

Winter Oilseed Rape (*Brassica napus* L.) Yield Components in Agro-ecological Conditions of Banja Luka Region

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Abstract

Due to its numerous agricultural and industrial purposes, oilseed rape is a very important species. The total production of oilseed rape in the Republic of Srpska is faced with noticeable variation throughout years, with an increase in last three years. The oilseed rape yield is strongly influenced by environmental factors. The objective of this study was to analyze yield components of oilseed rape in agro-ecological conditions of Banja Luka. Four oilseed rape hybrids were used: PR46W21, PR46W20, PR46W14 and PR45DO3 in two growing seasons: 2012/13 and 2013/14. Yield components tested were: pod mass (g), seed mass per pod (g), pod index (%), number of seeds per pod and 1000-seed weight (g). Factorial 2×4 ANOVA and Fisher's LSD test were used to analyze data, with growing seasons (years) and hybrids as factors. Growing season significantly affected the pod mass (g), total seed mass per pod (g) and 1000-seed weight. Generally, higher yield component values were obtained in the second examined year (2013/14).

Key words: rapeseed husk, winter hybrids, interaction, canola

Introduction

As one of the major oilseed crops, oilseed rape has 70.84 million metric tons of total production in the world, with 34.77 million hectares of harvested area, as an average for period from 2013/14 to 2016/17 (USDA, 2017a), which makes an average yield of 2.04 t ha⁻¹. In EU-28 countries, as the world's largest producer of oilseed rape, the total production of oilseed rape was 21.15 million metric tons from 6.48 million hectares of harvested area, as an average for period from 2015/16 to 2016/17 (USDA, 2017b), with an average yield of 3.26 t ha⁻¹. In the period from 2010 to 2017, the total production of oilseed rape in the Republic of Srpska was 2.073,13 metric tons from the 874.25 hectares, which makes an average oilseed rape yield in this period of 2.23 t ha⁻¹ (Republic of Srpska Institute of Statistics, 2016a, 2016b, 2017). However, in last years there is a trend in increasing both the production and harvested area, as well as average yield of this crop in the Republic of Srpska.

Cultivation of winter oilseed rape genotypes is very important in surrounding countries, especially in Serbia (Marjanović–Jeromela et al., 2008). Oilseed rape is used for different purposes. Its seed contains 40 to 48% oil, which can be used for human consumption and in industry, and 18 to 25% proteins, often used for animal feed after processing. Also, its green mass can be used as forage and different bee species feed on the oilseed rape flowers (Kondić, 1998; Kondić et al., 2008; Marinković et al., 2009).

The yield components affected by different oilseed rape plant density were analyzed by McGregor (1987), Ozer (2003), Vujaković et al. (2014) and Vujaković et al. (2015). Marjanović–Jeromela et al. (2007) tested seed yield and protein content of ten winter oilseed rape cultivars. Ahmadi and Bahrani (2009) investigated yield of Telayeh genotype, influenced by water stress. Marinković et al. (2009) presented specifics of winter rapeseed production, with accent on cultivation practices and characteristics of genotypes. Oilseed rape yield components were also tested in conditions of different sowing dates (Pospišil et al., 2009), nitrogen levels (Vujaković et al., 2010) and both planting dates and irrigation levels (Rad et al., 2014). The yield of oilseed rape is often restricted by water deficit and high temperatures during the reproductive growth. Flowering was the most sensitive stage for water stress damage resulting in a drastic reduction in yield (Ahmadi and Bahrani, 2009). Considering that environmental factors have great influence on oilseed rape yield, new oilseed rape genotypes should be tested in different localities and growing seasons (Marjanović–Jeromela et al., 2008).

Therefore, the objective of this study was to analyze main yield components of different oilseed rape hybrids in agro–ecological conditions of Banja Luka region.

