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Green Forage Yield and Yield Components of Five Oilseed Rape Genotypes (*Brassica napus* L.) in Response to Sowing Date and Harvest Stage

Tatjana Prentović[1], Biljana Ristakoska[2], Zoran Dimov[1], Zlatko Arsov[1], Romina Kabranova[1], Igor Iljovski[1]

[1]Faculty of Agricultural Sciences and Food, Skopje, Macedonia
[2]Agency for Financial Support of Agriculture and Rural Development, Skopje, Macedonia

Abstract

Five oilseed rape genotypes were tested at three sowing dates and harvested at two developmental phases to determine their effects on green forage yield and yield components during 2013/14 growing season. The highest density of canopy was observed at the third sowing date (86 - 157 plants/m^2). Among five genotypes, AbaKus formed the most plants/m^2 - 109, 106 and 157. The highest plant height was observed from the first sowing date (94.7 - 104 cm). The examined genotypes formed most leaves/plant, from 8.1 to 9.9 planted at the first sowing date. The cultivar AbaKus expressed a significantly higher forage yield (61.2 t/ha) during the second harvest phase. Together with cv. Perko, they had the greatest green forage production potential.

Key words: oilseed rape, genotype, forage yield, sowing date, plant density

Introduction

Oilseed rape (*Brassica napus* and *B. rapa* L., Brassicaceae) is now the second most important source of vegetable oil in the world (Starner et al., 1999). Apart from being one of the most valuable oil crops, oilseed rape could be cultivated for green forage and silage (Erić et al., 1996). Brassica species, including radish, turnip, swedes, broccoli, brussel sprouts, cauliflower, and cabbage (Ayres & Clements, 2002; Mihajlović et al., 2007) are known for their rapid fall growth, high biomass production, and nutrient scavenging ability (Clark, 2012). Grazing season could be extended using Brassica species (late fall and early winter) by up to 12 weeks, providing high yields of digestible nutrients to livestock (Reid et al., 1994). One of the goals in agriculture is to determine optimal sowing date and harvest period for desired yield. Sowing date moderately influences the quantity and quality of agricultural products, through exposing the crops to diverse environmental conditions (Singhet et al., 1998). A thirty-day delay in sowing of forage rape remarkably declines a total dry matter production by an increase of temperature from the optimal one in the early growth period (Keogh, 2011, 2014). Harvesting date significantly changes a dry matter production in plants by extending the growth period (Fraser et al., 2001). Wiedenhoeft (1993) reported that for maximizing total dry matter (DM) yield and maintaining good protein and energy levels, forage brassicas should be harvested any time from early podding stage, up to the stage where the lower leaves are starting to drop.

The aim of this study was to determine the effect of different sowing dates and different harvest stages on forage yield and yield components of five oilseed rape cultivars (*Brassica napus* L.) in Macedonian agro-ecological autumn planting conditions.

Materials and Methods

The research was carried out in village Stajkovci near Skopje (42°2'1" north, 21°30'42" east, 264 elevation), R. Macedonia, during 2013/14 growing season. Five oilseed rape genotypes were used in this study: two oilseed rape hybrids – AbaKus, Rohan, two oilseed cultivars – Banacanka and Majdan and cultivar Perko PVH being typical forage type. Total precipitation (period September 2013/April 2014) was 313.1 mm, while an average temperature (in the same period) was 9.5 ^{0}C with registered maximum in September – 18.8 ^{0}C and minimum in December – 1.2 ^{0}C. The major soil characteristics (at 60 cm depth) were following: alluvium soil type with 2.1% organic matter, pH was 7.6 (in H_2O) i.e. 6.6 (in KCl), available P_2O_5 – 13.53 and available K_2O – 32.24 mg/100 g soil.

Three sowing dates (September 20th, October 4th and October 17th) and two harvest times (presence of flower buds, and 50% of flowering – codes 51 and 65 according to BBCH scale) were evaluated in a randomized complete block design with three replications. Seeding rate was 20 kg/ha. Individual plot size was 3.0 x 1.5 = 4.5 m^2 with 10 rows within a parcel. Basic fertilization of 560 kg/ha NPK 15:15:15 was applied after seeding and 280 kg/ha of calcium ammonium nitrate was applied in spring as topdressing. The number of plants per m^2 was counted before and after winter. The main forage yield components, such as plant height (cm) and number of leaves/plant, were measured on the basis of ten plants per plot during vegetation or sampled shortly before the harvest. The green forage yield per area unit (t ha^{-1}) was determined by recalculation of the green forage yield per plot measured *in situ*. Data were analyzed using the standard analysis of variance (ANOVA) and means were separated using the comparisons based on the least significant difference (LSD) using GLM linear model (SPSS for Windows, Sum of squares, Model III).

