THE IMPACT OF USING COMBINATIONS OF N, S AND B IN OILSEED RAPE - BRASSICA NAPUS L. ON QUANTITATIVE PROPERTIES OF SEED

Igor Iljovski, Romina Kabranova, Zoran Dimov, Vjekoslav Tanaskovikj, Ile Canev, Tatjana Prentovic

Faculty of Agricultural Sciences and Food – Skopje, R. Macedonia

Corresponding author: iiljovski@fznh.ukim.edu.mk

Abstract

As a result of the use of the following elements - nitrogen (N), sulphur (S) and boron (B) - quantitative properties of two genotypes of oilseed rape - Brassica napus L., Zorica (variety) and Rohan (hybrid) were determined. The main purpose of the study was determination of the production mode, set in both genotypes of oilseed rape versus managing various nutrients. An experiment was set in the Skopje region, on total experimental area of 650m^2. For this purpose, the following combinations of fertilizers were used: N_1 with 110 kg/ha nitrogen, N_2 with 150 kg/ha nitrogen, S_1 with 30 kg/ha sulphur, S_2 with 70 kg/ha sulphur, B_1 with 1.0 kg/ha boron, and B_2 with 2.0 kg/ha boron (at spring time, foliar application) versus standard variant: N:P:K in the ratio 10:20:30 (N 50kg/ha, 90 kg/ha P_2O_5 and 180 kg/ha K_2O) used in autumn. During the experiment the following parameters were monitored: height of plants (cm), number of branches per plant, number of pods per plant, length of pod (cm), number of seeds in the silique, and seed yield (t/ha). From the combinations of nutrients and variations that have been set in terms of genotypes, the results of yield showed statistical significance at level of 0.05 from variants N_2PK, $N_2PK+S_2+B_2$ in variety Zorica and $N_1PK+S_1+B_1$ in the hybrid Rohan.

Keywords: *Brassica napus L.*, nitrogen, sulphur, boron, foliar application, yield.

Introduction

During the 20th century, agricultural production has developed a strategy to improve the efficiency of the use of fertilizers and to obtain higher yields through low-cost investments. Today, science has the challenge and opportunity to develop efficiency from the use of certain nutrient element and to present best management practices. In modern agriculture, the application of this strategy should prioritize the development of effective genotypes and perceive the importance of the use of nutrients in increasing yield (Fageria, et al., 2008). Properly used nitrogen levels positively affect the vegetative and reproductive development of the rape, but at the same time increase the utilization of other nutrients such as sulfur (S) and boron (B) (Barker and Bryson, 2006). On the other hand, the use of nitrogen more than necessary can cause the falling down of the stem, increase the content of chlorophyll in the seeds and have a negative impact on the environment (Brennan et al., 2000; Karamanos et al., 2003 and 2007; Et al., 2005). Concerning obtaining the yield of 2000 kg / ha, the needs of nitrogen range from 124-150 kg / ha (Ukrainetz et al., 1975). Sulfur is the fourth most important element in the agricultural production system. The sulfur deficit always reduces the yield of oilseed rape (Malhi and Gill, 2007). Sulfur not only affects the yield increase, but at the same time improves the utilization of nitrogen by plants (Karamanos et al., 2007). The balanced relationship between N and S is crucial in achieving the maximum yield of oilseed rape in sulfur-free conditions (Mahli and Gill, 2007). The requirements of sulfur in oilseed rape are 3-10 times higher compared to barley (Mahli and Gill, 2002). On the other hand, the larger amounts of sulfur cause adverse effects on the quality, increasing the content of glucosinolates - a non-feedable component of oilseed rape (Falk et al., 2007). From microelements, boron (B) plays a leading role in the yield of oilseed rape (Malhi et al., 2003). The lack of boron (B) is a global problem in the production of oilseed rape, with its susceptibility far more pronounced compared with cereals (Grant and Bailey, 1993; Shorrocks,

1997. As a high-demand crop, the demand for oilseed rape for boron are 2 kg / ha, in contrast to corn and wheat where needs for boron are less than 1 kg / ha (Malhi, 2001; Gupta, 2007). The correct use of boron can affect positively the height of plants, number of branches / plants, number of fruits, number of seeds in the silique, oil content, etc. and the seed yield (Stevenson and Cole, 1999), leading to a yield increase of up to 7% (Porter, 1993), or from 7 to 11% (Troeh and Thompson, 2005). The negative effects of boron application are also registered as on the yield of seed (Karamanos et al., 2003). The main purpose of the research is to determine the production regime in the oilseed rape as opposed to the management of various nutrients. The specific objectives are to determine the optimum amount and time of use of nitrogen (N), sulfur (S) and boron (B), on the development, yield components and yield of seed in the examined genotypes.