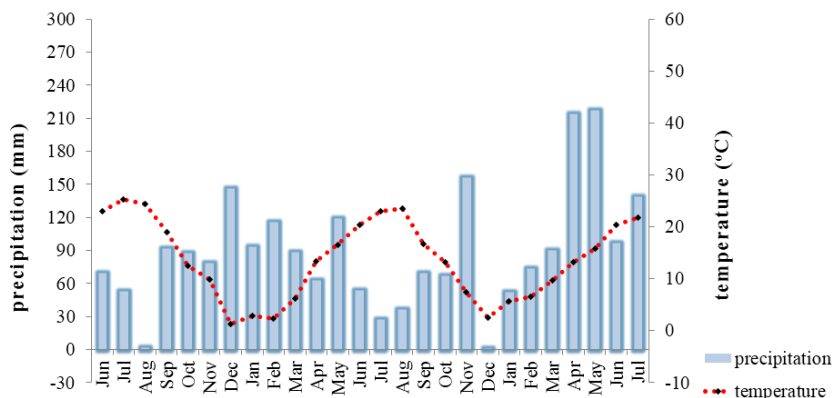
Material and Methods

The experiment on oilseed rape hybrids was conducted in two growing seasons: 2012/13 and 2013/14 in agro–ecological conditions of Banja Luka (44°46' N; 17°11' E, and 164 m altitude).

Four winter oilseed rape hybrids were tested: PR46W21, PR46W20, PR46W14 and PR45DO3. Standard agronomic practices for winter oilseed rape were performed. Sowing was carried out on the 22nd of September in 2012/13 and on the 1st of October in 2013/14 growing season. In both growing seasons, oilseed rape was harvested in the last decade of June.

Several oilseed rape yield components were analyzed: pod mass (g), seed mass per pod (g), pod index (calculated as ratio of total seed mass per pod and pod mass, in %), number of seeds per pod and 1000–seed weight (g). Experimental arrangement was randomized design, with years and hybrids as main factors. Winter oilseed rape hybrids were sown in four replications. For the measurements, ten plants from each replication were randomly taken. A total of 20 pods per plant i.e. 200 pods per replication were then averaged for different hybrids in two growing seasons, providing data for the analysis of each yield component. Two–way ANOVA was conducted in 2×4 factorial design and significant differences between treatment means were tested by Fisher's least significant difference test (LSD) at the 0.05 and 0.01 probability level of α . Statistical analyses were done in Microsoft Office Excel 2013.

Graph 1 presents total monthly precipitation (mm) and average monthly temperatures (°C) for 2012/13 and 2013/14 growing seasons of oilseed rape.



Graph 1. Climate diagram for 2012/13 and 2013/14 growing season of winter oilseed rape hybrids
Климадијаграм за 2012/13 и 2013/14 вегетациони период хибрида озиме уљане ретице

Total precipitation from September to June was 1075.1 mm in 2012/2013 and 1315.5 mm in 2013/14. Average temperature was 12.19 °C in 2012/13 and 11.51 °C in 2014/2015 growing season. In 2012/13 growing season, total precipitation for August was only 1.8 mm and for September 92 mm. In the same period in 2013/14, total precipitation was higher and evenly distributed between two months, in the time before sowing of oilseed rape.

Also, the total precipitation in December was obviously different in these two years (146.3 mm in 2013/14 and 0.4 mm in 2013/14). The total precipitation was 62.9 mm in April (dry period according to Graph 1) and 119.6 in May 2012/13 (182.5 mm for both months) which is far below the total precipitation for these two months in the second growing season (431.8 mm) and this is the flowering period of oilseed rape.

Results and Discussion

Pod mass (g), seed mass per pod (g) and pod index (%)

In Table 1 data for the average pod mass (g) in four tested winter oilseed rape hybrids is shown. The pod mass was the highest in oilseed rape hybrid PR46W21 (0.1691 g) and the lowest in hybrid PR46W20 (0.1611 g). Also, considering different years, pod mass was higher in the second year (0.1731 g).

Tab. 1. The average pod mass (g) for oilseed rape hybrids in 2012/13 and 2013/14
Маса љуске (g) хибрида уљане репице у 2012/13 и 2013/14 години

hybrid / year <i>хибрид / година</i>	2012/13	2013/14	$\bar{X} \pm s_x$ <i>hybrids / хибриди</i>
PR46W20	0.1569 \pm 0.0039	0.1652 \pm 0.0038	0.1611 \pm 0.0041
PR46W21	0.1638 \pm 0.0067	0.1743 \pm 0.0057	0.1691 \pm 0.0053
PR45WD03	0.1532 \pm 0.0044	0.1788 \pm 0.0032	0.1660 \pm 0.0128
PR46W14	0.1614 \pm 0.0045	0.1741 \pm 0.0049	0.1678 \pm 0.0063
$\bar{X} \pm s_x$ for years / <i>за године</i>	0.1588 \pm 0.0024	0.1731 \pm 0.0029	
factors / interaction: <i>фактори / интеракција</i>	A (years)	B (hybrids)	AB (year \times hybrid)
ANOVA – F calculated	18.0437 **	1.0915 ^{ns}	1.3475 ^{ns}
ANOVA – F <i>израчунато</i>			

Note: ns = not significant (P > 0.05), * significant at P \leq 0.05, ** significant at P \leq 0.01

According to the analysis of variance, the difference between years was statistically significant at $P \leq 0.01$. The difference between winter oilseed rape hybrids was not statistically significant. Interaction year \times hybrid was not statistically significant. Obtained results indicate that pod mass in 2013/14 was significantly higher than pod mass in 2012/13. Dry conditions in sowing time as well as in the flowering period in 2012/13 growing season could be the reason for the lower pod mass of different oilseed rape hybrids.

