Research Findings

Photo by T. Popp.

The Effect of Different Potash and Magnesium Fertilizers and Timing of Application on Yield and Oil Content of Oilseed Rape

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Abstract

In recent years oilseed rape has become an important oil producing crop in Bulgaria. Lack of both experience in cultivation and knowledge of best fertilizer management gave IPI grounds for carrying out farm field trials. The results of the experiment conducted at two locations varying in phosphorus (P), potassium (K) and magnesium (Mg) levels are presented in the paper, studying the effect of different potash and magnesium fertilizers and timing of their application on yield and oil content of the crop. Nitrogen (N) and P were applied in the autumn (15% of N and all P) and in spring (85% of N). In both locations, the positive effect of potassium fertilization was clear. K application increased yield of seeds, oil content in the seeds and consequently the oil yield per unit area. The effect of K on both yield and oil content resulted in an increase of up to 50% in the oil yield: the yield was highest in Bardarski Geran, where soil K is high. Summarizing the results of the two experiments, we can conclude that split application of K (120 kg K_2O ha^{-1} in autumn and 60 kg K_2O ha^{-1} in spring) is more effective than a single autumn application. The effect of Mg application was not so clear-cut, probably due to the different moisture conditions during the experimental years. The results

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are important for agricultural practice in Bulgaria. They clearly show that K, and to a lesser extent Mg, are important nutrients for successful rapeseed cultivation and that split application of K and Mg between autumn and spring is of benefit.

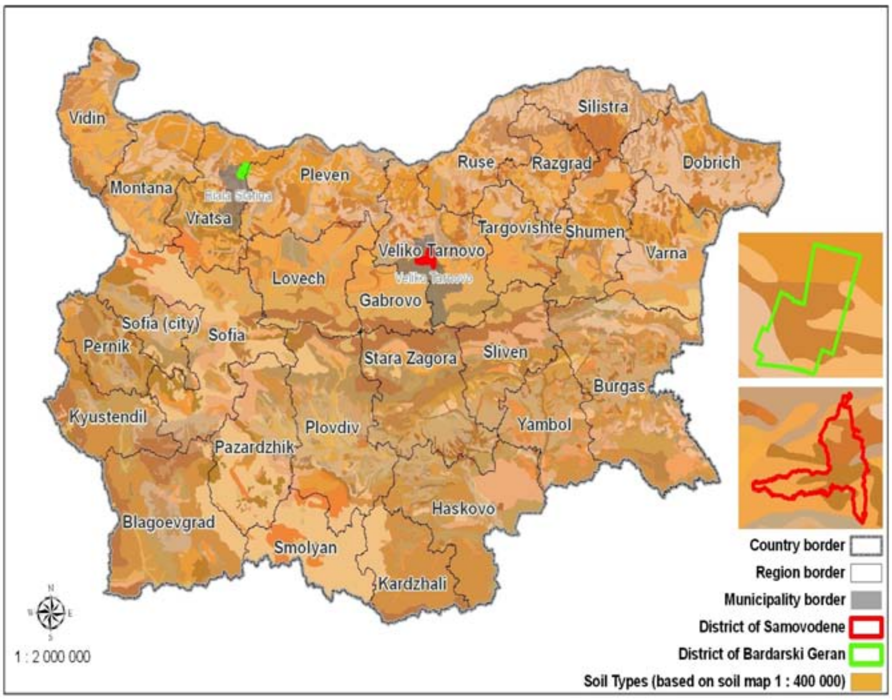
Introduction

Winter rapeseed comes second to sunflower as an oil producing crop in Bulgaria. It is a crop that has not been grown traditionally in Bulgaria but has become more popular with the production of biofuels. The area under cultivation has grown significantly over recent years from 8,000 ha in 2000 to 144,000 ha in 2012. Farmers are therefore not greatly experienced in the management of this crop, i.e. tillage, fertilization, plant protection and rotational considerations, and only a few investigations in the country have been made on the response of rapeseed to fertilization (Ivanova, 2008; Ivanova and Stoyanova, 1998). Fertilizer recommendations are thus mainly based on experience from abroad.

