Progress Report

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Task 2.3 YIELDING POTENTIAL OF FIBER PLANTS IN EUROPE

Prepared for

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I. Executive Summary

The project 4 F CROPS deals with crops for food, feed, fiber and fuel. The project is coordinated by Dr. Eftinia Alexopoulouů (CRES), Greece. At the Institute of Natural Fibres and Medicinal Plants work on the project is coordinated by Prof. Dr. Ryszard M. Kozlowski and M. Mackiewicz-Talarczyk.

The main aim of the 4F CROPS project is to survey and analyze all the parameters that will play an important role in successful non-food cropping systems in the agriculture of EU27 alongside the existing food crop systems.

The aim of the work for INF in Task 2.3 YIELDING POTENTIAL OF FIBER PLANTS IN EUROPE was to evaluate and compare the yielding potential of fiber plants.

The best results achieved in the field trials were compared with the reported yields obtained in practice, called here commercial yields.

The comparison has been done for fibrous flax, hemp and the cotton, grown in European countries.

Presented results have been sourced from the publicly available statistical databases and from the databases complied in the Institute of Natural Fibres & Medicinal Plants/ FAO-ESCORENA European Research Network on Flax and other Bast Plants.

The results on potential yielding have been gained as well from the official bodies responsible for registration of the cultivars such as research centres for cultivar testing, as well as, directly from the flax and hemp research institutions. The information on commercial yields has been provided by the relevant bodies, responsible in the particular countries for the collection of the data in agriculture and industry.

The basic data regarding commercial yields are gathered in tables and are provided in the annex.

II. Background

The main objectives of the 4F CROPS Future Crops for Food, Feed, Fiber and Fuel project:

- Review of the agricultural land uses in EU27 and the prediction in short (2020) and longer terms (2030),
- Mapping of cropping possibilities
- Comparative cost analysis of the food and non-food crops
- Evaluation of the most important environmental criteria
- Record of the existing policies and the driving forces in the future crops

- Development of scenarios for promising non-food cropping alongside food cropping systems, by defining systems' boundaries and evaluating the priorities and trends, in short and long time frameworks.

The task for INF: 2.3 yielding potential of fiber plants in Europe is a part of the objective regarding mapping of cropping possibilities.

As far as the scientific and flax varieties potential in scope of fibrous flax is concerned – the major research centres having long lasting and recognized achievements are in Europe (including the Institute of Natural Fibres, which conducts research in scope of flax and hemp for almost 80 years). The linseed (oil flax) research and very valuable varieties are in Canada, which is the biggest producer of linseed. The significant linseed (oil flax) producers are: Argentina, USA, India. In Europe major players in scope of linseed: Hungary, Turkey, Poland, Ukraine, Czech Republic. It is necessary to underline that there is the lack of the GM research in the scope of fibrous flax.

III. YIELDING POTENTIAL OF FIBER PLANTS IN EUROPE

III. 1. The yielding of fibrous flax

Table 1. Fibrous flax cultivated area in the world [ha]

Country	2000	2001	2002	2003	2004	2005	2006	2007	2008 est.
AUSTRIA	450[1/]	132[1/]	171[6/]	142 [5/]	109[6/]	134[1/]	129[1/]	0,02[10/]	°/
BELARUS	81 800	70 000°	67 900	70 900	79 000	78 500	75 200	78 500[1/]	°/
BELGIUM	13 355[3/]	16 990[3/]	15 315[5/]	19 306 [5/]	19 823[1/]	18 670 [1/]	16 354[1/]	14 630[1/]	12 030[/]
BULGARIA	300	210	470	150°	70	°/	°/	°/	°/
CHINA	100 000[6/] °	100 000[6/]	80 000[6/]	133 000[6/]	200 000[6/] 130 000[7/]	130 000	118 500	110 000	°/
CZECH REPUBLIC	6 302-	7 095	5 885	6 003	5 500	4 318[1/]	2 736[11/]	824[10/]	°/
DENMARK	45[1/]	19[1/]	0 [1/]	0 [1/]	°/	°/	°/	°/	°/
EGYPT	3 994[9/]	7 649[9/]	8 936[9/]	13 010[9/]	17 138[9/]	5 847[9/]	°/	20 000[1/]	°/
ESTONIA	137	89	35	17	0	Fibrous Flax 0, Linseed 91ha	°/	°/	°/
FINLAND	1 067[1/]	365[6/]	202 [5/]	97 [5/]	67[5/]	57[1/]	17[1/]	°/	°/
FRANCE	55 629[3/]	67 970[3/]	68 416[1/]	76 439[5/ x]	80 081[1/]	81 508[1/]	76 497[1/]	75 523[1/]	67 000[1/]
GERMANY	402[1/]	200[1/]	200[6/]	224[6/]	180[6/]	38[1/]	30	51	°/
IRELAND	°/	0[3/]	°/	°/	°/	°/	°/	°/	°/
ITALY	°/	1[3/]	0 [5/]	20 [5/]	80	18[1/]	°/	°/	°/
LATVIA	300-linseed; 1600-fiber flax	°/	°/	°/	1 654[6/]	2 072[1/]	1 420	220[10/]	°/

LITHUANIA	8 600	9 600	9 346	9 444[1/]	5 494	3 599[1/]	1 057[1/]	950[1/]	°/
NETHERLANDS	4 016[1/]	4 415[1/]	4 000 [5/]	4 615 [5/]	4 517[1/]	4 691[1/]	4 366[11/], [1/]	3 458[1/]	2 500[1/]
POLAND	5 093[4/]	4 520[4/]	5 100[4/]	6 000[4/]	6 345 [4/]	6 843[4]	4 225[11/]	2 056[10/]	1991[4/]
PORTUGAL	3 522[3/]	0[3/]	0[1/]	°/	°/	°/	°/	°/	°/
RUMANIA	2 000[6/]	300[6/]	300[6/]	°/	°/	°/	°/	107[10/]	°/
RUSSIA	107 610	127 340 127 361 [6/]	110 820 100 000[6/]	118 060 104 000[6/]	112 300	95 450	86 000	75 000	81 000
Slovak Rep.	°/	°/	°/	°/	°/	°/	°/	67[10/]	°/
SPAIN	13 595[3/]	342[1/]	60[5/]	2[5/]	°/	°/	°/	°/	°/
SWEDEN	21[1/]	32[3/]	25[1/]	0[1/]	30[1/]	°/	°/	34	°/
UKRAINE	19 300	28 280	28 200	32 480[8/]	38 220[8/]	25 530[8/]	16 164	12 000[8/]	°/
UNITED KINGDOM	11 816[3/]	4 430[1/]	156[5/]	175[5/]	1 820[1/]	196[1/]	21[1/]	°/	°/

Total flax cultivated area in EU countries: in 2000 103 867[3/] ha, in 2001 94 631[3/]ha, in 2002: 88 885[1/]ha, in 2003: 98 965[1/]ha., in campaign 2004/2005: 118 251 ha, in campaign 2005/2006: 122 379 ha, 2006: [10/]105 025 ha; in 2007: [10/]78 500 ha. *In entire Europe total flax cultivated area in 2007: [10/]95 117 ha.*

Source**:** Generally, data provided by relevant countries' official organizations (see also the country data). Those data are not marked. Another source of information is described below:

[1/] A. Daenekindt: Algemeen Belgisch Vlasverbond, Oude Vestingsstraat 15, B-8500 Kortrijk, Belgium, e-mail: albert.daenekindt@vlasverbond.be

[2/] FAOSTAT Statistical Database Results 1997 http://apps.fao.org

[3/] Mr. Jordi Petchamé Ballabriga, Administrateur, Olives, huile d'olive et plantes textiles, D.G. VI.C.4 - Loi 130 7/126, European Commission, Rue de la Loi 200, B-1049, Bruxelles, Belgium

[4/] Polish Chamber of Flax and Hemp, office at the Institute of Natural Fibres, Poznan, Poland, t.: +48-61 8 455 851, f.: +48 61 8 417 830, hempflax@inf.poznan.pl, data provided by the Ministry of Agriculture and Rural Development.