Results and Discussion

Number of plants m^2

The number of plants per m2 effects the forage mass of oil seed rape, and is also an indicator of the plant tolerance to lower temperatures. High plant densities are creating favorable microclimate for diseases and pests, and at the same time reducing yield (Kymbr & McGregor, 1999, in: Khorshidi et al., 2014). Our data showed that numbers of plants/m^2 were higher before winter than after winter for all sowing dates. The exceptions were cv's Rohan, Perko and Banacanka with more plants/m^2, 68.3, 50.3 and 64.0 respectively after winter than before winter when planted on September 20th (Table 1a). This could be accounted to the genetic potential of the cv's, and to the importance of the sowing time for plants to resist lower temperatures. Obviously, later sowing dates caused lesser plant densities, attributed to snowless 2013/14 winter.

Regarding the sowing date and genotypes examined (Table 1b), the most dense canopy was observed at the third sowing date, with averages from 85.5 (Banacanka), to 157 plants/m^2 (AbaKus). The statistical analysis proved a significant difference at the 0.05% level between the third and the first sowing date (57.0 plants/m^2), and between the third and the second sowing date (44.9 plants/m^2). Between the genotypes tested, statistically significantly higher densities were observed for cv's AbaKus, Rohan and Perko (Table 1b).

Leach et al. (1999) in their multiannual experiment with oilseed rape, where crop density varied from 5.13 to 372 plants/m^2, concluded that higher yield is obtained with crop density from 50 to 150 plants/m^2.

From the plot with the highest density, the effect was just the opposite, the yield was lower.

Tab. 1a. Number of plants/m^2 before and after winter depending on genotype and sowing date

Број биљака/m^2 прије и након зиме у зависности од генотипа и датума сјетве

Date *Дат.*	Genotypes / *генотипови*									
	AbaKus		Rohan		Perko		Banacanka		Majdan	
	before winter *пре зиме*	after winter *након зиме*	before winter *пре зиме*	after winter *након зиме*	before winter *пре зиме*	after winter *након зиме*	before winter *пре зиме*	after winter *након зиме*	before winter *пре зиме*	after winter *након зиме*
I	112.3	105.7	60.3	68.3	41.3	50.3	43.3	64.0	45.0	28.7
II	130.3	81.7	106.7	60.0	100.7	33.7	83.0	32.7	89.0	22.3
III	189.3	124.7	194.3	76.7	214.7	45.0	138.0	33.0	153.0	20.7

Tab. 1b. Average number of plants/m^2 depending on genotype and sowing date

Број биљака/m^2 у зависности од генотипа и датума сјетве (просјек)

Date *Дат.*	Genotypes / *генотипови*					Average *просјек*
	AbaKus	Rohan	Perko	Banacanka	Majdan	
I	109	64.3	45.8	53.7	36.8	61.9
II	106	83.3	67.2	57.8	55.7	74.0
III	157	135.5	129.8	85.5	86.8	118.9*
Average *просјек*	124*	94.4*	80.9*	65.7	59.8	-

*The difference between average values is significant at 0.05 level

Plant height

Plant height varied from 94.7 cm (Majdan) to 104.0 cm (Perko) for the first planting date. For the second sowing date the shortest plants had cv. Majdan (63.4 cm) and the highest AbaKus (89.3 cm), while the minimum and maximum values for the third sowing date were observed for cv's Majdan (62.1 cm) and Perko (67.1 cm). The statistical analyses showed significant differences between first, second and third and between the second and the third sowing date. Statistically significant differences between cultivars were calculated at 0.05% level between AbaKus, Banacanka and Majdan (Table 2).

Marjanović-Jeromela et al. (2010) reported results on ten oilseed rape genotypes sowed at the beginning of September. At the initial phase of flowering the average plant height varied from 50.0 to 95.0 cm. These values are similar to the averages from our experiment for the second sowing date (October 4th). They are as well very similar to those from Spirkovska (2013), where the average plant height at full maturity varied from 89.0 to 96.0 cm.

