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Influence of sulphur on the yield and quality of winter oilseed rape

Wpływ siarki na plon i jakość rzepaku ozimego

Key words: oilseed rape, sulphur, sulphur fertilization, ammonium sulphate, Hydro Sulfan, quality, yield, oil content, glucosinolate content

Słowa kluczowe: rzepak, nawożenie siarką, siarczan amonu, Hydro Sulfan, jakość, plon, zawartość oleju, zawartość glukozynolanów

Klíčová slova: řepka olejná, síra, hnojení sírou, síran amonný, Hydro Sulfan, kvalita, výnos, obsah oleje, obsah glukosinolátů

Požadavek ozimé řepky na síru byl sledován stupňovanými dávkami S ve formě síranu amonného (SA) (40, 80, 120, 160 kg S/ha) s aplikací na jaře. Do pokusu bylo též zařazeno hnojivo Hydro Sulfan (HSF), které je optimálně přizpůsobeno potřebě živin pro rostliny. Obsahuje N v okamžitě působící nitrátové formě (50%) a dalších 50% je v pomaleji působící formě amoniakální. Takto vyvážené hnojivo se projevilo rychlým růstem po zahájení jarní vegetační aktivity což se positivně projevilo jak na výnosu biomasy tak i semene. Dávka 40 kg S/ha ve formě HSF aplikovaná na jaře je srovnatelná v produkci biomasy s dávkou 160 kg S/ha ve formě SA. Výnos semene vzrůstá se stupňovanými dávkami síry, nejvyšší je při dávce 160 kg S/ha ve formě SA, ale nedosahuje výnosu při 40 kg S/ha ve formě HSF aplikované na jaře. Olejnatost je také ve srovnání s ostatními dávkami S ve formě SA vyšší. Glukosinoláty narostly cca o 10% u varianty s HSF aplikované na jaře, což při jejich nízkém obsahu nemůže ohrozit kvalitu ozimé řepky.

Badano zapotrzebowanie rzepaku ozimego na siarkę stosując wiosną dawki siarczanu amonowego (SA) 40, 80, 120, 160 kg S/ha. W doświadczeniu zastosowano również nawóz Hydro Sulfan (HSF), który jest optymalnie dostosowany do potrzeb żywieniowych rośliny. Zawiera on azot w łatwo przyswajalnej formie azotanowej (50%), a pozostałe 50% jest w wolniej pobieranej formie amonowej. Tak zrównoważony nawóz powodował szybki wzrost po ruszeniu wiosennej wegetacji, co wpłynęło pozytywnie na plon biomasy i nasion. Dawka 40 kg S/ha w formie HSF, zastosowana wiosną równała się w produkcji biomasy z dawką 160 kg S/ha w formie (SA). Plon nasion wzrastał ze zwięk-

The demand of oilseed rape for sulphur was observed by increased rates of S in form of ammonium sulphate (SA 40, 80, 120, 160 kg S/ha), in spring application. Hydro Sulfan (HSF) fertilizer was included into the trial which is the optimum nutrient need adapted for a plant. It contains N in immediately nitrate form (50%) and the next 50% is in less impressive ammonium form. This balancing fertilizer manifested quick growth after the beginning of spring vegetation activity, which positively exhibited the yield of biomass and seeds. The rate 40 kg S/ha in form of HSF, applied in spring can be compared with the production of biomass with the rate of 160 kg S/ha in form of ammonium sulphate. Seed yield

szaniem dawek siarki, najwyższy był przy dawce 160 kg S/ha w formie SA, ale nie dorównywał plonowi uzyskanemu przy stosowaniu wiosną 40 kg S/ha w formie HSF. Zawartość tłuszczu była także wyższa w porównaniu z dawkami siarki w formie SA. Zawartość glukozynolanów wzrosła około 10% u kombinacji z HSF stosowanym wiosną, co przy ich niskiej zawartości nie może zagrozić jakości rzepaku ozimego .

increases with the increased rates of S. The highest is at 160 kg/ha dose as ammonium sulphate, but does not reach the yield at 40 kg S/ha as HSF. Oil content at the variant with HSF is also higher in comparison with the next doses S as ammonium sulphate. Glucosinolates increased about 10% at the variant with HSF, which can not threaten quality of oilseed rape for their low content.