[5/] 54ème Congrès CELC – Berlin, Réunion d'information Générale / Section commune Culture-Teillage

[6/] CELC/MASTERS OF LINEN, 15, rue du Louvre, 75001 Paris, France, t.: +33(0)1 42 21 06 83, f.: +33(0)1 42 21 48 22, e-mail: info@mastersoflinen.com

[7/] Research Institute of Industrial Crops of Heilong Academy of Agricultural Sciences, Harbin, China, 150086, t:(86)0451-55261351, f.(86)451866 77431, E-mail: wuguangwenflax@163.com

[8/] Dr Pavel Goloborod'ko, Institute of Bast Crops, Lenina 45, 245130 Glukhov, Sumy, Ukraine, t./f: 3805444 22643

[9/] Prof. Dr. D. M. El-Hariri, The Network Representative in the Near East, NRC, Cairo, Egypt, e-mail: profelhariri@netscape.net; acc. to Agricultural Economics Bulletins of the Central Administration for Agricultural Economics and Statistics of Egypt.

[10/] Ministry of Agriculture and Rural Development of Poland (basing on European Commission documents)

[11/] Data of European Commission, DG AGRI of May 2008, Doc. No 9875/08

note: in all tables the mark °/ means data not available

III.1.1. The potential yielding of fibrous flax in Europe

III. 1.1.1. In-depth examples of potential fibrous flax yielding in selected European countries

III.1.1. 2. Fiber flax yielding potential in France

Table 2. Fiber flax yielding potential in France

	Specification	One of the best results in 2008/ real farmer field
1.	Total yield [t/ha]	
2.	Ginned (deseeded) straw yield [t/ha]	10.76
3.	Seed yield [t/ha]	0.55
4.	Total fiber content in ginned straw yield [%]	33.32
5.	Long fiber content in ginned straw yield [%]	26.76
6.	Short fiber content in ginned straw yield [%]	6.56
7.	Yield of total fiber [t/ha]	3.584
8.	Yield of long fiber [t/ha]	2.879
9.	Yield of short fiber [t/ha]	0.705

Source: Eng. Trouvé Jean-Paul, Responsable de la Recherche, Research Manager, Terre de Lin, 76740 Saint Pierre le Viger, France, +33 (0)2 35 97 41 33, fax: +33 (0)2 35 97 13 18, www.terredelin.com

III.1.1. 3. Fiber flax yielding potential in Poland

The results of over 40 years of the observations (years 1967-2008); 315 plot trails indicate that there is significant diversification in the flax yields and their quality, according to the environmental conditions.

In the years with the weather conditions favourable for this plants: (i.e. moisture level, the length of growing period, amount of light, etc.; and when the optimal flax cultivation technologies have been applied, total yield and yield of ginned straw of fiber flax totalled over 10.0 t/ha. Those parameters resulted in the total yields of fiber at the level of 2,266 kg/ha and 1,740 kg/ha of fiber, with total fiber content and content of long fiber (22.0% and 16.9% accordingly). The described results have been obtained for the flax variety Svapo (Pl), in the conditions plot trials conducted over 20 years ago.

In the described over 40 years observation and trials, the total flax yielding potential was often recorded at the level over 10.0 t/ha, while the average commercial yields (Tab. 1) were able to deliver only 50% of potential yielding. This lower yield was observed even in the countries having a high level of agriculture, and at the optimal climatic conditions for flax (cool and rainy weather during vegetation period).

The results of the plot experiments indicate on the significant yielding potential, which might be double comparing to the yields obtained in the current practice.

Table 3. Fiber flax yielding potential in Poland
(the best results from 315 field trials carried out in the period 1967-2007)

No.	**Specification**	**The results Experimental Farm of INF, Wojciechow, Poland, 1984**
1.	Total yield [t/ ha]	11.75
2.	Ginned (deseeded) straw yield [t/ha]	10.30
3.	Seed yield [t/ha]	0.90
4.	Total fiber content in ginned straw yield [%]	22.0
5.	Long fiber content in ginned straw yield [%]	16.9
6.	Short fiber content in ginned straw yield [%]	5.1
7.	Yield of total fiber [t/ha]	2.266
8.	Yield of long fiber [t/ha]	1.740
9.	Yield of short fiber [t/ha]	0.525

Source: Computer Data Base Access 2007, the Institute of Natural Fibers, Poznan, Poland

Table 4. Fiber flax yielding potential in the Netherlands

	Specification	The best results in breeding or field trials
1.	Total yield [t/ha]	
2.	Ginned (deseeded) straw yield [t/ha]	6.0
3.	Seed yield [t/ha]	0.1
4.	Total fiber content in ginned straw yield [%]	40.0
5.	Long fiber content in ginned straw yield [%]	22.5
6.	Short fiber content in ginned straw yield [%]	17.5
7.	Yield of total fiber [t/ha]	2.4
8.	Yield of long fiber [t/ha]	1.35
9.	Yield of short fiber [t/ha]	1.05

III.1.1.4 Fiber flax yielding potential in Czech Republic

Table 5. Potential yield of straw, seeds and fiber of flax obtained from experimental trials in Czech Republic [Pavelek, Tejklova, Journal of Natural Fibers 2002]

Variety	Unretted stem yield [t/ha]	Total fiber content [%]	Long fiber content [%]	Total fiber yield [t/ha]	Long fiber yield [t/ha]	Short fiber yield [t/ha]	Seed yield [t/ha]
Agatha	8.27	37.6	24.1	2.51	1.66	0.85	1.27
Escalina	8.04	35.6	21.6	2.28	1.43	0.85	1.23
Electra	7.96	35.7	22.6	2.22	1.39	0.83	1.25
Ilona	7.73	34.7	23.0	2.31	1.42	0.89	1.29
Viola	7.65	34.5	22.3	2.07	1.27	0.8	1.12
Viking	7.41	37.5	21.8	2.18	1.29	0.89	1.19
Bonet	7.67	37.6	24.8	2.23	1.39	0.84	1.3
Jordan	7.9	38.1	22.8	2.39	1.51	0.88	1.14
Tabor	7.6	37.8	21.8	2.31	1.37	0.94	1.27
Jitka	6.92	33.9	20.9	1.9	1.21	0.7	1.18
Venica	7.37	36.9	21.8	2.23	1.39	0.84	1.34

III.1.1.5 Fiber flax yielding potential in Russia

Table 6. Fibrous flax potential of yielding in Russia

	Specification	**The best results in breeding of late** *varieties*
1.	Total yield of unretted straw [t/ha]	7.5-8.0
2.	Ginned straw yield [t /ha]	5-6
3.	Seed yield [t/ha]	1.8
4.	Total fiber content in ginned straw yield [%]	45
5.	Long fiber content in ginned straw yield [%]	24
6.	Short fiber content in ginned straw yield [%]	11
7.	Yield of total fiber [t/ha]	2. 5
8.	Yield of long fiber [t/ha]	1. 6
9.	Yield of short fiber [t/ha]	0.9

Source: [1] Alexander Goncharov, Deputy Director, Department for Public and International Relations, Federal Service of State Statistics of the Russian Federation, Moscow, Russia.
[2] Flax Research Institute(VNIIL), Torzhok, Russia, E-mail: uschapovsky@mail.ru;

III.1.1.6 Fiber flax yielding potential in Belarus

Table 7: Fibrous flax yielding potential in Belarus

	Specification	**Cultivar**	**The best results in field trials**
1.	Total yield [t/ha]	Bielich	12.48
2.	Ginned straw yield [t/ha]	Bielich	11.58
3.	Seed yield [t/ha]	Iva	2.01
4.	Total fiber content in ginned straw yield [%]	Tabor	43.7
5.	Long fiber content in ginned straw yield [%]	Tabor	26.0
6.	Short fiber content in ginned straw yield [%]	Tabor	17.7
7.	Yield of total fiber [t/ha]	Medium yield	5.060
8.	Yield of long fiber [t/ha]	Medium yield	3.011
9.	Yield of short fiber [t/ha]	Medium yield	2.049

Source: Results of the official sorts testing of crops of the Republic of Belarus in 2005-2007. Data provided by the Institute of the Agrarian Economics, Minsk, Belarus, E-mail: agrecinst@mail.belpak.by

Generally, potential production capabilities of fiber flax are significant.. As from results of table 2, flax cultivated in good conditions can give following yields: straw yield – 7-8 t/ha, total fiber yield – 2.5 t/ha, long fiber yield – 1.6 t/ha, short fiber yield – 0.8 t/ha, seed yield – 1.3 t/ha, total fiber content – 38%, long fiber content – 24.8% (Tab.2) .

However, average yields of fiber flax varieties from industrial cultivation are at the level of: total fiber yield – 1.7 t/ha, long fiber yield – 1.2 t/ha, seed yield – 0.9 t/ha, total fiber content – 30% and long fiber content – 22% (Tab. 3) and those results are 30-35% lower than data observed in the trials.