In Table 2 data for the average seed mass per pod (g) for tested hybrids is presented. The average seed mass per pod was the highest in oilseed rape hybrid PR46W21 (0.1089 g) and the lowest in hybrid PR46W20 (0.1073 g). Considering different years, the average seed mass per pod was higher in the second year (0.1156 g).

Tab. 2. The average seed mass per pod (g) for different oilseed rape hybrids in 2012/13 and 2013/14

Укупна маса сјемена у љусци (g) различитих хибрида уљане репице у 2012/13 и 2013/14 години

hybrid / year <i>хибрид / година</i>	2012/13	2013/14	$\bar{X} \pm s_x$ hybrids / хибриди
PR46W20	0.1034 \pm 0.0028	0.1112 \pm 0.0022	0.1073 \pm 0.0039
PR46W21	0.1025 \pm 0.0031	0.1154 \pm 0.0041	0.1089 \pm 0.0065
PR45WD03	0.0964 \pm 0.0026	0.1196 \pm 0.0022	0.1080 \pm 0.0116
PR46W14	0.1007 \pm 0.0030	0.1162 \pm 0.0034	0.1085 \pm 0.0078
$\bar{X} \pm s_x$ for years / <i>за године</i>	0.1008 \pm 0.0015	0.1156 \pm 0.0017	
factors / interaction: <i>фактори / интеракција</i>	A (years)	B (hybrids)	AB (year \times hybrid)
ANOVA – F calculated	49.7758 **	0.1086 ns	2.3261 ns
ANOVA – F израчунато			

Note: ns = not significant ($P > 0.05$), * significant at $P \leq 0.05$, ** significant at $P \leq 0.01$

According to the analysis of variance, the difference between years was statistically significant at $P \leq 0.01$. The difference between oilseed rape hybrids was not statistically significant. Interaction year \times hybrid was not statistically significant. However, oilseed rape hybrids had significantly higher total seed mass per pod in 2013/14 growing season.

Table 3 presents the data for the average pod index (%) of different oilseed rape hybrids.

Tab. 3. Pod index for oilseed rape hybrids in 2012/13 and 2013/14

Индекс љуске хибрида уљане репице у 2012/13 и 2013/14 години

hybrid / year <i>хибрид / година</i>	2012/13	2013/14	$\bar{X} \pm s_x$ hybrids / <i>хибриди</i>
PR46W20	0.6597 \pm 0.2000	0.6734 \pm 0.0075	0.6665 \pm 0.0068
PR46W21	0.6265 \pm 0.0102	0.6618 \pm 0.0024	0.6441 \pm 0.0177
PR45WD03	0.6298 \pm 0.0059	0.6690 \pm 0.0021	0.6494 \pm 0.0196
PR46W14	0.6236 \pm 0.0037	0.6674 \pm 0.0011	0.6455 \pm 0.0219
$\bar{X} \pm s_x$ for years / <i>за године</i>	0.6349 \pm 0.0084	0.6679 \pm 0.0024	
factors / interaction: <i>фактори / интеракција</i>	A (years)	B (hybrids)	AB (year \times hybrid)
ANOVA – F calculated	27.9815 **	2.7531 ^{ns}	1.1450 ^{ns}
ANOVA – F <i>израчунато</i>			

Note: ns = not significant ($P > 0.05$), * significant at $P \leq 0.05$, ** significant at $P \leq 0.01$

Obtained data indicate that pod index ranged from 64.41 to 66.65% for different oilseed rape hybrids. The pod index was significantly higher ($P \leq 0.01$) in the second year (66.79%), with an average increase of 5.01%.

As opposed to the pod mass (g) and total seed mass per pod (g) parameters, pod index (%) was the highest in PR46W20 hybrid and the lowest in PR46W21 hybrid.

