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Effect of cultivar, production year and row spacing on protein content in rapeseed (*Brassica napus* L.)

Balalić I[1], Marjanović-Jeromela A[1], Crnobarac J[2], Radić V[1]

[1] *Institute of Field and Vegetable Crops, Novi Sad, Serbia*
[2] *Faculty of Agriculture, University of Novi Sad, Serbia*
igor.balalic@nsseme.com

INTRODUCTION

According to the total production of major oilseeds in the world, rapeseed takes the second place just after soybean (FAOSTAT, 2017), with the production of over 34 million hectares. Rapeseed (*Brassica napus* L.) is together with sunflower (*Helianthus annuus* L.) and soybean (*Glycine max* Merr.), a major oil crop in Serbia (Marjanović-Jeromela et al., 2016). The seed has a high value of oil (40-48%) and protein (18-25%). Primarily rapeseed is grown for the production of seed with high oil and protein content. It is also used as animal feed and a potential future source for renewable biofuel production. The winter type of rapeseed is preferred over the spring type due to superiority in yield.

The protein content of rapeseed depends on various factors, including genetical and environmental factors, as well as the interaction between them. Proper field practices as crop rotation, plant density, and sowing date can also influence oil and protein content in rapeseed (Balalić et al., 2017).

The aim of the study was to investigate the effect of cultivar, production year and row spacing (sowing density) on protein content in three rapeseed cultivars during two vegetation periods.

MATERIAL AND METHODS

Three winter rapeseed cultivars (Banaćanka, Slavica and NS-H-R-1) developed at the Institute of Field and Vegetable Crops, Novi Sad, Serbia, were sown in two growing seasons (2009/2010 and 2010/2011) at Rimski šančevi (45°19´51´´N; 19°50´59´´E; 84 m altitude), the experimental field of the Institute of Field and Vegetable Crops. In each of the 2 seasons the rape seeds were sown in five row spacings (sowing density): 16 cm (RS1, 25 plants/m^2), 10 cm (RS2, 40 plants/m^2), 8 cm (RS3, 50 plants/m^2), 6 cm (RS4, 67 plants/m^2) and 5 cm (RS5, 80 plants/m^2). The rows were 25 cm apart. The experiments were arranged in a randomized complete block design with four replications. The content of total protein was determined after harvest, using standard Kjeldahl procedure. Collected data were analyzed using three-way analysis of variance (ANOVA), in the STATISTICA 12.0 package computer program (*StatSoft*).

RESULTS AND DISCUSSION

Analysis of variance (ANOVA) based on results of the two-year average showed that the mean squares for main effects year (Y) and cultivar (C) were highly significant (**P < 0.01), but protein content was not significantly affected by row spacing (RS). Protein content was predominantly influenced by the year of growing (62.78%). The influence of cultivar on protein content amounted to 17.29% and of row spacing to 3.87%, which was not significant. This is in agreement with the results of Morrison et al. (1990), van Deynze et al. (1992) and Bagheri et al. (2011). These authors also concluded that the protein content in rapeseed was not affected by changes in plant density. On the contrary Shrief et al. (1999) in the experiment with three population densities (30, 60 and 90 plants/m^2) informed that higher protein content was obvious under higher population densities and the differences from the lowest density were significant in both years. Harker et al. (2017), using five seeding rates (50, 75, 100, 125 or 150 seeds m^2) concluded that increasing seeding rates also increased seed protein content in rapeseed.

Table 1. ANOVA for protein content in rapeseed cultivars (2009/2010 and 2010/2011)

Source of variation	df	SS (%)	MS	*P*
Year (Y)	1	62.78	62.67	0.000**
Cultivar (C)	2	17.29	8.63	0.000**
Row spacing (RS)	4	3.87	0.97	0.132
Y × C	2	6.21	3.10	0.004**
Y × RS	4	1.81	0.45	0.497
C × RS	8	3.16	0.39	0.653
Y × C × RS	8	4.88	0.61	0.340
Error	87		0.53	

*$P < 0.05$; **$P < 0.01$

Most of the first (Y×RS, C×RS), as well as the second-order interactions (Y×C×RS) were not significant. Concerning interactions only Y×C (6.21%) for protein content was significant, indicating that Banaćanka, Slavica and NS-H-R-1 cultivars responded differently to varying production years. The non-significant interaction C×RS for protein content showed that cultivars reacted similarly to row spacings (Table 1). Most of the first as well as the second order interactions were insignificant for protein content in rapeseed, as stated by Schrief et al. (1990).

Table 2. Mean values and variability for protein content in rapeseed cultivars (2 years average)

Year (Y)	Cultivar (C)	Row spacing (RS) RS1	RS2	RS3	RS4	RS5	Mean (Y×C)	Mean (Y)
2009/2010	Banaćanka	21.40	20.94	21.09	20.80	21.06	21.05	21.02
	Slavica	21.00	20.10	20.72	19.78	19.74	20.27	
	NS-H-R-1	21.73	22.01	21.44	21.68	21.77	21.73	
	Mean	21.38	21.02	21.08	20.75	20.85		
2010/2011	Banaćanka	20.49	19.33	19.52	19.21	20.13	19.73	19.57
	Slavica	19.05	19.12	19.53	19.41	19.43	19.31	
	NS-H-R-1	19.68	19.27	20.09	19.53	19.80	19.67	
	Mean	19.74	19.24	19.71	19.38	19.78		
Mean (2 years)	Banaćanka	20.95	20.14	20.31	20.01	20.60	Mean (C)	20.40
	Slavica	20.03	19.61	20.13	19.60	19.59		19.79
	NS-H-R-1	20.71	20.64	20.77	20.61	20.79		20.70
	Mean	20.56	20.13	20.40	20.07	20.32		
V (%) = 5,93								

LSD	Y	C	RS	Y×C	Y×RS	C×RS	Y×C×RS
0.05	0.26	0.31	0.41	0.45	0.59	0.60	0.84
0.01	0.34	0.42	0.55	0.80	0.79	0.74	1.31

LSD	2009/2010 C	RS	C×RS	2010/2011 C	RS	C×RS
0.05	0.44	0.57	0.99	0.49	0.63	1.09
0.01	0.59	0.77	1.33	0.65	0.84	1.46

The protein content was significantly higher in 2009/2010 (21.02%) than in 2010/2011 (19.57%). A comparison of cultivars Banaćanka, Slavica and NS-H-1 used in this study showed highly significant differences in protein content. Significantly higher protein content was stated in NS-H-R-1 (20.70%) and Banaćanka (20.40%) in relation to cultivar Slavica (19.79%), taking into account the mean values for two years experiment. In the first year of the experiment NS-H-R-had sigificantly highest protein content. In the second year, NS-H-R-1 and Banaćanka showed significantly highest mean value in relation to cultivar Slavica. The variability for protein content was 5.93% (Table 2).

Regarding row spacing, it varied between 20.07% (RS4) and 20.56% (RS1) on average for 2 years, but the differences were non-significant. The same situation was when analyzing the results for each year separately (Table 2).

CONCLUSION

The results of these experiments over two vegetation periods suggested that protein content in rapeseed was significantly affected by cultivar, and by the year of investigation, but not by row spacing. Concerning interactions only Y×C for protein content was significant, indicating that Banaćanka, Slavica and NS-H-R-1 cultivars responded differently to varying production years.

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