Introduction

Oilseed rape has high requirements for sulphur (Mc. Grath et al. 1996). Sulphur is a structural element of essential amino acids (methionine, cysteine) which are the integral components of full-value proteins. These can be considered as primary metabolites. Oilseed rape has higher content of these components in comparison with other oilseed plants. Secondary metabolites in oilseed rape are glucosinolates (Zhao et al. 1993, Wallsgrove et al. 1999). Glucosinolates are supposed to play an important role in the defense mechanism of oilseed rape against pests and diseases and also as significant taste element. The anti-quality nature of glucosinolates in the nutrition of humans and farm animals was the reason for breeders´ efforts to minimize glucosinolate content in products, which caused important intervention in sulphur metabolism. The function of glucosinolates as sinks is challenged by a low concentration of glucosinolates in the vegetative parts of oilseed rape (Fieldsen and Milford 1994).

Appropriate sulphur supplies to oilseed rape plants also imply important environmental consequences in the intensive system of crop production. Fertilizer nitrogen utilization is increased while possible environmental contamination with surplus of mineral nitrogen is decreased (Haneklaus et al. 1999).

The reduction of atmospherical SO_2 — S deposition increased number of S deficiency sites and therefore opened the question of sulphur role in nutrition of a plant and especially oilseed rape with its high demand.

The goal of this study was to determine the effect of graded sulphur application rates on production capacity of oilseed rape and its quality.

Materials and methods

The experiment was carried out at the experimental station Červený Újezd in the second year. The plot area was 10 m^2. Four variants of Lirajet line variety were fertilized by increased rate of S (40, 80, 120, 160, kg S/ha) in the form of ammonium sulphate applied in spring with total rate 190 N kg/ha (scheme of trial,

the dose of N was splitted up into four rates in spring). The control variant was without S and with the standard rate of N (155 kg/ha). The other two variants without S and with total rate 190 N kg/ha and the variant without S and N should underline an extreme of closed metabolical links versus N. Considering the results of experiments from the previous year the trial was further expanded by suplphate fertilizer Hydro Sulfan — 40 kg/ha (scheme)

Scheme of trial – Variety Lirajet — *Schemat doświadczenia – odmiana Lirajet*

Variant — *Wariant*		Application time / fertilizer *Termin nawożenia / nawóz*
1.	40 kg S/ha + 190 kg N/ha	spring — ammonium sulphate (21% N, 24% S)
2.	80 kg S/ha + 190 kg N/ha	spring — ammonium sulphate (21% N, 24% S)
3.	120 kg S/ha + 190 kg N/ha	spring — ammonium sulphate (21% N, 24% S)
4.	160 kg S/ha + 190 kg N/ha	spring — ammonium sulphate (21% N, 24% S)
5.	0 kg S/ha +190 kg N/ha	spring — ammonium sulphate (21% N, 24% S)
6.	0 kg S/ha + 0 kg N/ha	—
7.	control 0 kg S/ha + 155 kg N/ha	—
8.	40 kg S/ha + 190 kg N/ha	autumn — ammonium sulphate (21% N, 24% S)
9.	40 kg S/ha + 190 kg N/ha	autumn — Hydro Sulfan (24% N, 5,6% S)— 1/4 spring — ammonium sulphate (21% N, 24% S)— 3/4
10.	40 kg S/ha + 190 kg N/ha	autumn — Hydro Sulfan (24% N, 5,6% S)— 1/4 spring — Hydro Sulfan (24% N, 5,6% S)— 3/4
11.	40 kg S/ha + 190 kg N/ha	spring — Hydro Sulfan (24% N, 5,6% S)

