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Effect of Top-fertilizing of Raw Protein and Glucosinolates Content of Winter Turnip Rape

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Abstract. Rapeseed is a major oil–yielding crop, ranking third place after soybeans and oil palm in the world. Rapeseed contains as average 36–38% crude protein and content of anti–nutritional compounds, among which glucosinolates have received the major attention. The object of the present study was to evaluate the effect of the nitrogen rate and different application times to the crude protein and glucosinolate content of winter turnip rape. The trials were carried out at the Jõgeva Plant Breeding Institute in the 2007–08, 2008–09 and 2009–10 growing seasons. Ammonium sulfate (nitrogen content 21%, sulphur 24%) was used as top–fertilizer. Three different nitrogen rates, 120, 140 and 160 kg N ha^{-1} and three different application times were used: A) once at the beginning of spring growth (oilseed rape growing code 26), B) A + when the main stalk was 10 cm (code 33), C) B + start of flowering (code 60) (a total of nine different variants) in equal portions. The results indicate that the quantity of the fertilizer has not as strong an impact as application time on the glucosinolate content. The lowest glucosinolate content was obtained from the variant of one N application. The highest protein content was obtained from the variant of three times split-N.

Key words: glucosinolates, fertilizer, protein, winter turnip rape

INTRODUCTION

Rapeseed, which includes winter turnip rape (*Brassica rapa* L. *ssp. oleifera* (DC.) Metzg), is a major oil-yielding crop, ranking third after soybeans (*Glycine max*) and oil palm (*Elaeis sp.*) in the world. On average, rapeseed meal contains on an as-fed basis (90% dry matter) 36–38% crude protein, 10–12% crude fibre, 1–2% lipids, 6–8% ash, less than 1% calcium, and 1.2% total phosphorus (Scarisbrick & Daniels, 1986). Rapeseed meal is a high protein-containing material that can be used as a feed for livestock and poultry (Rutkowski, 1970; Uruakpa & Arntfield, 2005).

Rapeseeds contain levels of anti-nutritional factors that cause problems in all production animals. These factors include glucosinolates (goitrogenic), erucic acid (toxic), tannins, sinapine, phytic acid, and mucilage (Mavromichalis, 2010). The glucosinolates receive the most attention, because they have been shown to dramatically depress animal performance. Symptoms of poisoning in poultry may include depressed growth, poor egg production, enlarged thyroid in chick embryos, and liver damage. Symptoms of poisoning in swine include growth depression, goiters, and enlarged livers (Cornell University homepage). Interestingly, a lower level of glucosinolates content has been reported to have positive effect on human health (Tan et al., 2010). Song & Thornalley (2007) found that a glucosinolates level of 0.61 μmol g^{-1} in broccoli can be linked to a reduced cancer risk. Glucosinolates, which are secondary metabolites, are suggested to have an important role in plant resistance to herbivores and pathogens (Koroleva et al., 2010).

The object of the present study was to evaluate the effect of the nitrogen rate and different application times to crude protein and glucosinolates content of winter turnip rape.

MATERIALS AND METHODS

The trials were carried out at the Jõgeva Plant Breeding Institute (PBI) (N 58°76'; E26°40') in the 2007-08, 2008-09 and 2009-10 growing seasons. The soil was soddy-calcarous podzolic, soil texture sandy-clay. Chemical composition of the soil (analyses made by Estonian Agricultural Research Centre) is shown in Table 1.

Table 1. Chemical composition of the soil of the trial area in 2007–09.

Year	P	K	Ca	Mg	Cu	S	pH	Organic matter, %
	mg kg^{-1}							
2007	104	143	1,670	110	4.5	6,8	6.1	2.5
2008	244	195	1,710	85	1.2	6,6	6.3	2.2
2009	201	203	1,670	86	1.1	7.0	6.0	2.0

Every year black fallow was used as the precrop. Before sowing the trial area was fertilized by Kemira Power 5-10-25, 300 kg ha^{-1} (N – 15; P – 13.2; K – 62.3; S – 21; Fe – 6; B – 0.06 kg ha^{-1}). In 2007 and 2008 sowing was carried out on August 15th, in 2009 on August 13th. The trial was established on 10 m² plots using NNA (nearest neighbour adjustment) randomised design in three replications. The sowing rate was 100 germinated seeds per m². The winter oilseed turnip rape varieties Largo and Prisma were used for testing. All the years winter hardiness of the variety was good. No chemical plant protection was used during the growing period.

Ammonium sulfate (nitrogen content 21%, sulphur 24%) was used as top-fertilizer. Three different nitrogen rates, 120, 140 and 160 kg N ha^{-1} and three different application times were used: A) once at the beginning of spring growth (oilseed rape growing code 26), B) A + when the main stalk was 10 cm (code 33), C) B + start of flowering (code 60) (the total of nine different variants) in equal portions. Timing of the nitrogen application was based on the growth stages described by Paul (1988).

