THE INFLUENCE OF NUTRIENT SUPPLY AND PLANT DENSITY ON THE YIELD OF FIBRE HEMP

ILDIKÓ IVÁNYI-ZOLTÁN IZSÁKI
Tessedik Sámuel College, Faculty of Agricultural Water and Environmental Management, Szarvas, Hungary, H-5541 P.O.B. 3.

1. INTRODUCTION

In the developed countries, e.g. US, UK and Netherlands and Germany national rural community development programs have been started, reviving and for increasing their sustainability in recent years. (BAGBY 1988, WERF 1991, RIDDLESTONE-DESAI 1994, BÓCSA-KARUS 1997).

In these countries among others, the feasibility of reviving the cultivation and processing of fibre crops (kenaf, fibre hemp, flax) was investigated as a sustainable industry for the bioregion. The possibility of producing textiles and paper mats for thermal insulanon, press-melded intenor panels for the automobile industry and other products from these crops were examined based on sustainable land use, utilising modern intermediate scale technology for their processing.

Research institutes across continental Europe are studying hemp. Research has produced a plant with a low narcotic content which caused the revival of hemp growing since 1993. Reviving the cultivation of fibre hemp may be a start of a success story in these countries.

Hemp production in Hungary has high quality, internationally recognized traditions. Hungary has high yield, high quality, low THC content-hemp varieties. Hemp production and processing boomed before 1989, but is at a low today. Lack of capital and long overdue technicaimp- orvements are facing the Hungarian hemp industry.

The establishment of the necessary industrial background, this plant can become a viable and stable crop for Hungarian agriculture. It is not hreatened by overproduction as crops in the food industry, it is profitable, and satisfies the requirements of sustainable agricultural production.

Publications before 1990 on hemp in Hungary mainly cover the varieties, breeding, biological, ecological and general cultural practices of the hemp crop (BÓCSA 1967, 1968/a, 1968/b, 1969, 1970, BÓCSA-HORKAY 1977, BÓCSA-MANNINGER 1981, MÁNDY-BÓCSA 1962, 1965, HORKAY 1977, 1978, 1979, 1980, 1982, 1986, HORKAY-BÓCSA 1978, JAKOBEY 1953/a, 1953/b, 1965). The literature in fertilization was very limited (CSÓKÁS 1914, BEKE 1962, JAKOBEY 1970, RUZSÁNYI 1967, 1970, GYÖRGY 1989).

Among the plant nutrients the nitrogen plays the main role in the formation of hemp yield. VAN DER WERF et. al (1995/a, b) reported the inter-plant competition which may cause self-thinning and it reduces stem yield and quality. More self-thinning took place at 200 kg than 80 kgNha^{-1}, and 50 cm row width then 12,5 and 25 cm. In Netherlands the stem yield was maximum at 90 plants m^{-2}. The stem yield was 10,4 tha^{-1} at 80 kgNha-1 and 11,3 tha^{-1} at 200 kgNha^{-1}.

The data on exact fertilization trials which would take into consideration the soil type, fertility status and the crop rotation are needed to form a fertilization advicery system of fibre hemp.

One of the important goals of agrochemical research for plant analysis purposes is to examine the optimal nutrient supply limits, nutrient ratios of crops, and interactions between different nutrients in the different developmental phases of the plant. (MOLLER - NIELSEN, 1976, FRIIS - NIELSEN 1976, SUMNER 1977, DEBRECZENI 1979, ELEK - KADAR 1980, KADAR et al.1981, IZSAKI 1988).

Results of these studies will enable the practical applictaion of plant analysis, described by BERGMANN - NEUBERT /1976/, BUZAS /1987/ , KADAR /1987/ and IZSAKI /1988/ as the following:
- diagnosis of nutrient deficiency and surplus
- analysis of plant's nutrient supply and nutrient content in order to achive high yield and good quality
- confirmation of soil analysis
- control of fertilisation practice, fertilisation advising
- yield and quality forecast
- analysis of developmental problems

The wide applicability of plant analysis methods is clear, but based on the limitations of its interpretation and employment, it cannot substitute soil analysis. In the fertilisation recommendation system the results of soil and plant analysis should be built. /AMBERGER 1980, KADAR 1980, SARKADI 1981, BERINGER 1985/..

From 1989 the goal of our research were to determine:
- the dry matter accumulation of fibre hemp on different nutrient supplies of the soil,
- the change of nutrient concentration and rates of 9 elements in the plant during the growing season,
- the nutrient accumulation of fibre hemp,
- the optimum time of diagnostic plant analysis of fibre hemp,
- nutrient supply limit values for diagnostic plant analysis for fibre hemp,
- the specific nutrient uptake of 1t of good quality fibre hemp yield,
- the effect of nutrient supply on the quantity and quality of the yield,
- the influence of nutrient supply on self-thinning of fibre hemp.
- the influence of decreased plant density on the yield.

2. MATERIALS AND METHODS

Fibre hemp fertilization experiment was undertaken in the south-east part of Hungary from 1990 to 1993 and 1996- 1999. Sojabean and broad bean were grown prior to the hemp every year.

We applied four levels of N, P, K fertilizers in total combinations (4x4x4=64) to determine the stem yield, we selected eleven treatments to examine the development of the dry matter accumulation, nutrient content and nutrient accumulation of fibre hemp during the growing season. From P and K treatments the P_1, K_1 aimed at the maintenance of sufficient nutrient supply level in the soil, whereas the P_2, P_3 and K_2, K_3 aimed at the development of the different nutrient supply level (Table 1.).

The total area of the basic plots was 20 m^2, in split-spit plots design and with three replicates.

Kompolti fibre hemp variety was planted in the first week of April. The seeding rate was 90 $kgha^{-1}$ in 1990-1993 and 1996, 90 $kgha^{-1}$ and 45 $kgha^{-1}$ in 1997 and 45 $kgha^{-1}$ in 1999 with a row space of 12 cm. Total above-ground plant organ samples were taken every second week, six times during the growing season.

The samples contained the above ground plant organ of 2x1 m rows by plots (and did not contain the, fallen leaves). We measured the green matter, dry matter and determined nine mineral elements from samples.

In 1999, we took leaf samples on 30th of May for determine nutrient supply limit value of fibre hemp for diagnostic plant analysis. In this time the hemp was 70-80 cm tall and has 5-6 couple total formed leaves.

At harvesting time we measured the stem yield weight of every 192 netto plots (15,75 m^2 area/plot), technical height and straw diameter of 100 plants by plots.

The soil was chernozem meadow which was calcareous in the depth and it had adequate N, P, K supply (Table 2.).

From 1990 to 1993, in three of the four years the annual precipitation was less than the average of the previous 75 years. In 1993, three was a drought because the accumulated deficiency of precipitation including the three previous years, was about 400 mm. From 1996, years the precipitation was average or more than the previous years.

We did not use chemical protection excepct for against Psylloides attenuate at emergence time, and we did not need to use any other cultivation.

The data of the test were evaluated by analysis of variance according to SVÁB (1981) methods.

