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EFFECT OF PLANT DENSITY ON SEED QUALITY AND YIELD OF OILSEED RAPE (*Brassica napus* L.)

UTICAJ GUSTINE BILJAKA NA KVALITET SEMENA I PRINOS ULJANE REPICE (*Brassica napus* L.)

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ABSTRACT

Due to its compostion the oilseed rape is widely used in the production of oil, animal feed and biodisel production. Due to a wide range of rapeseed use, the aim of this paper was to determine the influence of genotype, production year and planting density on seed germination, seed moisture content, mass of 1000 seed, hectoliter mass, seed yield per plot, and oil and protein content in the seed. Tests were carried out on four rapeseed genotypes sown at a distance of 5 cm (80 plants/m^2), 10 cm (40 plants/m^2), 15 cm (27 plants/m^2) and 20 cm (20 plants/m^2) within the raw during 2007/2008 and 2008/2009 vegetation period. Seed germination, hectoliter mass and seed yield depended on production year, mass of 1000 seeds depended on genotype, plant density and production year, while the oil and protein content depended on genotype and production year.

***Key words**: rapeseed, planting density, seed quality, seed yield.*

REZIME

Uljana repica, zbog svog sirovinskog sastava nalazi veliku primenu u proizvodnji ulja, ishrani domaćih životinja i proizvodnji biodizela. Cilj istraživanja je bio da se utvrdi uticaj gustine setve, tj. različitog razmaka biljaka unutar reda na kvalitet semena i komponente prinosa četiri sorte ozime uljane repice proizvedene u dve vegetacione sezone. Ispitivanja su izvršena na četiri genotipa uljane repice (Slavica, NS-L-7, Artus, NS-L-21), posejane sa razmakom u redu od 5 cm (80 biljaka/m^2), 10 cm (40 biljaka /m^2), 15 cm (27 biljaka /m^2) i 20 cm (20 biljaka /m^2) u vegetacionim sezonama 2007/2008. i 2008/2009. godina. Nakon žetve utvrđeni su prinos semena po parceli, hektolitarska masa, masa 1000 semena, sadržaj vlage u semenu, klijavost semena, sadržaj ulja i sadržaj ukupnih proteina. Klijavost semena ispitivanih genotipova uljane repice proizvedene u vegetacionoj sezoni 2007/2008. je bila viša od klijavosti semena proizvedenog 2008/2009. Uticaj različitih gustina setve, na ispitivani parametar, nije utvrđen. Sadržaj vlage nije zavisio od genotipa, niti od gustine setve. Masa 1000 semena zavisila je od godine proizvodnje i genotipa. U zavisnosti od godine proizvodnje, ispitivani genotipovi, su različito reagovali na gustinu setve i dobijeno je seme sa različitom masom 1000 semena. Prinos semena uljane repice nije zavisio od genotipa i gustine setve, a zavisili su od godine proizvodnje. Sadržaj ulja i proteina u semenu zavisio je od genotipa i godine proizvodnje.

***Ključne reči**: uljana repica, gustina setve, kvalitet semena, prinos semena.*

INTRODUCTION

Rape seed is a significant oilseed crop species in the world. According to the area it covers it occupies the third place among the oilseed crops after palm and soybean (FAOSTAT 2012). It is grown mainly for seed containing 40-48% of oil and 18-25% of protein. Due to its composition it is widely used in edible oil production. In additon to oil production the rapeseed is used for rapeseed meal production containing 25-40% of protein and 8% of oil used for domestic animal feed *(Enami, 2011)*. Rcently, the rapeseed oil has increasingly been used for methyl ester production, which has successfully been used for diesel engine operation. Many countries are financially encouraging and advertising the use of biodisel fuel, and thus the growing of rapeseed *(Marjanović et al., 2006)*. An opinion worth of discussion is the possibility of using bio-ethanol instead of fossil methanol (made from natural gas pre-vailingly) in the transesterification of the rapeseed oil *(Kiss and Bošković, 2012)*.

