

VALUES OF QUALITY TRAITS OF OILSEED RAPE SEEDS DEPENDING ON THE FERTILISATION AND PLANT DENSITY

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Abstract

The aim of this paper has been to evaluate yields and seed quality of winter oilseed rape depending on the plant density, foliar fertilisation with magnesium, sulphur, boron and Asahi growth biostimulant combined with constant NPK fertilisation. The research was performed in 2006-2008 as a two-factor field experiment. The first factor involved plant density (A – 20, B – 30, C – 40 plants per 1 m²) and the second one comprised fertilisation treatments ($n = 7$). Foliar fertilisation was applied once or twice. In rape seeds, the following were determined: the content of total nitrogen, content of fat and its fractions.

The results show that the concentrations of total nitrogen and fat in rape seeds were significantly dependent on both the plant density and fertilisation. Significantly the highest content of those nutrients occurred after a double application of magnesium sulphate (VI), Solubor and Asahi biostimulant at the plant density of 40 and 30 plants m², respectively. The composition of fatty acids extracted from seeds of the hybrid oilseed rape cultivar Nelson significantly depended only on fertilisation. The highest content of oleic acid and its increase, as compared with the control, was identified after a single application of magnesium sulphate (VI), Solubor and Asahi biostimulant. The fertilisation significantly decreased the value of the sum of polyenic acids C_{18:2} and C_{18:3} in rape seeds against the control. It was only after a double application of magnesium sulphate (VI), microelement fertiliser (Solubor) and Asahi biostimulant that the accumulation of these fatty acids remained at the level of concentration reported in the control seeds.

Keywords: winter rape, quality traits, plant density, fertilisation variants.

OCENA CECH JAKOŚCIOWYCH NASION RZEPAKU W ZALEŻNOŚCI OD NAWOŻENIA I OBSADY ROŚLIN

Abstrakt

Celem badań była ocena plonowania i jakości nasion rzepaku ozimego w zależności od obsady roślin, nawożenia dolistnego magnezem, siarką, boronem i biostymulantem wzrostu Ashai w połączeniu ze stałym nawożeniem NPK. Badania przeprowadzono w latach 2006-2008 jako dwuczynnikowe doświadczenie polowe. Pierwszy czynnik to gęstość obsady roślin (A – 20, B – 30, C – 40 roślin na 1 m²), drugi – to warianty nawożenia ($n = 7$). Nawożenie dolistne zastosowano jedno- lub dwukrotnie. W nasionach rzepaku określono zawartość całkowitą azotu, zawartość tłuszczu oraz jego frakcji.

Wyniki badań wskazują, że zawartość całkowita azotu oraz zawartość tłuszczu zależały istotnie od gęstości obsady roślin oraz nawożenia. Istotnie najwyższą zawartość wymienionych składników stwierdzono po podwójnym zastosowaniu siarczanu magnezu (VI) lub biostymulantu Ashai Solubor przy obsadzie roślin odpowiednio 40 oraz 30 roślin na m². Skład kwasów tłuszczowych ekstrahowanych z nasion mieszańcowej odmiany rzepaku ozimego Nelson był istotnie zależny od nawożenia. Istotnie najwyższą zawartość kwasu olejowego oraz wzrost jego zawartości, w porównaniu z kontrolą, określono po pojedynczym zastosowaniu siarczanu magnezu (VI) oraz Soluboru i Ashai. Nawożenie istotnie obniżyło wartość sumy wielonienasyconych kwasów tłuszczowych C_{18:2} i C_{18:3} w nasionach rzepaku w porównaniu z kontrolą. Jedynie po zastosowaniu dwukrotnie siarczanu magnezu (VI), nawozu mikropierwiastkowego Solubor i biostymulantu Ashai akumulacja tych kwasów tłuszczowych utrzymała się na poziomie odpowiadającym zawartościom określonym w nasionach kontrolnych.

Słowa kluczowe: rzepak ozimy, cechy jakościowe, obsada roślin, warianty nawożenia.

INTRODUCTION

Owing to progress in quality breeding as well as production of high yielding population and hybrid cultivars, oilseed rape has become one of the most important plants in the moderate climatic zone. The acreage of oilseed rape and agrimony (winter and spring in total) in Poland was 796.8 thousand ha in 2006, being about 172.9 thousand ha higher (by 27.7%) than in 2005, and 317.4 thousand ha higher than the 2001-2005 mean (by 66.2%) (ROSIĄK 2006).

Rape seeds are most often used in oil and animal feed industry, although oil produced from improved cultivars can be also processed for non-food purposes (BARTKOWIAK-BRODA 2005, WALKOWSKI 2002).