III.1.2. The commercial yielding of fibrous flax Europe

Table 8. The survey of average commercial yields of fiber flax in western and eastern Europe

	Specification	Years															
		2002		2003		2004		2005		2006		2007		2008		Average	
		Eastern Europe	Western Europe	Eastern Europe	Western Europe	Eastern Europe	Western Europe	Eastern Europe	Western Europe	Eastern Europe	Western Europe	Eastern Europe	Western Europe	Eastern Europe	Western Europe	Eastern Europe	Western Europe
1	Ginned straw yield [t/ha]	4.49	5.40	3.23	5.20	3.57	4.95	3.85	4.45	3.56	4.75	3.46	48.00	36.20	56.0	36.83	49.9
2	Seed yield [t/ha]	0.82	1.00	0.60	0.98	0.70	0.92	0.80	0.83	0.65	0.89	0.60	0.90	0.73	1.05	0.70	0.93
3	Total fiber content in ginned straw yield [%]	30.00	35.30	30.20	36.10	33.60	33.90	31.10	31.80	30.80	31.20	28.80	32.30	30.70	32.10	30.74	33.50
4	Long fiber content in ginned straw yield [%]	18.90	22.60	18.50	25.00	22.40	21.80	19.50	21.30	19.60	20.60	18.70	20.80	20.70	25	19.76	22.50
5	Short fiber content in ginned straw yield [%]	11.10	12.70	11.70	11.10	11.20	12.10	11.60	10.40	11.20	10.50	10.10	11.50	11.00	7.10	11.13	11.00
6	Yield of total fiber [t/ha]	1.350	1.905	0.980	1.875	1.200	1.680	1.200	1.415	1.100	1.480	1.000	1.550	1.150	1.800	1.134	1.675
7	Yield of long fiber [t/ha]	0.850	1.220	0.600	1.300	0.800	1.080	0.750	0.950	0.700	0.980	0.650	1.000	0.750	1.400	0.723	1.130
8	Yield of short fiber [t/ha]	0.500	0.685	0.380	0.575	0.400	0.600	0.450	0.465	0.400	0.500	0.350	0.550	0.400	0.400	0.411	0.545
9	Cultivation area [ha]	5 200	15 315	3 000	19 306	6 345	19 823	6 000	18 670	4 243	16 354	2 056	14 630	1 991	12 030	4 119	16 590

Source: The data in the above table are based on the data achieved in the commercial scale, in the flax industries of Poland and Belgium.

The data are provided by the following sources: in case of Poland— Flax and Hemp Chamber, which obtains the data from the Ministry of Agriculture and Rural Development and the Institute of Natural Fibers data; in case of Belgium—Algemeen Belgisch Vlasverbond (Belgian Flax Association), Kortrijk, Belgium. The data from Belgium, provided by the Belgian Flax Association- the member of CELC (Confédération Européenne Du Lin et Du Chanvre) are comparable with data on fibrous flax parameters and yielding in France and the Netherlands.

The next tables gather together the data regarding the average commercial yields of fibrous flax obtained in the different countries-the producers and processors of flax in Europe in some recent years.

Table 9: The survey of the **average** commercial yields of fibrous flax in flax producing countries in Europe

Specification	Belarus	Belgium	Bulgaria	Czech Rep.	Denmark	Estonia	France	Latvia	Lithuan.	Nether.	Poland	Russia	Spain	UK	Ukraine
Straw yield [t/ha]	2.73	4.99	2.26[1]	3.11	0. 746[1]	0.888	7.05	n/a	3.15	5.014[1]	4.43[3]	2.84[5]	1.27[1]	3.44[1]	2.3
Seed yield [t/ha]*of fiber flax	0.25	0.93	n/a	0.51	n/a	0.9	0.472	0.294	0.39	0.798	0.70[3]	0.11[5]	n/a	n/a	0.23
Long fiber yield [t/ha]	0.304	1.125	n/a	0.412	n/a	n/a	1.459	0.0732	0.3.3	1.041	0.729[3]	0.459[5] - 0.565[4]	n/a	n/a	0.149
Long fiber production [t]	n/a	n/a	n/a	1 865	n/a	n/a	n/a	1 258	2 108	n/a	10 523[3]	52 712[4]	n/a	n/a	4477
Short fiber yield [t/ha]	0.324	0.545	n/a	0.506	n/a	n/a	0.891	n/a	0.50	0.662	0.411[3]	0.153[5]	n/a	n/a	0.2525
Short fiber production [t]	n/a	n/a	n/a	2389	n/a	n/a	n/a	n/a	3 174	n/a	5 542[3]	158 136[6]	n/a	n/a	7841
Percentage of dew retting [%]	100[2]	100[2]	n/a	100	100[2]	100	100[2]	100[2]	100[2]	100[2]	100[3]	100[2]	100[2]	100[2]	100[2]
Cultivated area av.[ha]	75 000	16 590	183. 3[1]	4 822	266[1]	140	70 883[1]	1 728	8 158	4 516.7[1]	5 091[3]	111 930[4]	2 383[1]	4 400[1]	29 415

Sources of data: calculation of average data from several years

1/ EUROSTAT

2/ EUROFLAX Bulletins of the European Cooperative Research Network on Flax and other Bast Plants, No. 22-28.

3/ Polish Flax and Hemp Chamber

Note: * for 1ha harvested area, n/a- not availabl

Other sources than EUROSTAT regarding the particular countries are provided by:

Belarus: Institute of the Agrarian Economics, Minsk, Belarus, E-mail: agrecinst@mail.belpak.by

Belgium: Algemeen Belgisch Vlasverbond, Kortrijk, Belgium, Tel.: +32/ 56 22 02 61, Fax +32/56 22 79 30, E-mail: albert.daenekindt@vlasverbond.be

Czech Republic: P. Šmirous, H. Suchomelová, S. Krmela, ATOK Praha and Flax Union CR, Šumperk-Temenice, Czech Republic, E-mail: len@agritec.cz

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France: Dr. Trouvé Jean-Paul, Responsable de la Recherche, Research Manager, Terre de Lin, 76740 Saint Pierre le Viger, France, +33 (0)2 35 97 41 33, fax: +33 (0)2 35 97 13 18, www.terredelin.com with a help of Mr Christophe Mallet, Association Générale des Producteurs de LIN, 5, rue du Louvre - Boîte n°84, F-75 001 PARIS, Tel. 00.33.(0)1.40.41.11.66, Fax 00.33.(0)1.40.41.11.55

Latvia: U. Apels, Department of Information, Ministry of Agriculture of the Republic of Latvia, Riga

Lithuania: LIA – The Lithuanian Institute of Agriculture Upyte Research Station, Upyte, Lithuania; E-mail: soja@upyte.lzi.lt; “Crops". 2005 (ISSN 1648-0198) - statistical bulletin of Statistikos departamentas / Statistics Lithuania, published in Vilnius, Lithuania in 2005

The Netherlands: Source: Ms. Eugene Van de Bilt, Van de Bilt zaden en vlas bv, PO BOX 16, 4540 AA SLUISKIL, The Netherlands, T: +31 115 471922, F.+31 115 472229, E-mail: info@vandebiltzadenvlas.com

Russia: [4/]Department for Public and International Relations, Federal Service of State Statistics of the Russian Federation, Moscow, Russia, Fax: (7-095)207-31-86, e-mail: goncharov@gks.ru and [5/]Flax Research Institute(VNIIL), Torzhok, Russia, E-mail: uschapovsky@mail.ru;

[6/]Calculated data

Ukraine: Institute of Bast Crops, Glukhov, Sumy, Ukraine, Tel.: /Fax: 3805444 22643, E-mail: ibc@sm.ukrtel.net and Prof. Dr. I. Karpets, Agriculture Institute of Ukrainian Academy of Agrarian Sciences, Chabany, Ukraine

Table 10: Cultivation of fibrous flax and fiber production in the World

	2000		2001		2002		2003		2004	
	ha	Long flax fiber [tons]	ha	Long flax fiber [tons]	ha	Long flax fiber [tons]	ha	Long flax fiber [tons]	ha	Long flax fiber [tons]
France + Belgium + Neth.	71 016	89 900	87 836	46 647	86 153	123 856	98 360	144 500	102 621	131 445
Germany	402	n/a	200	n/a	200	280	224	n/a	180	112
Austria	450	n/a	132	n/a	171	n/a	142	n/a	109	82
Finland	1 067	n/a	365	n/a	202	n/a	97	n/a	67	n/a
Estonia	137	n/a	27	1 000	30	n/a	n/a	n/a	n/a	n/a
Latvia	1 600	1 100	n/a		n/a	n/a	n/a	n/a	1 654	317
Lithuania	8 600	2 900	9 600	1 400	9 346	2 300	10 000	3 000	5 494	2 553
Czech Rep.	6 302	2 235	7 095	1 591	5 885	2 000	6 003	2 100	5 499	2 930
Poland	5 093	2 700	4 520	2 712	5 100	1 300	6 000	4 200	5 745	4 050
Bulgaria	300	35	210	25	470	n/a	n/a	n/a	n/a	n/a
Romania	2 000	300	300	100	300	100	n/a	n/a	n/a	n/a
Russia	107 610	51 170	127 361	58 000	100 000	30 000	104 000	10 000	112 300	58 020