Material and methods

The experiment was placed in the Skopje region, at the site Hippodrome (41 ° 99'42.57 "N; 21 ° 52'21.07" E), on a total experimental area of 650 m^2, by applying standard agrotechnical measures. The sowing was carried out on October 1 with two genotypes of oilseed rape: Rohan (hybrid) and Zorica (variety), with sowing rate of 8.0 kg / ha (with spinning, if necessary in the spring months). The trial was set in 4 replications, with the dimensions of the basic parcel of 6,6 m^2 (1,10 m x 6,0 m), with five rows in the parcel at the interim distance of 25 cm. The distance between the variants was 0.5 m, and between replications of 1 m. The combinations in the treatment by variants were in the following order: Control Ø, N_1PK, N_2PK, $N_1PK + S_1 + B_1$, $N_2PK + S_2 + B_2$. The choice of dosing was also the amount of application arranged in the following way:

- N_1 - with 100 kg / ha (50 kg pre-season and 50 kg by spring harvesting, at the end of the stem elongation stage and the stage of beginning of flowering, (3rd and 4th stage according to BBCH - Biologische Bundesanstalt, Bundessortenamt and Chemical Industry) in order to create the potential for the formation of fertile branches and complement the loss of wintering;
- N_2 - with 150 kg / ha (50 kg pre-seed and 100 kg by feeding in the spring, at the end of the stretching stage and the stage of beginning of flowering);
- S_1 - with application of sulfur 30 kg / ha of spring soil (beginning of vegetation),
- S_2 - with application of sulfur 70 kg / ha of spring soil (beginning of vegetation),
- B_1 - with the application of pine 1.0 kg / ha (whole quantity at spring time, in stage budding), which is equivalent to 150 g / ha foliar application.
- B_2 - with application of the boron 2.0 kg / ha (on two occasions): 1.0 kg / ha at vegetation start + 1.0 kg / ha in the butonization phase, which is equivalent to 300 g /ha foliar application.
- The quantities of P and K were standard in all variants: 90 kg / ha P_2O_5 and 180 kg / ha K_2O, used from autumn.

The fertilizers used in this research were regulary available on the market: Ammonium nitrate (34%) (17% ammonia and 17% nitrate form), Ammonium sulphate (24%) and boron 8% (Agrosal). The data analysis was perceived through the arithmetic mean, the ratio for the calculation and yield representation in t / ha for each of the variants. The results of the mean values for all parameters were statistically processed by ANOVA single factor analysis and the LSD test was calculated, with the M.Office Excel and SPSS program (PSAW 18).

Results and disscusion

The overwintering of the oilseed rape began in the phase of the foliage (BBCH 3, 13, 19, 21), that was when more than 3 and up to 9 leaves were formed, and the beginning of the forming and development of first side shoots. The plants that have well developed leaf rosette, short and thick hypocotyl and well developed but less elongated epicotyl in autumn successfully withstand low temperatures. In this period, the winter genotypes oilseed rape successfully crossed both development stages – jarization and light stage, when even after severe winter damages caused by low temperatures, they had exceptional regeneration capacity.

Table 1. Height of plants (cm), number of branches / plant, length of silique (cm)

VARANTS	±	Genotype		±	Genotype		±	Genotype	
		Zorica	Rohan		Zorica	Rohan		Zorica	Rohan
ø Contol	193.8	187.5	188.8	7.9	7.2	8.1	6.6	6.7	6.5
N_1PK	194.8	188.8	200.8	8.5	8.0	9.0	6.7	6.8	6.6
N_2PK	193.9	192.5	195.3	8.1	7.3	8.8	6.8	6.9	6.8
$N_1PK+S_1+B_1$	200.3	194.5*	206.0	8.3	7.8	8.3	7.0	7.3	6.8
$N_2PK+S_2+B_2$	196.1*	196.0	196.3	8.3	8.0	8.4	7.1*	7.1	7.2
LSD 0.05	5.04	16.0	16.9	1.10	1.92	2.36	0.54	1.05	1.27
0.01	6.68	21.4	22.5	1.45	2.57	3.10	0.71	1.40	1.70