With the prospect of a continued growth in rape acreage and oilseed rape applications, a closer look should be paid at elements of the agronomic practise dedicated to this crop in order to ensure possibly highest yields of adequate quality while optimising costs. Among some important components of the cultivation technology are: preparation of the stand, the type of crop rotation, tillage method, cultivar selection, the application of certified seeds, sowing date and rate, chemical control of the plantation, as well as the

harvest date combined with a selected harvest method as well as fertilisation (MALHI, LEACH 2000, PODLEŚNA 2003, SZEWCZUK 2003, BARTKOWIAK-BRODA et al. 2005).

With that in mind, research has been undertaken, which aimed at determining whether or not and – if so – to what extent winter rape yielding as well as seed quality depend on the plant density and foliar application of magnesium, sulphur and boron against constant NPK fertilisation.

MATERIAL AND METHODS

The experiment was carried out in 2006-2008, in the village of Piecki near i Kruszwica (Figure 1) on soil classified as quality class soil V. The experiment was designed as a two-factor trial in three replicates.



Fig. 1. Location of the experiment

Fertilisation with nitrogen, phosphorus and potassium was constant. The first research factor involved the plant density (A – 20, B – 30, C – 40 plants per 1 m²), and the second one – fertilisation treatments: 7 treatments with varied foliar fertilisation according to the following pattern:

- 0) control,
- 1) magnesium sulphate (VI) + microelement fertilisation (Solubor),
- 2) Asahi biostimulant,
- 3) magnesium sulphate (VI) + microelement fertiliser (Solubor) + Asahi biostimulant,

- 4) magnesium sulphate (VI) + microelement fertiliser (Solubor),
- 5) Asahi biostimulant,
- 6) magnesium sulphate (VI) + microelement fertiliser (Solubor) + Asahi biostimulant.

The plants in treatments 1, 2, 3 were fertilised and treated with the biostimulant once (April), while in treatments 4, 5, 6 – twice with a two-week break.

The following were applied pre-sowing: 120 kg K_2O , 50 kg P_2O_5 and 25 kg N ha^{-1} . In spring, at the beginning of the growing season, the following were applied as top dressing treatments: 70 kg S ha^{-1} (Wigor), 80 kg K_2O ha^{-1} (potash salt) and 20 kg P_2O_5 ha^{-1} (triple superphosphate) as well as 100 kg N ha^{-1} (ammonium nitrate). The treatments were carried out in the first decade of March. Two weeks later, 90 kg N ha^{-1} was applied.

Winter barley constituted the forecrop for oilseed rape. In each year, the plants were sown in the last decade of September, while the harvest took place in the last decade of July of the successive year. Each year, representative rape seed samples were taken for determination of total nitrogen with Kieldahl method. The content of fat was determined with an analyzer NMR – MQA 7005 Oxford, while the fat fractions were assayed using gas chromatography.

The results underwent analysis of variance in a two-factor design with Tukey's semi-intervals of confidence.

RESULTS AND DISCUSSION

The rape seed yield, as a result of the fertilisation applied, varied a lot and ranged from 4.66 t ha^{-1} to 4.76 t ha^{-1} , with the mean value of 4.69 t ha^{-1} (Figure 2). The seed yield was significantly determined by the foliar application of the tested fertilisers.

The significantly highest rape seed yield was recorded after a double foliar application of magnesium sulphate (VI), Solubor, Asahi (treatment 6) at the density of 30 plants m^{-2} . SZEWCZUK (2003) demonstrated that it was also justifiable to apply multi-component fertiliser on two dates with since foliar fertilisers usually enhanced the yield structure components, especially the 1000 seed weight, and thus raised the yield. Interestingly, in the present research the highest yields were reported from the plots with an increased dose of microelement fertiliser containing boron (treatment 6). A similar reaction of rape to boron is reported by BOWSZYS, KRAUZE (2000). SIENKIEWICZ-CHOLEWA (2005) also points to a yield-forming role of boron and claims that rape seed yield after microelement fertilisation in most of the experiments tended to increase noticeably.