Number of seeds per pod

Table 4 indicates that average number of seeds per pod was the highest in hybrid PR46W14 (24.46) and the lowest in hybrid PR46W21 (22.72). Also, considering different years, number of seeds per pod was higher in the second investigated year (23.63).

Conducted analysis of variance showed that the difference between growing seasons (years) was not statistically significant. The difference between different winter oilseed rape hybrids was statistically significant at $P \leq 0.05$. However, tested interaction effect year \times hybrid was statistically significant at $P \leq 0.01$.

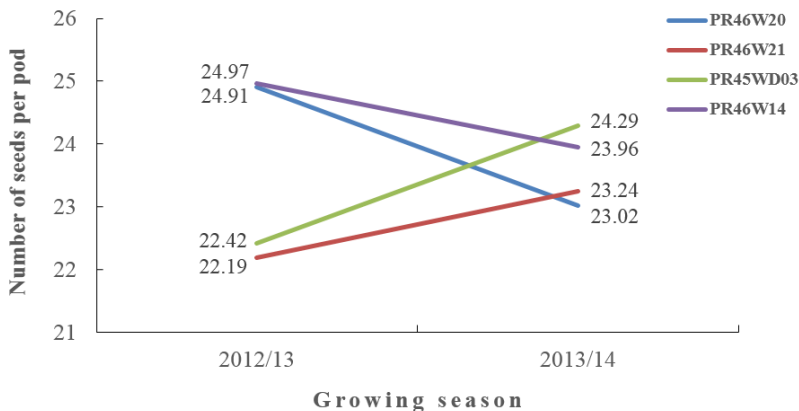
Tab. 4. The average number of seeds per pod for different oilseed rape hybrids in 2012/13 and 2013/14

Број сјеменки у љусци различитих хибрида уљане репице у 2012/13 и 2013/14 години

hybrid / year <i>хибрид / година</i>	2012/13	2013/14	$\bar{X} \pm s_x$ hybrids / <i>хибриди</i>
PR46W20	24.91 \pm 0.23	23.02 \pm 0.44	23.96 \pm 0.94
PR46W21	22.19 \pm 0.78	23.24 \pm 0.72	22.72 \pm 0.53
PR45WD03	22.42 \pm 0.32	24.29 \pm 0.29	23.36 \pm 0.94
PR46W14	24.97 \pm 0.21	23.96 \pm 0.83	24.46 \pm 0.51
$\bar{X} \pm s_x$ for years / <i>за године</i>	23.62 \pm 0.76	23.63 \pm 0.30	
factors / interaction: <i>фактори / интеракција</i>	A (years)	B (hybrids)	AB (year \times hybrid)
ANOVA – F calculated	0.0004 ^{ns}	3.9798 [*]	5.3604 ^{**}
ANOVA – F <i>израчунато</i>			
LSD	0.01	-	1.50
	0.05	-	1.98

Note: ns = not significant ($P > 0.05$), * significant at $P \leq 0.05$, ** significant at $P \leq 0.01$

Graph 2 presents two different tendencies in average number of seeds per pod considering four winter oilseed rape hybrids in 2012/13 and 2013/14.



Graph 2. The number of seeds per pod affected by different oilseed rape hybrids and growing seasons

Утицај различитих хибрида и вегетационог периода на број сјеменки у љусци

Hybrids PR46W14 and PR46W20 had a decline in average number of seeds per pod in the second year while hybrids PR45WD03 and PR46W21 had growth of this yield component in the second year. Also, variability in number of seeds per pod was higher in the second year and in PR46W20 and PR45WD03 hybrids. The presence of interaction effect could be due to different reaction of oilseed rape hybrids to agro-ecological conditions in two growing seasons i.e. it is a genotypic response for the number of seeds per pod.

The number of seeds per pod in our study, ranging from 22.72 to 24.46 for different oilseed rape hybrids, was in accordance with other researchers. McGregor (1987) found that number of seeds per pod varied from 14.7 to 24.7. Ozer (2003) obtained the average number of seeds per pod from 23.67 to 25.15. In the study of Ahmadi and Bahrani (2009) average number of seeds per pod varied from 21.1 to 21.3. Rad et al. (2014) found that number of seeds per pod varied from 3.28 to 18.75 for different oilseed rape cultivars.

1000–seed weight (g)

In Table 5 data for the average 1000–seed weight (g) for tested hybrids is presented. The 1000–seed weight was the highest in winter oilseed rape hybrid PR46W21 (4.8034 g) and the lowest in hybrid PR46W14 (4.4450 g). Considering different years, 1000–seed weight was higher in the second year (4.8944 g).