Table 1. The applied treatments and their influence on the nutrient supplies of the soil (1989-1995, Szarvas)

Treatments of "A" factor	N, $kgha^{-1}$		NO_3-N, $kgha^{-1}$ in 0-60 cm soil						
	Yearly	Cumulative 1990-1993	1989	1990	1991	1992	1995	1996	1998
N_0	N_0	0	72	57	50	70	68	25	12
N_1	N_{80}	320	72	84	74	102	95	34	20
N_2	N_{160}	640	72	110	71	125	146	36	24
N_3	N_{240}	960	72	144	79	119	208	35	25
$LSD_{5\%}$			-	26	-	41	31	-	-

Treat- 1992 factors	P_2O_5, kgha^{-1}			AL-P_2O_5, mgkg-1 in 0-40 cm soil*						
	Shared	Cumulative		1989	1990	1991	1992	1995	1996	1998
		1989-1992	1989-1994							
P_0	P_0	0	0	132	111	113	107	125	133	126
P_1	P_{100}/year	400	600	132	110	112	120	137	159	154
P_2	P_{500}/4 years	500	1000	132	168	143	151	195	192	170
P_3	P_{1000}/4 years	1000	2000	132	233	206	210	287	233	225
$LSD_{5\%}$				-	47	40	42	59	-	-

Treat-ments of "C" factors	K_2O, kgha^{-1}			AL-K_2O, mgkg^{-1} in 0-40 cm soil						
	Shared	Cumulative		1989	1990	1991	1992	1995	1996	1998
		1989-1992	1989-1994							
K_0	K_0	0	0	296	280	281	268	246	254	272
K_1	K_{300}/year, from autumn 1993 100 kg/year	1200	1400	296	317	333	307	356	359	370
K_2	K_{600}/4 year	600	1200	296	360	353	289	406	408	402
K_3	N_{1200}/4 year	1200	2400	296	388	391	318	466	436	442
$LSD_{5\%}$				-	56	49	35	67	-	-

* 0-40 cm = average of 0-20 cm and 20-40 cm

Table 2. Examined characteristics of soil before the trial
Szarvas, 1989 autumn

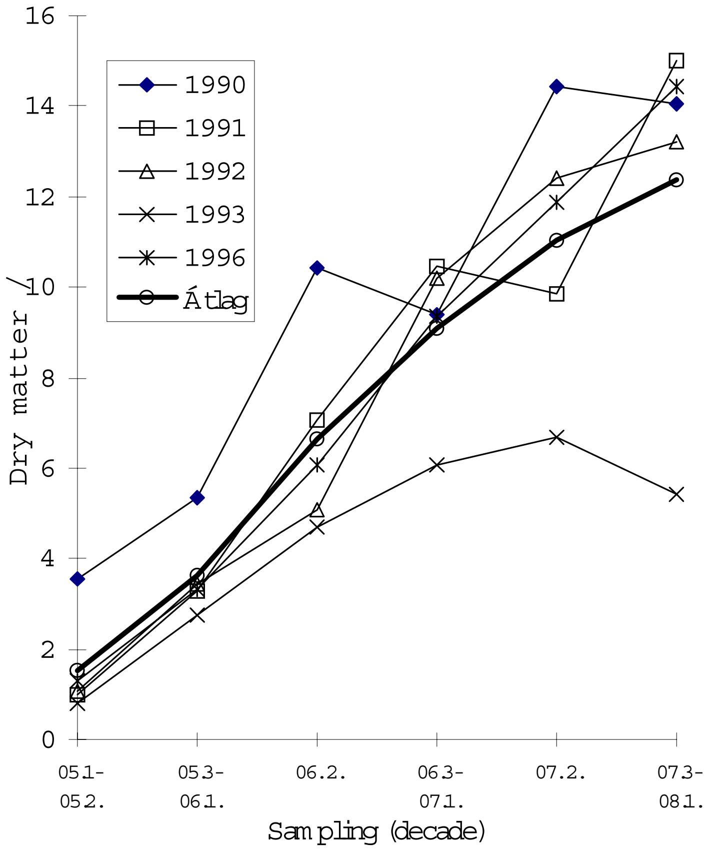
Soil Levels Cm	pH (KCl)	Upper limit of plasticity according to Arany	$CaCO_3$ %	Total salt %	NO_3+NO_2	AL-P_2O_5	AL-K_2O
					mg/kg		
0 – 20	5,2	50	0,0	0,03	13,7	156	322
20 – 40	5,2	48	0,0	0,03	9,6	109	270
40 – 60	6,0	48	0,1	0,05	4,8	57	234

3. RESULTS AND DISCUSSION

3.1. Dry matter accumulation

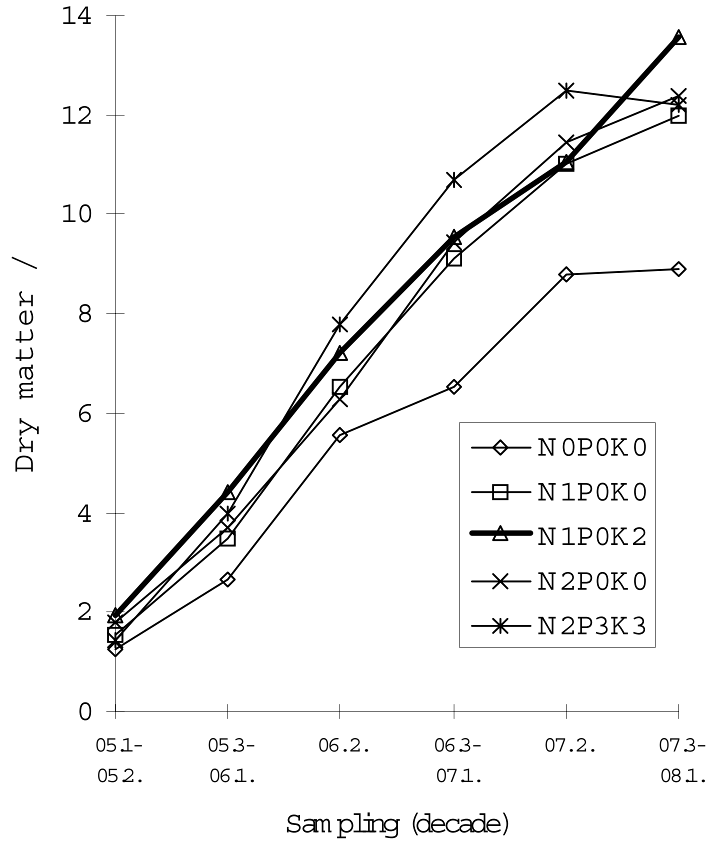
The dry matter yield was 11,92 tha^{-1} in 1991-1993 on average in spite of the precipitation deficiency (402 mm) during the experiment. It was 15,01 tha^{-1} in good precipitation supply year (1991) and 5,44 tha^{-1} in drought year (1993). It was 14,22 tha^{-1} in 1996. The intensive dry matter accumulation began from beginning of June. In 1992 and 1996 the accumulation curves were continued and in 1993 it was condescending. (Figure 1.)

