INFLUENCE OF CULTIVATION CONDITIONS ON LUPIN SEEDS, TANNINS AND PHYTATE CONTENTS AS WELL AS MINERALS (CA, MG, FE, ZN, CU) BIOACCESSIBILITY

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ABSTRACT

Lupin (*Lupinus luteus*, Paris cultivar) was obtained from field experiments with different cultivation and fertilisation treatments in the years 2002-2004 and assessed for tannin and phytate content and mineral release.

The tannin content of lupin seeds was increased by the fertilisation treatments with the largest increase achieved with the double application of Mikrosol foliar fertiliser applied within a ploughed tillage system. The content of phytates in lupin seeds varied from year to year with the highest level recorded in 2003. Neither soil tillage nor fertilisation treatments exerted any statistically significant effect. The highest percentage of mineral release from lupin seeds subjected to enzymatic digestion was found for Copper and Magnesium, while the lowest percentage was found for Calcium. Bioaccessibility of minerals was independent of the soil tillage system utilised and it varied with the years.

Trial results indicate no statistically significant simple regression between the content of tannin or phytate and potential bioaccessibility of the elements studies.

KEY WORDS

yellow lupin, soil tillage systems, foliar fertilisation, elements, bioaccessibility, tannins, phytates

INTRODUCTION

Lupin seeds containing valuable nutritive components (protein, lipids, saccharides), as well as functional components (tocopherols, oligosaccharides, polyphenols, dietary fibre) are increasingly used in food production in many countries, including Europe.

Recent studies on the improvement of agrotechnical treatments for lupin cultivation have shown that the replacement of deep ploughing by a shallow superficial cultivation and limit of other treatments can give the same or better production and economic response (Faligowska, Szukała 2007). An important factor contributing to yield increase is the correct supply of nutritive components by the application of fertiliser to both soil and leaves (Prusiński and Borowska, 2002; Faligowska, Szukała, 2007).

Numerous transformations in living organisms take place in association with indispensable macro- and microelements. The contents of these components as well as of tannins and phytates, which theoretically may contribute to the availability and accessibility of bioelements, depend upon the type of raw material and on the conditions of obtaining it (Hunt, 2002).

The objective of the presented work was to estimate in yellow lupin Parys cultivar the change in content of tannins and phytates and the degree of release of Ca, Mg, Fe, Zn and Cu obtained from the implementation of different cultivation and fertilisation treatments in field experiments.

MATERIAL AND METHODS

LUPIN CULTIVATION

Yellow lupin was grown in a two-factorial field experiment at the Experimental Farm in Złotniki near Poznań, Poland in the years 2002-2004 (grey-brown podsolic soils, random sub-block design, four replications). Two soil tillage systems, ploughing and no-ploughing, were applied and six foliar fertiliser treatments of microelements were compared against the control. Three of the fertiliser treatments were applied before flowering and included, Ekolist Standard, Mikrosol U, and Wuxal Top N Universal. Three fertiliser treatments of Ekolist Standard, Mikrosol U and Wuxal Top N Universal were applied both before and after flowering.

DETERMINATION OF TANNINS CONTENT

Modified colorimetric vanillic method according to Swain, Hills (1959) was applied.

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DETERMINATION OF PHYTATES

Modified HPLC method according to Czarnecka *et al.* (2003) was applied according to Zawadzka and Wojciechowska-Mazurek (1984).

DETERMINATION OF CA, MG, ZN, CU AND FE RELEASE PERCENTAGE

Samples were subjected to enzymatic digestion *in vitro* (Bosscher *et al.* 2003), and then, Ca. Mg. Zn, Cu and Fe were determined by F/GF-AAS method

All analyses were carried out in three replications and the obtained results were statistically analysed using Statgrafics (Manugistic Inc. USA) computer program.

Table 1. Effect of soil tillage system on the content of tannins in seeds (mg/g).

