Effect of increasing doses of boron on oil production of oilseed rape (*Brassica napus* L.)

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Abstract: The aim of the experiment was monitoring importance of boron in nutrition of oilseed rape (*Brassica napus* L.) as well as the effect of rising doses of boron on oiliness of rapeseed. The small plot field experiments were based at the Research – Breeding Station Vígľaš – Pstruša. The block method of experimental plot size of 10 m^2 in quadruplicate was used and hybrid Baldur was seeded and fertilized by the same doses of nitrogen and sulfur (183 kg $N.ha^{-1}$, 46.5 kg $S.ha^{-1}$) and different doses of boron (200 g $B.ha^{-1}$, 400 g $B.ha^{-1}$, 800 g $B.ha^{-1}$). The highest oil content in seed was observed at unfertilized control treatment 41.61 % and the lowest 37.49 % at the treatment, where only nitrogen and sulfur was applied. The increasing oil content in the seed was also observed. The oil content was by 3.96 % higher at the treatment fertilized by the highest dose of boron than at the treatment fertilized only by nitrogen and sulfur. From this it follows that the boron nutrition positively influences the oil content in seeds of oilseed rape (*Brassica napus* L.).

Key-Words: oilseed rape, boron, oil content

Introduction

Oilseed rape (*Brassica napus* L.) has really significant position in the global cultivation of oilseed crops. Its share in the total production of oil reached about 10.5 to 12.5% in recent years. Oilseed rape (*Brassica napus* L.) and the sunflower (*Helianthus annuus*) belong to the main oilseed crops in the Slovak Republic. The seed of oilseed rape (*Brassica napus* L.) is mostly processed in food industry to produce oil. The oilseed rape´s seed contains on average 45 to 47% oil, 28-30% protein, 3% fiber, nitrogen-free extract (NFE) and ash. About 20% of the total weight of the seed of oilseed rape consists of the testa, which contains 15% oil, 15 protein and 30% fiber [1]. Especially the content of the saturated and unsaturated fatty acids is the decisive factor of the quality of the obtained fat. The oil obtained from the seed is used also in industry to produce varnish, detergents and cleaning products, soaps, glycerin, cosmetics and in the leather and rubber industry, too. In addition to the use of oilseed rape (*Brassica napus* L.) in food industry, seed of oilseed rape (*Brassica napus* L.) is used to produce a biodiesel in recent years. This type of biodiesel is called rape methyl ester, which is used as a renewable source of energy instead of oil and fossil fuels [2]. Besides the nutrition and fertilization the content of oil in oilseed rape´s seeds is affected also by following factors: crop year (0.5%), variety (1 – 4%), soil compaction (0.5%), post-harvest treatment (0.5 – 1%) and some agrotechnical influence [3].

Dicotyledonous plants of the crucifer family demand a high level of boron. Especially oilseed rape (*Brassica napus* L.) is sensitive to boron deficiency [4]. The collapse of growth cone and roots are symptoms of boron deficiency. Strong growth of side shoots which usually collapse shortly is also observed. Chlorosis of upper leaves is sometimes noticed. Plants flower fewer, loose their flowers, produce only a few seeds or even any seeds. Pods and seeds are deformated. Symptoms of boron deciciency may be confused with symptoms of potassium deficiency [5]. At present, boron fertilization of oilseed rape is often discussed theme [6, 7]. The specificy of boron is its extremely narrow margin between lack and surplus (toxicity) [8]. For this reason, there are different opinions on boron fertilization methods, application rates and economics (profitability) of oilseed rape´s growing. Foliar application of boron in conditions of its limited availability may be more effective than the application of boron to the soil [6, 7]. Appropriate time for foliar nutrition is from a phase of extension growth to a phase of start flowering [2]. Boron fertilization has a significant impact not only on yield seeds, but also on the oil content in seeds. Boron fertilization increases yield seeds and partially improves the quality of the oil [9, 10].

We focused on monitoring the effect of increasing foliar doses of boron on oiliness of oilseed rape (*Brassica napus* L.), in this paper. We explored its influence on the content of oil in oilseed rape´s seeds.