Due to diverse usage of rapeseed the demand for quality seed production is on the rise. On one hand, the seed with high seed quality in order to obtain successful sowing, and optimal stand and high yield. On the other hand, the seed with higher oil content and good oil quality. In order to achieve good oil quality the rapeseed should be grown in well aerated and deep soils, with the proper distribution of preticipation since it has a long vegetation period *(Marjanović-Jeromela and sar. 2007)*.

Since there are both winter and spring varieties this crop can be successfully grown under various agro-ecological conditions. Successful production ie. quality seed and yield depend on various biotic and abiotic factors. In rapeseed the plant density plays a significant role in achieving desired yield *(Marinković, et al., 2011)*. According to Al-Barzinjy et al. (1999) in different parts of the world the rapeseed plant density ranges between 20 to 130 plants /m^2, depending on production conditions and genotypes. In our country, the rapeseed is sown at a distance between the rows of 20-30 cm, the most often 25 cm, and the distance within the row of 5-6 cm or plant density ranges between 55 to 100 plants /m^2. Production of rapeseed at low density leads to development of greater vegetative mass, greater number of pods per plant with uneven maturation, which can affect the seed quality and yield components. On the other hand, at higher density the plants are elongated, prone to logging and susceptible to disease attack, which can have negative effect on quality and yield of seed *(Leach, et al., 1999)*.

The aim of this investigation was to determine the influence of planting density, ie. various distances within the row on seed quality and yield components of the four winter rapeseed varieties produced in two growing seasons.

MATERIAL AND METHOD

Tests were carried out on four winter rapeseed genotypes (Slavica, NS-L-7, Artus and NS-L-21) produced in 2007/2008 and 2008/2009 growing seasons. The survey was set in the trial field of the Institute of field and vegetable crops in Novi Sad. Sowing was done in optimal time (30.08.2007. and 25.08.2008) on plot areas of 4 m^2. Sowing was done in rows spaced at 25 cm distance between rows and distances within rows of 5 cm (80 plants/m^2), 10 cm (40 plants/m^2), 15 cm (27 plants/m^2) and 20 cm (20 plants/m^2). Trial was set in four replications.

Harvest occurred on June 26, 2008 and July 3, 2009. Seed yield per plot, hectoliter mass, mass of 1000 seeds (ISTA, 2008), moisture content (ISTA, 2008), seed germination (ISTA, 2008), oil content (NMR method), and content of total proteins (Kjeldahl method) were determined after harvest.

Obtained results were statistically evaluated using analysis of variance and test of least significant differences for threshold significance level of 0.05 *(Hadživuković, 1991)*. MSTAT statistical package was used for data analysis.

RESULTS AND DISCUSSION

Germination of rapeseed produced in 2007/2008 growing season ranged from 94.75 to 98.25% (Tab. 1), and in 2008/2009 the values were somewhat lower and ranged from 83.25 to 88.50% (Tab. 3). Obtained values in both production years were significantly above those prescribed by the Rule on on quality of seed of agricultural plants (Official Gazette SFRY 47/87). In all tested genotypes there were no statistically significant differences in germination of seed obtained from different planting density. During 2008/2009 growing season the following was noticed: a lack of rainfall during autumn, law temperatures and frost in January, drought during intensive plant growth and seed formation (April and first half of May) and long rainy period in June, which made that season unfavourable for rapeseed production in relation to 2007/2008 (Tab. 2). Influence of production year on tested parameter was determined by Elias and Copeland, (2001), while dependence of seed germination on variety (not confirmed by our study) was determined by Jovičić et al. (2011).

Seed moisture content during 2007/2008 growing season in all tested variants ranged from 6.6 to 7.5% (Tab. 1), and during 2008/2009 from 6.5 to 7.2% (Tab. 3). Moisture content was below that defined by the Rule on quality of seed of agricultural plants. Planting of seed at different distances within row had no influence on tested parameter in both years of investigation. The harvest of the seed is done in all genotypes and plant density at the same time it is assumed that for that reason, are not obtained in the difference value of the tested parameter.

