ECOLOGICAL CHEMISTRY AND ENGINEERING A

Vol. 16, No. 5/6 2009

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EFFECT OF SULPHUR FERTILIZATION ON YIELDING AND TOTAL CONTENT OF NITROGEN, NITRATES(V) AND SULPHUR IN WHITE MUSTARD

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Abstract: In 2-year pot experiments the direct and consequent effect of sulphur contained in the new fertilizer: ammonium nitrate sulphate designed for manufacturing, on yielding and the contents of nitrogen and sulphur in white mustard were analyzed. Effectiveness of the new fertilizer was compared with ammonium sulphate and NPK fertilization without sulphur. Two doses of sulphur fertilizers were applied in the 1st year of the experiment, while in the 2nd its consequent effect was researched at the identical NPK treatment. Mustard was harvested at flowering stage.

In the 1st year of the experiment increase in mustard yields depended on NPK fertilization without any significant sulphur effect. In the second year the consequent effect of sulphur led to an increase in yields by between 10 and 27 % and the greatest was registered in treatments where the new fertilizer was used. Sulphur fertilization had no significant effect on nitrogen content or the degree of this element utilization from fertilizers. In comparison with NPK treatment application of fertilizers containing sulphur caused a considerable increase in sulphur content in mustard.

Fertilization with sulphur caused an increase in nitrate(V) content in mustard shoots in the 1st year of the experiment, particularly in treatments where a double dose of this element was used. In the 2nd year of the experiment at absolutely higher $N\text{-}NO_3$ content a decline in the level of this nitrogen form was detected in plants under which sulphur was applied. The share of $N\text{-}NO_3$ in total nitrogen content in mustard ranged between 1.73 and 7.46 % in the 1st year of the experiment, whereas it was higher in the second year and ranged from 6.14 to 11.45 %.

Keywords: pot experiment, mustard, sulphur fertilization, yield, contents of sulphur, nitrogen, nitrates(V)

Considerable limiting industrial emissions over the last twenty years of the previous century in Poland and in other countries [1, 2] was particularly evident as a diminishing sulphur deposit in soils. Estimated SO_2 fall in 1980 in Poland was about 5 Tg (10^6 Mg), whereas currently registered values are over 5 times smaller [3, 4]. Under these con-

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ditions sulphur, as the basic element for plants became a deficit nutrient in soils [5–7], particularly in cultivation of plants with great demand for sulphur, often similar to the amount of absorbed phosphorus [1, 2, 5, 8]. Fertilization with this element became inevitable. It is possible owing to an extensive offer of industries manufacturing multicomponent fertilizers with various proportions of sulphur [2, 3].

The necessity of treatment with sulphur results mainly from the role this element plays in nitrogen metabolism [8, 9]. Intensive nitrogen fertilization is more efficiently utilized at proper plant supply with sulphur. It affects both increase in yield and the quantity of absorbed nitrogen [1, 7]. There are reports on the effect of sulphur fertilization on the content of nitrates(V) in plant [7, 10, 11].

Material and methods

The experiment was conducted for two years (2006 and 2007) in pots with 5 kg of air-dried, medium compact and slightly acid soil (pH in KCl = 6.1), containing 9.68 $g \cdot kg^{-1}$ of organic carbon, 0.73 $g \cdot kg^{-1}$ of total nitrogen and 0.19 $g \cdot kg^{-1}$ of total sulphur. Each year white mustard, 'Barka' c.v., was cultivated and harvested at the flowering stage. This vegetation stage allows for an optimal assessment of the degree of plant supply with nutrients [7, 12].

The research aimed to determine the effect of fertilization with sulphur applied in the form of ammonium sulphate and ammonium nitrate sulphate planned for manufacturing, in two doses: 0.15 and 0.30 g $S \cdot pot^{-1}$. The control was NPK treatment with chemically pure salts. Sulphur was applied in the 1st year of the experiment, whereas in the 2nd the consequent effect of sulphur was analyzed at equal NPK fertilization. Nutrient doses in both years were 1.12 g N; 0.3 g P and 1 g $K \cdot pot^{-1}$.

Each year of the experiment dry mass yield of white mustard roots and shoots was determined. This paper gives only the shoot yields.