Belarus	81 800	20 000	70 000	17 500	40 000	16 000	60 000	10 000	79 146	16 000
Ukraine	19 300	2 509	28 280	5 076	28 200	4 323	32 000	4 000	37 000	6 000
Egypt	14 500	14 000	25 000	20 000	25 000	20 000	36 000	33 000	36 000	35 000
China	100 000	31 000	100 000	31 000	80 000	25 000	133 000	26 000	200 000	30 000
Total	420 177 ha	217 849 t	460 926 ha	185 051 t	381 057 ha	225 159 t	485 826 ha	236 800 t	585 815 ha	286 509 t
%										
France + Belgium + Netherland		41,3%		25,2%		55%		61%	17,50%	45,88%
EU									20,70%	49,38%

Source: CELC 2005

III.1.2.1.Discussion

III.1.2.1. i Discussion of the results regarding the flax potential of yielding

In the described over 40 years observation and trials, the total flax yielding potential was observed often at the level over 10.0 t/ha, while the average commercial yield (Tab. 1) were noticed on the level of 50% of potential yielding in the countries of high level of agriculture, in the optimal climatic conditions for flax (cold and rainy weather during vegetation period). [The Institute of Natural Fibers, Poland]

- ❖ Fiber flax belongs to the plants which respond significantly to the applied cultivation technologies and the environmental conditions (soil, weather conditions).
- ❖ The average commercial yield was only 30 – 35% of values of obtained in test trials, due to several factors which influence the yields in the agricultural practice as well as in processing.

The results of more than 40-year observations (the database with the 315 results of field trials carried out in INF Poznan) allow for conclusion that among evaluated habitat conditions the following ones show the strongest effect on growth, development and yielding of flax:

- sowing date – a simple positive correlation was found; the earlier sowing, the higher yield of straw, fiber and seed of fiber flax ,
- rainfalls distribution during vegetation of fiber flax – high moisture content in the habitat has a positive effect on elongation of growing season of fiber flax,
- air temperature – cool weather caused elongation of growing season,
- the highest yield of straw and fiber was obtained at long vegetation period,
- level of flax infestation with weeds – it was found that higher infestation with weeds causes decrease in number of flax plants per square unit resulting from higher thinning.

In fiber flax cultivation, the following factors have a significant effect on the fiber quality and its yield. Those measures do not require additional financial, material and energy inputs:

- forecrop – the best one for flax are cereals (oats, wheat),
- soil – the best for flax are fertile soils in a high culture, medium compacted and compacted, high humus clays and clay sandy soils, of soil valuation class (at least IVa),

- sowing density – 24-26 million of seeds per 1 ha (120-130 kg/ha),
- right-in-time and quality of plant protection treatments of flax plants (e.g. earlier application of herbicides allows for decreasing of a preparation),
- time of flax pulling – beginning of green-yellow maturity of flax,
- controlled dew-retting of flax.

In remaining 80 %, physico – chemical properties of soils and climatic conditions have influence on flax production results. It is estimated, that three factors are responsible (in 20%) for so big difference in flax yield are as follows: diseases, insects and weeds.

It is generally accepted, that increase of fiber flax yield production capacity is possible to achieve through following practices:

- Breeding of cultivars with high functional characteristics
- Optimization of agrotechnical conditions of cultivation
- Regionalization of production
- Because fibrous flax and hemp are non-food crops it is very important to investigate and introduce GM crop, especially e.g. resistant to drought, with low level of pectine and lignin.

III.1.2.1. ii Discussion regarding potential yields versus commercial yields of fibrous flax in Europe

The average commercial yields are noticed in practice on the level from 50 – 70 % of potential yielding in the countries of high level of agriculture, in the optimal climatic conditions for flax. It means, that there is still potential and the need to increase the flax yielding in the commercial scale. What practices and actions are needed?

To increase practical yields of bast plants such as flax and hemp it is important to follow the well established routines, which include:

- to start the sowing process as soon as the relevant temperature of the soil is achieved;
- control the stage of retting process carefully (to avoid e.g. over-retting);
- to follow strictly the indicated, elaborated cultivation and agro techniques (described above);
- to aim towards full mechanization of the harvesting process.

- to accelerate the research and introduction of GM modified fibrous flax cultivars, which will enable e.g. production of significantly higher biomass and oil. It is also possible to conduct modification in statu nascendi (Poly-hydroxy-alcanates- PHA)

III.2. The yielding of fibrous hemp in Europe

III.2.1. The potential yielding of fibrous hemp

Table 11. Hemp harvested area in European Union countries and some other countries [ha]

COUNTRY OF EU	2000/2001[2)]	2002[1)]	2004 [3)]	2005 [4)]	Campaign 2005/2006	Campaign 2006/2007	2007 Data by [8)]	2008 Data by [8)]	2009-forecast Data by [8)]
Austria	287	277	399	353	342	545	500	500	500
Belgium	0	0		6					
Czech Republic			150	159	156	1 086[6]	1 200	700	1 200
Denmark	7	0	40	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*
Finland	59	0	7	*n/a*	0	0	*n/a*	*n/a*	500
France	7 700	7 729	8 800	9 600	9 315	8 083	8 103	7 500	11 500
Germany	2 967	2 035	1 730	2 005	1 985	1 233[6]	824	800	800
Hungary	*n/a*	*n/a*	500	*n/a*	277	*n/a /*	*n/a*	*n/a*	*n/a*
Italy	151	300	885		157	500	450	250	250
Ireland	6	0	0	0	0	0	100 OCM for Biomass	100 OCM for Biomass	n/a
Latvia	*n/a*	*n/a*	*n/a*	6	0	*n/a*	*n/a*	*n/a*	*n/a*
Netherlands	806	2 100	27	49	49	23			
Poland	111	83 In 2003– 101 ha[3)]	910	216	129	1007[7)]	1 376	1 200	1 200
Romania						1 450[6]	108	n/a	n/a
Spain	6 103	691	654	700	853	3			
Sweden	0	0	141	368	*n/a /*	*n/a*	700 OCM for Biomass	200 OCM for Biomass	700 OCM for Biomass
UK	2 245	1 413	1 658	3 000	1 274	1 671[6]	800	1 300	2 500
Switzerland	250[1*]	°/	°/	°/	°/	°/			
Total area in EU	**20 404**[2)]	**14 584**[2)]	**14 557**	**16 462**	**14 541**	**13 974**	**14 261**	**12 650**	**18 750**
Ukraine	*n/a*	1 910[5)]	1 510[5)]	1 940[5)]	1 940	2 490	760	910	n/a

Source: [1)] Michael Dr. Karus, nova –Institut für politische und ökologische Innovation, Nachwachsende Rohstoffe, Thielstr. 35, 50354 Hürth Germany

[2)] Mr. Jordi Petchamé Ballabriga, Administrateur, Olives, huile d'olive et plantes textiles, D.G. VI.C.4 - Loi 130 7/126, European Commission, Rue de la Loi 200, B- 1049, Bruxelles, Belgium

[3)] *LEN I KONOPIE. (FLAX AND HEMP)* No 4. 2005. pp. 2-10. The Bulletin of the Polish Chamber of Flax and Hemp, office at the Institute of Natural Fibers, Poznan, Poland, Ph.: +48-61 8 455 851, fax: +48 61 8 417 830, e-mail: hempflax@inf.poznan.pl

[4)] Polish Chamber of Flax and Hemp, office at the Institute of Natural Fibers, Poznan, Poland, Ph.: +48-61 8 455 851, fax: +48 61 8 417 830, e-mail: hempflax@inf.poznan.pl (data based on EC documents)

[5)] Institute of Bast Crops, Lenina 45, 245130 Glukhov, Sumy, Ukraine, Tel.: /Fax: 3805444 22643, E-mail: ibc@sm.ukrtel.net

