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EFFECT OF SULPHUR FERTILISATION ON SEED YIELD AND YIELD COMPONENTS OF BROAD BEAN ON THE BACKGROUND OF DIFFERENT LEVELS OF POTASSIUM CONTENT IN SOIL*

Przemysław Barłóg[1], Alicja Niewiadomska[2], Katarzyna Ambroży-Deręgowska[3]

[1]*Katedra Chemii Rolnej i Biogeochemii Środowiska, Uniwersytet Przyrodniczy w Poznaniu, ul. Wojska Polskiego 71F, 60-625 Poznań*
[2]*Katedra Mikrobiologii Ogólnej i Środowiskowej, Uniwersytet Przyrodniczy w Poznaniu, ul. Szydłowska 50, 60-656 Poznań*
[3]*Katedra Metod Matematycznych i Statystycznych, Uniwersytet Przyrodniczy w Poznaniu, ul. Wojska Polskiego 28, 60-637 Poznań*

Abstract. The aim of the study was to determine the yield reaction of broad bean, which is treated as a model plant for the entire group of leguminous plants, on variation in the soil potential to supply plants with potassium and sulphur. From 2010 to 2012 we carried out a field experiment, which was part of a static experiment. The study is an assessment of the influence of two factors: I – the content of potassium in the soil and current fertilisation with this component (K-0; K-25%; K-50% and K-100%; where 100% = 133 kg $K \cdot ha^{-1}$); II – fertilisation with elementary sulphur (0, 25 and 50 kg $S \cdot ha^{-1}$). The experiment proved that the reaction of broad bean to the potassium treatments depended on the vegetative season. The highest productivity of potassium was observed in the most humid vegetative season. The influence of sulphur fertilisation on plants depended on the potassium fertilisation system. The highest increase in the seed yield was noted in treatment K-0, i.e. in the soil with the smallest amount of available potassium. Sulphur fertilisation decreased the yield of seeds in the soil with the highest amount of potassium (K-100%). This factor did not have significant influence on the content of total protein in the seeds.

Key words: potassium fertilisation, elementary sulphur, crop residues, protein content

INTRODUCTION

Seeds of leguminous plants are a precious source of amino acids, especially lysine, in human and animal diets [Crépon et al. 2010]. Unfortunately, in spite of numerous advantages of growing leguminous plants the area of such plantations in Poland is still too small in comparison with the demand for vegetable protein [Florek et al. 2012]. The most important causes of this situation include the low yield level, yield instability over years, the content of anti-nutritional compounds and high susceptibility to diseases [Podleśny 2005]. The yield of seeds is the outcome of the hierarchic effect of a wide range of yield factors, starting with (i) the dominant factors (genotype), through (ii) the limiting factors (water, nitrogen, other mineral components) and (iii) reducing factors (diseases, pests) [Rabbinge 1993]. In Poland the soil and climactic conditions do not guarantee sufficient water resources from winter precipitation or from regular rainfall and they cause abiotic stress. In comparison with other crops leguminous plants are distinguished by high sensitivity to water deficiency *Vicia faba* [Lopez-Bellido et al. 2005].

[1] Adres do korespondencji – *Corresponding address*: przembar@up.poznan.pl
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Moreover, in Poland the water stress is also intensified by domination of low-potassium soils [Lipiński 2005]. This component plays a vital role in the regulation of water management in plants [Cakmak 2005]. In recent years the importance of appropriate nourishment of plants with sulphur has grown, which is chiefly related with a decrease in the deposition of this element in soils because of reduction in industrial emissions [Scherer 2001]. The shortage of this component in the soil reduces the yield level and quality of leguminous plants [Barczak et al. 2013, Cazzato et al. 2012, Habtemichial et al. 2007, Zhao et al. 1999]. Sulphur fertilisation, moreover, improves the yield quality, increasing the content of protein and sulphur amino acids in seeds [Elsheikh and Elzidany 1997, Saito 2000].