Year	2002	2003	2004		2002	2003	2004	
Soil tillage system	Ploughing			a	No-ploughing			A
Control	0,028	0,028	0,029	a	0,029	0,029	0,030	A
Mikrosol 1x	0,076	0,078	0,075	d	0,079	0,047	0,051	B
Ekolist 1x	0,041	0,043	0,050	b	0,070	0,049	0,052	B
Wuxal 1x	0,032	0,037	0,041	ab	0,025	0,027	0,029	A
Mikrosol 2x	0,114	0,112	0,103	e	0,052	0,028	0,030	A
Ekolist 2x	0,052	0,053	0,062	c	0,098	0,078	0,077	C
Wuxal 2x	0,033	0,040	0,047	b	0,018	0,021	0,020	A
	a	a	a		a	a	a	

a, b, c – values marked with different letters show a significantly statistical difference at $p < 0,05$.

Table 2. Effect of lupin soil tillage system on the content of phytates in seeds (mg/100 g).

Phytate	IP5				IP6				Total			
Year	2002	2003	2004		2002	2003	2004		2002	2003	2004	
Soil tillage system	Ploughing			a	Ploughing			a	Ploughing			A
Control	0,841	0,882	0,627	a	15,398	11,895	11,374	a	16,579	12,833	12,034	A
Mikrosol 1x	1,176	0,919	0,576	a	8,978	12,685	10,344	a	10,229	13,657	10,950	A
Ekolist 1x	1,280	0,874	0,515	a	9,161	13,355	11,922	a	10,553	14,282	12,473	A
Wuxal 1x	1,210	0,879	0,698	a	8,677	13,540	11,705	a	9,960	14,473	12,445	A
Mikrosol 2x	1,226	1,038	0,697	a	9,628	13,312	12,257	a	11,087	14,405	12,986	a
Ekolist 2x	1,271	0,728	0,744	a	9,328	10,343	11,721	a	10,768	11,112	12,503	a
Wuxal 2x	0,943	0,718	0,627	a	6,822	10,388	11,814	a	7,843	11,143	12,470	a
	c	b	a		a	b	b		a	a	a	
	No-ploughing			a	No-ploughing			a	No-ploughing			a
Kontrola	0,694	1,553	0,647	a	6,432	14,344	11,109	a	7,224	16,086	11,794	a
Mikrosol 1x	0,977	1,416	0,564	a	8,621	14,587	10,441	a	9,685	16,163	11,041	a
Ekolist 1x	1,045	1,477	0,510	a	9,209	12,552	9,560	a	10,325	14,214	10,096	a
Wuxal 1x	1,004	1,444	0,547	a	8,972	13,301	9,689	a	10,057	14,923	10,264	a
Mikrosol 2x	1,191	1,118	0,441	a	9,808	11,499	8,632	a	11,085	12,907	9,096	a
Ekolist 2x	1,085	1,333	0,427	a	9,394	12,236	8,579	a	10,548	13,724	9,030	a
Wuxal 2x	0,833	1,328	0,402	a	7,360	13,011	6,921	a	8,276	14,482	7,342	a
	b	c	a		a	b	a		a	b	a	
	b	b	a		a	c	b		a	c	b	

a, b, c – values marked with different letters show a significantly statistical difference at $p < 0.05$.

Table 3. Effect of lupin soil tillage system on the percentage of element release.