[6)] Data of European Commission, DG AGRI of May 2008, Doc. No 9875/08

[7)] Ministry of Agriculture and Rural Development, Warsaw, Poland, E-mail: Grazyna.Bernatowicz@minrol.gov.pl

[8)] Mr. Sylvestre Bertucelli, Director, Federation Nationale des Producteurs de Chanvre, 20, rue Paul Ligneul, 72000 Le Mans, France, Tel: : + 33/2 43 51 15 00, Fax: +33/2 43 51 15 09, E-mail: s.bertucelli@fnpc.org

Table 12. Hemp in Europe: evolution 2007/2008/2009

Surface [ha] cultivation evolution

Country	**2007**	**2008 (estimation)**	**2009 (forecast)**
France	8 103	7 500	11 500
Germany	824	800	800
UK	800	1 300	2 500
Poland	1 530	1.792 *	1 800**
Czech Rep.	1 200	518	500
Hungary	200	0	200
Austria	500	500	500
Italy	450	250	250
Romania	108	n/a	n/a
Sweden (with no biomass OCM)	700	200	700
Ireland (with no biomass OCM)	100	100	n/a
Finland	300	300	300
Others	100	100	100
Total	14 915	12 768	18 550

Source: Materials of 59th CELC Congress, 16-18.10.2008, Como, Italy

* Ministry of Agriculture and Rural Development, Warsaw, Poland, E-mail: Grazyna.Bernatowicz@minrol.gov.pl

** Polish Chamber of Flax and Hemp, E-mail: hempflax@inf.poznan.pl

Table 13. The survey of average fibrous hemp straw and fiber yields

Specification	Austria	Finland	France	Hungary	Italy	Netherlands	Poland	Romania	Turkey	Ukraine	UK
Hemp harvested straw, [1000 t]	n/a	n/a	57.57[1]	3.12[1]	1.57[1]	5.87[1]	0.23[1]	3.14[1]	178.21[1]	30.05[3]	10.05[1]
Straw yield [t/ha]	n/a	0.1 [1]	7.18[1]	6.40[1]	4.50[1]	6.58[1]	7.77	3.20[1]	12.58[1]	2.16[2]	4.58[1]
Hemp fiber yield [t/ha] (based on yield 2004/2005)	1.13	1.39	1.66	1.75	0.48	3.00	1.80	n/a	n/a	0.41[2/]	0.81

Sources of data: [1] EUROSTAT

[2/] Ukraine: Institute of Bast Crops, Glukhov, Sumy, Ukraine, Tel.: /Fax: 3805444 22643, E-mail: ibc@sm.ukrtel.net

[3/] calculated data

[4/] Ministry of Agriculture and Rural Development of Poland, Warsaw.

[5/] Steering Committee on Natural Fibers of the European Commission

III.2.1. 1. In-depth examples of hemp yielding potential:

III.2.1.2. Fibrous hemp yielding potential in France

Table 14. Fibrous hemp yielding potential in France

	Specification	The best results in fibrous hemp cultivars
1.	Total yield [t/ha] Biomass 16% RH	28.20 (Futura 75)
2.	Ginned straw yield [t/ha]	23.76 (Dioïca 88)
3.	Seed yield [t/ ha]	
4.	Total fiber content in ginned straw yield [%]	40.85 (Santhica 27)
5.	Yield of total fiber [t/ ha]	10.5 (Santhica 27)

Source: Mr. Sylvestre Bertucelli, Director, Federation Nationale des Producteurs de Chanvre, 20, rue Paul Ligneul, 72000 Le Mans, France, Tel: : + 33/2 43 51 15 00, Fax: +33/2 43 51 15 09, E-mail: s.bertucelli@fnpc.org

III.2.1.3. Fibrous hemp yielding potential in Hungary

Table 15. The potential yields of fibrous hemp observed in Hungary

No.	Specification	The best results in field trials
1.	Total yield [t/ha]	20.0
2.	Ginned straw yield [t/ha]	18.0-19.0*
3.	Seed yield [t/ha]	1.0
4.	Total fibre content in ginned straw yield [%]	35.0
5.	Long fibre content in ginned straw yield [%]	26.0
6.	Short fibre content in ginned straw yield [%]	9.0
7.	Yield of total fibre [t/ha]	4.3
8.	Yield of long fibre [t/ha]	3.2
9.	Yield of short fibre [t/ha]	1.1

Source: results partly from of the Institute of Kompolti Research Institute, partly from Tessedik Sámuel College Agricultural Water and Environmental Management research farm. *calculated data

III.2.1.4. Fibrous hemp yielding potential in Poland

The yields of fibrous hemp derived from the official trials of the Centre For Cultivar Testing

Table 16. Fibrous hemp yielding potential in Poland, based on cultivar testing trials

	Specification	The best results in fibrous hemp cultivar testing				
		2004	**2005**	**2006**	**2007**	**Average**
1.	Total yield [t/ha]	13.98	14.38	11.66	18.88	14.73
2.	Ginned straw yield [t/ha]	12.70	13.10	10.40	17.95	13.54
3.	Seed yield [t/ha]	1.23	1.23	1.21	0.88	1.14
4.	Total fiber content [%]	27.30	26.90	25.80	25.75	26.44
5.	Yield of total fiber [t/ha]	3.47	3.47	3.20	4.24	3.60

Source: COBORU- Research Centre For Cultivar Testing, Slupia Wielka near Poznan, tel.: (+48) 61 285 23 41–47, fax: (+48) 61 285 35 58, E-mail : sekretariat@coboru.pl

Table 17. Fibrous hemp yielding potential in Poland, obtained in breeding

No.	Specification	The results in breeding in field conditions
1.	Total yield [t/ha]	23.5
2.	Ginned straw yield [t/ha]	22.0
3.	Seed yield [t/ha]	1.4
4.	Total fiber content in ginned straw yield [%]	28.0
5.	Long fiber content in ginned straw yield [%]	12.0
6.	Short fiber content in ginned straw yield [%]	16.0
7.	Yield of total fiber [t/ha]	6.16
8.	Yield of long fiber [t/ha]	2.64
9.	Yield of short fiber [t/ha]	3.52

Source: Breeding farm KOW-MAR, Blaszki, average results from 2005-2007

Table 18. The potential yields of fibrous hemp observed in the experimental farm of the Institute of Natural Fibers, Poznan, Poland

No.	Specification	The best results in cultivation
1.	Total yield [t/ha]	15.0
2.	Ginned straw yield [t/ha]	12.0
3.	Seed yield [t/ha]	1.5
4.	Total fiber content in ginned straw yield [%]	35.0
5.	Long fiber content in ginned straw yield [%]	15.0
6.	Short fiber content in ginned straw yield [%]	20.0
7.	Yield of total fiber [t/ha]	4.20
8.	Yield of long fiber [t/ha]	1.80
9.	Yield of short fiber [t/ha]	2.40

Source: results of the Institute of Natural Fibers, Poznan, Poland (experimental farm LENKON, Steszew)

III.2.1.5. Fibrous hemp yielding potential in Ukraine

Table 19. The potential yielding of fibrous hemp in Ukraine

	Specification	The best results in breeding and pot or field trials
1.	Total yield [t/ha]	15.0
2.	Ginned straw yield [t/ha]	12.0
3.	Seed yield [t/ ha]	0.20
4.	Total fiber content in ginned straw yield [%]	33.0
5.	Yield of total fiber [t/ ha]	3.0

Source: Institute of Bast Crops, Lenina 45, 245130 Glukhov, Sumy, Ukraine, Tel.: /Fax: 3805444 22643, E-mail: ibc@sm.ukrtel.net

III.2.2. The commercial, practical yielding of fibrous hemp in Europe

In-depth examples

Table 20. Commercial yields of fibrous hemp in France

	Specification	Average
1	Total yield [t/ha]	
2	Ginned straw yield [t/ha]	7.5
3	Seed yield [t/ha]	0.9
4	Total fiber content in ginned straw yield [%]	37.0
5	Long fiber content in ginned straw yield [%]	
6	Short fiber content in ginned straw yield [%]	
7	Yield of total fiber [t/ha]	2.7
8	Yield of long fiber [t/ha]	
9	Yield of short fiber [t/ha]	

Source : Mr. Sylvestre Bertucelli, Director, Federation Nationale des Producteurs de Chanvre, 20, rue Paul Ligneul, 72000 Le Mans, France, Tel: : + 33/2 43 51 15 00, Fax: +33/2 43 51 15 09, E-mail: s.bertucelli@fnpc.org

