Chemical composition of winter oilseed rape seeds in relation to the influence of nitrogen fertilisation and cultivar

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Abstract

The experiment was carried out in order to investigate the effect of nitrogen fertilisation on content of crude fat, total protein and glucosinolates in seeds and fatty acid composition in oil of five cultivars of oilseed rape. The effect of spring nitrogen fertilisation on qualitative characters was similar in all cultivars cultivated in the experiment. Small but significant effect of nitrogen fertilisation on total glucosinolate content in seeds was observed. Nitrogen fertilisation did not influence significantly fatty acid composition in oil. Environment conditions and interaction of environment conditions with agronomy and cultivar factors had not significant effect on qualitative characters evaluated in the experiment.

Key words: winter oilseed rape, nitrogen application, cultivars, glucosinolates, fatty acids.

Introduction

Quality of seeds is determined by cultivar genotype, environmental conditions and agronomical practices. Among agronomical practices the highest effect on quality of winter oilseed rape seeds has mineral fertilisation. Fat and protein content in winter oilseed rape seeds is significantly modified by spring nitrogen fertilisation (Muśnicki et al. 1999). The effect of nitrogen fertilisation on glucosinolate content in winter oilseed rape seeds (Wójtowicz et al. 2002, Wielebski and Wójtowicz 2004) and fatty acid composition (Delhaye and Guyot 1969, Kotecki et al. 2001, Muśnicki et al. 1999) in general is not significant. Nevertheless Bilsborrow P. E. et al. (1995) proved significant increase in glucosinolate content and Jędrzejak et al. (2005) showed variability of fatty acid composition under the influence of nitrogen fertilisation. Effect of fertilisation on quality of seeds can depend on environmental conditions. Also cultivars can react differently to nitrogen fertilisation level (Grate and Schweiger 1991).

The experiment was carried out in order to investigate the effect of nitrogen fertilisation on quality of seeds of five cultivars of oilseed rape.

Material and Methods

The subjects of laboratory investigation were seeds from two-year experiment performed in 2004 and 2005 in Łagiewniki Experimental Station situated in Greater Poland region. The experiment was conducted in split-plot design in four replications. The effect of nitrogen fertilisation applied in the form of ammonium nitrate (60, 100, 140, 180, 220 kg N·ha^{-1}) to the content of crude fat, total protein and glucosinolates in seeds and fatty acid composition in oil of five cultivars of oilseed rape: Lisek - open pollinated variety, Mazur, Kaszub - composite hybrid varieties, BOH 3103, MR 153 – restored hybrid varieties, was investigated. Fat content was determined by Nuclear Magnetic Resonance. Protein content was estimated by Kjeldahl N determination x 6.25. Glucosinolate content and fatty acid composition was analysed using gas chromatography method.

Results and Discussion

Cultivars differed in crude fat and total protein content in seeds (Table 1). The smallest crude fat (44.4%) and total protein (18.0%) content were registered in seeds of cultivar Lisek. Seeds of Kaszub were characterised by the highest content of crude fat (46.0%). Cultivars did not differ in yield of fat and differences between protein yield were noticed only between restored hybrid cultivars.

Nitrogen fertilisation significantly influenced the content of crude fat and total protein in seeds. The increase of nitrogen dose from 60 to 220 kg·ha^{-1} caused the decrease of crude fat content from 46.0 to 44.2% and the increase of total protein from 18.4 to 20.1%. These results are consistent with previous work which demonstrated fat reduction and protein rise with an increase of nitrogen dose (Holmes and Ainsley 1978, Budzyński 1986, Wright et al. 1988, Taylor et al. 1991, Jasińska et al. 1993, Muśnicki et al. 1999, Wójtowicz et al. 2002).

The yield of fat and protein was dependent on nitrogen doses as well. The increase of fat yield was noticed up to the dose of 180 kg N·ha^{-1}, and protein yield up to the dose of 220 kg N·ha^{-1}.

