wzrostu zainteresowania rolnictwa, ruchów ekologicznych i przemysłu odtwarzalnymi surowcami roślinnymi, w tym konopiami włóknistymi. Oprócz tradycyjnego włókienniczego wykorzystania, konopie znalazły zastosowanie między innymi w przemyśle papierniczym, materiałów budowlanych, motoryzacyjnym, energetycznym, kosmetycznym, farmaceutycznym i chemicznym. Wzrost zainteresowania konopiami w Polsce wyraża się także wzrostem areału ze 100 ha w 2003 r. do ponad 1600 ha w roku 2008. W Polsce prace hodowlane z konopiami rozpoczęto w 1946 roku. Zawartość włókna w słomie surowej wynosiła wówczas zaledwie 14,3%. W wyniku wieloletnich prac hodowlanych zawartość ta wzrosła obecnie do 25-30%. W 1968 do Rejestru Odmian Oryginalnych wpisano pierwszą polską jednopienną odmianę konopi - Białobrzeskie. Odmiana ta, z uwagi na dużą wartość gospodarczą, z powodzeniem uprawiana jest do dnia dzisiejszego w Polsce i innych krajach naszej strefy klimatycznej. Aktualnie w Rejestrze Krajowym COBORU i we Wspólnotowym Katalogu Odmian Roślin Rolniczych (CCA) znajdują się cztery odmiany jednopiennych konopi włóknistych wyhodowanych w IWNiRZ w Poznaniu: Białobrzeskie, Beniko, Tygra i Wielkopolskie. Są to odmiany przystosowane do polskich warunków klimatyczno-glebowych. Zgodnie z wymaganiami Ustawy z dnia 29 lipca 2005r. o Przeciwdziałaniu Narkomanii, która reguluje uprawę konopi w Polsce, wszystkie polskie odmiany oraz perspektywiczne rody hodowlane zawierają poniżej 0,2% substancji halucynogennej. Uprawa konopi nie wymaga z reguły stosowania środków ochrony roślin, zapewnia wysokie plony pozostawiając glebę w bardzo dobrej strukturze. Nowe odmiany, technologie uprawy i zbioru konopi pozwalające na całkowitą mechanizację i uzyskanie surowca o określonych parametrach technologicznych spowodowały, że konopie stały się rośliną atrakcyjną zarówno dla rolnictwa jak i przemysłu.

Słowa kluczowe: *włókna naturalne, konopie, hodowla konopi, konopie dwupienne, konopie jednopienne, agrotechnika*