Year	2002	2003	2004		2002	2003	2004		2002	2003	2004		2002	2003	2004		2002	2003	2004	
Soil tillage system	Ca Ploughing			a	Mg Ploughing			a	Zn Ploughing			a	Cu Ploughing			a	Fe Ploughing			b
Control	6,16	2,04	7,14	a	24,21	34,43	46,36	a	18,47	0,00	1,67	a	23,72	81,92	32,75	a	9,48	17,57	12,51	a
Mikrosol 1x	4,51	0,94	4,20	a	23,01	24,87	38,05	a	33,40	0,00	3,19	a	18,57	59,98	26,73	a	8,67	10,48	9,34	a
Ekolist 1x	8,66	3,70	7,22	a	22,24	29,02	46,85	a	9,23	11,89	-	a	19,16	76,78	24,32	a	7,44	7,81	10,24	a
Wuxal 1x	5,62	3,61	7,06	a	22,24	32,07	44,83	a	13,28	22,04	5,82	a	13,96	81,22	29,54	a	9,41	9,54	8,26	a
Mikrosol 2x	-	7,77	5,43	a	-	30,95	47,23	a	-	12,47	5,00	a	-	74,95	32,50	a	-	8,09	10,52	a
Ekolist 2x	0,88	9,71	2,62	a	15,22	40,09	36,78	a	14,42	13,86	3,71	a	10,62	87,12	24,61	a	7,80	7,14	8,23	a
Wuxal 2x	-	9,73	6,53	a	-	55,03	43,46	a	-	9,33	6,75	a	-	92,22	35,31	a	-	15,91	1,79	a
	a	b	b		a	b	c		c	b	a		a	c	b		a	a	a	
	Ca No-ploughing			a	Mg No-ploughing			a	Zn No-ploughing			a	Cu No-ploughing			a	Fe No-ploughing			
Control	6,05	5,22	6,14	a	17,81	18,75	45,78	a	18,96	9,31	21,26	a	14,47	62,08	33,3	a	6,11	9,03	0,08	a
Mikrosol 1x	-	4,69	15,64	a	-	18,93	52,60	a	-	2,15	14,13	a	-	62,78	33,71	a	-	2,01	2,16	a
Ekolist 1x	6,39	7,10	8,56	a	21,21	20,71	39,80	a	21,61	0	13,25	a	11,57	61,92	32,63	a	8,54	0	6,22	a
Wuxal 1x	-	2,34	8,69	a	-	22,64	48,20	a	-	2,96	7,14	a	-	77,11	22,08	a	-	2,22	6,34	a
Mikrosol 2x	-	3,77	8,00	a	-	23,85	44,96	a	-	1,22	17,01	a	-	72,46	26,75	a	-	0,71	5,83	a
Ekolist 2x	0,47	3,33	8,77	a	15,81	25,70	39,95	a	6,74	7,43	5,09	a	8,75	74,11	17,78	a	4,32	5,61	5,97	a
Wuxal 2x	4,38	8,26	6,73	a	18,91	48,66	53,97	a	10,11	0	5,16	a	13,43	0	23,33	a	6,63	0	10,67	a
	a	a	b		a	b	c		a	a	a		a	c	b		a	a	a	
	a	bc	c		a	b	c		a	a	a		b	b	a		a	a	a	

a, b, c – values marked with different letters show a significantly statistical difference at $p < 0.05$.

RESULTS AND DISCUSSION

Fertilisation generally increased the tannins content in yellow lupin seed as compared with the control with treatment responses similar in each of the three years studied (Table 1). The highest (4-fold) increase of tannins was shown following the double application of Mikrosol fertiliser. The resultant level of tannins was at least 2-fold higher for the ploughed soil tillage system as compared to the no-ploughed system. Within the no-ploughed system, the double application of Ekolist resulted in the highest (3-fold) increase in tannins as compared with the control. Statistical analysis of results indicated that a significant effect on the content of tannins was exerted by the weather conditions dominating in April. Both the amount of rainfall ($r = 0.25$; $p < 0.05$) and the mean temperature ($r = 0.39$; $p < 0.01$) correlated positively with the content of tannins (Table 4). The greatest amount of phytates was contained in lupin seeds originating from no- ploughing soil tillage system in 2003 (Table 2). The content of these components changed under the influence of the applied soil tillage systems and fertilisation, but the differences were not statistically significant. On the other hand, weather exerted a significant influence on phytates content (Table 4). Studies of Helsper *et al.* (2006) indicate that climatic and soil conditions may cause a significant change in phytates content in seeds of the same cultivar.

Weather conditions exert an influence not only on the morphological features of plants, but also on the physiological processes and generative features, like the number of pods and seeds and the seed mass from one plant. Therefore, it is obvious that climatic conditions may determine quantitative and qualitative changes in the lupin seed components.

The highest percentage of mineral release from lupin seeds subjected to enzymatic digestion was found for Cu and Mg, while the lowest was for Ca (Table 3). Bioaccessibility of minerals, like that for tannins and phytates, varied between the studies years. For Ca and Mg, bioaccessibility was the highest for 2004 and bioassessibilty for Cu was greatest in 2003. Fertilisation, independent treatment, did not change in a statistically significant way the percentage of the studied elements released from the lupin seed.

In conclusion, the obtained results do not indicate that there exist statistically significant simple regressions between the potential bioaccessibility of the studied elements (expressed by their release percentage) and the content of phytates and tannins in the lupin seeds of Parys cultivar when applied with different fertiliser treatments and tillage systems.

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