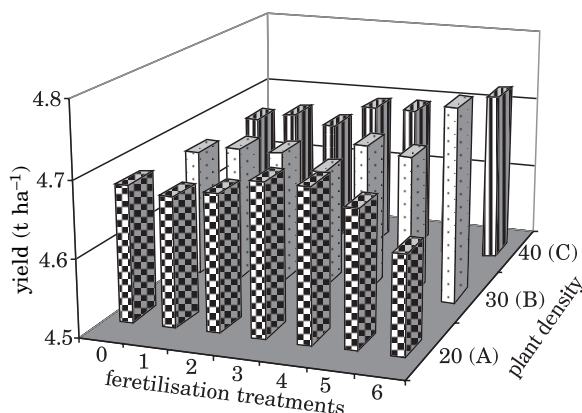


Fig. 2. Winter rape seed yielding (t ha^{-1})

The content of total nitrogen in oilseed rape seeds ranged from 35.6 g kg^{-1} to 40.9 g kg^{-1} , with the mean total of 38.12 g kg^{-1} , and depended significantly on the plant density as well as on the fertilisation applied (Table 1).

Table 1

Content of nitrogen and fat in winter rape seeds

Plant density	Mineral fertilisation						
	0	1	2	3	4	5	6
Content of total nitrogen in rape seeds (g kg^{-1})							
20 (A)	37.1Bd	37.8Bc	37.2ABc	37.9Bab	38.6Aa	36.9Ad	38.6Aa
30 (B)	35.6Cd	39.2Aa	37.8Abc	39.0Aa	39.1Aa	37.3Ac	38.0Bab
40 (C)	38.2Ac	38.1Bc	38.1Ac	39.8Ab	38.3ABc	37.1Ad	40.9Ba
Content of fat in winter rape seeds (%)							
20 (A)	44.7Cc	44.2Cd	45.0Bb	45.3Aab	43.9Be	45.4Aa	45.0Bb
30 (B)	45.1Bc	45.1Ac	45.6Ab	45.3Ac	44.5Ad	45.6Ab	46.4Aa
40 (C)	45.5Aa	44.6Bb	44.8Bb	43.7Bd	43.6Bd	44.2Bc	43.2Ce

a, b, c, d – means marked with different letters in the row differ significantly depending on the ($p < 0.05$); *A, B, C* – means marked with different letters in the column differ significantly depending on the plant density ($p < 0.05$)

In general, a significantly higher content of total nitrogen occurred in the seeds of plants growing at the density of 40 plants m^{-2} , while the lowest N content was identified in the seeds growing at the density of 20 plants m^{-2} .

On average, the significantly highest total N content was found following a double application of magnesium sulphate (VI), microelement fertiliser (Solubor) and Asahi biostimulant (treatment 6). It was also observed that

after a double application of magnesium sulphate (VI) and Solubor as well as after a single foliar application of magnesium sulphate (VI), microelement fertiliser (Solubor) and Asahi biostimulant (treatment 4), the content of nitrogen in rape seeds was significantly bigger than the control, on average by 5.8%.

Numerous authors (FOTYMA et al. 2000, WIELEBSKI, WÓJTOWICZ 1998, 2001, SIENKIEWICZ-CHOLEWA 2001, KOTECKI et al. 2001, PAŁKA et al. 2003, PODLEŚNA 2004, WIELEBSKI 2005) have demonstrated that the application of nitrogen and the treatment of rape with multi-component fertilisers as well as with sulphur enhance the content of total nitrogen, and thus the content of protein in seeds, an observation which is supported by the present research.

Technological usability of oilseed rape seeds for fat production depends on the content of fat and the percentage composition of fatty acids. The content of fat in the rape seeds ranged from 43.2% to 46.4% and it was determined by both experimental factors (plant density and fertilisation) as well as their interaction (Table 1).

SIENKIEWICZ-CHOLEWA (2001) reports a slightly lower (from 39% to 43%) content of fat in rape seeds as a result of microelement application. According to MUŚNICKI et al. (1999), it is the genetic factor which is decisive in creating the content of fat in rape seeds; the differences in extreme cases ranged from just 6.3% to 6.5%. JĘDRZEJAK et al. (2005), on the other hand, claim that the productivity of crude fat depends mostly on the moisture and thermal conditions as well as on nitrogen fertilisation and, to a little extent, on the genetic factor.

The significantly highest content of fat was found in rape seeds collected from the plots of the density of 30 plants m^{-2} , following the successive application of twice magnesium sulphate (VI), Solubor and Asahi (treatment 6), twice Asahi (treatment 5) as well as once Asahi (treatment 2). They were, respectively, 2.8%, 1.1% and 1.1%, higher than the control (treatment 0). BARŁÓG, POTARZYCKI (1997) found that foliar fertilisation of rape with magnesium, at a split dose, demonstrated a significant increase in the content of fat in rape seeds from 0.5 to 1.0%. Interestingly, the number of applications of Asahi biostimulant did not affect the content of fat in rape seeds. Rape obtained from the plots on which the density was 20 plants m^{-2} accumulated significantly less fat in seeds as compared with the content produced from the plots where the density was 30 plants m^{-2} (by an average of 1.3%). The literature reports show that microelements have a favourable affect on the content of fat in rape seeds (LÄÄNISTE et al. 2004); positive effects were recorded for single microelements as well as for their mixtures.