In plant shoots total sulphur was assessed after wet mineralization in concentrated nitric(V) acid and after evaporation with HNO_3 the samples were treated with magnesium nitrate(V), evaporated again and incinerated at the temperature of 300 ^oC for 2 h and at 450 ^oC for 3 hours. After dissolving the remains in 25 % HNO_3 sulphur was determined with ICP-AES method on JY238 Ultrace apparatus. Total nitrogen was assessed with Kjeldahl method and nitrates(V) with colorimetry in phenololisulfonic acid.

The obtained results concerning yields were verified using analysis of variance and differences estimation using Duncan test at the significance level $p < 0.05$ [13].

Results and discussion

In the 1st year of the experiment yields of white mustard depended on NPK fertilization, without any significant effect of sulphur used in the fertilizers (Table 1).

Table 1

Yields of white mustard dry mass [g · pot^{-1}]

Treatment	2006 – I year	2007 – II year
	Top parts	
1. No fertilization – Control	23.85a*	5.02a
2. NPK	41.58b	19.79b
3. NPK + S1 – A	38.25b	21.70b
4. NPK + S2 – A	41.13b	21.76b
5. NPK + S1 – B	40.25b	24.91c
6. NPK + S2 – B	39.20b	25.16c

* Homogeneous groups according to the Duncan test, $p < 0.05$, A – $(NH_4)_2SO_4$; B – ammonium nitrate sulphate 26:13, S1 – 0.15 g S · pot^{-1}; S2 – 0.30 g S · pot^{-1}

This effect has been described also by other authors [7, 11, 14]. In comparison with the control treatment, without fertilizers, yields of shoots in the fertilized treatments increased by between 60 and 74 %, and most in NPK treatment.

In the 2nd year of the experiment, mustard yields were generally smaller than in the 1st year. In all treatments fertilized with sulphur a raise between 10 and 27 % in mustard yields was registered in comparison with yields obtained at exclusive application of NPK. In the second year fertilization with ammonium nitrate sulphate revealed a markedly better effect, in comparison with pure ammonium sulphate, particularly at higher sulphur dose. In their previous research conducted on the soil with similar content of sulphur the Authors did not note an increase in mustard yields in the 1st year, either. However, the consequent positive effect of these fertilizers on the amount of yields was statistically proved [11, 15]. Other authors also registered the consequent effect of sulphur fertilization as the increase in yields, particularly on heavy soils [14].

Table 2

Content of total nitrogen and N-NO_3 in white mustard dry mass [g · kg^{-1}]

Treatment*	Year 2006 – I year			Year 2007 – II year		
	total-N	N-NO_3	N-NO_3 in total-N [%]	total-N	N-NO_3	N-NO_3 in total-N [%]
1. No fertilization – Control	10.96	0.19	1.73	14.90	0.20	1.34
2. NPK	32.04	1.27	3.96	32.90	2.38	7.23
3. NPK + S1 – A	31.04	1.33	4.28	34.61	2.99	8.64
4. NPK + S2 – A	30.42	2.27	7.46	35.01	4.01	11.45
5. NPK + S1 – B	29.41	1.08	3.67	30.01	1.85	6.16
6. NPK + S2 – B	29.39	1.71	5.82	31.29	1.92	6.14

* See Table 1

Nitrogen content in mustard (Table 2) was affected by fertilization with this element, but sulphur addition did not significantly diversify its level in dry matter. In relation to the 1st year of the experiment, nitrogen content increased in plants cultivated in the 2nd year on treatments receiving sulphur fertilization, while the level in plants from NPK treatment remained the same. Nitrogen utilization from the applied dose was high in both years (74 % on average) and slightly diversified depending on sulphur fertilization. It confirms the results obtained by Fotyma [7] in the field experiment on crop rotation.

The content of $N\text{-}NO_3$ in mustard shoots in the treatments with sulphur was generally greater than when solely NPK was used in the 1st year of the experiment, particularly at the double dose of this element. In the experiments carried out by Brodowska and Kaczor [10] on wheat and rapeseed sulphur fertilization caused diminishing of nitrate(V) contents. The Authors obtained such result in their research while applying a single dose of sulphur as ammonium nitrate sulphate.