* Significant at the level of probability P=0.05

Plant height in oilseed rape represents a genetic hereditary characteristic, changes according to the phenological phase in which they are located and is right-oriented with the uptake of genotypes in the later stages of development. Thus, an average of the inflorescence emergence (BBCH 53, 55), until maturing (BBCH 79 - almost all siliques reached the final size), and full ripeness (89 - nearly all siliques ripe, seeds dark and hard), the plants increased their height almost three times, which was the result of intense growth and development in this period of vegetation. The highest plants were recorded in variant $N_1PK+S_1+B_1$ (200.3 cm), while the lowest growth was recorded by plants from the control variant. Statistical significance for the plant height parameter was determined in the variant $N_2PK+S_2+B_2$ (196.1cm) at the level of 0.05 (Table 1). Regarding the two genotypes, the applied doses of fertilizers showed a statistically significant effect in the Zorica genotype at a level of 0.05 in variants $N_1PK+S_1+B_1$ (194.5 cm). The number of branches of the plant in oilseed rape depends on the time of sowing and the application of other agrotechnical measures during the vegetation. In the specific trials, the number of branches / plants was determined on two occasions: 1. flowering stage and 2. full-maturation stage (89). The data in Table 2 shows that the average number of branches in all examined variants ranges from 7.9 to 8.3 in the variant $N_2PK+S_2+B_2$. Among the genotypes there is no statistical difference, and the difference in the number of branches per plant ranges from 7.2 in the control variant to 8.0 in variants N_1PK and $N_2PK + S_2 + B_2$ for Zorica genotype and 8.1 to 9 , 0 for Rohan genotype. With respect to the length of the siliques, the values range from 6.6 cm in the control variant to 7.1 cm in the variant $N_2PK+S_2+B_2$. In terms of statistical feasibility, the values of this characteristic showed the significance of the variant $N_2PK+S_2+B_2$ at level of 0.05.

Table 2. Number of siliques / plant and numper of seeds / silique

VARIANTS	±	Genotype		±	Genotype	
		Zorica	Rohan		Zorica	Rohan
ø Control	281.1	257.3	305.0	25.0	24.5	25.5
N_1PK	332.6	297.0	368.3	27.4*	24.8	28.5*
N_2PK	330.6	295.8	365.5	27.0*	26.5	27.3
$N_1PK+S_1+B_1$	352.5*	348.5*	356.5	29.0**	27.3**	29.5**
$N_2PK+S_2+B_2$	363.8**	338.0*	389.5*	29.3**	28.2**	28.8*
LSD 0.05*	59.5	69.12	87.81	1.90	2.79	2.64
0.01**	78.7	92.48	117.49	2.52	3.73	3.54

*;** Significant at the level of probability P=0.05 and P=0.01

In the study, the number of siliques / plants ranged from 288.1 in the control variant to 363.8 in the variant $N_2PK+S_2+B_2$ with a difference of 82.7 siliques (Table 2). Regarding the genotypes, the Rohan hybrid had a minimum of 305 siliques in the control variant up to maximum of 389.5 siliques in the variant $N_2PK+S_2+B_2$ and was characterized by the formation of a greater number of siliques of the plant in almost all other variants of the experiment. In the Zorica genotype, the lowest number of siliques was found in control whey, whereas the highest number of fruits (348.5) were determined with the applied quantities of the variant $N_1PK+S_1+B_1$. For the number of siliques per plant, the smallest significant difference at the level of 0.05 showed the variant $N_1PK+S_1+B_1$, and at the level of 0.01% quantities of the variant $N_2PK+S_2+B_2$ (363.8). The highest number of seeds per silique was obtained in the variants $N_1PK + S_1 +B_1$ (29.0) and in the variant $N_2PK+S_2+B_2$ (29.3), the control variant formed siliques with the lowest number of seeds, on average 25.0. The genotype Rohan had a higher number of seeds / pod in all other variants in relation to the genotype Zorica. Statistically significant difference was appeared in all variants: the variants and the level of 0.05, the variants N_1PK (27.4), and N_2PK (27.0), while the level of 0.01 in variants $N_1PK+S_1+B_1$ and $N_2PK+S_2+B_2$. In terms of genotype, genotype Zorica showed significance only at the level of 0.01 in variants $N_1PK+S_1+B_1$ and $N_2PK+S_2+B_2$, while genotype Rohan determining a significance level 0.05 in variants N_1PK and $N_2PK+S_2+B_2$, and level of 0.01 in the variant with the smaller applied quantities of all used elements $N_1PK+S_1+B_1$.

Table 3. Yield (t/ha)

VARIANTS		±	Genotype		STDEV (ρ)
			Zorica	Rohan	
Ø Control		3.96	3.33	4.54	0.84
N_1PK		4.29	3.83	4.75	1.00
N_2PK		4.63	4.83*	4.42	0.82
$N_1PK+S_1+ B_1$		5.21*	4.42	6.00*	1.01
$N_2PK+ S_2 +B_2$		5.08*	4.92*	5.25	0.87
LSD	0.05 *	1.02	1.27	1.15	
	0.01**	1.35	1.69	1.54	

* Significant at the level of probability P=0.05

In terms of yield (Table 3), statistical significance at the level of 0.05 showed variants $N_1PK+S_1+B_1$ and the variant $N_2PK+S_2+B_2$ with realized yields of 5.21 t / ha and 5.08 t / ha. Regarding the genotypes, the statistical significance at the level of 0.05 showed genotype Zorica with variants N_2PK (4.83 t / ha) and $N_2PK+S_2+B_2$ (4.92 t / ha), while genotype Rohan achieved the highest yield in the variant $N_1PK+S_1+B_1$ (6.00 t / ha).