Tab.2. Average plant height (cm) depending on sowing date and genotype
Висина биљака (cm) у зависности од генотипа и датума сјетве (просјек)

Date *Дат.*	Genotypes / *генотипови*					Average *просјек*
	AbaKus	Rohan	Perko	Banacanka	Majdan	
I	103.1	101.2	104.0	97.4	94.7	100.1*
II	89.3	71.3	70.1	63.5	63.4	71.5*
III	61.5	65.4	67.1	62.3	62.1	63.7
Average *просјек*	84.6*	79.3	80.4	74.4	73.4	-

*The difference between average values is significant at 0.05 level

Number of leaves/plant

The number of leaves per plant is proportional to the yield of the forage mass. In our experiment the number of leaves per plant was determined by counting leaves during three periods, for each genotype and each sowing date separately.The lowest values were registered during first count, before winter, and ranged from 2.9 leaves/plant (Majdan) to 3.4 (AbaKus). The results before the first and the second harvest (second and third count) were higher, ranging from 8.4 (Banacanka) to 10.4 (Perko), and from 9.1 (AbaKus) to 11.7 (Perko), respectively (Table 3). Cultivars that were planted at the first sowing date formed the most leaves/plant, on average 8.8, ranging from 8.1 to 9.9 (Banacanka and Perko). The second sowing date yielded on average 7.6 leaves/plant, where 6.7 leaves/plant were recorded for cv. Rohan and 8.9 for cv.Perko. The third sowing date had an average of 6.3 leaves/plant, with min. 6.2 (Banacanka), and max. 6.4 (Rohan) (Table 4).

The statistical analyses proved significant differences at 0.05% between the first, second and the third, and between the second and the third sowing date. The significant differences were found between cv's Perko, AbaKus, Rohan, Banacanka and Majdan, and between Majdan and Banacanka (Table 4).

Mihajlovic et al. (2007) examined eight oilseed rape genotypes sowed in autumn and in spring, and found that the average number of leaves per plant varied from 13.3 to 18.9 with no significant differences for the autumn-sown crop, whereas the average number of leaves per plant in the spring-sown crop varied from 6.0 to 47.7.

Tab. 3. The number of leaves per plant depending on genotype and period of counting
Број листова по биљци у зависности од генотипа и вријемена бројања

Period of counting *Вријеме бројања*	Genotypes / *генотипови*					
	AbaKus	Rohan	Perko	Banacanka	Majdan	Average *просјек*
Before winter *Прије зиме*	3.4	3.04	3.03	3.1	2.9	3.1
Before 1st harvest *Прије 1. жетве*	9.3	9.4	10.4	8.4	9.1	9.3*
Before 2nd harvest *Прије 2. жетве*	9.1	9.6	11.7	9.9	11.0	10.3*

*The difference between average values is significant at 0.05 level

Tab.4. The number of leaves per plant depending on genotype and sowing date
Број листова по биљци у зависности од генотипа и датума сјетве

Date *Дат.*	Genotypes / *генотипови*					Average *просјек*
	AbaKus	Rohan	Perko	Banacanka	Majdan	
I	8.8	8.9	9.9	8.1	8.3	8.8*
II	6.8	6.7	8.9	7.1	8.3	7.6*
III	6.3	6.4	6.3	6.2	6.3	6.3
Average *просјек*	7.3	7.3	8.4*	7.1	7.6	-

*The difference between average values is significant at 0.05 level

Green forage yield

The forage yield of the Brassica cultivars depends on the time of the harvest (Harper & Compton, 1980). In our study, all genotypes, except Rohan, had a higher forage yield in the second harvest period (BBCH 65), ranging from 30.1 t/ha^{-1} (Majdan) to 86.8 t/ha^{-1} (AbaKus) (Table 5). The decline in the above ground biomass due to the later sawing date results in a significant forage yield reduction (40.1% for II and 52.8% for III) (Table 5).

Cultivar AbaKus had the significantly highest green forage yields (61.2 t ha^{-1}) compared to other varieties, showing its great potential for green forage

yield. The other three cv's, (Rohan 47.7 t ha^{-1}, Perko 46.5 t ha^{-1}and Banacanka 44.2 t ha^{-1}), can be considered as promising.