The trials were harvested on August 7th (2008), August 11th (2009) and July 20th (2010). Seeds were dried to the moisture content of 7.5% and sorted. Raw protein and glycosinolates (GSL) content in seeds were analysed by Near Infrared Reflectance Spectroscopy (NIRS) at the laboratory of the Jõgeva PBI.

The Least Significant Difference (LSD) procedure was used when the F-test was significant ($P > 0.05$) and correlation analysis was carried out (R < 0.05 and 0.001). The results were processed by the program Statistica 4.5.

RESULTS AND DISCUSSION

The average GSL content in the trial was 14.1 µmol g^{-1}, maximum was in 2008 – 15.9 µmol g^{-1}, minimum was in 2009 – 12.7 µmol g^{-1}. The variety Prisma produced higher GSL content every year (Table 2). Söchtling & Verret (2004) have indicated that GSL content is not significantly affected by N fertilizer. Bilsborrow et al. (1993), Thakral et al. (1996) reported that GSL content increased with the increasing rate of N. In our trial significant positive correlation between GSL content and N application time (R = 0.40***) was found, which indicates that increasing the N applications increased GSL content in seeds. N rates had no significant influence on the GSL content of seeds. The highest GSL content was obtained in variety Prisma in the variant with N 160 kg ha^{-1} (split in three applications). The level of GSL in *Brassica* plants is highly dependent on genetic factors as well as environmental determinants, such as the available soil sulphur content (De Pascale et al., 2007). There was positive significant correlation (R = 0.31*) between GSL content and variety.

Table 2. Glucosinolates content (µmol g^{-1}) and raw protein content (%) of winter turnip rape in 2008–10 (in dry matter); application times: A) once at the beginning of spring growth, B) A + when the main stalk was 10 cm, C) B + start of flowering.

Variety	Nitrogen rate, kg ha^{-1}	Application variant	Glucosinolates content, µmol g^{-1}			Crude protein content, %		
			2008	2009	2010	2008	2009	2010
Largo	120	A	10.8	11.5	10.9	19.1	27.4*	19.8
	120	B	16.1*	11.5	13.2	22.7	26.9*	19.9
	120	C	15.0*	13.0	11.3	23.6*	27.2*	21.3
Prisma	120	A	10.1	14.6	15.2*	18.5	26.0*	18.3
	120	B	20.5*	12.8	12.7	23.2	25.6*	19.1
	120	C	19.2*	14.6	17.1*	23.7*	26.3*	20.1
Largo	140	A	11,9	10.6	12.3	18.9	27.3*	20.7
	140	B	16.5*	11.0	11.0	23.7*	27.4*	20.8
	140	C	15.1*	11.5	13.9	26.1*	27.9*	22.1
Prisma	140	A	11.8	14.7	14.1	18.6	26.4*	18.8
	140	B	20.2*	13.1	11.5	23.5*	26.6*	20.4
	140	C	20.3*	14.7	17.1*	24.7*	27.1*	20.3
Largo	160	A	8.0*	11.4	12.5	21.3	28.3*	20.7
	160	B	16.5*	11.1	10.4	23.9*	27.8*	21.2
	160	C	17.1*	11.1	14.5	26.2*	27.9*	22.5
Prisma	160	A	11.0	13.5	16.5*	18.5	27.1*	19.3
	160	B	22.7*	13.8	14.6	23.2	27.2*	20.1
	160	C	23.2*	14.3	15.5*	25.1*	25.9*	20.6
$LSD_{0.05}$				3.27			3.28	

*statistically significant *P < 0.05*

Several researchers (Asare, 1995; Rathke et al., 2005) noticed that protein content increased with the increase of N fertilizer rate. The average crude protein content in the trial was 23.3%, maximum in 2009 – 27.0%, minimum in 2010 – 20.3%. Crude protein contents of 2009 showed significant differences; the highest raw protein content was produced by the variety Largo variant with N 160 kg ha^{-1} (28.3%). There was positive significant correlation (R = 0.31*) between crude protein content and N application time. Between crude protein content and N rates there was no significant correlation (R = 0.12). In our trial significant positive correlation between GSL content and crude protein content (R = 0.82***) was found.

CONCLUSIONS

Nitrogen fertilization in higher rates significantly increased protein content. The results indicated that the quantity of the fertilizer had not as strong an impact as fertilizer application time to glucosinolates content. The lowest glucosinolates content of winter turnip rape seeds was obtained from the variant with one N application. The highest protein content of seeds was obtained from the variants of three time split-N. While cultivation winter turnip rape attention should be paid to fertilizing to avoid excess glucosinolates content in seeds.

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