In the group of leguminous plants the species of *Vicia faba* L., with *major* and *minor* varieties, plays an important economic role. The large-seed form of the species is treated as a vegetable plant (broad bean), whereas the small-seed form is treated as a forage plant. The species has a big yield potential and at the same time it has high demand for water and mineral components [Duc 1997]. Broad bean seeds are rich in amino acids, carbohydrates, vitamins, fibre, chlorophyll and minerals. They also contain anti-nutritional compounds, including tannins, protease inhibitors, phytates and glycosides [Crépon et al. 2010]. In comparison with soybeans the economic value of broad bean seeds is above all limited by low concentration of sulphur amino acids – cysteine and methionine [Tabe and Higgins 1998]. Therefore, agrotechnical treatment, including fertilisation with sulphur, which would enable increase in the concentration of sulphur amino acids in *Vicia faba* seeds, would also increase the economic value of the species [Duc 1997].

The aim of this study was to determine the yield reaction of broad bean, which is treated as a model plant for the entire group of leguminous plants, in response to variation in the soil potential to supply plants with potassium and sulphur.

MATERIAL AND METHODS

Trials with broad bean (*Vicia faba* L. ssp. *major*) were carried out in years 2010–2012 in Brody Experimental Farm, which belongs to Poznań University of Life Sciences (16°28′ E and 52°44′ N). The trials were a part of the static experiment, which was started in 1990. According to the World Reference Base for Soil Resources (WRB) classification system, the soil under the experiment classified as Haplic Luvisols and characterized by loamy sand texture. Accordance with the utility classification, it represents a very good rye complex of quality class IVa. The study assessed the influence of two factors: I – potassium fertilisation treatments (K-0; K-25%; K-50% and K-100%); II – sulphur fertilisation (0, 25 and 50 kg $S \cdot ha^{-1}$). The experiment was made in accordance with the randomised block design, with four repetitions. The area of an individual plot was 22.4 m^2. At K-0 and K-100% levels the soil has remained in the unchanged system of K fertilisation since 1990. The first treatment represents absolute control, whereas the other one represents the dose of K equal to 100% nutritional demand of a particular plant in crop rotation. From 2001 to 2008 the treatments were divided into two extra ones: i) regeneration of the control object with full doses of potassium and ii) exclusion from potassium fertilisation. In the experiment with the broad bean 25% of the full potassium dose was applied in the first treatment (K-25%), whereas in the second treatment 50% of the full potassium dose was applied (K-50%). A full dose of K in treatment K-100% was 133 kg $K \cdot ha^{-1}$. It was determined upon the assumed yield of seeds (4 $t \cdot ha^{-1}$) and unitary collection value (33.2 kg $K \cdot ha^{-1}$). Potassium and sulphur were applied before sowing in spring. The former component was applied as potassium salt (49.8% K), whereas the latter was applied in its elementary form (S^0), in Wigor fertiliser (90% S).

The Bachus variety was tested in the experiment. It is an early variety, with traditional type of growth. After preparation of the seedbed seeds were sown manually at the depth of 5 cm, spaced 40 cm from each other, 30 pieces per square meter (late March/early April). Before sowing the seeds were treated with the Marshal 250 DS preparation and vaccinated with nitragine. No nitrogen fertilisers were used in the experiment. There was phosphorus fertilisation of 26.2 kg P·ha^{-1} (enriched superphosphate – 17.4% P) in autumn after harvesting the previous crop (winter wheat). During vegetation the plant protection included the application of herbicides Afalon 450 SC and Command 360 CS0 (a.i. linuron and chlomazon, respectively), fungicide Gwarant 500 SC (chlorotalonil), insecticid Primor 500 WG (pirymikarb) and manual weeding. Broad bean plants were harvested from an area of 7.5 m^2 at the stage of BBCH 97 – plant dead and dry [Meier 2001]. Content of total protein in the seeds was determined with Kjeldahl method (nitrogen-to-protein conversion factor – 6.25).