Application time N/fertilizer — *Termin stosowania nawożenia azotem*

Variant	I dose N autumn I dawka jesienią			II dose N regen/spring II dawka wiosną			III dose N spring III dawka wiosną			IV dose spring IV dawka wiosną			V dose spring V dawka wiosną		
	SA*	HSF	LAV	SA	HSF	LAV	SA	HSF	LAV	SA	HSF	LAV	SA	HSF	LAV
1.	–	–	–	35	–	35	–	–	50	–	–	35	–	–	35
2.	–	–	–	35	–	35	35	–	15	–	–	35	–	–	35
3.	–	–	–	35	–	35	35	–	15	35	–	–	–	–	35
4.	–	–	–	35	–	35	35	–	15	35	–	–	35	–	–
5.	–	–	–	–	–	70	–	–	50	–	–	35	–	–	35
6.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
7.	–	–	–	–	–	70	–	–	50	–	–	35	–	–	–
8.	35	–	–	–	–	70	–	–	50	–	–	35	–	–	–
9.	–	40	–	–	–	35	–	–	50	–	–	35	–	–	30
10.	–	40	–	–	35	–	–	50	–	–	35	–	–	12	18
11.	–	–	–	–	171	–	–	–	19	–	–	–	–	–	

* — SA — ammonium sulphate; HSF — Hydro Sulfan; LAV (27,5%N)

Oil content

The oil content was determined by nuclear magnetic resonance (NMR).

Glucosinolate content

Total glucosinolates content was determined by near-infrared reflectance spectrophotometry on device NIR Systems 6500.

Results and discussion

The development of dry matter biomass at 0, 40, 80, 120 and 160 kg S/ha is very similar to the beginning of flowering, when S is applied in the form of ammonium sulphate in spring. Substantial difference is evident during the sulphur transport from leaves into the reserve organs. The dose of 160 kg S/ha has a significant effect upon the biomass. The other doses of sulphur enhance the dry matter production, but not in proportion to applied sulphur. The dose of 160 kg S/ha has a significant effect upon the biomass. Higher influence on production of dry matter has a date of fertilisation and the form of fertilizer. Hydro Sulfan has a positive effect in buttonisation and was the highest when the total of dose 40 kg/ha had been applied in spring. The spring dose 40 kg/ha in the form of ammonium sulphate is manifested by a decrease of dry matter yield in comparison with the same dose in autumn (Tab. 1, Fig. 1).

This is in accordance with the development of root systems (Tab. 1, Fig. 2).

Seeds yield (Tab. 2) increases with gradated sulphur in spring in the form ammonium sulphate. Seed yield at the dose of 40 kg/ha in the autumn can be compared with 160 kg S/ha in spring. Applied nitrogen fertilizer Hydro Sulfan, beside the fast growing after the spring vegetation activity, causes a positive effect on the biomass and seed yields. The seed yields were increased by 19%, but it is not significant (Tab. 2)