Figure 1. Dry matter accumulation of fibre hemp
(1990-1993, 1996, Szarvas)



The typical accumulation curve has two peaks which happened in the two better years 1990, 1991. This was mentioned by BREDEMANN (1945), in MÁNDY-BÓCSA (1962), too. This is in connection with the female plants' energetic development during and after male plants' flowering.

Figure 2. Influence of nutrient supply on dry matter accumulation
(1990-1993, Szarvas)

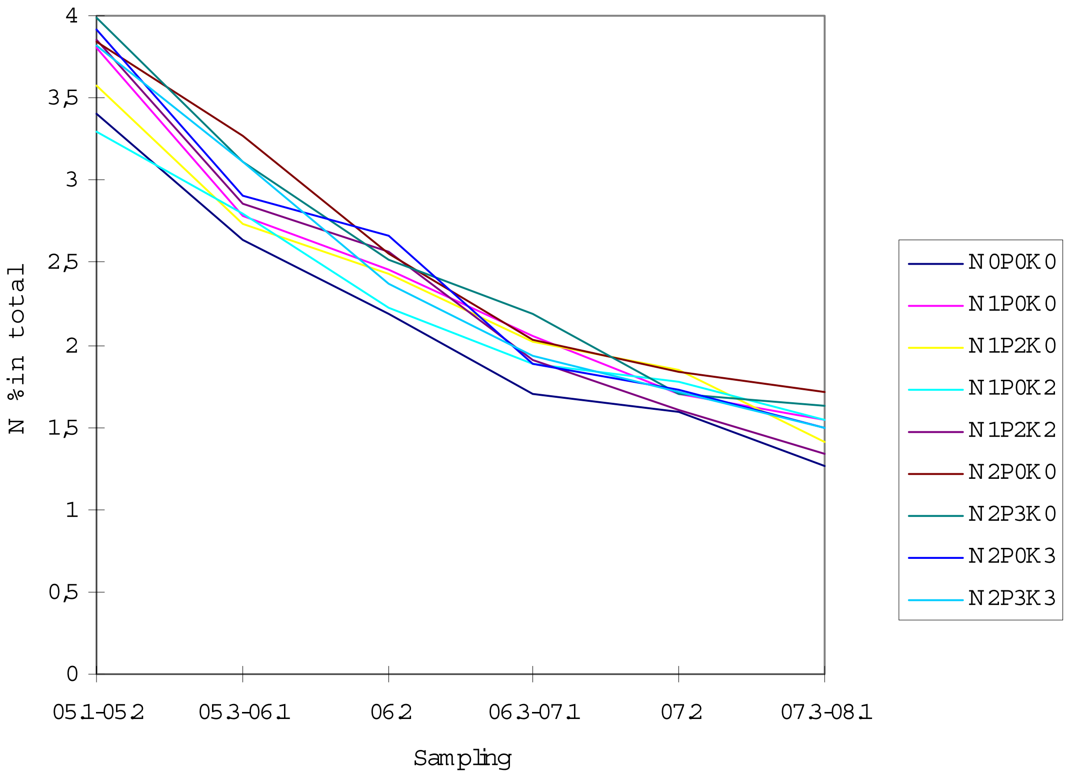


The N fertilization and its every P and K combination increased the dry matter yield of the hemp on chernozem meadow soil which had medium humus and P-, and high K content. The best result was given by $N_1P_0K_2$ treatment (N_1= 80 kgNha^{-1}; P_0= 110-130 ppm AL-P_2O_5 and K_2= 360 AL-K_20 level in the soil).

3.2. Changes of nutrient concentrations of fibre hemp

The best time to sampling of hemp for plant analysis is the end of May , becouse in this time the differences in nutrient supply are already expressed in the nutrien concentration and it is before the intensive dry matter accumulation.(Figure 3.)

Figure 3. The change of N content of fibre hemp



(1990-1993, Szarvas)

3.3. Nutrient accumulation

The intensive nutrient uptake of fibre hemp occur before the middle of June. Eighty-ninety percent of the total N, 70 % of the total P, 86 % of total K, 100 % of total Ca and 95 % of total Mg accumulated by the middle of June (Figure 4.).

To form high quantity (in the average of 4 experiment year 13,57 tha^{-1}) and good quality stem yield needed maximum 215 $kgNha^{-1}$, 23 $kgPha^{-1}$ and 234 $kgKha^{-1}$ (Figure 5., 6., 7.)

Figure 4. The dry matter and macronutrients uptake of fibre hemp (1990-1993, Szarvas)

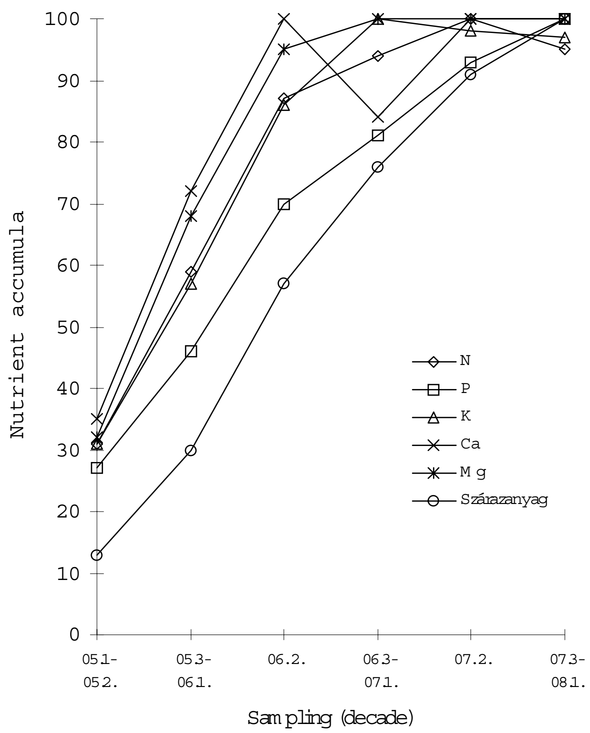
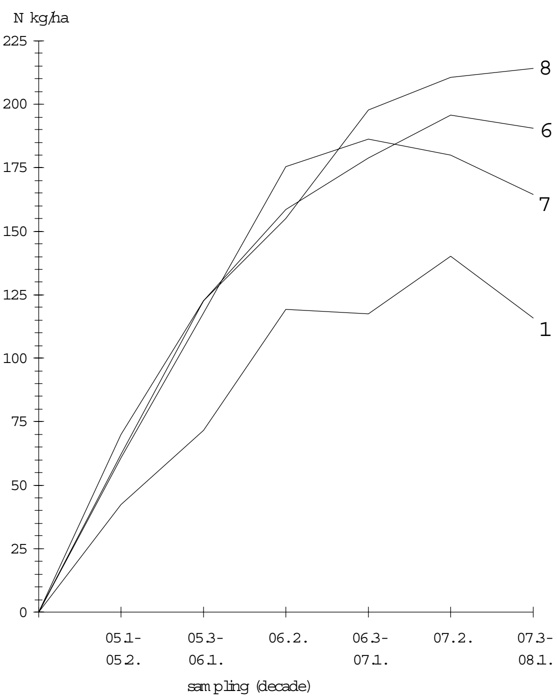
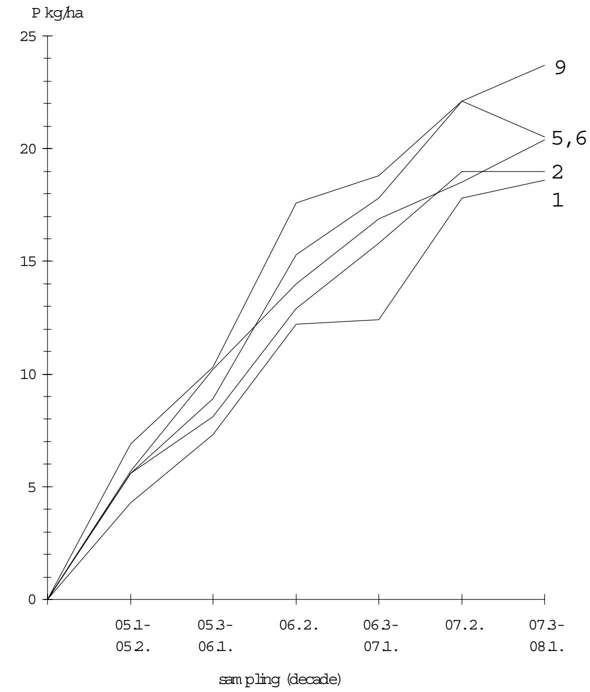