With average green forage yield of 35.6 t ha^{-1}, the cultivar Majdan is the least suitable for forage production, especially when sown late in autumn and harvested at the beginning of the budding stage (15,3 t ha^{-1}) (Tab.5). Marinkovic & Marjanovic-Jeromela (1998) concluded that the forage yield of oilseed rape is related to the plant height, number of leaves/plant, and plant density.

Tab. 5. The forage yield (t ha^{-1}) depending on the harvest time, genotype and sowing date
Принос крме (t ha^{-1}) у зависности од датума сјетве, датума жетве и генотипа

Genotypes / *генотипови*											
Date *Дат.*	AbaKus		Rohan		Perko		Banacanka		Majdan		
	Forage yield t ha^{-1}/ BBCH scale *Принос крме t ha^{-1} према* BBCH *скали*										
	51	65	51	65	51	65	51	65	51	65	
I	82.4	86.8	67.8	67.5	70.7	71.6	59.4	68.7	42.1	64.4	
II	57.8	64.5	30.7	50.1	33.8	47.9	26.7	43.3	23.3	30.1	
III	30.8	45.1	27.0	43.4	22.7	32.5	19.1	48.2	15.3	38.7	
	Average forage yield t ha^{-1}/BBCH scale *Просјечан принос крме t ha^{-1} према* BBCH *скали*										Average forage yield t ha^{-1} depending on the sowing date *Просјечан принос крме t ha^{-1} у зависности од датума сјетве*
I	84.6		67.6		71.1		64.1		53.2		68.1*
II	61.1		40.4		40.9		35.0		26.7		40.8*
III	37.9		35.2		27.4		33.6		27.0		32.2
	Average forage yield t ha^{-1} depending on the genotype *Просјечан принос крме/t/ha^{-1}у зависности од генотипа*										
	61.2*		47.7		46.5		44.2		35.6		

*The difference between average values is significant at 0.05 level

Our experiments gave similar results when considering cultivar AbaKus. On the other hand Mihajlovic et al. (2007) reported that Banacanka

sown in spring produced higher forage yield (31.6 t ha^{-1}) compared to the crop sown in autumn (28.6 t ha^{-1}).

Conclusion

Brassica species have a potential to provide additional or supplement fodder with high fresh forage yields. Generally the forage yields from the first sowing date – September 20, were higher than the forage yields from the second and third sowing date. Regarding the production, it is recommended for the forage mass as feed for livestock to be harvested at 50% of flowering stage. According to our results oilseed rape cultivar AbaKus proved to be the best for the green forage production. In addition, the yield of cv. Perko as a typical forage type is considered as promising.

The two cultivars could be recommended for producing fresh green forage in the Skopje region.

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Принос надземне масе и компоненте приноса пет генотипова уљане репице (*Brassica napus* L.) у зависности од датума сјетве и фазе жетве

Татјана Прентовић[1], Биљана Ристакоска[2], Зоран Димов[1], Златко Арсов[1], Ромина Кабранова[1], Игор Иљовски[1]

[1]Пољопривредно-прехрамбени факултет, Скопље, Република Македонија
[2]Агенција за финансијску подршку у пољопривредни и руралном развоју, Скопље, Република Македонија

Сажетак

Пет генотипова уљане репице је тестирано у условима три различита датума сјетве и жетве извршене у двије фазе развића, у циљу одређивања њиховог утицаја на принос надземне масе и компоненте приноса током вегетационог периода 2013/14. Највеће вриједности густине усјева уочене су у уљаној репици посијаној у трећем року сјетве (86 - 157 биљака/m^2). Од пет генотипова, *AbaKus* је имао највише формираних биљака/m^2 - 109, 106 и 157. Највећа висина биљака била је присутна код биљака посијаних у првом року сјетве (94.7 - 104 cm). Испитивани генотипови су имали највише формираних листова по биљци, од 8.1 то 9.9, у првом року сјетве. Генотип *AbaKus* је показао значајно већи принос крме (61.2 t/ha) у другој фази жетве а скупа са генотипом *Perko* је имао највећи потенцијал приноса надземне масе.

Кључне ријечи: уљана репица, генотип, принос крме, вријеме сјетве, густина склопа

Zoran Dimov
E-mail address: dimov632002@yahoo.co.uk

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