Tabela 1

Analizy wariancji do tabeli 1

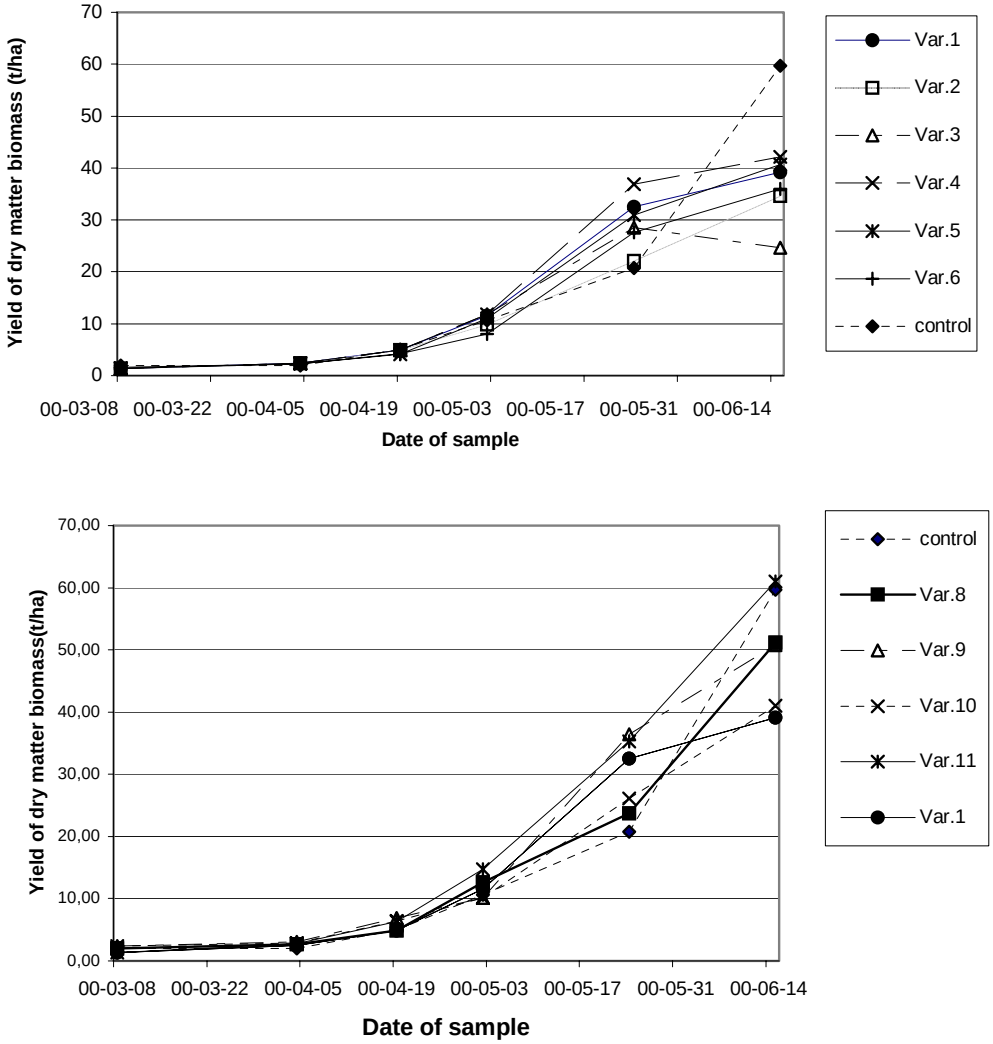

Fig. 1. Dry matter production of vegetative organs depending on increasing S-fertilisation doses during growth — *Produkcja suchej masy w organach wegetatywnych w zależności od nawożenia siarką podczas wzrostu*