This lack of information on winter rapeseed response to potassium (K) and magnesium (Mg) application led IPI to conduct field trials. In this paper we present the results of two trials studying the effect of different potash and magnesium fertilizers and their times of application on yield and oil content of the crop.

Materials and methods

The trials were conducted during 2008/2009 and 2010/2011 in the West (district of Bardarski Geran, Montana region) and in the central part of North Bulgaria (district of Samovodene, V. Tarnovo region) - representative of oilseed rape regions (see Map). The initial chemical characteristics of these soils are given in Table 1. The two soils differ markedly in K and Mg content - in Bardarski Geran (A), the soil is well supplied with K and Mg whereas in Samovodene (B) the soil was low in both nutrients.



Map. Location of the experiments in Bulgaria.

Table 1. Initial soil nutrient contents and pH values in the upper layer (0-30 cm) and soil classification of the two experimental sites.

Trial	Site area	Classification	pH	P_2O_5	K_2O	MgO
			KCl	----------*mg 100 g*$^{-1}$----------		
A	Bardarski Geran, Montana region	Haplic Chernozem, medium	6.1	4.1	28.0	45.0
B	Samovodene, V. Tarnovo region	Haplic Chernozem, medium	7.1	2.6	11.6	8.0

Standard analytical methods of the country were used for soil analysis:

- pH - in KCl (ISO 10390:2002).
- Available phosphorus (P) and K - extraction with ammonium acetate and potassium lactate (pH-4.2) followed by measurement of P spectrophotometrically and K by flame photometer.
- Exchangeable Mg - extraction with 1M KCl (1:10) followed by measurement using AAS.

The rapeseed grown in the trial was the variety Trabant. At harvest the yields were recorded and soil and plant samples were taken for chemical analysis (data of soil analysis is not reported in this paper).

The analytical determination of oil content of the seeds was determined using petroleum ether as an extraction solvent (AOAC Official Method, 2003).

Experimental design and treatments

In each experiment there were two controls - a control without fertilization and an NP control treatment without K and Mg. Nitrogen (N) rates were the same for both experiments at 187 kg N ha^{-1}, applied as ammonium nitrate (33.5% N). P rates differed depending on the soil content; TSP (46% P_2O_5) was applied. K rates were the same at both locations - 180 kg K_2O ha^{-1} - and in three of the treatments Mg was added. The effect of basal and split application of K and Mg was also investigated. The K and Mg fertilizers applied were MOP (60% K_2O) and kieserite (25% MgO, 20% S). K and Mg were applied in different forms and times as shown in Table 2. As Mg was supplied as kieserite ($MgSO_4$), both Mg and sulfur (S) were applied simultaneously. Unfortunately this addition of S together with the Mg was not balanced in the treatments without kieserite application. This omission to some extent complicates the interpretation of the effect of kieserite as a source of Mg because yield and oil content can be influenced by both Mg and S. This point is taken into consideration in interpretation of the results.

Results

Trial A: Bardarski Geran (2008/2009)

Yield

The 2008/09 growing season was not very favorable for winter rapeseed, being relatively dry during vegetative growth and with heavy rains during the harvest period. As a consequence the yields obtained were relatively low (Table 3).

K and K-Mg fertilization exerted a strongly positive influence, increasing yield by 12-43% compared to the control. The highest yield associated with high oil content was obtained after application of MOP + kieserite in the autumn and kieserite in the spring - the yield increase was 43.5% or 645 kg ha^{-1} more than in NP treatment and an additional 765 kg ha^{-1} compared to the control. This is the treatment with highest Mg and S rate, which clearly indicates that split application of kieserite (40% in autumn and 60% in spring) is most effective. On the other hand, however, split application of K (⅔ in autumn and ⅓ in spring) produced almost equally good results with a yield increase of 31.7% compared to the control. The importance of K for rapeseed cultivation can be demonstrated in the K autumn treatment, which gave 24% more yield compared to the control. The lowest yield increase of 12-13% was achieved by K+Mg application, both as basal (autumn) and split (autumn + spring).