III. 2.2.1 Commercial, practical yielding of fibrous hemp Poland

Table 21. Commercial yields of fibrous hemp in Poland

	Specification	**Years**							
		2002	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**Average**
1.	Total straw yield [t /ha]	6.7	8.6	8.5	8.0	7.5	7.0	8.1	7.77
2.	Ginned straw yield [t/ha]	5.4	6.9	6.8	6.4	6.0	5.6	6.5	6.23
3.	Seed yield [t/ha]	0.7	0.9	0.8	0.8	0.10	0.7	0.8	0.814
4.	Total fiber content in ginned straw yield [%]	30.0	34.0	32.0	33.0	34.0	35.0	33.0	33.0
5.	Long fiber content in ginned straw yield [%]	10.0	8.0	9.0	10.0	10.0	9.0	10.0	9.43
	Short fiber content in ginned straw yield [%]	20.0	26.0	23.0	23.0	24.0	26.0	23.0	23.57
	Yield of total fiber [t/ha]	1.620	2. 346	2.176	2.112	2.040	1.960	2.145	2.057
	Yield of long fiber [t/ha]	0.540	0.552	0.612	0.640	0.600	0.504	0.650	0.585
	Yield of short fiber [t/ha]	1.080	1.794	1.564	1.472	1.440	1.456	1.495	1.472
	Cultivation area of fibrous hemp In Poland [ha]	83*	101*	909*	214*	1007*	1376*	1 791.58*	615

Source: LENKON- Experimental farm of the Institute of Natural Fibers, Steszew, Poland
*Ministry of Agriculture and Rural Development

The results in the above table derive from industrial plantations.

Table 22. Comparison between the potential yields and commercial yields of hemp in Poland

Specification	**Average potential yields of hemp**	**Average practical yields of hemp**	**Practical yields versus potential yields of fibrous hemp [%]**
Total yield of straw [t/ha]	14.73	8.42	57.0
Ginned straw yield [t/ha]	13.538	6.50	48.0
Seed yield [t/ha]	1.138	0.814	72.0
Total fiber content [%]	35.00	33.0	94.0
Yield of total fiber [t/ha]	3.595	1.867	52.0

Table 23. Commercial yields of fibrous hemp in Hungary

	Specification	
		Average
1.	Total straw yield [t /ha]	8.6
2.	Ginned straw yield [t/ha]	
3.	Seed yield [t/ha]	0.7-0.9
4.	Total fibre content in ginned straw yield [%]	27.0-30.0
5.	Long fibre content in ginned straw yield [%]	15.0-17.0
6.	Short fibre content in ginned straw yield [%]	12.0-13.0
7.	Yield of total fibre [t/ha]	3.00
8.	Yield of long fibre [t/ha]	2.8
9.	Yield of short fibre [t/ha]	0.9
10.	Cultivation area of fibrous hemp In Poland [ha]	615

The results in the above table derive from industrial plantations. Source: results partly from of the Institute of Kompolti Research Institute, partly from Tessedik Sámuel College Agricultural Water and Environmental Management research farm.

*p. 2-9-calculated data

Table 24. Commercial yields of fiber hemp in Romania

	Specification	Years							
		2002	2003	2004	2005	2006	2007	2008	Average
1.	Total yield [t/ha]	5.3	2.7	1.6	2.2	1.2	4.7	5.0	3.24
2.	Ginned straw yield [t/ha]	4.8	2.4	1.4	2.0	1.1	4.2	4.5	2.92
3.	Seed yield [t/ha]	0.5	0.5	0.4	0.5	0.5	0.6	0.5	0.5
4.	Total fiber content in ginned straw yield [%]	33.0	33.0	34.0	32.0	35.0	35.0	33.0	33.57
5.	Long fiber content in ginned straw yield [%]	13.0	9.0	8.0	12.0	12.0	10.0	10.0	10.57
6.	Short fiber content in ginned straw yield [%]	20.0	24.0	26.0	20.0	23.0	25.0	23.0	23.00
7.	Yield of total fiber [t/ha]	1.574	0.802	0.490	0.634	0.378	1.481	1.485	0.98
8.	Yield of long fiber [t/ha]	0.620	0.219	0.115	0.238	0.130	0.423	0.450	0.31
9.	Yield of short fiber [t/ha]	0.954	0.583	0.374	0.396	0.248	1.058	1.035	0.66

Source: Ms. Ina Miu, Ministry of Agriculture in Romania - “Bast Plants Department”.
E-mail: ina.miu@madr.ro.

III. 2.2.2. Commercial, practical yielding of fibrous hemp Ukraine

Table 25. Commercial yields of fibrous hemp in Ukraine

	Specification	**Years**							
		2002	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**Average**
1.	Total yield [t/ha]	2.38	2.25	2.23	1.75	3.00	1.38	n/a	2.16*
2.	Ginned straw yield [t/ha]	1.90	1.80	1.78	1.40	2.40	1.10	n/a	1.70
3.	Seed yield [t/ ha]	0.20	0.15	0.12	0.38	0.37	0.24	n/a	0.24
4.	Total fiber content in ginned straw yield [%]	27.0	27.0	28.0	27.0	27.0	28.0	n/a	27.0
5.	Yield of total fiber [t/ha]	0.466	0.439	0.412	0.340	0.570	0.270	n/a	0.417
6.	Hemp cultivated area [ha]	1 910	820	1 510	1 940	2 490	760	910	1 391

Source: Institute of Bast Crops, Glukhov, Sumy, Ukraine, Tel.: /Fax: 3805444 22643, E-mail: ibc@sm.ukrtel.net, *calculated data

Hemp discussion

Hemp was a commonly grown, wide spread crop in the 1930s and 1940s. After World War II, however, the cultivation in many countries (USA, West Europe – except France) has been forbidden and stopped due to problem with narcotic properties (THC). Hemp was mainly used for production of technical textiles: twine, ropes, tarpaulin, non-wovens, plumber fiber, sacks, etc. The most intensive cultivation of hemp in Eastern Europe took place in turn of 1950s and 1960s. In the following years, hemp fiber utilization was decreasing in favour of first, cheaper tropical fibers (jute, coir, etc.) and then synthetic fibers. In most East European countries the turn of 1980s and 1990s was the time of considerable and sudden decline in hemp cultivation due to the economical changes in those countries. In early 1990s more attention was paid in Europe to non-food crops and renewable resources and as a consequence ban for hemp cultivation was lifted.

Recently the role of industrial hemp is growing due to many reasons such as developed techniques and technologies of the textile application of hemp fiber, high biomass production – potential even up to 28 tones from 1 ha. There is a growing interest of hemp application in e.g. modern composites, which are applied in such industries as transportation, building and also as by-product for agro-fine chemicals (with a very high added value).

Today the area of hemp cultivation in Europe totals for ca 12 768 ha in 2008. This makes hemp relatively marginal crop in Europe and although research on utilization of hemp for many industrial application is carried out in different research centres in the EU, the agronomic studies are very limited. This has a consequence in relative scarcity of available data in this field, both scientific and statistical. For instance EUROSTAT reports only three parameters for hemp: area of cultivation, straw production and straw yields.

The data from experiments shown above indicate that hemp has the significant yielding potential. The yields of ginned straw from experiments vary from ca 10 to almost 18 t/ha, and average at ca 13.5 t/ha. A comparison to commercial yields (6.5-7.7 t/ha on average) reveals that in practice only about 50% of plant potential is explored. This ratio is pushed even much further down when compared to data found in literature (34%). The trial results reported in the literature reach even much higher hemp (straw) yield figures – up to 22.5 t/ ha of dry matter (P.C. Struik et al. 2000). Some unpublished data reach even 25 and more t/ha.

Recently, the research at the INF and other centres has concentrated at intensive genetic and breeding work to obtain new hemp cultivars with qualities tailored to non-textile applications. With special focus on renewable energy and biomass suitable for pulp and paper industry. With this regard the work of INF is concentrated on obtaining high yields of air-dry mass (over 20 t/ha) and reduction of hallucinogenic compounds (THC) to trace amounts.

The actually utilized fibrous hemp varieties in France have 0.0 Δ 9 THC content e.g. Santhica 27, Santhica 70, while tests proved in USO 31: 0.005 % Δ 9 THC [Mr. Sylvestre Bertucelli, Director, Federation Nationale des Producteurs de Chanvre, 20, rue Paul Ligneul, 72000 Le Mans, France, tel: : + 33/2 43 51 15 00, fax: +33/2 43 51 15 09, E-mail: s.bertucelli@fnpc.org]

Parallel work is continued on increasing fiber content which is important when hemp is used for production of different types of insulation mats and composites. High content of cellulose in industrial hemp biomass (ca 50%) and in different by-products and waste material from hemp processing is a very good raw material for second generation alcohol.
Additionally, role of hemp is growing in soil environment improvement by transferring nutrients from deeper layers of the soil and extraction of heavy metals. Another important feature is collecting CO_2 from air (10 tones of dry mass of hemp is able to extract 2.5 tons of CO_2) [Institute of Natural Fibers & Medicinal Plants].