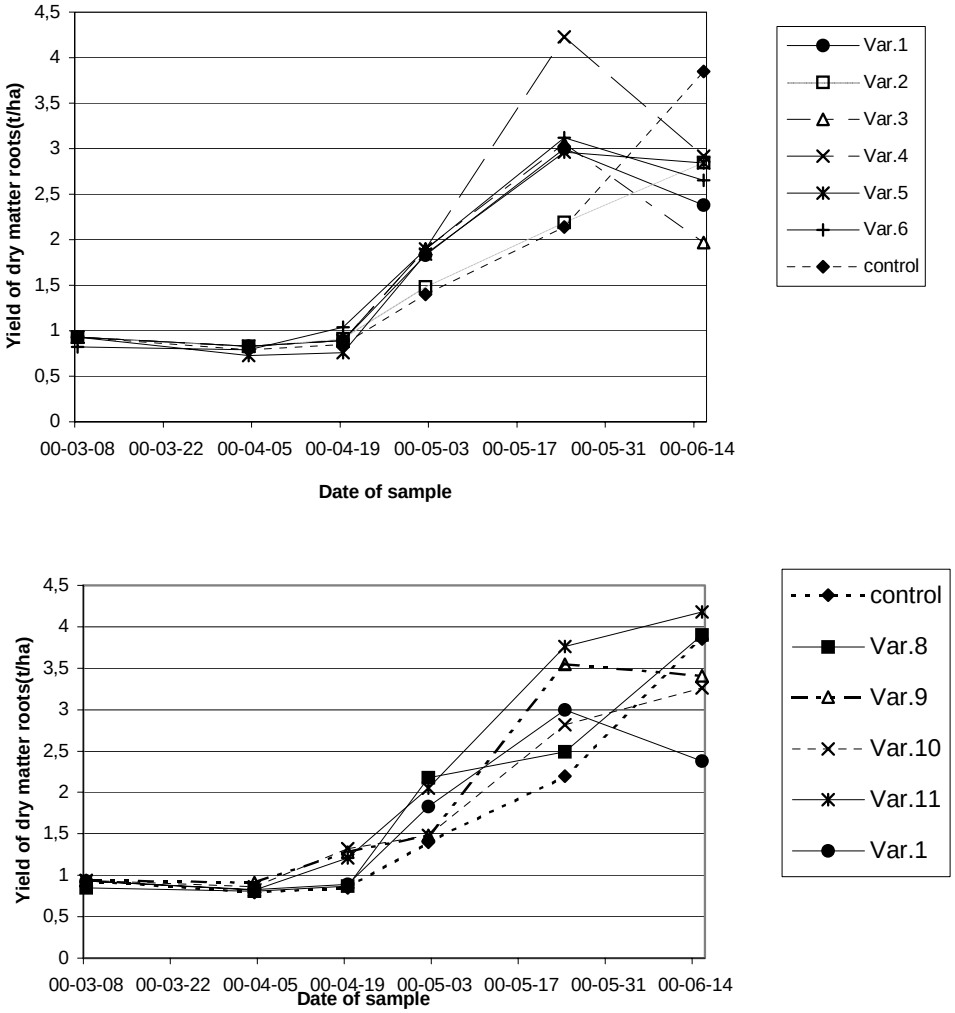

Fig. 2. Dry matter production of roots depending on increasing S-fertilisation doses during growth
Produkcja suchej masy korzenia w zależności od nawożenia siarką podczas wzrostu

Table 2

The influence of sulphur on the yield, MTS, oil and glucosinolate content — *Wpływ nawożenia siarką na plon, masę tysiąca nasion oraz zawartość tłuszczu i glukozynolanów*

Variant *Wariant*	MTS [g] *MTN*	Yield [t/ha] *Plon nasion*	Oil content [%] *Zawartość tłuszczu*	Glucosinolates [µmol/g seed] *Glukozynolany*
1.	4,472	4,40	42,25	15,92
2.	4,300	4,45	42,98	14,52
3.	4,456	4,53	42,89	15,63
4.	4,476	4,69	43,33	15,31
5.	4,351	4,44	43,48	13,88
6.	4,347	3,65	43,59	13,89
7.	4,338	4,03	43,17	15,86
8.	4,442	4,65	43,14	16,98
9.	4,446	4,34	42,50	13,42
10.	4,366	4,79	43,46	14,52
11.	4,291	4,78	43,30	16,58

Variance analysis — *Analiza wariancji*

Variation *Zmienność*	Sum of squares *Suma kwadratów*	D_f	Mean square *Średni kwadrat*	F-Ratio *F obl.*	P
Yield — *Plon nasion*					
among variants *między kombinacjami*	4,62324	10	0,4623	1,16	0,3501
total — *całkowita*	13,1337	33	0,39799		
MTS — *MTN*					
among variants *między kombinacjami*	0,260245	10	0,0260245	1,01	0,4542
total — *całkowita*	0,848512	33	0,0257125		
Oil content — *Zawartość tłuszczu*					
among variants *między kombinacjami*	6,98785	10	0,698785	0,77	0,6579
total — *całkowita*	30,0361	33	0,910185		
Glucosinolates — *Glukozynolany*					
among variants *między kombinacjami*	54,8716	10	5,48716	0,70	0,7144
total — *całkowita*	257,399	33	7,79996		

These results correspond with the feature of nitrogen fertilizer Hydro Sulfan with 24% N enriched with 5,6% S. This fertilizer is ideal for the plant nutrients needs. Hydro Sulfan contains N in immediately active nitrate form (50%) and the next 50% in less impressive ammonium form. This balancing fertilizer manifested a quick growth after the beginning of spring vegetation activity, which positively exhibited the yield of biomass.

The oil content is also higher but this qualitative character is not related to the content of sulphur. These results are not significant (Tab. 2)

The glucosinolate content increased by 10% for the variant with Hydro Sulfan applied in spring, which does not for their lower content, threaten the quality of oilseed rape. Again these results are not significant (Tab. 2).

Conclusion

1. Optimum of S dose is 40 kg/ha in the form Hydro Sulfan
2. Hydro Sulfan should be applied in spring
3. Hydro Sulfan in the dose 40kg S/ha has a positive effect on yield and oil content.

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