Tested varieties showed various mass of 1000 seeds in the 2007/2008 growing season (Tab. 1). Lower values of this parametere were determined in genotypes Slavica and NS-L-21, and they were of statistical significance. In Slavica variety the mass of 1000 seeds was the highest in seed obtained per planting density of 80 plants/m^2 (4.11 g). In other tested varieties the highest value of this parameter was obtained for seed produced per planting density of 20 plants/m^2. There were no statistically significant differences between tested genotypes during the 2008/2009 growing season. (Tab. 3). Statistically significant differences for the tested parametere were found in seed produced per various planting densities. Mass of 1000 seeds produced per density of 40 plants/m^2 had statistically significantly higher values (3.36 g) than the seed produced per

Table 1. Mean values regarding seed germination. seed moisture content. 1000 seed weight. hectoliter mass. seed yield. oil and protein content of rapeseed varieties produced at different plant density during 2007/2008 growing season

Genotype	Plant density (plant/m^2)	Germination (%)	Seed moisture content (%)	1000 seed weight (g)	Hectoliter mass (kg)	Seed yield (kg/plot)	Oil content (%)	Protein content (%)
Slavica	80	98.25	6.6	4.11	69.70	2.10	39.74	19.19
	40	98.0	6.7	3.47	69.90	1.58	40.53	18.34
	27	97.75	7.1	3.56	69.70	1.47	40.55	18.07
	20	97.50	6.7	3.56	69.60	1.38	41.51	18.77
NS-L-7	80	95.75	6.7	4.00	68.00	1.81	34.49	19.08
	40	94.75	7.1	3.75	68.15	1.36	42.39	18.06
	27	94.75	6.7	3.83	67.90	1.31	43.01	18.52
	20	96.25	6.9	4.15	68.10	1.42	42.87	18.67
Artus	80	96.25	6.9	3.94	69.35	1.75	40.73	19.18
	40	95.5	7.5	3.78	69.35	1.64	39.60	19.09
	27	94.75	7.1	3.84	69.15	1.60	40.17	19.03
	20	97.5	7.0	4.05	69.60	1.96	39.44	20.00
NS-L-21	80	96.75	7.0	3.60	68.55	1.53	41.97	18.11
	40	96.75	7.3	3.52	68.68	1.71	41.19	18.24
	27	97.75	6.9	3.52	68.45	1.84	41.84	18.43
	20	96.25	6.7	3.67	68.65	1.70	40.65	19.10
Average Slavica		97.88	6.8	3.67	69.72	1.63	40.58	18.59
Average NS-L-7		95.38	6.8	3.93	68.04	1.48	40.69	18.58
Average Artus		96.00	7.1	3.90	69.36	1.74	39.98	19.32
Average NS-L-21		96.88	7.0	3.58	68.58	1.70	41.42	18.47
Average 80 plants/m^2		96.75	6.8	3.91	68.90	1.80	39.23	18.89
Average 40 plants/m^2		96.25	7.1	3.63	69.02	1.58	40.93	18.43
Average 27 plants/m^2		96.25	6.9	3.69	68.80	1.55	41.39	18.51
Average 20 plants/m^2		96.88	6.8	3.86	68.99	1.62	41.12	19.14
$LSD_{0.05}$ genotype		1.33	0.30	0.19	0.24	0.26	2.89	0.51
$LSD_{0.05}$ plant density		1.33	0.30	0.19	0.24	0.26	2.89	0.51
$LSD_{0.05}$ genotype × plants density		2.65	0.61	0.37	0.48	0.53	5.77	1.02

Table 2. Precipitation and mean monthly temperatures during 2007/2008 and 2008/2009 growing season (Rimski Šančevi)