The highest contents of total and alkenyl glucosinolate were registered in seeds of composite hybrid varieties: Kaszub and Mazur (16.4 and 14.6 µM·g^{-1} seeds) and the smallest restored hybrid varieties: BOH 3103 and MR 153 (10.8 and 9.0 µM·g^{-1} seeds) (Table 2). Lisek was characterised by the smallest content of indol glucosinolate in seeds (3.9 µM·g^{-1} seeds).

Nitrogen fertilisation had not significant effect on indol and alkenyl glucosinolate but influenced significantly total glucosinolate content in seeds. The increase of nitrogen dose from 60 to 220 kg·ha^{-1} caused glucosinolate content increase from 12.0 to 13.2 μM·g^{-1}. Bilsborrow P. E. et al. (1995) suggest that nitrogen access to biosynthesis of glucosinolates increase with the growth of nitrogen fertilisation level.

Table 1. Influence of spring nitrogen fertilisation on content and yield of fat and protein (average for 2 years)

Factor		Content (%)		Yield (dt·ha^{-1})	
		crude fat	total protein	crude fat	total protein
Cultivar	Lisek	44.4 a*	18.0 a	25.8 a	10.5 ab
	Mazur	45.0 ab	19.5 b	25.0 a	10.9 ab
	Kaszub	46.0 c	19.3 b	24.9 a	10.5 ab
	BOH 3103	45.7 bc	19.3 b	24.2 a	10.2 a
	MR 153	45.1 ab	19.5 b	25.3 a	11.0 b
$LSD_{0.05}$		0.78	0.61	ns**	0.73
Nitrogen dose (kg·ha^{-1})	60	46.0 c	18.4 a	23.7 a	9.5 a
	100	45.7 bc	18.6 a	24.7 ab	10.1 ab
	140	45.3 bc	19.0 ab	25.5 b	10.7 bc
	180	44.9 ab	19.6 bc	25.8 b	11.2 c
	220	44.2 a	20.1 c	25.4 b	11.5 c
$LSD_{0.05}$		0,95	0.91	1.68	1.07

*numbers in columns marked with the same letters did not differ significantly
**ns – no significant difference

Table 2. Influence of spring nitrogen fertilisation and cultivar on glucosinolate content in seeds (average for 2 years)

Factor		Indol glucosinolate content (μM·g^{-1} of seeds)	Alkenyl glucosinolate content (μM·g^{-1} of seeds)	Total glucosinolate content (μM·g^{-1} of seeds)
Cultivar	Lisek	3.9 a	7.7 c	11.6 c
	Mazur	4.6 b	10.0 d	14.6 d
	Kaszub	4.8 b	11.7 e	16.4 e
	BOH 3103	4.8 b	6.0 b	10.8 b
	MR 153	4.8 b	4.2 a	9.0 a
$LSD_{0.05}$		0.38	1.36	1.37
Nitrogen dose (kg·ha^{-1})	60	4.4	7.6	12.0 a
	100	4.6	7.5	12.1 ab
	140	4.4	7.7	12.1 ab
	180	4.6	8.3	13.0 ab
	220	4.8	8.4	13.2 b
$LSD_{0.05}$		ns	ns	1.12

Explanations below Table 1

Seeds of cultivars investigated in the experiment differed in fatty acid composition in oil (Table 3). Significant differences referred to the content of stearic, oleic, linolenic, eicosenic acid and PUFA (linoleic and linolenic). Nitrogen fertilisation had not significant effect on fatty acid composition in oil. Nevertheless small decrease of oleic acid and increase of PUFA was noticed when higher nitrogen doses (180 and 220 kg·ha^{-1}) were applied.