Figure 5. Influence of nutrients supply of N-uptake of fibre hemp (1991-1993, Szarvas)



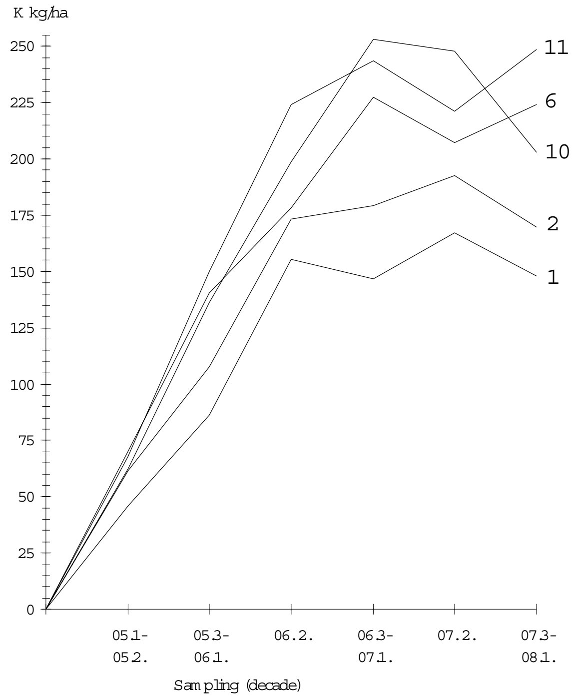
1: $N_0P_0K_0$ 6: $N_1P_0K_2$ 7: $N_1P_2K_2$
8: $N_2P_0K_3$

Figure 6. Influence of nutrient supply on P-uptake of fibre hemp
(1991-1993, Szarvas)



$1:N_0P_0K_0$ $2:N_0P_2K_2$ $5:N_1P_2K_0$
$6:N_1P_0K_2$ $9:N_2P_3K_0$

Figure 7. Influence of nutrient supply on K-uptake of fibre hemp
(1991-1993, Szarvas)



$1:N_0P_0K_0$ $2:N_0P_2K_2$ $6:N_1P_0K_2$
$10:N_2P_0K_3$ $11:N_2P_3K_3$

3.4. The optimum time of the diagnostic plant analysis of fibre hemp

The optimum time of the diagnostic plant analysis of fibre hemp - on the bases of nutrient content, dry matter accumulation and nutrient uptake - is between in the end of May and the beginning of June, when the plants have 70-80 cm length and 4-5 tha^{-1} dry matter weight. The fibre hemp nutrient supply limit value in the 5-6 couple of leaves are in the Table 3.

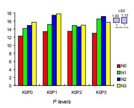
Table 3. The nutrient supply limit values of fibre hemp in the 5-6. leave couple (the just have finished their formation) (Szarvas, 1999)

Nutrient	Low	Optimum	High
N %	< 5	5 - 6	6 <
P %	< 0,5	0,50 - 0,60	0,6 <
K %	< 2,50	2,70 - 3,00	3,30 <
Ca %	< 2,40	2,40 - 3,00	3,20 <
Mg %	< 0,60	0,60 - 0,80	0,80 -
Fe mg/kg	< 65	65 – 105	105 <
Mn mg/kg	< 85	85 – 130	130 -
Zn mg/kg	< 25	25 – 40	40 -
Cu mg/kg	< 2	2 - 5	5 <

3.5. The influence of nutrient supply on stem yield.
3.5.1. The effects of N fertilization at different soil P levels

As shown in Figure 8., N fertilization resulted in significant stem yield increasing at all P levels of the soil as compared to the control.

Figure 8. The effect of N supply and P level of the soil on stem yield of fibre hemp (1990-1992, Szarvas)



P_2O_5 fertilization/4 years:

| 0 | 100/year | 500 | 1000 |

Average AL-P_2O_5 ppm:

| 110 | 120 | 150 | 230 |

At P_1 and P_3 level 80 $kgha^{-1}$ and 160 $kgha^{-1}$ of N caused significant increase in stem yield but a further increase in the amount of N had no significant effect (Figure 8. ,Table 4.).

Table 4. The influence of N, P, K supplies on the yield of fibre hemp (1999, Szarvas)