Material and methods

Small plot field nutritionists experiments were based at Research – Breeding Station Vígľaš – Pstruša. These experiments were focused on oilseed rape´s nitrogen, sulfur and boron nutrition. There was used block method of experimental plots with plot size 10 m^2 tested in quadruplicate. Hybrid Baldur was seeded. Quantity of seeds was 0.5 million germinable seeds per 1 ha. The oat (*Avena sativa* L.) was a previous crop. Research – Breeding Station Vígľaš - Pstruša belongs to the potato growing region at an altitude of 375 m. Soil type is podzolic brown soil. Climatic region is warm, slightly damp with cold winters. The average annual temperature during the growing season is 14°C . Average annual rainfall is 666 mm, with prevailing north winds. The amount of rainfall in autumn fluctuated in the long-term standard, in years of cultivation (see Table 1).

Also there was good conditions for emergence and rooting of oilseed rape. Temperatures were relatively steady during the years of cultivation (see Table 2).

In small plot field experiment was studied the effect of increasing foliar boron doses on oiliness of oilseed rape´s seeds. Before setting up a coppice was applied 100 kg of ammonium nitrate (27 kg $N.kg^{-1}$), 100 kg of potassium salt (50 kg $K.ha^{-1}$) and 100 kg of ammophos (12 kg $N.ha^{-1}$, 23 kg $P.ha^{-1}$). On the basis of soil agrochemical analysis, spring regeneration fertilizing of oilseed rape (*Brassica napus* L.) by nitrogen and sulfur in the form of ANAS was realized in growth phase BBCH 19-20. The production and qualitative foliar fertilization of UAN by Folibor (4% B) in growth phases BBCH 29 – 30 and BBCH 59 – 60. Doses of nitrogen, sulfur and boron are stated in the Table 3.

Soil analysis were performed by routin analytical methods (Mehlich III). The impact of treatments of fertilization on the content of oil in oilseed rape´s seed was monitored after the harvesting. The oil content was performed according to the standard STN 4610111-28. The determination was realized by the extraction for assistance to petroleum ether (50/70). The apparatus DET-GRAS N (P Selecta) was used for this determination. A superfluous extractant was distilled after the extraction. An obtained oil was drained and weighed. For the calculation of oil content in oilseed rape´s seed was used this formula:

$W = m_1/m_2 * 100$

m_1 = the amount of extracted oil (g)

m_2 = mass of the test sample (g)

Table 1 The average monthly precipitation in 2007-2009 (the evaluation of month precipitation normality according to the long-term average of 1961 – 2001)

Month	Long-term average	2007		2008		2009	
		Percipi-tation (mm)	Evaluation of normality	Percipi-tation (mm)	Evaluation of normality	Percipi-tation (mm)	Evaluation of normality
I.	28.1	-	-	29.9	normal	39.2	wet
II.	28.5	-	-	19.9	normal	40.2	wet
III.	29.8	-	-	49.6	wet	49.4	wet
IV.	46.7	-	-	36.3	normal	11.0	very dry
V.	63.9	-	-	64.2	normal	62.8	normal
VI.	85.2	-	-	59.4	dry	96.4	normal
VII.	75.6	-	-	117.5	wet	34.2	dry
VIII.	61.6	-	-	35.9	normal	35.6	normal
IX.	49.5	49.6	normal	40.9	normal	-	-
X.	45.7	38.9	normal	49.8	normal	-	-
XI.	53.5	18.6	very dry	35.8	normal	-	-
XII.	41.8	32.8	normal	83.5	very wet	-	-

Table 2 The average monthly temperatures in 2007-2009 (the evaluation of month air temperature normality according to the long-term average of 1961 – 2001)