In early spring before sowing fertilisers soil was collected for chemical analysis. Standard methods were used to calculate the content of available forms of P, K, Mg and S in it and to specify the pH. The arable layer of the soil (0-0.3 m) had a slightly acidic pH, high content of available P and diversified content of available K depending on the fertilisation system (Table 1). Table 2 shows the weather conditions at the time of research. As results from the table, there were differences in the years both in the total amount and distribution of precipitation.

The effect of individual research factors (year, potassium, sulphur) and the interaction between them was assessed by means of three-way ANOVA. Differences between the mean values were compared by means of the LSD value, calculated according to Tukey method, where the significance level was $\alpha = 0.05$. The relationships between the traits were analysed by means of correlation and linear and multivariate regression. STATISTICA software was used for statistical analyses.

Table 1. Chemical properties of soil (mean 2010–2012 ± SD)

Soil depth (m)	Treatments	pH [1)]	P [2)]	K [2)]	Mg [3)]	$S\text{-}SO_4$ [4)]
			mg·kg^{-1}			
0–0.3	K-0	6.22 ± 0.62	110.5 ± 8.5	82.7 ± 27.8	55.0 ± 15.0	8.46 ± 5.68
	K-25%	6.35 ± 0.57	112.9 ± 7.5	133.2 ± 38.3	61.8 ± 20.3	7.01 ± 3.93
	K-50%	6.35 ± 0.57	113.1 ± 10.5	103.2 ± 31.2	53.0 ± 15.4	7.23 ± 3.28
	K-100%	6.44 ± 0.51	111.8 ± 8.9	161.8 ± 35.8	60.3 ± 20.7	6.64 ± 2.34
0.3–0.6	K-0	6.02 ± 0.52	92.9 ± 14.7	88.2 ± 19.2	63.3 ± 24.3	5.88 ± 1.24
	K-25%	6.10 ± 0.50	93.9 ± 22.1	105.7 ± 29.2	69.5 ± 16.4	7.86 ± 4.87
	K-50%	6.27 ± 0.63	91.8 ± 31.8	106.4 ± 35.4	65.2 ± 9.5	7.01 ± 3.93
	K-100%	6.43 ± 0.64	93.5 ± 18.1	114.7 ± 29.3	61.8 ± 19.0	7.19 ± 3.65

Methods: [1)] 1 M KCl, 1:2.5 m/v ratio; [2)] DL-method (Egner-Riehm method); [3)] Schachtschabel method – 0.0125 M $CaCl_2$, 1:10 m/v ratio; [4)] 2% CH_3COOH, 1:10 m/v ratio

Table 2. Weather conditions during vegetation of broad bean

Months	Rainfalls (mm)				Temperature (°C)			
	2010	2011	2012	1954–2009	2010	2011	2012	1954–2009
III	53.3	25.0	20.0	40.1	4.4	3.1	5.7	2.9
IV	38.9	13.9	22.9	38.1	10.0	11.7	8.8	7.9
V	92.7	34.0	77.2	56.7	12.5	14.1	14.8	13.2
VI	17.0	52.6	163.0	62.7	18.7	18.6	16.0	16.4
VII	98.2	175.4	197.0	77.2	21.6	17.9	19.2	18.1
Sum/Mean	300.1	300.9	480.1	274.8	13.4	13.1	12.9	11.7

RESULTS AND DISCUSSION

The main factor which determined the seed yield was the season factor. Depending on the vegetative season the seed yield at the BBCH 97 growth stage ranged from 1.72 to 3.03 t·ha^{-1} (Table 3). The low yield of broad bean in 2010 and 2011 was chiefly caused by the deficiency of water at the stage of florescence and development of pods, which is critical to the broad bean yield [Łabuda 2012].