The similar pattern can be found when seed yields are concerned. The experimental and commercial data show that they can vary from 0.88 to 1.5 t/ ha and from 0.1 to 0.9 t/ha, respectively (on average about 1.2 versus a 0.8 t/ha). This indicates that seed plant potential is explored at the level of about 67%.

The explanation of potential vs. commercial yield discrepancies is not simple and involves numerous factors including genetic, environmental and agronomic ones.

Hemp in terms of cultivated cultivars is represented by very diverse material. It involves dioecious and monoecious cultivars and cultivars belonging to different geographical types which reflect hemp susceptibility to photoperiod which especially has significant consequence for yield. There are three geographical types of hemp distinguished: northern hemp, middle European hemp (intermediate hemp) and southern hemp. The northern hemp is characterized by a short growing period (60-75 days), high yields of seeds and low yields of poor quality fiber (and straw). The southern hemp gives high yields of vegetative biomass, including good quality fiber and low yields of seeds; they also have a long growing period – over 150 days. The group of intermediate hemp is characterized by factors between these values. This way, cultivars with genetic predominance of southern type yield low seed and high straw. The differences are even bigger if such cultivars are grown further north of their origin area. Therefore, generalization on yield potential must be considered in connection with genetic potential of particular cultivar and location of cultivation.

Considering seed yields the above mentioned dependencies apply even stronger. Although offering high yield of straw and fiber, southern hemp produces very little or no seed as it requires much longer vegetation period to reach full maturity.

There is another aspect of seed yield potential in hemp. It fact hemp breeding has always been focused on the fiber. Hence, no truly seed forms, neither cultivars are selected. Therefore, certainly it is possible to improve hemp potential in this field by breeding.

Improvement in exploitation of hemp potential in terms of genetic resources lies in very well adaptation of cultivated crop to particular region of cultivation especially in seed production (cultivar regionalization). Alternatively selection of cultivars that offer the best straw potential in particular region and could include southern cultivars grown in northern countries. However, having in mind problems with seed production in southern hemp, the economical conditions, including seed supply from countries where sowing seed production is possible, should be very carefully investigated.

When investigating genetic factors that have influence on hemp yield, the fiber content is as important as potential yield of straw as it is the fiber that is the product hemp is usually grown for. Therefore, to improve the use of hemp yield potential both maximum yield of straw and maximum content of fiber should be taken into account in breeding process.

Among environmental factors limiting exploitation of hemp yield potential is water and soil, especially when considered jointly. Hemp water requirements are quite high. Although deep and well developed root system allows hemp to use water from soil levels unavailable to many other crops, for instance flax, insufficient water supply especially in connection with poorer soils results in significant yield reduction.

To minimize the effect of unfavourable environmental factors on hemp yield the actions should concentrate on agronomic solutions: optimum sowing time (to use water accumulated after winter), optimization of plant density depending on direction of cultivation (seed, fiber, and biomass), application of water saving tillage treatments, treatments reducing evapotranspiration. Naturally, one should not forget the genetic improvement of the cultivars by developing cultivars with better drought tolerance.

Among agronomic factors, besides those mentioned for minimizing the effect of unfavourable environmental, one more should be mentioned, especially in connection with seed production.

Construction of more efficient machinery is necessary to minimize losses of seed during harvest. However, seed loss in hemp is not only connected with agronomic or environmental factors. Also genetics of hemp takes responsibility for this problem. Hemp seed matures gradually in course of maturity advancement and shed when mature. By the time the seed in upper part of panicle is mature, this in the bottom part is lost. In practice farmer must compromise trying to harvest seeds when seeds are maturing in middle part of the panicle and is never able to harvest 100% of the seed yield.

In practical farm operation all these factors having limiting effect on potential of hemp are usually amplified by economics of production connected with a human factor. Farmer, trying to reduce his costs is usually not able to provide crop management at the level used for experiments.

Finally, with a scarcity of agronomic research on hemp, a grate part of our knowledge about hemp yields is missing or based on the old cultivars, that were grown in Europe twenty and more years ago. It is though advisable to set a pan European network of experiments with a reference list of cultivars that would clearly and univocally answered his problem.

III.3. The yielding of cotton in Europe

Cultivation area of cotton

The world area under cotton fluctuates between 30 and 36 million ha. In the season 2007/2008 the cotton cultivation area in the world decreased to 33.363 million ha. The main global reason for this reduction of area was severe competition with food/fodder as well as corn, soybean, cereals used for energy.

The production of cotton lint (fiber) in the world in this season totalled 26 247 000 tons.

The average yield of cotton lint in 2007/2008 in the world was observed 787 kg/ha.

The estimated data regarding the season 2008/2009: 31 167 775 ha of cultivated area, production of cotton lint: 24 143 000 tons and the average yield: 775 kg/ha of cotton lint.

It means a slight decrease of the estimated world cotton area, production and yield. Source: International Cotton Advisory Committee (ICAC) – January 2009 (data collected by Andrzej Drozdz, Gdynia Cotton Association, Derdowskiego 7, 81-963 Gdynia, Poland, tel.: +48 (58) 620 75 77, www.cotton.org.pl)

Main cotton producers in the world: Australia, China, India, Pakistan, USA, Uzbekistan.

Main cotton producers in Europe. Turkey and Greece

Table 26: Cotton lint (fiber) production. Main actors in the world.

Country	Annual production (average 1999-2006) million tones	Global share [%]
China	4.5	22.6
USA	4.0	20.1
Pakistan	2.6	13.1
India	1.8	9.0
Uzbekistan	1.1	5.5
CFA-Zone Africa	0.9	4.5
European Union	0.5	2.5
Total represented	15.4	77.4
World total	19.9	100.0

Source: USDA, DG AGRI-EU and Dr Fotios Xanthopoulos, Director, National Agricultural Research Foundation, Cotton and Industrial Plants Institute, 574 00 SINDOS-THESSALONIKI, Greece, TEL: +30 2310 /79 65 12 &799 444, FAX: +30 2310 79 6513, e-mail: cottonin@otenet.gr

Table 27. Cotton cultivation area, production and yield of cotton lint in Europe and in the world

	Season*	**2004/2005**	**2005/2006**	**2006/2007**	**2007/2008**	**2008/2009** Estimated
TURKEY	Area [000 ha]	698	600	630	520	385
	Yield [kg/ha]	1 289	1 333	1 190	1 298	1 299
	Production [000 t]	900	810	750	675	505
GREECE	Area [000 ha]	375	363	300	300	250
	Yield [kg/ha]	1 040	1 185	1 067	950	900
	Production [000 t]	390	430	320	285	225
SPAIN	Area [000 ha]	90	86	62	60	50
	Yield [kg/ha]	1 219	1 279	726	683	450
	Production [000 t]	110	110	45	41	23
BULGARIA	Area [000 ha]	9	4	4	3	3
	Yield [kg/ha]	257	250	250	250	250
	Production [000 t]	2,4	1	1	0,9	0,9
WORLD	Area [000 ha]	35 790	34 328	34 760	33 363	31 167
	Yield [kg/ha]	755	744	766	787	775
	Production [000 t]	27 011	25 525	26 636	26 247	24 143

**Note: The cotton season: from 1st August to 31st July of the next year. The data on yield and production concern cotton lint.*

Source: International Cotton Advisory Committee (ICAC) – January 2009 (data collected by Andrzej Drozdz, Gdynia Cotton Association, Derdowskiego 7, 81-963 Gdynia, Poland, tel.: +48 (58) 620 75 77, www.cotton.org.pl)

Table 28. Cotton fiber (lint) production in Europe [1000 t]

Country	2008	2007	2006	2005	2004	2003	2002	2001	2000
Bulgaria	n/a	0.8	1.1	1.3	2.6	4.2	10.0	10.1	7.2
Greece	n/a	241.0	284.8	352.0	331.0	311.0	362.0	400.0	395.0
Spain	41.2	39.9	47.8	113.4	115.1	96.5	101.8	104.0	96.1
Turkey	2073.0	868.0	2550.0	2240.0	2455.1	900.5	988.1	922.0	879.9

Source: Eurostat

n/a- not available

Table 29. Cotton cultivation in Greece [ha]