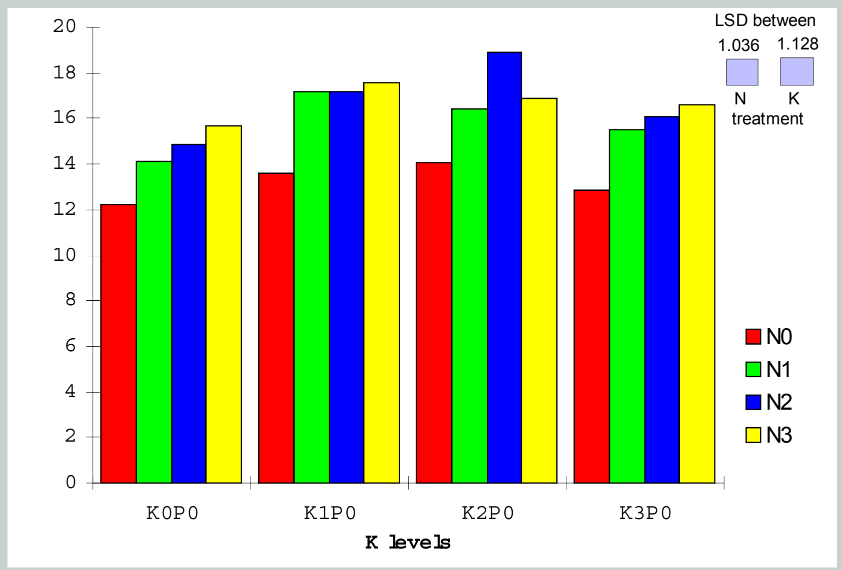
N-, P- supply	A_1 272 K_0	A_2 370 K_1	A_3 402 K_2	A_4 442 K_3	Average
P_0 = 126 mg/kg AL-P_2O_5					
N_0P_0	3,61	7,01	6,09	5,72	5,60
$N_{80}P_0$	9,49	12,44	7,06	6,25	8,81
$N_{160}P_0$	10,13	13,32	7,56	10,48	10,37
$N_{240}P_0$	12,77	13,48	8,60	9,97	11,20
Average	9,00	11,56	7,32	8,10	8,99
P_1 = 154 mg/kg AL-P_2O_5					
N_0P_1	10,80	7,62	5,70	8,88	8,25
$N_{80}P_1$	11,95	10,25	7,45	13,52	10,79
$N_{160}P_1$	12,22	14,91	13,81	14,84	13,94
$N_{240}P_1$	13,15	14,30	16,89	15,33	14,91
Average	12,03	11,77	10,96	13,14	11,97
P_2 = 170 mg/kg AL-P_2O_5					
N_0P_2	7,62	10,85	6,30	9,64	8,60
$N_{80}P_2$	8,04	11,07	7,94	14,25	10,32
$N_{160}P_2$	12,00	12,44	9,77	17,21	12,85
$N_{240}P_2$	16,83	16,83	17,10	17,05	16,90
Average	11,12	12,74	10,22	14,53	12,16
P_3 = 225 mg/kg AL-P_2O_5					
N_0P_3	10,96	8,05	8,93	9,64	9,39
$N_{80}P_3$	14,19	9,37	9,15	14,25	11,74
$N_{160}P_3$	14,04	10,85	9,15	16,21	12,56
$N_{240}P_3$	15,73	13,92	9,86	17,05	14,14
Average	13,73	10,54	9,27	14,28	11,95
In the average of P treatments					
N_0	8,24	8,38	6,75	8,47	7,96
N_{80}	10,91	10,78	7,90	12,06	10,41
N_{160}	12,09	12,88	10,07	14,68	12,43
N_{240}	14,62	14,58	13,11	14,85	14,29
Average	11,46	11,65	9,45	12,51	11,27

The P supply of the soil with no P fertilization of the experiment was between 110-130 ppm AL-P_2O5 . This P supply level is considered sufficient on chernozem meadow soil for the fibre hemp, because with the annual application of 100 $kgha^{-1}$ P_2O_5 (P_1) - preserving the supply level increased stem yield can be achieved. At higher P levels the stem yield did not increase significantly.

5.2. The effects of N fertilization at different soil K levels

K fertilization resulted in significant stem yield increase up to K_2 level, as shown in Figure 9 and Table 4..

Figure 9. The effect of N supply and K level of the soil on stem yield of fibre hemp (1990-1992, Szarvas)



K_2O fertilization/4 years:

0	300/year	600	1200

Average AL-K_2O ppm:

280	320	360	390

N fertilization resulted in a consistent increase in yield at all K levels compared to the control. The highest increase was found at K_1 and K_2 levels. The K supply of the soil (without K fertilization) was between 250-280 ppm AL-K_2O in the experimental years. This K supply level is considered medium on chernozem meadow soil for the fibre hemp, because with K fertilization on better (K_1-K_2) supply level (300-400) ppm AL-K_2O) a 1-3 tha^{-1} surplus can be achieved.

3.6. The specific nutrient uptake

The specific nutrient uptake of fibre hemp (18-19 tha^{-1} stem yield).

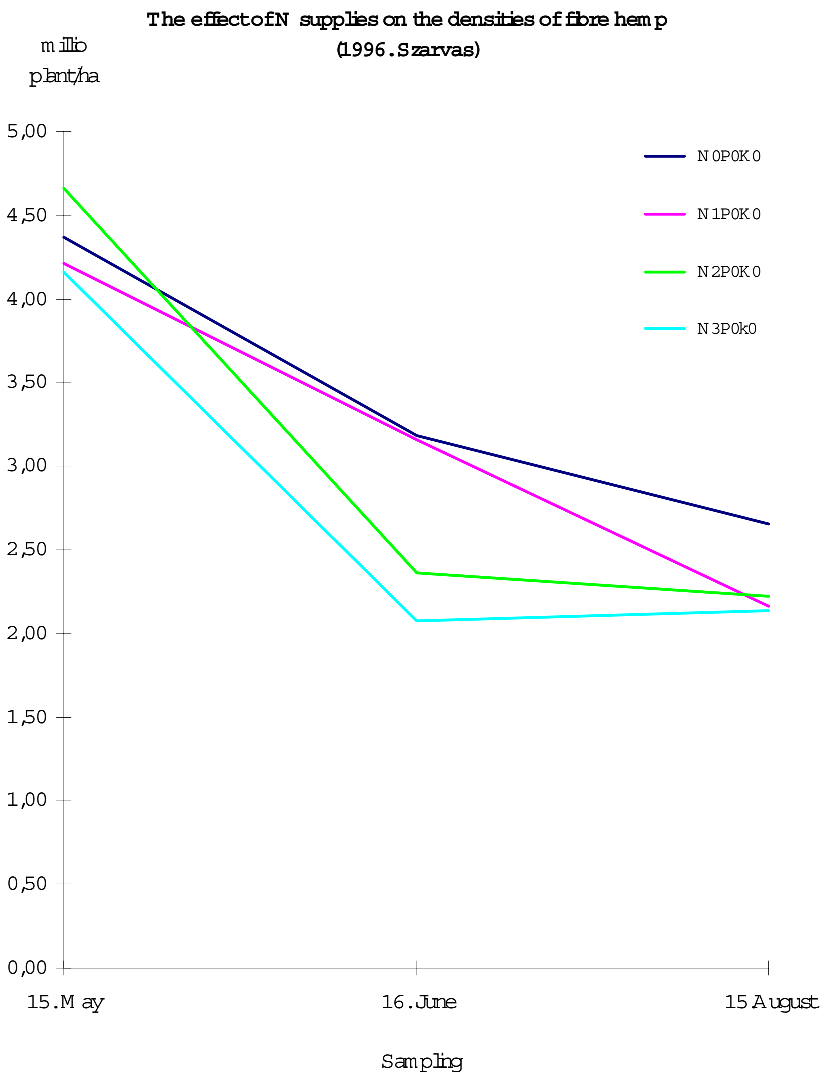
Specific nutrient uptake stem yield (+belong to leaves)								
kgt^{-1}					gt^{-1}			
N	P_2O_5	K_2O	CaO	MgO	Fe	Mn	Cu	Zn
10-14	3,3-3,9	14-20	14-16	5-6	150-170	43-48	2,8-3,6	12,16

The reporting of specific nutrient uptake of fibre hemp helps to state precisely on specific nutrient requirement of hemp.