The effect of K fertilisation on the seed yield depended significantly on the vegetative season. In 2010 and 2011 this factor was observed to have positive influence on the level of yield,

Table 3. Effect of K fertilisation on the seed yield and crop residues weight of broad bean in relation to vegetation seasons (t DM·ha^{-1})

Year (Y)	Potassium fertilization (A)				Mean
	K-0	K-25%	K-50%	K-100%	
Seed yield					
2010	1.42	1.68	1.93	1.99	1.76
2011	1.31	1.72	1.96	1.87	1.72
2012	2.24	3.60	2.55	3.72	3.03
Mean	1.65	2.33	2.15	2.53	–
$LSD_{0.05}$	Y – 0.27; A – 0.36; Y x A – 0.62				
Crop residues					
2010	1.48	1.73	1.85	2.00	1.77
2011	1.25	1.18	1.34	1.33	1.28
2012	2.11	3.30	2.62	4.06	3.02
Mean	1.61	2.07	1.94	2.47	–
$LSD_{0.05}$	Y – 0.36; A – 0.41; Y x A – 0.69				

but it was not statistically significant. The highest yields were noted in treatments K-100% (2010) and K-50% (2011). In comparison with the yield from K–0 the difference ranged from 41 to 50%. In 2012, potassium was observed to have significant influence on the seed yield. In comparison with the yield from K-0 there was a significant increase in the yield observed in K-25% and K-100%. The difference amounted to 61 and 66%, respectively. The high increase of seed yield in treatments K-25% and K-100% resulted from the longer period of retention of green leaves on the plant and thus, from the assimilation of CO_2 nearly until the end of vegetation (data not shown). The positive influence of K on the seed yield results from a broad spectrum of its functions in the plant. The component has positive effect on the water management in plants, regulating such aspects as the osmotic pressure, cell turgor and the functioning of the stomatal apparatus. It also improves the N management and plant immunity to the biotic stress [Cakmak 2005]. Potassium deficiency at the initial stage of plant development significantly disturbs the distribution of assimilates between the aboveground organs and roots [Marschner et al. 1996] and it has negative effect on the processes of atmospheric N_2 fixation [Lifang et al. 2000]. As a result, K deficiency in the soil causes decreased yield of broad bean seeds [Mona et al. 2011, Xia and Xiong 1991]. We found in our own research that the yield of broad bean was significantly correlated with the content of available K in the soil. Moreover, the value of R^2 coefficient in regression equations was greater for the subarable layer ($y = -0.8034 + 0.2376x$; $R^2=0.75^{***}$; n=12) than for the arable one ($y = 0.4254 + 0.1202x$; $R^2=0.64^{**}$; n=12). We did not obtain a similar correlation for doses of K fertiliser. Thus, besides the weather conditions the content of K in the soil was the second factor accounting for differences in the yield level between individual years and K fertilisation variants. The research findings also confirm the fact that only when the soil is sufficiently humid, plants can fully make use of the K accumulated in the soil [Grzebisz et al. 2013].

In contrast to K, elementary sulphur fertilisation did not have significant influence on the average yield of seed. The reaction of plants to this factor depended on the content of K in the soil (Table 4). The highest increase in the seed yield stimulated by consecutive doses of S was

Table 4. Effect of S fertilisation on the seed yield and crop residues weight of broad bean in relation to K fertilisation systems – mean 2010–2012 (t DM·ha^{-1})

Sulphur doses (B) kg S·ha^{-1}	Potassium fertilization (A)				Mean
	K-0	K-25%	K-50%	K-100%	
Seed yield					
0	1.46	2.23	1.89	2.72	2.08
25	1.63	2.30	2.03	2.61	2.14
50	2.06	2.47	2.52	2.26	2.33
$LSD_{0.05}$	B – ns; A x B – 0.61				
Crop residues					
0	1.43	2.14	1.67	2.66	1.97
25	1.55	2.02	1.90	2.52	2.00
50	1.86	2.06	2.25	2.21	2.09
$LSD_{0.05}$	B – ns; A x B – ns				