Table 3. Influence of spring nitrogen fertilisation and cultivar on fatty acid composition in winter oilseed rape oil (%) (average for 2 years)

$C_{16:0}$ – palmitic
$C_{18:0}$ – stearic
$C_{18:1}$ – oleic
$C_{18:2}$ – linoleic
$C_{18:3}$ – linolenic
$C_{20:1}$ – eicosenic
$C_{22:1}$ – erucic

Factor		Fatty acid composition (%)									
		$C_{16:0}$	$C_{18:0}$	$C_{18:1}$	$C_{18:2}$	$C_{18:3}$	$C_{20:1}$	$C_{22:1}$	$C_{18:1}+C_{18:2}+C_{18:3}$	$C_{18:2}+C_{18:3}$	$C_{18:2}/C_{18:3}$
Cultivar	Kaszub	4.69 a	1.74 a	61.36 abc	20.40 ab	10.02 b	1.54 ab	0.26 a	91.77 a	30.42 b	2.04 b
	Lisek	4.70 a	1.87 b	62.56 d	19.67 a	9.46 a	1.52 ab	0.26 a	91.68 a	29.12 a	2.08 c
	Mazur	4.65 a	1.73 a	60.89 ab	20.39 ab	10.25 b	1.72 b	0.37 a	91.52 a	30.63 bc	1.99 a
	BOH 3103	4.71 a	1.88 b	61.70 cd	20.47 b	9.68 a	1.42 a	0.14 a	91.84 a	30.14 b	2.11 d
	MR 153	4.67 a	1.73 a	60.55 a	21.38 c	9.98 b	1.48 a	0.22 a	91.91 a	31.36 c	2.14 e
$LSD_{0.05}$		ns	0.052	0.927	0.753	0.291	0.230	ns	ns	0.913	0.014
Nitrogen dose (kg·ha^{-1})	60	4.73 a	1.79 a	61.50 a	20.37 a	9.80 a	1.52 a	0.28 a	91.67 a	30.18 a	2.08 a
	100	4.69 a	1.80 a	61.59 a	20.27 a	9.86 a	1.51 a	0.30 a	91.72 a	30.13 a	2.06 a
	140	4.63 a	1.77 a	61.70 a	20.36 a	9.82 a	1.50 a	0.23 a	91.88 a	30.18 a	2.07 a
	180	4.69 a	1.80 a	61.20 a	20.67 a	9.96 a	1.54 a	0.17 a	91.83 a	30.63 a	2.08 a
	220	4.69 a	1.81 a	61.06 a	20.64 a	9.93 a	1.61 a	0.28 a	91.63 a	30.56 a	2.08 a
$LSD_{0.05}$		ns	ns	ns	ns	ns	ns	ns	ns	ns	ns

Explanations below Table 1However, Jędrzejak et al. (2005) on the basis of the experiment with spring rape, showed significant growth of palmitic, stearic, linoleic and linolenic acid and reduction of oleic acid under the influence of nitrogen fertilisation increase. This dependence likely resulted from nitrogen fertilisation effect on the rate of seed ripening.

Bartkowiak-Broda and Krzymański (1981) showed that during seed ripening palmitic, stearic, linoleic, linolenic acids decreased and intensive oleic acid accumulation took place.

Conclusions

The effect of spring nitrogen fertilisation on investigated quality features was similar in all cultivars evaluated in the experiment. The increase of nitrogen dose from 60 to 220 kg·ha^{-1} caused the decrease of crude fat content from 46.0 to 44.2% and the increase of total protein from 18.4 to 20.1% and glucosinolate from 12.0 to 13.2 μM·g^{-1}.

In investigated cultivars the increase of fat yield was noticed up to the dose of 180 N·ha^{-1}, and protein yield to the dose of 220 kg N·ha^{-1}.

The cultivars differed in crude fat and total protein content and fatty acid composition. Seeds of cultivar Kaszub were characterised by the highest content of fat and glucosinolate. The smallest content of fat, protein and indol glucosinolate were noticed in seeds of cultivar Lisek.

Small but significant differences referred to the ratio of linoleic to linolenic acid content, which ranged from 1.99 in cultivar Mazur to 2.14 in cultivar MR 153.

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