Month	Long-term average	2007		2008		2009	
		Tempera-ture (ºC)	Evaluation of normality	Tempera-ture (°C)	Evaluation of normality	Tempera-ture (ºC)	Evaluation of normality
I.	-3.8	-	-	0.1	very warm	-4.4	normal
II.	-1.5	-	-	1.8	very warm	-1.2	normal
III.	2.8	-	-	4.0	normal	3.4	normal
IV.	8.4	-	-	9.7	normal	11.5	very warm
V.	13.1	-	-	14.5	normal	14.4	normal
VI.	16.3	-	-	18.4	very warm	16.1	normal
VII.	17.8	-	-	18.7	normal	19.8	very warm
VIII.	17.3	-	-	18.1	normal	19.5	very warm
IX.	13.2	11.8	cold	12.8	normal	-	-
X.	8.1	8.0	normal	10.0	warm	-	-
XI.	3.0	2.3	normal	4.9	very warm	-	-
XII.	-1.6	-2.6	normal	1.5	very warm	-	-

Table 3 Variants of oilseed rape nutrition, hybrid Baldur, Vígľaš

Treatment	Fertilization level						The total spring dose of N ($kg.ha^{-1}$) and B ($g.ha^{-1}$)	
	Regenerative fertilization		Production fertilization		Qualitative fertilization			
	BBCH (19 - 20)		BBCH (29 - 30)		BBCH (59 - 60)			
	N ($kg.ha^{-1}$)	S ($kg.ha^{-1}$)	N ($kg.ha^{-1}$)	B ($g.ha^{-1}$)	N ($kg.ha^{-1}$)	B ($g.ha^{-1}$)	N total	B total
1	0	0	0	0	0	0	0	0
2	93	46.5	60	0	30	0	183	0
3	93	46.5	60	200	30	0	183	200
4	93	46.5	60	400	30	0	183	400
5	93	46.5	60	400	30	400	183	800

Results and Discussion

The average yield of seeds of oilseed rape (*Brassica napus* L.) fluctuated from 2.15 to 3.19 $t.ha^{-1}$. The lowest average yield of rapeseed was found out in unfertilized control treatment 1 (2.15 $t.ha^{-1}$). Statistically significant differences compared to the unfertilized treatments 3, 4 and 5, where were applied different doses of boron (200 g, 400 g, 800 $g.ha^{-1}$). It is increase by 30.7%, 42.3% and 48.4%, in percentage term. The highest yield of seeds of oilseed rape (*Brassica napus* L.) 3.19 $t.ha^{-1}$ was found out where was to nitrogen and sulfur fertilization added boron at dose 800 $g.ha^{-1}$ [11]. The average oil content of variants moved a range from 37.49% to 41.61%. The highest average oil content was found at the first control (unfertilized) treatment, where the oil content was 41.61%. The lowest average oil content 37.49% was observed at the second treatment, where only nitrogen and sulfur was applied. The oil content at this treatment was statistically significantly lower by 9.9% compared to the control treatment. The averege oil content 41.45% was at the fifth experimental treatment where the highest boron dose 800 $g.ha^{-1}$ was applied. The oil content at the fifth treatment was statistically significant by 3.96% higher compared to the treatment fertilized only by nitrogen and sulfur.

From the following findings it follows that by application of increasing boron doses at different treatments was observed increasing oil content compared to treatment fertilized only by nitrogen and sulfur (see Table 4, 5).

Table 4 Effect of increasing doses of boron on oil content in oilseed rape seed (hybrid Baldur) in 2007-2008 and 2008-2009

Treatment	Oil content in seed %			
	2007 - 2008	2008 - 2009	Average 2007-2008 and 2008-2009 in %	Relatively in %
1	41.64	41.57	41.61 ± 1,45 Cb	100
2	37.31	37.66	37.49 ± 1,45 Aa	90.10
3	38.02	37.65	37.84 ± 1,45 ABa	90.94
4	38.91	42.46	40.69 ± 1,45 BCb	97.79
5	39.88	43.01	41.45 ± 1,45 Cb	99.62
LSD $_{0,05}$ treatment			2.25	
LSD $_{0,01}$ treatment			3.12	

Averages indicated by different letters are statistically significantly different on the significance level of α = 0.05 (small letters) and α = 0.01 (capital letters)