ns – difference not significant

noted in the soil with the lowest content of K, i.e. in K-0 and K-50%. The increase in the seed yield after application of 50 kg S·ha^{-1} was 41 and 37%, respectively. According to Habtemichial et al. [2007], fertilisation with sulphur at a dose of 30 kg S·ha^{-1} in K_2O_4 increased the yield of broad beans by 21-40%. On the other hand, after the application of 60 kg S·ha^{-1} Cazzato et al. [2012] found that the seed yield increased by 19%. However, the authors suggest that the optimal dose of S should not exceed 30 kg S·ha^{-1}. It results from the fact that S fertilisation increases the content of anti-nutritional compounds – tannins [Elsheikh and Elzidany 1997, Elsheikh et al. 1999].

Sulphur fertilisation had positive influence on the mean weight of crop residues, but this effect was only a trend (Table 4). The highest increase in the weight of crop residues was obtained at K-0 and K-50%. In comparison with the treatment without S°, the differences after application of 50 kg S·ha^{-1} amounted to 30 and 35%, respectively. Also, Scherer and Lange [1996] and Cazzato et al. [2012] observed the increase in the weight of broad bean leaves and stems when sulphur was applied. The positive effect of S on the growth and yield of leguminous plants results from improvement in the state of nourishment of the host plant and from the stimulation of N_2 fixation [Scherer and Lange 1996]. Sulphur is necessary in the biosynthesis and functioning of enzymatic structures containing Mo [Kaiser et al. 2005, Mendel and Bittner 2006] and it is necessary for the regulation of N_2 fixation mechanisms [Zhao et al. 1999]. The effective functioning of the symbiosis between the plant and *Rhizobium* requires a high input of energy. The research on *Vicia faba* ssp. *minor* shows that the proper nutrition of plants with S increases the amount of glucose flowing to the roots and ATP biosynthesis [Pacyna et al. 2007]. The effect is a larger number of nodules developing on the roots, their higher weight and an increase in the amount of $N_{2\ bound}$ [Scherer and Lange 1996]. Sulphur also has positive influence on the biosynthesis of secondary metabolites, which have defensive effect against pathogens [Datnoff et al. 2007]. The positive effect of sulphur on the seed yield can also be explained by reduction in the soil pH in consequence of S^0 oxidisation in the soil. As a result, the plant starts making use of nutrient from its reserves of soil components [Zhou et al. 2009].

In our own research on the soil rich in K and fertilised with the highest dose of K we observed the negative influence of S° on the seed yield. Because of the increase in soil acidification, the fertilisation with S° may have had negative influence on the process of development of nodules and N_2 fixation [Tang and Thomson 1996] or it may have stimulated the intake of large amounts of K and thus it may have had negative influence on the Mg and Ca uptake by plants [Cakmak 2005]. Another hypothesis under consideration says that there may have been antagonism between SO_4^{-2} and MoO_4^{-2} ions [Mona et al. 2011] or negative influence of a large K and S doses on the plant growth rate and the distribution of assimilates between vegetative and generative organs at early growth stages [Marschner et al. 1996].

Potassium fertilisation significantly increased the number of pods on the plant, the number of pods per square meter and the weight of a thousand seeds, as compared with the control object (Table 5). This factor especially improved the values of the elements of yield structure in objects K-25% and K-100%. Potassium fertilisation also had favourable influence on the number of seeds in pods and on the harvest index, but this reaction was a trend. In contrast to K, sulphur fertilisation significantly influenced only the number of pods per square meter. This factor also had positive influence on the number of pods on the plant, the weight of one thousand seeds and the harvest index (except K-100%). As was proved in the research, the seeds yield was positively correlated with the weight of crop residues, the number of pods on the plant and the weight of one thousand seeds. However, the number of pods on the plant had the greatest direct influence on the yield of seeds (Table 6). According to Alan and Geren [2007], this trait is the least heritable of all the elements of the yield structure and it is chiefly dependent on the