In the 2nd year of the experiment $N\text{-}NO_3$ content in mustard was higher than in the 1st year. In comparison with NPK treatment, in the ammonium nitrate sulphate treatments this nitrogen fraction diminished by between 19 and 22 %. In treatments fertilized with sulphur mustard contained the greatest quantities of $N\text{-}NO_3$ at the double ammonium sulphate dose and at the highest total N content in this treatment. It evidences nitrogen uptake stimulation by sulphur, whose considerable portion in this very treatment remained unused for organic compounds synthesis in the plant. In previous investigations sulphur fertilization caused a slight (ammonium form) or apparent (sodium salt) increase in nitrate(V) content in mustard siliques in the 1st year of the experiment. On the other hand in the 3rd year the effect of sulphur on a decrease in this nitrogen form in both plant fractions was visible [11].

The share of $N\text{-}NO_3$ in total nitrogen content in mustard ranged from 1.73 to 7.46 % in the 1st year of the experiment, while in the 2nd it was higher in fertilized treatments (6.14–11.45 %). The lowest share of nitrates(V) in total nitrogen was registered in mustard under which ammonium nitrate sulphate was applied. It evidences a beneficial

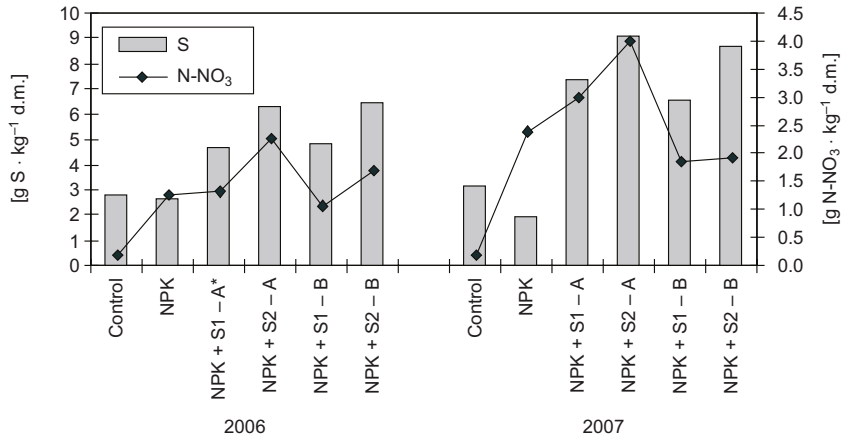

Fig. 1. Content of sulphur and nitrates(V) in white mustard
* See Table 1

effect of sulphur originating from this fertilizer in the process of nitrate reduction, also noted in other research [7, 11].

In comparison with NPK treatment, sulphur fertilization caused a considerable increase in sulphur content in mustard (Fig. 1).

Conclusions

1. In the two-year pot experiment yields of white mustard gathered at the flowering stage in the 1st year after sulphur fertilization depended on NPK treatment. Proven increase in yields in result of consequent effect of sulphur occurred only in the 2nd year of the experiment. New sulphur fertilizer – ammonium nitrate sulphate caused significantly more favourably increase in mustard yield in this year than ammonium sulphate and exclusive NPK fertilization.

2. Sulphur fertilization did not have any effect on nitrogen content in mustard or on the degree of nitrogen utilization from the applied fertilizers.

3. In the 1st year of the experiment sulphur fertilization led to an increase in nitrate(V) content in mustard shoots, particularly in treatments with a double dose of this element. In the 2nd year of the research, at absolutely higher content of $N\text{-}NO_3$ in comparison with plants fertilized exclusively with NPK a decline in this form level was observed in the plants fertilized with ammonium nitrate sulphate.

4. The share of $N\text{-}NO_3$ in the total nitrogen content in mustard ranged from 1.73 to 7.46 % in the 1st year of the experiment, it was higher in the 2nd year and ranged from 6.14 to 11.45 %.