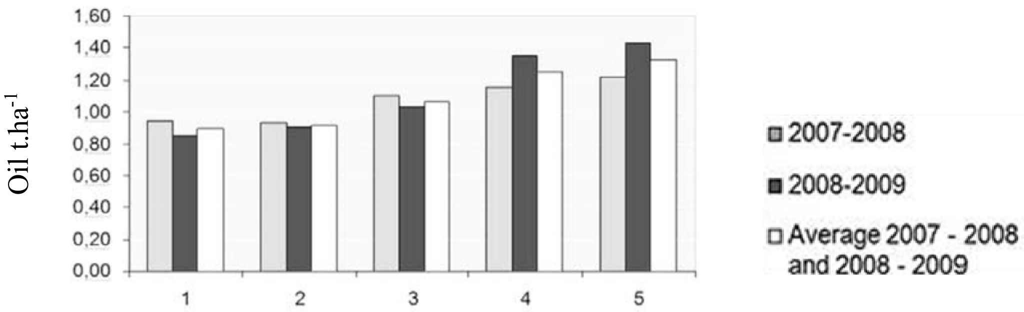
Table 5 Statistical evaluation of oil content in oilseed rape seed (hybrid Baldur) in experimental years (average of treatments)

Year	Oil content %	LSD test $_{0.05}$	LSD test $_{0.01}$
2007 – 2008	39.15	1.42	1.98
2008 – 2009	40.47		

Averages indicated by different letters are statistically significantly different on the significance level of α = 0.05 (small letters) and α = 0.01 (capital letters)

In other experiments was oilseed rape fertilized by nitrogen doses 0, 80, 160 and 240 kg $N.ha^{-1}$. There was found out the lowest oil content in seeds (43.8 – 44.1%) at treatments fertilized by nitrogen doses 160 and 240 kg $N.ha^{-1}$. The highest oil content 47.25% was at treatment, where wasn´t any nitrogen dose [12]. A large number of thesis clearly demonstrate the connection of boron with complex of processes of plant mineral nutrition [2]. In experiments with oilseed rape fertilized by 120 kg $N.ha^{-1}$, 20 kg $P.ha^{-1}$, 56.8 kg $K.ha^{-1}$ and 300 g $B.ha^{-1}$ was found out the oil content in seeds 42.5%. Compared to unfertilized treatment (41.9% oil), oil content increased by 0.6%, at the treatment fertilized by N, P, K and B [13]. The variety of oilseed rape Huashuang 4 was fertilized by 150 kg $N.ha^{-1}$ a 250 g $B.ha^{-1}$. The oil content was 37.8%. It was by 3% higher compared to the control (unfertilized) treatment (34.8%) [10]. The highest average yield of oil 1.33 $t.ha^{-1}$ was reached at fifth treatment, where was applied the highest boron dose. Compared to the unfertilized treatment, where was the highest average percentage oil content in dry mater, oil content at fifth treatment was by 0.43 $t.ha^{-1}$ higher. The lowest average oil content 0.90 $t.ha^{-1}$ was achieved at the unfertilizered control treatment (see Fig. 1). These findings indicate that boron is an essential nutrient for oilseed rape (*Brassica napus* L.) and boron nutrition positively influences the oil content in seeds of oilseed rape (*Brassica napus* L.). However, it is necessary to take into account the fact that oilseed rape (*Brassica napus* L.) is sensitive to boron, when the dose of boron is determinated.

Fig. 1 Effect of increasing doses of boron on the oilseed rape oil yield (hybrid Baldur) in 2007 – 2008 and 2008 – 2009.



Conclusion

The effect of the increasing foliar boron doses on the oiliness of rapeseed during the spring vegetation was monitored in the small field experiments. The highest average oil content was found out at the first control unfertilized treatment, where the oil content was 41.61%. The highest boron dose 800 $g.ha^{-1}$ was applied at the fifth treatment. There was found out average oil content 41.45%, at this treatment.

The oil content at this treatment was statistically significantly higher by 3.96% compared to the treatment fertilized only by nitrogen and sulfur. The oil content in seeds of oilsed rape (*Brassica napus* L.) was stabilized by boron application. There was applied, besides nitrogen and sulfur, also boron 400 $g.ha^{-1}$ and 800 $g.ha^{-1}$, at these treatments. From this it follows that, boron application in fertilization of oilseed rape (*Brassica napus* L.) is well-founded.

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