	Precipitation (mm)		Temperature (^oC)	
	2007/2008	2008/2009	2007/2008	2008/2009
August	59	33	21.3	22.7
September	72	71	17.2	16.4
October	106	28	11.4	13.9
November	108	45	4.8	8.3
December	35	68	0.5	4.1
January	32	53	1.6	-0.3
February	11	54	2.6	2.4
March	41	51	8.6	7.2
April	47	15	12.8	14.1
May	10	43	17.5	18.1
June	68	128	21.6	20.1

density of 27 plants/m^2 (2.84n g). Mass of 1000 seeds depended on production year and tested genotypes, which was confirmed by Marjanović-Jeromela et alr. (1999). Contrary to our findings, *Ozer (2003)* determined that distance within the row had no influence on the mass of 1000 seeds.

Hectoliter mass depended on tested genotypes in 2007/2008 growing season and statistically significantly higher values were obtained in variety Slavica (69.72 kg) (Tab. 1). Hectoliter mass of seed produced in 2008/2009 was lower in relation to the values obtained in 2007/2008 (Tab. 3). Statistically significant differences were observed between tested genotypes and the seed produced per various densities.

The seed yield per plot of genotypes NS-L-7 (1.31 – 1.81 kg/plot), Artus (1.60 - 1.94 kg/plot) and NS-L-21 (1.53 - 1.84 kg/plot) (Tab. 1) showed no dependence on the planting density in the growing season of 2007/2008. Statistically significant difference for the tested parameters were obtained between the planting density of 80 plants/m^2 (2.10 kg/plot), and the density of 20 plants/m^2 (1.38 kg/plot) in Slavica variety. The seed yield per plot in 2008/2009 growing season showed neither genotype nor the planting density dependence, but the values were lower than those in the previous year. *Vujaković et al. (2011)* determined that the terms of production and the year had significant effect on the seed yield, which was also confirmed by our studies.

The seed oil content in all tested varieties ranged from 34.49 to 43.01% (Tab. 1) in the 2007/2008 growing season. Statistically significantly lower value of the tested parameter was obtained in the line NS-L-7 produced with plant density of 20 plants/m^2 (34.49%) in relation to the seed produced with other planting density. No statistically significant differences in seed oil content were found in other genotypes produced with various planting densities. During the growing season of 2008/2009 the studied parameter depended on genotype (Tab. 3). Statistically significantly higher values were obtained in line NS-L-7 (42.48%) in relation to Slavica variety (40.55%) and hybrid Artus (40.51%). Statistically significantly higher oil content in this variety was found in seed produced with the planting density of 40 plants/m^2 (41.79%), while statistically significantly lower value in line NS-L-21 was obtained for seed produced with the planting density of 40 plants/m^2 (40.18%). In other tested genotypes no statistically significant diferences in oil content were found in seed produced per various densities. *Jovičić et al. (2011)* determined that this parameter mainly depended on the variety itself, while *Ozer (2003)* determined that the increased distance within the row caused the increased seed oil content. However, those differences were not significant, which was largely confirmed by our studies.

In 2007/2008 the protein content ranged from 18.06 to 20.00% (Tab. 1). In genotypes Slavica and NS-L-7 somewhat higher values were obtained with density of 80 plants/m^2, and in genotypes Artus and NS-L-21 with density of 20 plants/m^2. The tested parameter in 2008/2009 was somewhat higher than in the previous year and ranged from 19.99 to 23.03% (Tab. 3). Statistically significant differences of the tested parameter were observed only in the line NS-L-7. Seed produced with density of 20 plants/m^2 had statistically significantly higher value in relation to the protein content obtained in seed when densities of 20 plants/m^2 were applied. Influence of genotype on protein content in rapeseed was determined by *Marinković et al. (2010). Shrief et al. (1990)* determined that the protein content in seed was higher in seed produced when higher densities were applied, while *Van Deynze et al. (1992)* observed no influence of density on the tested parameter. *Rathke et al. (2005)* determined that the presence of increased nitrogen had effect on protein synthesis increased at the expense of fatty acid synthesis, resulting in lower oil content in seed. On the other hand, *Hao et al. (2004)* found negative correlation coefficient between oil and protein contents. Negative coefficient of correlation between protein and oil content, and we get and it are -0.481 in the 2007/2008 growing season and -0.391 in the 2008/2009 growing season. With this in mind, the care regarding the mode of rapeseed production and obtaining larger quantities of protein or oil should be taken.