Conclusion

Methodologically set and used combinations of nutrients that have a higher importance for oilseed rape achieved a higher yield in variants $N_1PK+S_1+B_1$ and variant $N_2PK+S_2+B_2$. In relation to the examined genotypes, significant results for specific quantitative properties were obtained from variants N_2PK, $N_2PK+S_2+B_2$ in variety Zorica and $N_1PK+S_1+B_1$ in the hybrid Rohan (yield of 6.00 t / ha). Our research will expanding over the next years to monitor the impact of these nutritional elements in given combinations and in different meteorological conditions. Thus, we could recommend an adequate and economical combination for high yield and high quality rapeseed on the territory of Macedonia.

References

1. Barker A. V., Bryson G. M. (2006). Handbook of plant nutrition. CRC Press, Boca Raton, USA 2149.
2. Brennan R., Mason M., Walton G. (2000). Effect of nitrogen fertilizer on the concentrations of oil and protein in canola (Brassica napus) seed. Journal of Plant Nutrition, 23(3), 339-348.
3. Falk K., Tokuhisa J., Gershenzon J. (2007). The effect of sulfur nutrition on plant glucosinolate content: physiology and molecular mechanisms. *Plant Biology, 9* (5), 573-58.

4. Fageria N. K., Baligar V. C., LiY. C.(2000).The Role of Nutrient Efficient Plants in Improving Crop Yields in the Twenty First Century, Journal of Plant Nutrition, Volume 31, pages 1121-1157.
5. Grant C., Bailey L. (1993). Fertility management in canola production. *Canadian Journal of Plant Science, 73*(3), 651-670.
6. Gupta U. (2007). Boron, in *A.V. Barker, D.J. Pilbeam (eds.) Handbook of plant nutrition.* CRC Press, Boca Raton, USA 241-277.
7. Karamanos R., Goh T., Flaten D. (2007). Nitrogen and sulphur fertilizer management for growing canola on sulphur sufficient soils. *Canadian Journal of Plant Science, 87*(2), 201-210.
8. Karamanos R., Goh T., Stonehouse T. (2003). Canola response to boron in Canadian prairie soils. *Canadian Journal of Plant Science, 83*(2), 249-259.
9. Malhi S. S. (2001). Improving Canola Yields with Balanced and Efficient Nutrition. Final report prepared for canola council of Canada [Online] www.saskcanola.com/ quadrant/System/research/reports/report-Malhi-balancednutrition-long.pdf
10. Malhi S., Gill K. (2002). Effectiveness of sulphate-S fertilization at different growth stages for yield, seed quality and S uptake of canola. *Canadian Journal of Plant Science, 82*(4), 665-674.
11. Malhi S., Raza M., Schoenau J., Mermut A., Kutcher R., Johnston A., Gill, K. (2003). Feasibility of boron fertilization for yield, seed quality and B uptake of canola in northeastern Saskatchewan. *Canadian Journal of Soil Science, 83*(1), 99-108.
12. Nadian H., Najarzadegan R., Saeid K. A., Gharineh M., Siadat A. (2010). Effects of Boron and Sulfur Application on Yield and Yield Components of Brassica napus L. in a Calcareous Soil. *World Applied Sciences Journal, 11*(1), 89-95.
13. Porter, P. (1993). Canola response to boron and nitrogen grown on the southeastern coastal plain 1. Journal of Plant Nutrition, 16(12), 2371-2381.
14. Rathke G.W., Christen O., Diepenbrock W. (2005). Effects of nitrogen source and rate on productivity and quality of winter oilseed rape (*Brassica napus L.*) grown in different crop rotations. *Field Crops Research, 94* (2), 103-113.
15. Shorrocks V. M. (1997). The occurrence and correction of boron deficiency. Plant and Soil, 193 (1-2), 121-148.
16. Stevenson F. J., Cole M. A. (1999). Cycles of soils: carbon, nitrogen, phosphorus, sulfur, micronutrients: Wiley.com
17. Troeh F. R., Thompson L. M. (2005). Soils and soil fertility: Blackwell Ames 211-231, 269-305.
18. Ukrainetz H., Soper R. J., Nyborg M. (1975). Plant nutrient requirements of oilseed and pulse crop, in J. T. Harapiack, ed. Oilseed and pulse crops in western Canada - A symposium. Western Cooperative Fertilizers Ltd.Calgary, AB 325-374.
19. Weber E., BleiholderH. 1990. Erläuterungen zu den BBCH-Dezimal-Codes für die Entwicklungsstadien von Mais, Raps, Faba-Bohne, Sonnenblume und Erbse – mit Abbildungen. Gesunde Pflanzen 42, 308-321.