5. Sulphur fertilization caused a considerable increase in sulphur content in shoots.

References

[1] Zhao F.J., Mc Grath S.P., Blake-Kalff M.M.A, Link A. and Tucker M.: Nawozy Nawożenie – Fertilizers Fertilization 2003, **3**(16), 26–51.
[2] Walker K. and Dawson Ch.: Nawozy Nawożenie – Fertilizers Fertilization 2003, **3**(16), 71–89.
[3] Biskupski A., Winiarski A. and Malinowski P.: Nawozy Nawożenie – Fertilizers Fertilization 2003, **3**(17), 9–30.
[4] Ochrona Środowiska 2007. Informacje i opracowania statystyczne. GUS, Warszawa 2007.
[5] Grzebisz W. and Fotyma E.: Rośl. Olei. 1996, **XVII**, 275–298.
[6] Terelak H. and Motowicka-Terelak T.: Siarka w glebach Polski, stan i zagrożenia. Bibl. Monitor. Środow., Wyd. Państ. Inspek. Ochr. Środow., Warszawa 1998.
[7] Fotyma E.: Nawozy Nawożenie – Fertilizers Fertilization 2003, **4**(17), 117–136.
[8] Gorlach E. and Mazur T.: Chemia Rolna. Wyd. Nauk. PWN, Warszawa 2002.
[9] Marska E. and Wróbel J.: Fol. Univ. Agric. Stetin., 204, Agricultura 2000, **81**, 61–76.
[10] Brodowska M.S. and Kaczor A.: Nawozy Nawożenie – Fertilizers Fertilization 2003, **4**(17), 92–103.
[11] Filipek-Mazur B., Gondek K. and Mazur K.: Zesz. Probl. Post. Nauk Rol. 2006, **513**, 99–106.
[12] Fismes J., Vong P.C., Guckert A. and Frossard E.: Eur. J. Agron. 2002, **12**(2), 127–141.
[13] Stanisz A.: Przystępny kurs statystyki w oparciu o program Statistica PL na przykładach z medycyny. Wyd. Statsoft Polska, 1998.
[14] Kulczycki G.: Nawozy Nawożenie – Fertilizers Fertilization 2003, **4**(17), 151–159.
[15] Filipek-Mazur B. and Gondek K.: Acta Agrophys. 2005, **6**(2), 343–351.

WPŁYW NAWOŻENIA SIARKĄ NA PLONOWANIE ORAZ ZAWARTOŚĆ AZOTU OGÓLNEGO, AZOTANÓW(V) I SIARKI W GORCZYCY BIAŁEJ

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Abstrakt: W 2-letnim doświadczeniu wazonowym badano bezpośredni i następczy wpływ siarki zawartej w projektowanym do produkcji nowym nawozie saletrosiarczanie amonu na plonowanie oraz zawartość azotu i siarki w gorczycy białej. Efektywność nowego nawozu porównywano z siarczanem amonu i nawożeniem NPK bez siarki. Nawożenie siarką w dwóch dawkach stosowano w I roku doświadczenia, a w II roku badano następcze jej działanie przy jednakowym nawożeniu NPK. Gorczycę zbierano w fazie kwitnienia.

W I roku doświadczenia zwiększenie plonów gorczycy zależało od nawożenia NPK, bez znaczącego wpływu siarki. W drugim roku następcze działanie siarki spowodowało wzrost plonów o 10 do 27 %, największy w obiektach z nowym nawozem. Nawożenie siarką nie miało znacznego wpływu na zawartość azotu w gorczycy i stopień wykorzystania tego składnika z nawozów. W porównaniu z obiektem NPK stosowanie nawozów zawierających siarkę spowodowało znaczne zwiększenie zawartości siarki w gorczycy.

Nawożenie siarką powodowało w I roku doświadczenia wzrost zawartości azotanów(V) w częściach nadziemnych gorczycy, zwłaszcza w obiektach z podwójną dawką tego pierwiastka. W II roku badań, przy bezwzględnie większej zawartości $N\text{-}NO_3$, stwierdzono obniżenie poziomu tej formy azotu w roślinach, pod które stosowano siarkę. Udział $N\text{-}NO_3$ w całkowitej zawartości azotu w gorczycy mieścił się w zakresie od 1,73 do 7,46 % w I roku doświadczenia, a w II roku był większy i wynosił 6,14–11,45 %.

Słowa kluczowe: doświadczenie wazonowe, gorczyca, nawożenie siarką, plon, zawartość siarki, azotu, azotanów(V)