3.7. The density of hemp

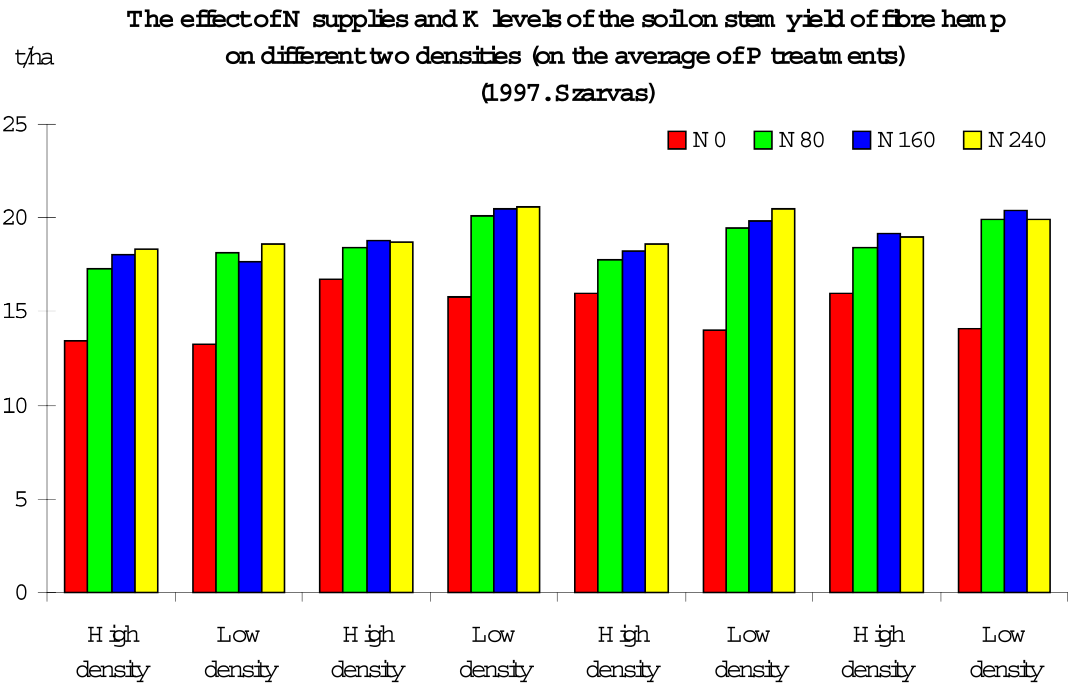
The N fertilization decreased the number of plants during the growing season. From 4,5 million planted germs ha^{-1} we harvested only 2,29 million plants ha^{-1}. More N caused more self thinning (Figure 10.).

Figure 10. The effect of N supplies on the densities of fibre hemp (1996, Szarvas)



With 2,2 million planted germs ha^{-1} resulted in the same - 50 % - self-thinning. The quantity and the quality of stem yield was higher at 2,2 than 4,5 million planted germs ha^{-1} (Figure 11, 12.).

Figure 11.

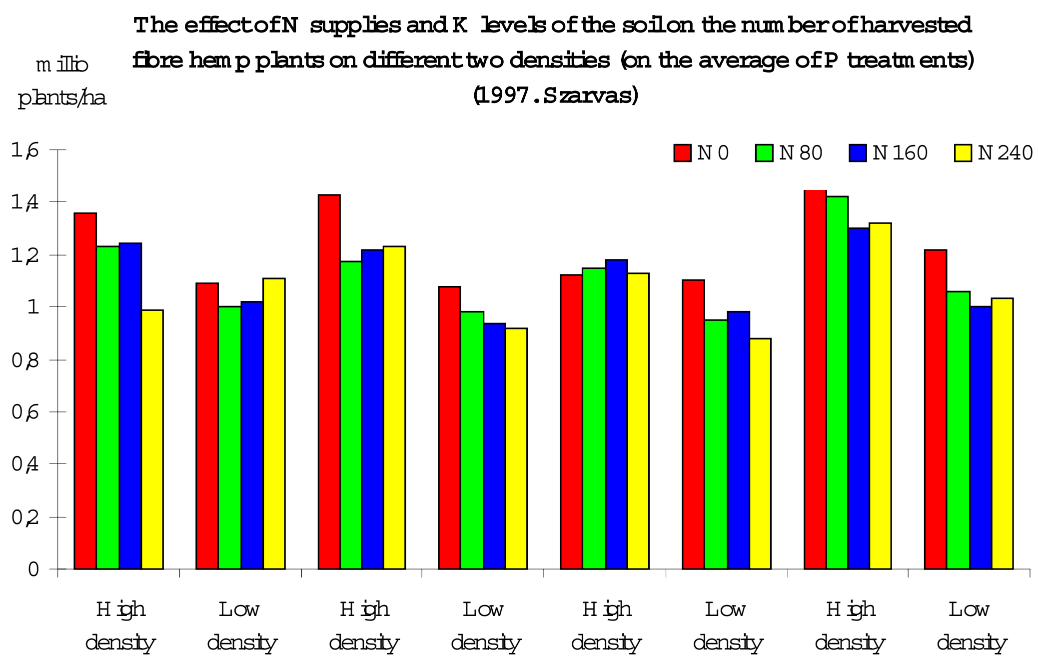


K0 K1 K2 K3

AL-K_2O ppm (0-40 cm) average:

254 359 408 436

Figure 12.



K0 K1 K2 K3

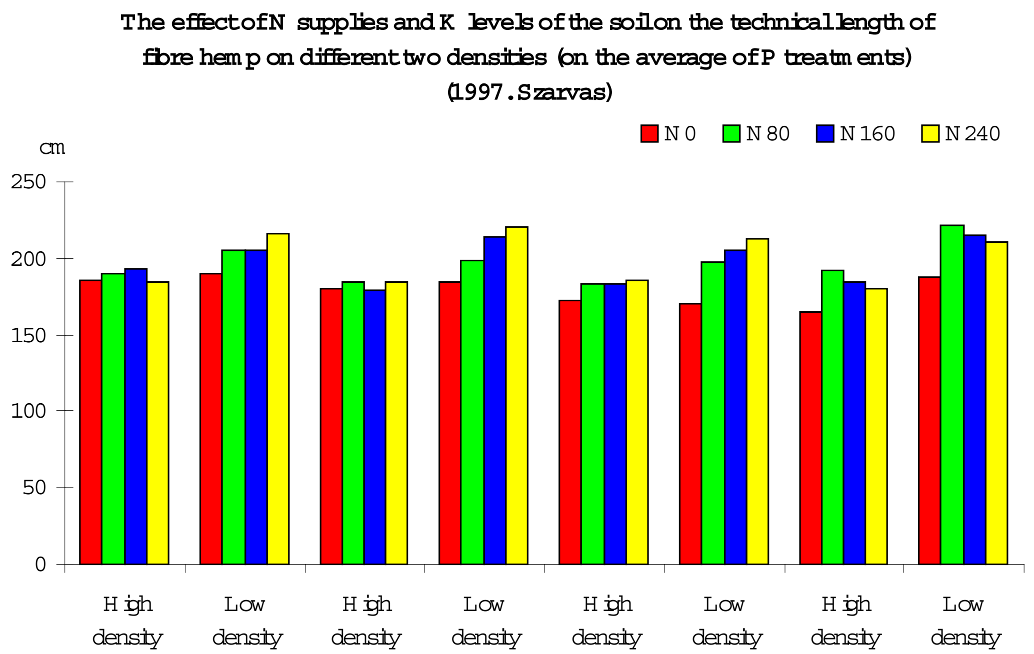
AL-K_2O ppm (0-40 cm) average:

254 359 408 436

High density:4.5 millio germs/ha

Low density:2.2 millio germs/ha

Figure 13.