Table 5. Effect of S fertilisation on the yield components of broad bean in relation to K fertilisation systems (mean 2010–2012)

Feature	Sulphur doses (B) kg S·ha^{-1}	Potassium fertilization (A)				Mean
		K-0	K-25%	K-50%	K-100%	
Plant Density (No.·m^{-2})	0	22.4	23.7	23.2	25.5	23.7
	25	22.3	22.8	22.7	24.2	23.0
	50	24.1	22.6	22.8	23.8	23.3
	Mean	22.9	23.0	22.9	24.5	–
	$LSD_{0.05}$	A – ns; B – ns; A x B – ns				
No. of pods per plant	0	2.0	2.5	2.3	2.6	2.4
	25	2.0	2.6	2.6	2.7	2.5
	50	2.5	2.8	2.9	2.5	2.6
	Mean	2.2	2.6	2.6	2.6	-
	$LSD_{0.05}$	A – 0.4; B – ns; A x B – ns				
No. of pods per m^2	0	44.5	58.1	52.7	63.3	54.6
	25	44.3	56.6	56.5	62.2	54.9
	50	58.5	59.4	63.7	58.0	59.9
	Mean	49.1	58.0	57.6	61.2	–
	$LSD_{0.05}$	A – 7.1; B – 5.0; A x B – 12.1				
No. of seeds per pod	0	3.0	3.2	3.2	3.3	3.2
	25	3.2	3.2	3.2	3.2	3.2
	50	3.0	3.3	3.3	3.2	3.2
	Mean	3.1	3.3	3.2	3.3	–
	$LSD_{0.05}$	A – ns; B – ns; A x B – ns				
Weigth of 1000 seeds (g)	0	1061	1169	1140	1264	1158
	25	1010	1240	1134	1223	1152
	50	1171	1230	1201	1189	1198
	Mean	1081	1213	1158	1225	–
	$LSD_{0.05}$	A – 70; B – ns; A x B – ns				
Harvest index (%)	0	49.5	51.5	53.7	51.4	51.5
	25	50.3	54.0	52.4	52.8	52.4
	50	52.8	55.0	53.7	52.0	53.4
	Mean	50.8	53.5	53.3	52.1	–
	$LSD_{0.05}$	A – ns; B – ns; A x B – ns				

ns – difference not significant

Table 6. Seed yield of broad bean as a function of crop residues weight and yield components; correlation (r) and *BETA* coefficients; n = 36

Feature	r	*BETA*
Crop residues	0.936***	0.350***
Plant density	0.116	0.124***
Number of pods per plant	0.946***	0.413***
Number of seeds per pod	0.234	0.129***
Weigth of 1000 seeds	0.659***	0.349***
R^2	–	0.99***

*. **. *** – significant for p ≤ 0.05; 0.01; 0.001 respectively

external environment. In our own research the dependence between the yield level (y) and the number of pods (x) on the plant can be described with the following equation: y = -0.9316 + 1.2463x; R^2 = 0.89***; n = 36.

Depending on the year the content of total protein in the dry weight of seeds ranged from 25.7% to 29.6%. Content of protein depended on the treatments of potassium fertilisation. In treatments K-0 and K-50% the content of this compound was significantly higher than in K-100% (tab. 7). The content of protein in the seeds was negatively correlated with the weight of thousand seeds (y = 37.0636 - 0,0079x; R^2=0.49***; n=36) and with the yield of seeds (y =

Table 7. Effect of S-fertilisation on the content and yield of total protein in relation to K fertilisation systems (mean 2010–2012)