It is interesting to note that while yield levels were low at this site due to adverse growing conditions (see above), a response to the application of both K and Mg fertilizers was obtained. Despite the very high levels of native K and Mg in the soil on this trial site, these were inadequate to cover the demand of the crop for these nutrients at certain growth stages, even under relatively low yield demand. It can be presumed that kieserite application, especially in the spring, had a positive S effect on crop performance.

Oil content

The oil content in the seeds varied between 20.9 and 24.9%. The data in Table 3 show clear positive effect of Mg/S on the oil content. The NP and NPK fertilization did not influence the oil content in the seeds compared to the control. The highest increase in oil content was observed in treatments with Mg/S.

Oil yield

The calculated oil yield data shows visible differences between the treatments (Table 3). A very high increase in oil yield was recorded in rapeseed applied with K+Mg in the autumn and Mg in the spring - 55% more than in the control treatment and 50% more than in the NP treatment. Oil yield was also greatly raised by the

Table 2. Treatments applied in the experiments (A in 2009 and B in 2011).

No.	Fertilizer	Autumn					Spring			
		N	P_2O_5	K_2O	MgO	S	N	K_2O	MgO	S
		kg ha^{-1}								
		Trial A (Bardarski Geran, Montana region)								
1	Control	0	0	0	0	0	0	0	0	0
2	NP	27	69	0	0	0	160	0	0	0
3	NPK	27	69	180	0	0	160	0	0	0
4	NPKMg (autumn Mg)	27	69	180	27	18	160	0	0	0
5	NPKMg (split Mg)	27	69	180	27	18	160	0	40	32
6	NPKMg (split K; spring Mg)	27	69	120	0	0	160	60	9	6
7	NPKMg (split K and Mg)	27	69	120	18	12	160	60	9	6
		Trial B (Samovodene, V. Tarnovo region)								
1	Control	0	0	0	0	0	0	0	0	0
2	NP	27	80	0	0	0	160	0	0	0
3	NPK	27	80	180	0	0	160	0	0	0
4	NPKMg (autumn Mg)	27	80	180	27	18	160	0	0	0
5	NPKMg (spring Mg)	27	80	180	0	0	160	0	40	32
6	NPK (split K)	27	80	120	0	0	160	60	0	0
7	NPKMg (split K and Mg)	27	80	120	18	12	160	60	9	12

Table 3. Yield and oil production in rapeseed (cv. Trabant) as affected by K fertilization, obtained from two growing seasons and two contrasting locations.

No.	Treatments		Trial A: Bardarski Geran (2008/2009)				Trial B: Samovodene (2010/2011)			
	Autumn	Spring	Yield	Relative yield	Oil content	Oil yield	Yield	Relative yield	Oil content	Oil yield
			kg ha⁻¹	-------------%-------------		*kg ha⁻¹*	*kg ha⁻¹*	-------------%-------------		*kg ha⁻¹*
1	0	0	1,758 a	100	23.0	404	4,406 a	100	27.0	1,190
2	NP	N	1,878 ab	107	22.3	418	5,094 bc	116	25.5	1,299
3	NPK	N	2,180 bcd	124	20.9	457	5,469 bc	124	24.7	1,352
4	NPKMg	N	1,973 abc	112	24.8	490	5,562 c	126	23.1	1,285
5	NKPMg(1)	NMg	2,523 d	143	24.8	625	5,300 bc	120	25.6	1,358
6	NPK	NKMg(1)	2,316 cd	132	24.9	577	5,625 c	128	26.4	1,485
7	NPKMg	NKMg	1,993 abc	113	22.8	454	4,875 ab	111	25.2	1,230

Means with the same letter are not significantly different at $p = 0.05$.
(1)Mg in location A only.

application of K in autumn and K+Mg in spring - 43% increase as compared to the non-fertilized control.