Central Greece	Thessaly	145,000
	Macedonia	101,000
North Greece	Thrace	45,000
South Greece	Sterea Ellada	85,000
West Greece	Epirus	4,000
Total Greece		380,000

Source: USDA, DG AGRI-EU and Dr Fotios Xanthopoulos, Director, National Agricultural Research Foundation, Cotton and Industrial Plants Institute, 574 00 SINDOS-THESSALONIKI, Greece, tel.: +30 2310 /79 65 12 &799 444, fax: +30 2310 79 6513, e-mail: cottonin@otenet.gr

Table 30. Cotton lint (cotton fiber) yields [100 kg/ha]

Country	2008	2007	2006	2005	2004	2003	2002	2001	2000
Bulgaria	n/a	9.9	10.4	11.5	11.5	13.2	15.9	6.9	7.4
Greece	n/a	7.0	7.5	9.7	9.0	8.5	10.0	10.5	9.8
Spain	7.8	6.3	7.6	13.2	12.9	10.2	11.8	11.4	10.5
Turkey	n/a	n/a	43.2	41.0	38.4	n/a	n/a	13.3	13.5

Source: EUROSTAT

n/a- not available in EUROSTAT

The situation of cotton cultivation, yielding and production of cotton in Europe in the season 2007/2008:

1. area of cotton in Europe 883,000 ha:

Turkey 520,000 ha, Greece 300,000 ha, Spain 60,000 ha, Bulgaria 3,000 ha (ICAC, Jan.2009)

2. The production of cotton lint in Europe 1 001 900 tones:

Turkey 675,000 tons, Greece 285,000 tons, Spain 41,000 tons, Bulgaria 900 tons (ICAC, Jan.2009)

3. The yield of cotton **lint** in Europe 2007/2008 – average 795 kg/ha:

Turkey 1,298 kg/ha, Greece 950 kg/ha, Spain 683 kg/ha, Bulgaria 250 kg/ha (ICAC, Jan.2009)

<u>The **cotton (seedcotton)** yielding in Europe:</u>

Bulgaria has lower yields in cotton, but Turkey and Spain more or less - about 3,500 kg/ha seedcotton and about 1,155 kg/ha of cotton lint/fiber. *

The situation of cotton in Greece:

During 2008 the cotton acreage was about 380,000 ha. For the present year 2009 it is expected about 260,000 to 270,000 ha. *

The mean yielding ability of cultivated varieties in Greece is 3,500 kg/ha of seedcotton while the maximum yielding ability can reach to 5,500 kg/ha. *

The yield of cotton fiber: as the mean yield of cotton (seedcotton) in Greece is about 3,500 kg/ha and the fiber percentage is about 33%, so the yield in cotton fibers is about 1,155 kg/ha*.

The maximum yielding ability in cotton lint/fibers in Greece is about 1,815 kg/ha*

[Source*:* *Dr Fotios Xanthopoulos, Director, National Agricultural Research Foundation, Cotton and Industrial Plants Institute, 574 00 Sindos-Thessaloniki, Greece, Tel.: +30 2310 /79 65 12 &799 444, Fax: +30 2310 79 6513, E-mail: cottonin@otenet.gr]

Summary regarding the cotton yielding situation in Europe:

The yields of cotton lint/fiber of conventional cotton varieties are about 20-25 % lower that those which are genetically modified (GM/ biotech), because GM varieties are protected e.g. against diseases, drought and insects.

The potential yield of cotton lint/fiber differ significantly from commercial yields.

As an example from Europe, in Greece the mean commercial yield of cotton lint (fibers) is about 1,155 kg/ha, while the maximum yielding ability in cotton lint/fibers in Greece is about 1,815 kg/ha [Cotton and Industrial Plants Institute, Sindos-Thessaloniki, Greece].

The average yield of cotton lint (fiber) in Europe 2007/2008 – 795 kg/ha, while in the world 787 kg/ha. The potential yielding of cotton lint in the world e.g. in USA (Texas) 1,600-1,700 kg, in California up to 1,800 kg/ha. [Gdynia Cotton Association, Poland]. In Australia the yields of cotton lint reach 1,929 kg/ha (perhaps sometimes max a bit more than 2,000 kg/ha), because here the weather is beneficial for cultivation of cotton, additionally plantations are equipped in watering systems, assisted by computer management and the agro-technical practices, harvesting and processing are appropriate [ICAC "Cotton this month", 2.01.2009].

The cotton yielding in Europe decreased significantly since 2006, when the European Commission changed the rules of subsidies, provided to farmers. The new rules has taken into consideration more acreage than the production. The farmers (especially in Spain) has withdrawn from the intensive/costly methods of cultivation. The decreased has been noticed as well in the tendency to increase the level of production (which appeared by 2006).

Note: Differences in statistical data: it is important to underline, that statistical data provided for the same parameters of cotton cultivation, and production differ, according to the source (EUROSTAT, ICAC, the cotton institution in e.g. Greece). All the data have been cited in this report to turn attention to the fact of existing such diversified sources of information.

COTTON IN USA

Perspectives for cotton in the USA. The September World Production Report from the USDA (United States Department of Agriculture) stated there was a reduction estimate of 1.8 million tons from 2007/2008 cotton crop to the 2008/2009 crop. This is mainly due to the decline in U.S. acreage, with largest fall (around 1.2 million tons), followed by China (with expected 0.4 million ton reduction) [Cotton International Magazine, Sept. 2008]. Since 2004 the harvested cotton area in the U.S. has dropped from 12.943 million acres to an expected 8.192 million in 2008. As agricultural priorities continue to shift towards higher-profit crops in the face of increased ethanol and food stock requirements, the United States is poised to be overtaken as one of the world's cotton superpowers. The huge price level surges occur in response to new players entering the market and demand for "priority crops" like corn, wheat and soybeans. [Cotton International Magazine, Nov.2008].
In the U.S. about 50 % of cultivated cotton varieties are GM.

GM COTTON

The estimation of International Cotton Advisory Committee (ICAC) regarding the production of GM cotton in the world.

The International Cotton Advisory Committee (ICAC) estimates that 51% of world cotton production in 2007/08 was from biotech varieties planted on 44% of the world area. This 44% of the total area refers to the legally grown biotech cotton in most countries, but unofficial reports from a number of countries suggest that biotech cotton is grown illegally on a much larger area. Based on the official numbers, ICAC also estimates that 48% of the cotton traded internationally in 2007/08 will be biotech cotton produced in nine countries. The commercially approved biotech cottons are BXN™, Roundup Ready®, Roundup Ready® Flex, LibertyLink®, Bollgard®, Bollgard® II, WideStrike™, Guokang, Roundup Ready® + Bollgard®, Roundup Ready® Flex + Bollgard® II, Event 1, WideStrike™ + Roundup Ready®, WideStrike™ + Roundup

Ready® Flex and LibertyLink® + Bollgard® II. Each type of biotech cotton is approved in a limited number of countries. However, all biotech cottons, except Guokang and Event 1, are approved in the United States. In general, insect-resistant biotech cotton is approved in more countries than herbicide-resistant biotech cotton. The production of cotton became cheaper and more green due to the decreased amount of applied plant protection chemicals.

Herbicide- resistant biotech varieties are grown on the greater part of the biotech cotton area in the United States. Biotech varieties were grown on 93% of the total cotton area in the United States in 2007/08 and it is estimated that, of that 93%, only 1-2% was planted to straight insect-resistant varieties. All the rest was planted to herbicide-resistant varieties, either alone or in combination with the insect- resistant gene. It is estimated that in 2007/08 approximately 1.5 million hectares in the United States were planted to Bollgard® II, which was almost double the area planted to it in 2006/07. Monsanto estimates that Bollgard® II will account for almost two million hectares in 2008/09, and 80% of that will be Bollgard® II stacked with Roundup Ready® Flex. The area planted to Bollgard varieties is decreasing, but the Cry 1Ac gene will still be around in the form of Bollgard®II. [THE ICAC RECORDER, Technical Information Section, VOL. XXVI No. 2 JUNE 2008]

The estimation by ICAC, that 51 % of world cotton production in 2007/08 was from biotech varieties (GM) planted on 44% of the world area is from May 2008, but there is an opinion, that the real part of GM cotton in the world production is more significant, because the data about GM cotton in China seem to be declared lower in comparison with the real situation (licenses for new varieties). [Andrzej Drozdz, Gdynia Cotton Association, Derdowskiego 7, 81-963 Gdynia, Poland, tel.: +48 (58) 620 75 77, www.cotton.org.pl]