Sulphur doses (B) kg S·ha^{-1}	Potassium fertilisation (A)				Mean
	K-0	K-25%	K-50%	K-100%	
Total protein content (%)					
0	28.0	27.7	28.1	27.6	27.8
25	28.5	27.6	28.1	27.4	27.9
50	27.4	28.2	28.0	27.5	27.8
Mean	28.0	27.8	28.1	27.5	–
$LSD_{0.05}$	A – 0.4; B – ns; A x B – ns				
Total protein yield (kg·ha^{-1})					
0	404	600	530	741	569
25	411	623	571	695	575
50	555	683	694	604	634
Mean	457	635	598	680	–
$LSD_{0.05}$	A – 100; B – ns; A x B – 172				

ns – difference not significant

31.5738 – 1.7249x; R^2=0.61***; n=36). The research did not prove the significant influence of sulphur fertilisation on the content of total protein in the seeds. Cazzato et al. [2012] observed a slight increase in the content of protein in the seeds (0.3%) after the application of 30-60 kg S·ha^{-1}. However, other authors proved bigger increases in the concentration of this compound in the seeds, as they ranged from 1 to 2.3% [El Fiel et al. 2002, Elsheikh et al. 1997, 1999].

Depending on the year and fertilisation variant the yield of total protein ranged from 327 to 1006 kg·ha^{-1}. On average, the influence of potassium fertilisation variants on the protein yield looked as follows: K-0 < K-50% < K-25% < K-100% (Table 7). The influence of this factor was modified by S-fertilisation. At level S-0 the highest yield was obtained from variant K-100%, whereas at level S-50 from variant K-50%. The highest protein yield stimulated by S-fertilisation was noted in the treatment with a balanced dose of potassium (K-50%). However, it is noteworthy that the highest yield of protein came from the soil which was rich in available form of K, but without S-fertilisation. According to Cazzato et al. [2012], the fertilisation with sulphur at a dose of 60 kg S·ha^{-1} increased the yield of total protein from 1087 to 1307 kg·ha^{-1}. However, the authors applied sulphur in K_2SO_4, so the result may also have depended on the higher dose of K.

CONCLUSION

1. The content of available potassium in the soil had a greater effect on seed yield and yield components of broad bean than current fertilisation with this nutrient.
2. The reaction of broad bean to fertilisation with elementary sulphur depended on the content of potassium in the soil.
3. Sulphur fertilization had no significant effect on the total protein content in the seeds of broad bean. The content of protein in the seeds was significantly dependent on vegetative season and potassium fertilisation systems.

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P. Barłóg, A. Niewiadomska, K. Ambroży- Deręgowska

WPŁYW NAWOŻENIA SIARKĄ NA PLONOWANIE BOBU NA TLE ZRÓŻNICOWANYCH POZIOMÓW ZAWARTOŚCI POTASU W GLEBIE

Synopsis. Celem niniejszych badań było określenie reakcji plonotwórczej bobu, traktowanego jako roślina wzorcowa dla całej grupy roślin strączkowych, na zmianę potencjału gleby do zaopatrzenia roślin w potas i siarkę. Doświadczenie polowe przeprowadzono w latach 2010–2012 w ramach doświadczenia statycznego. W pracy oceniano wpływ dwóch czynników: I – zawartość potasu w glebie i bieżące nawożenie tym składnikiem (K-0; K-25%; K-50% i K-100%; gdzie 100% = 133 kg K·ha^{-1}); II – nawożenie siarką elementarną (0, 25 i 50 kg S·ha^{-1}). W doświadczeniu wykazano, że reakcja bobu na zawartość potasu w glebie zależała od sezonu wegetacyjnego. Największą produktywność nagromadzonego w glebie potasu stwierdzono w najbardziej wilgotnym sezonie wegetacyjnym. Wpływ nawożenia siarką na rośliny zależał od systemu nawożenia potasem. Największe przyrosty plonu nasion pod wpływem tego czynnika otrzymano na obiekcie K-0, czyli na glebie o najmniejszej zawartości potasu przyswajalnego w glebie. Na glebie o największej zawartości potasu (K-100%) nawożenie siarką zmniejszało plon nasion. Czynnik ten nie miał istotnego wpływu na zawartość białka ogólnego w nasionach.

Słowa kluczowe: nawożenie potasem, siarka elementarna, resztki pożniwne, zawartość białka

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