These results indicate the importance of K and Mg under stress conditions. Despite the unfavorable conditions for the oilseed rape crop, the higher yields and higher oil contents in the K+Mg treatments assured higher oil yields.

Trial B: Samovodene (2010/2011)

Yield

The year 2011 was a good one for oilseed rape and high yields were obtained (Table 3). The application of K had a positive effect on yield increase (10-28% compared to the control). Adding Mg to the K fertilizer did not have such a significant effect on the seed yield compared to the Bardarski Geran site, even though the Mg content in the soil was relatively low. An explanation of this may be that the applied rates of Mg were not high enough to produce an effect. However, autumn application of K and Mg resulted in a yield increase of 24%, and K in autumn in combination with K and Mg in spring gave 20% more seed yield compared to the control. Concerning the time of K application, it should be mentioned that in Bulgaria K is traditionally applied in the autumn. In this treatment of the trial, the yield increase was about 24% higher than the unfertilized control and 7.4% more than the NPK_0 treatment. Splitting the K application between autumn and spring, however, induced an even greater effect - 27.7% yield increase compared to the control treatment and 10.4% compared to the NPK_0. Under the conditions of low K content in the soil, "spoon feeding" K had a strong influence on yield formation.

Oil content

The oil content of the rape seed was between 23.1% and 27.0% (Table 3). Generally in the fertilized treatments, oil content was slightly lower, most likely due to higher yields and the resulting dilution effect. Lowest oil content was registered after autumn K+Mg fertilization. In the treatments with K and Mg fertilization, the oil content was highest when split (autumn and spring) MOP fertilization was applied.

Oil yield

Despite the fact that K and K+Mg did not increase the oil content of the seeds compared to the untreated control, the oil yield data show positive effects of

Rapeseed crop before harvest. Photo by M. Nikolova.

K and Mg, due to increased seed yields (Table 3). The highest oil yield was registered in the treatment with highest seed yield and oil content - K applied in autumn and spring - which yielded about 25% more than the control and about 10% more compared to the single autumn K application. In general, increasing K supply raises seed yield and increases the oil content of the seeds, thereby resulting in an increase in the oil yield (Orlovius, 2003; Forster, 1977). The results of the two trials reported here similarly support this tendency.

Conclusions

Winter rapeseed trials were carried out in two typical locations, differing only in K and Mg content of the soil, i.e. Bardarski Geran (location A) was well supplied with K and Mg, whereas Samovodene (location B) had low K and Mg contents. The climatic conditions of the two experimental years differed markedly, 2009 being much less favorable than 2011 for winter rapeseed. It is for this reason that the yields in 2011 on the less fertile soil (location B) were almost double of the yields in 2009 on the site with high K and Mg contents (location A).

Nevertheless, in both trials a clear positive effect of K fertilization was registered. K application increased seed yield, oil content in the seeds and the oil yield per unit area. Summarizing the results of the two experiments, it may be concluded that split application of K (autumn and spring) was most effective. The response of Mg/S application was more varied, probably due to the different soil moisture conditions during the two experimental years.

The results obtained in the two rapeseed trials are important for agricultural practice in Bulgaria. They clearly show that K and Mg/S are important nutrients for successful rapeseed cultivation and that their split application in autumn and spring has beneficial effects on yield and quality of the crop. Since the traditional practice of the country is autumn application, both for winter and for spring crops, this may be one of the reasons for the popular misconception that K fertilization is without effect in Bulgaria.

Acknowledgements

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The paper "The Effect of Different Potash and Magnesium Fertilizers and Timing of Application on Yield and Oil Content of Oilseed Rape" also appears on the IPI website at:

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