Tab. 5. The 1000–seed weight (g) for oilseed rape hybrids in 2012/13 and 2013/14
Маса 1000 зрна хибрида уљане репице у 2012/13 и 2013/14 години

hybrid / year <i>хибрид / година</i>	2012/13	2013/14	$\bar{X} \pm s_x$ hybrids / <i>хиприди</i>
PR46W20	4.1524 ± 0.1108	4.8321 ± 0.0650	4.4923 ± 0.3398
PR46W21	4.6436 ± 0.2725	4.9633 ± 0.0512	4.8034 ± 0.1598
PR45WD03	4.3045 ± 0.1259	4.9242 ± 0.0525	4.6144 ± 0.3099
PR46W14	4.0321 ± 0.1135	4.8579 ± 0.1101	4.4450 ± 0.4129
$\bar{X} \pm s_x$ for years / <i>за године</i>	4.2832 ± 0.1325	4.8944 ± 0.0301	
factors / interaction: <i>фактори / интеракција</i>	A (years)	B (hybrids)	AB (year × hybrid)
ANOVA – F calculated	43.6435 **	2.9875 ns	1.3223 ns
ANOVA – F <i>израчунаго</i>			

Note: ns = not significant (P > 0.05), * significant at P ≤ 0.05, ** significant at P ≤ 0.01

According to the analysis of variance, growing season had statistically significant effect ($P \leq 0.01$) on the 1000–seed weight. The difference between winter oilseed rape hybrids was not statistically significant. Interaction year \times hybrid was not statistically significant. Winter oilseed rape hybrids had significantly higher 1000–seed weight (g) in 2013/14.

McGregor (1987) found that average 1000–seed weight of oilseed rape varied from 3.18 to 4.50 g. In a study conducted by Ozer (2003) the average 1000–seed weight of oilseed rape varied from 4.11 to 4.23 g. According to study of Marjanović–Jeromela et al. (2007) in *B. napus* cultivars 1000–seed weight varied from 3.39 to 4.13 g. In Rad et al. (2014) 1000–seed weight varied from 0.70 to 3.90 g for different oilseed rape cultivars. However, in Vujaković et al. (2014) a 1000–seed weight varied from 3.47 to 4.15 g in the first growing season and from 2.84 to 3.36 g in the second growing season and this yield component depended on the year and tested genotypes.

Conclusion

Obtained data could enable easier determination of appropriate oilseed rape hybrid for sowing in agro–ecological conditions of Banja Luka. All tested yield components of four oilseed rape hybrids were higher in the second growing season (2013/14). Across all tested oilseed rape hybrids, PR46W21 was found to have the highest pod mass (g), total seed mass per pod (g) and 1000–seed weight (g), and can therefore be considered as high–productivity oilseed rape hybrid. Obtained pod index (%) was the highest in PR46W20 hybrid, while the number of seeds per pod was the highest in PR46W14 hybrid. Most yield components of oilseed rape in this study were highly affected ($P \leq 0.01$) by different growing seasons. Future investigations should be aimed at studying the yield components of oilseed rape for more locations and growing seasons in the region of Banja Luka.

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Параметри приноса озиме уљане репице (*Brassica napus* L.) у агроеколошким условима Бање Луке

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Сажетак

С обзиром на велики број пољопривредних и индустријских производа, уљана репица је веома важна биљна врста. Вриједност укупне производње уљане репице у Републици Српској значајно варира у зависности од године, али у посљедње три године присутно је повећање укупних површина. Фактори спољашње средине имају значајан утицај на принос уљане репице. Циљ овог истраживања је анализа параметара приноса уљане репице у агро–еколошким условима Бање Луке. Тестирана су четири хибрида PR46W21, PR46W20, PR46W14 и PR45D03 у два вегетациона периода: 2012/13 и 2013/14 година. Испитивани су следећи параметри: маса љуске (g), маса зрна у љусци (g), индекс љуске (%), број зрна по љусци и маса 1000 зрна (g). Подаци су анализирани факторијалном анализом варијансе 2 × 4 и Фишеровим LSD–тестом, при чему су главни фактори били година и хибрид. Година је значајно утицала на масу љуске, масу зрна у љусци и масу 1000 зрна. Параметри приноса су углавном имали веће вриједности у другом вегетационом периоду.

Кључне ријечи: љуска, озими хибриди, интеракција, канола

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