Table 3. Mean values regarding seed germination. seed moisture content. 1000 seed weight. hectoliter mass. seed yield. oil and protein content of rapeseed varieties produced at different plant density during 2008/2009 growing season

Genotype	Plant density (plant/m^2)	Germination (%)	Seed moisture content (%)	1000 seed weight (g)	Hectoliter mass (kg)	Seed yield (kg/plot)	Oil content (%)	Protein content (%)
Slavica	80	88.50	6.8	2.91	67.00	0.63	40.26	21.41
	40	85.75	6.6	3.06	66.10	0.73	41.79	20.79
	27	85.00	6.7	2.94	66.60	0.74	39.83	20.84
	20	85.75	6.7	2.93	66.80	0.79	40.31	21.70
NS-L-7	80	87.50	6.5	3.18	66.30	0.70	42.11	23.03
	40	84.00	6.7	3.25	65.40	0.56	42.62	20.50
	27	87.50	6.7	3.00	66.25	0.43	41.98	20.11
	20	87.50	6.6	3.14	66.83	0.36	43.21	19.99
Artus	80	83.25	6.9	3.26	66.70	0.57	40.78	21.61
	40	85.25	6.9	3.36	67.00	0.56	39.98	21.90
	27	85.50	7.0	2.84	67.00	0.67	40.64	22.03
	20	86.75	7.2	3.32	67.30	0.74	40.65	21.34
NS-L-21	80	88.00	6.7	2.97	65.70	0.93	41.89	20.64
	40	83.75	6.7	3.14	65.90	0.44	40.18	21.90
	27	88.50	6.6	2.89	66.20	0.56	42.12	22.03
	20	88.25	6.9	3.16	66.60	0.96	41.88	21.34
Average Slavica		86.25	6.7	2.96	66.63	0.73	40.55	21.18
Average NS-L-7		86.63	6.6	3.14	66.19	0.51	42.48	20.91
Average Artus		85.19	7.0	3.19	67.00	0.64	40.51	21.72
Average NS-L-21		87.13	6.7	3.04	66.10	0.73	41.51	21.48
Average 80 plants/m^2		86.81	6.7	3.08	66.43	0.71	41.26	21.67
Average 40 plants/m^2		84.69	6.7	3.20	66.10	0.58	41.14	21.27
Average 27 plants/m^2		86.63	6.7	2.92	66.51	0.60	41.14	21.25
Average 20 plants/m^2		87.06	6.8	3.17	66.88	0.71	41.51	21.09
$LSD_{0.05}$ genotype		2.82	0.18	0.18	0.64	0.22	0.65	0.42
$LSD_{0.05}$ plants density		2.82	0.18	0.18	0.64	0.22	0.65	0.42
$LSD_{0.05}$ genotype × plant density		5.63	0.36	0.35	1.28	0.44	1.29	0.83

CONCLUSION

Based on the obtained results the following can be concluded:

Seed germination of tested rapeseed genotypes produced in 2007/2008 growing season was higher than the seed produced in

2008/2009. No effect of various planting densities on tested parameter was determined.

Moisture content depended neither on genotype nor the planting density.

Mass of 1000 seeds depended both on production and the genotype. In dependence on production year the tested genotypes showed different reaction to planting density and seed with various mass of 1000 seeds was obtained.

Hectoliter mass of seed of rapeseed showed dependence on genotype, planting density and production year.

Seed yield of rapeseed showed no dependence on genotype and planting density. Tested parameters depended on the production year.

Oil and protein content in seed depended on genotype and production year. Plant density had no influence on the tested parameters.

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