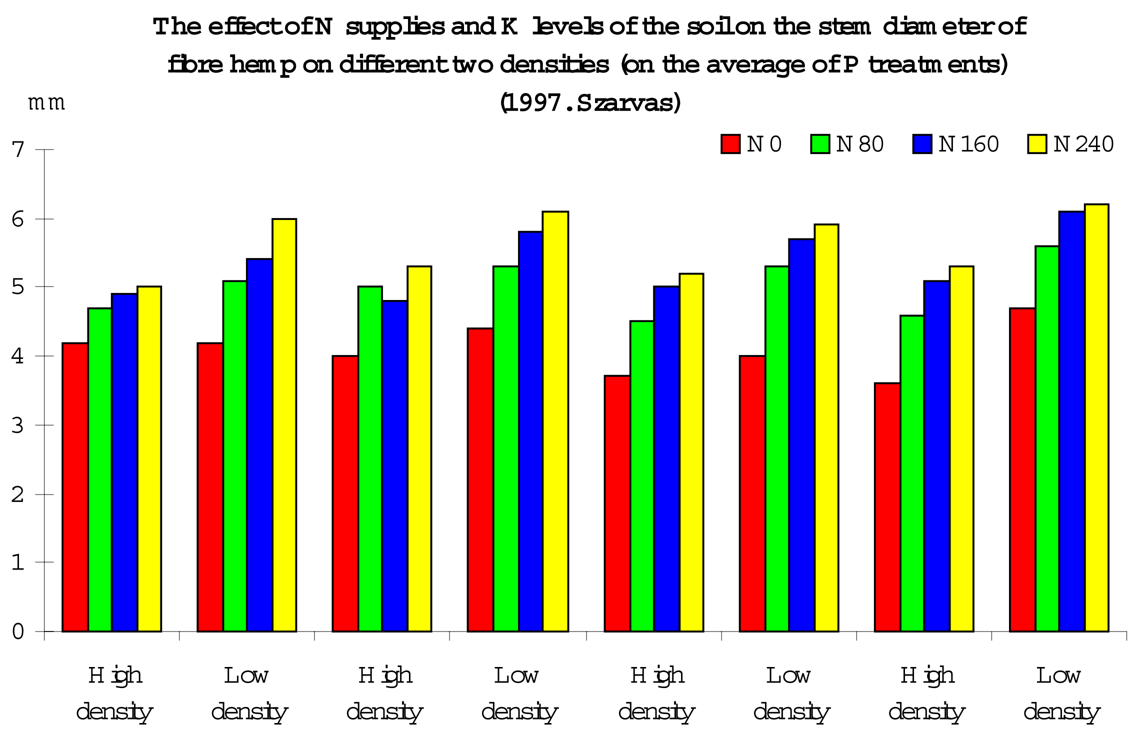


K0	K1	K2	K3

AL-K_2O ppm (0-40 cm) average:

254	359	408	436

Figure 14.



K0	K1	K2	K3

AL-K_2O ppm (0-40 cm) average:

254	359	408	436

High density:4.5 millio germs/ha
Low density:2.2 millio germs/ha

4. CONCLUSION

We have determined the otpimal plant analysis time for the Kompolt dioecious hemp variety. The otpimal time under circumstances in Hungary is the end of May. We have determined this time based on drymatter accumulation, nutrient concentration and nutrient uptake.

At this time the plant is about 70-80 cm tall and has about 5-6 pairs of completely developed leaves. We have provided the optimal concetration for nine nutrients in the stage of 5-6 pars of leaves.

We have determined the specific nutrient uptake of fibre hemp for nine nutrients. Under our circumstances for macronutrients these values are:10-14 kg N, 3,3-3,9 kg P_2O_5 and 14-20 kg K_20.

For good yield on chernosom meadow soil with medium humus content fibrehemp needs maximum 80- 160 $kgNha^{-1}$. Soil with 110 - 160 ppm AL-P_2O_5 and 300 - 400 ppm AL-K_20 content is sufficient, which can be maintained with a supply of 100 $kgha^{-1}$ P_2O_5 and 100-300 kgha-1 K_20.

For excellent quality hemp yield 2,5 million $germsha^{-1}$ is needed to plant. This also facilitates the hemp's weed-destruction ability.

5. REFERENCES

AMERGER, A.: 1980. Grenzen der Düngung für Ertrag und Qualitat. Die Dobenkultur, Wien. 31. 246-256.

BAGBY, M. O.: 1988. Kenaf Paper. A Forest-saving Alternative. Agricultural Research October: 6-8.

BEKE F.: 1962. A kender trágyázása. In: MÁNDI GY.-BÓCSA I.: A kender (Cannabis sativa L.). Magyarország kultúrflórája 14. Akadémiai Kiadó, Budapest.

BERGMANN, W.-NEUBERT, P.: 1976. Pflanzendiagnose und Pflanzenanalyse. VEB. Gustav
Fisher Verlag. Jena.

BERINGER, H.: 1985. Adequacy of soil testing for predicting fertilizer requirements. Plant and Soil, The Hague. 83. 21-37.

BÓCSA, I.: 1968/a. A kendernemesítés legújabb magyarországi eredményei. (Newresults of hemp breeding in Hungary.) Magyar Textiltechnika 20:75-78.

BÓCSA, I.: 1968/b. A kender rosttartalmának fokozására irányuló nemesítés magyarországi eredménye. (The results of hempbreeding on increasing of fibre contant in Hungary.) Rostnövények: 3-12.

BÓCSA, I.: 1969. A fajtajavító fenntartás elvi kérdései és korszerű módszerei a kendernél. (Matter of principles and modern methods of variety improvment maintenance on hemp.) Agrártudományi Közlemények 28:413-418.

BÓCSA, I.-E. HORKAY: 1977. A kenderrostra történő szelekció eredményei a Kompolti Kutató Intézetben. (The results of selection on hempfibre in Kompolt Research *Institute.) Len-Kenderipari Műszaki Tájékoztató XXV. 5:8-11.*

BÓCSA, I.-KARUS, M.: 1997. Der Hanfanbau Botanik, Sorten Anbau und Emte. Heidelber: Müller Verlag, Hüthig GmBH. 173.

BÓCSA I.-MANNINGER G.: 1981. A kender és a rostlen termesztése. Mezőgazdasági Kiadó, Budapest.(Production of fibre hemp and flax)

BREDEMANN, G.: 1945. Untersuchungen über die Nährstoffaufnahme und den Nährstoffbedarf des Hanfes. Bodenkunde u. Pflanzenernährung 36. Berlin. 167-204.

BUZÁS I.: 1987. Bevezetés a gyakorlati agrokémiába. Mezőgazdasági Kiadó, Budapest.(Introduction to practical agrochemistry)

CSÓKÁS GY.: 1914. A kender tápanyagfelvétele és ennek hatása a rost mennyiségére és *minőségére.(The nutrient uptake of fibre hemp and its effect on quantity and quality of* fibre). Kísérletügyi Közlemények. XVIII. 64-120.

DEBRECZENI B.: 1979. Kis agrokémiai útmutató. (Agrochemical handbook). *Mezőgazdasági Kiadó, Budapest.*

ELEK É.-KÁDÁR I.: 1980. Állókultúrák és szántóföldi növények mintavételi módszere. (Sampling methods of trees and arable crops) MÉM-NAK. Budapest, 52.

GYÖRGY A.: 1989. Műtrágyák hatása a rostkender termésére és a rostok minőségére. (The effect of fertilizers on quantity and quality of hemp). Doktori értekezés. Debrecen, 115 (Thesis , Debrecen, 115).

HORKAY E.: 1977. Örökölhetőségi vizsgálatok rosttartalomra és kórótermő képességre a Kompolti kendernél. (Investigations on the heredity of fibre content and dry stalk production in Kompolti hemp.) Növénytermelés. 26. 6:451-459.

HORKAY E.: 1979. Fenotípusos és genetikai korrelációk a Kompolti kendernél és *jelentőségük a nemesítésben. (Phenotypic and genetic correlations in the hemp variety* Kompolti and their significance in breeding.) Növénytermelés 28. 1:7-12.

HORKAY E.: 1980. A hím- és a nőkender rostminősége közötti különbség objektív értékelése. (Objectiv evaluation of differences in fibre quality between staminate and pistillate hemps.) Növénytermelés. 29. 1:21-24.

HORKAY E.: 1982. A rosttartalom növelésére irányuló szelekció hatása a kender primér és szekundér rostsejt-arányára. (Primary and secondary fibre-cell as affected by selection for increasing fibre content.) Növénytermelés 31. 4:297-301.

HORKAY E.: 1986. Az ön- és idegentermékenyülés részarányának megállapítása populációgenetikai módszerrel egylaki kenderállományban. (Establishing the share of self- and crossfertilization by means of population genetics in a monoecious hemp stand.) Növénytermelés 35. 3:177-182.

IZSAKI Z.: 1988. Összefüggés a cukorrépa tápláltsági állapota a termés mennyisége és *minősége között növényanalizis alapján. Kandidátusi értekezés.Szarvas.1-174.(* Relationship between nutrient supply and yield quantity and quality of sugarbeet).Thesis of PhD.

JAKOBEY I.: 1953/a. Háncsrosttartalmú növények objektív értékelése. (Objectiv-valuation of bast fibre content plants.) Növénytermelés. 2. (3):144-150.

JAKOBEY I.: 1953/b. A kenderkóró rosttartalmi értékének meghatározása oldalágai útján. (Statement of fibre contant value on hemp straw by collateral line.) Növénytermelés 2. (4):238-247.

JAKOBEY I.: 1965. Kísérletek finomrostú kender előállítására. (Experiments of Produce Hemp with Fine Fibres.) Növénytermelés, 14. 1:45-54.

JAKOBEY I.: 1970. A rostkender tápanyagfelvétele. (Nutrient uptake of the fibre hemp.) Rostnövények. 35-51.

KÁDÁR I.: 1980. A növényanalízis alkalmazása az agrokémiai szaktanácsadásban és kutatásban. Agrokémia és Talajtan. 29. 323-344.(Utilisation of plant analysis in agrochemical advisori and research).

KÁDÁR I. et al.: 1981. Diagnózis és Szaktanácsadás Egységes Rendszere (DRIS): új *értékelési lehetőség a növénytermesztésben. Agrokémia és Talajtan. 30. 465-486.(* The DRIS: new assesment possibility in crop production)

KÁDÁR I.: 1987. A növénymintavétel alapelvei és technikája. Növénytermelés. 36. 395-404.(Methods and thecnich of plant sampling)

KARUS M.: 1997. A kender Nyugat-Európában. Előnyben részesíthető kender termékvonalak. Nova Institut Hürth/köln. GATE "Fleischmann Rudolf" *Mezőgazdasági Kutató Intézet, Kompolt.(Hemp in West Europe : favoruable* products)

MÁNDY GY.-BÓCSA I.: 1962. A kender Cannabis sativa L. Magyarország kultúrflórája. VII. 14. Press, Akadémiai Kiadó, Budapest.(Hemp Cannabis sativa L. Cultural flora of Hungary)

MÁNDY GY.-BÓCSA I.: 1965. Adatok kenderfajtáink ökológiájához. (Details for ecology of hempvarieties.) Kísérleti Közlemények LVIII/A. Növénytemelés, 1:71-88.

MOLLER-NIELSEN, J.-FRISS-NIELSEN, B: 1976. Evaluation and controll of the nutritional status of cereals. I. dry matter weight level. II. Pore-effect of a nutrient. III. Metods of diagnosis and yield prognosis. Plant and Soil, The Hague. 45. 317-337, 339-350, 647-658.

RIDDLESTONE, E. and S. DESAI: 1994. Bioregional fibres the potential for a sustainable regional paper and textile industry based on flax and hemp. Bioregional Development Group. Sutton Ecology Centre, Honeyvood Walk, Carshalton, Surrey, UK.

RUZSÁNYI L.: 1970. Adatok a rostkender trágyázásához csernozjom talajon. (Details for fertilizer reaction of fibre hemp on chernozem soils.) Rostnövények. 53-61.

SUMNER, M.E.: 1977. Use of the DRIS system in foliar diagnosis of crops at high yield levels. Commun. Soil Sci. Plant anal. 8. 251-268.

VAN DER WERF, H.M.G.: 1991. Agronomy and crop physiology of fibre hemp - (literature wiew) CABO-DLO, Wageningen, The Netherlands.

VAN DER WERF, H.M.G.-VAN GEEL, W.C.A.-VAN GILS, L.J.C.-HAVERKORT, A.J.: 1995. Nitrogen fertilization and row width affect self-thinning and productivity of fibre hemp (Cannabis sativa L.). Field Crops Research. 42. 27-37.

VAN DER WERF, H.M.G.-WÍJLHUIZEN M., and DE SCHUTTER, J.A.A.: 1995. Plant density and self-thinning affect yield and quality of fibre hemp (Cannabis sativa L.). Field Crops Res., 40: 153-164.