The composition of fatty acids is highly cultivar-specific, so agrotechnical and weather factors do not actually change it (MUŚNICKI et al. 1999). Interestingly, the composition of fatty acids in oilseed rape seeds was typical and significantly determined only by fertilisation (the 2nd factor). In the

present research, it was found that winter rape seeds demonstrated the greatest share of oleic acid in crude fat, which – depending on the plant density – ranged from 62.66% to 62.87%. In dependence on the fertilisation applied, its share ranged from 61.93% to 63.53% (Figures 3, 4). The greatest increase in the content of oleic acid, as compared with the control, was found after a single application of magnesium sulphate (VI), Solubor and Asahi biostimulant (treatment 3).

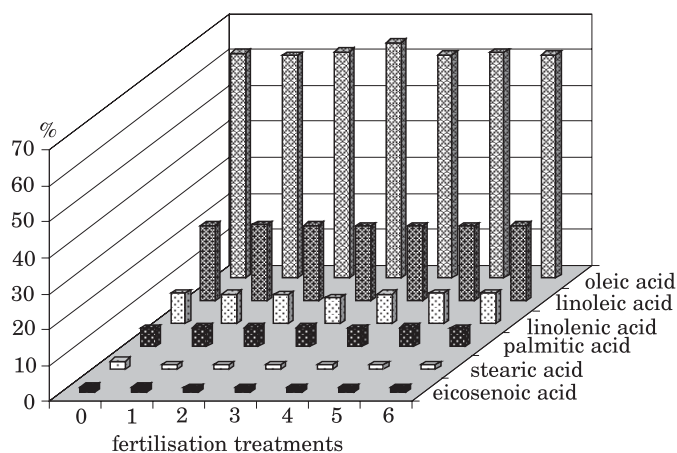


Fig. 3. Content of respective fatty acids depending on fertilisation

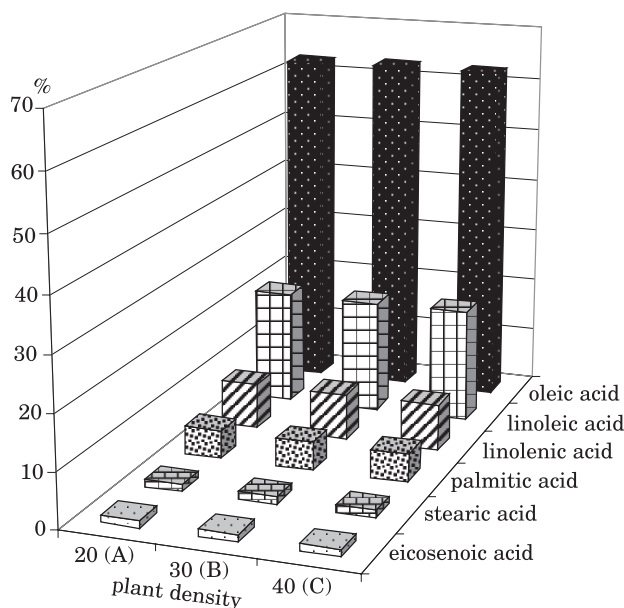


Fig. 4. Content of respective fatty acids depending on the plant density

The composition of fatty acids in rape seeds can be cultivar-specific dependent on the harvest date (JACKOWSKA, TYS 2006, MURAWA et al. 2000) or slightly dependent on nitrogen fertilisation (KOTECKI et al. 2001). Moreover, KRAUZE, BOWSZYS (2001) demonstrated that fertilisation with sulphur increased the share of essential fatty acids (linolenic and linoleic acids) in fat, thus enhancing the nutritive value of fat. The fertilisation applied in the present research decreased the sum of polyenic acids $C_{18:2}$ and $C_{18:3}$ (linoleic acid+linolenic acid) in rape seeds, as compared with the control. Interestingly, the values of the sum of the content of those acids were identical and the highest (29.73%) in rape seeds obtained from the control and after a double application of magnesium sulphate (VI), microelement fertiliser (Solubor) and Asahi biostimulant (Figure 4).

After a single application of magnesium sulphate (VI) and Solubor (treatment 1) an increase in the content of linoleic acid ($C_{18:2}$) in rape seeds appeared, accompanied by a decrease in the content of oleic acid. Numerous results reported by other authors have shown changes in the composition of fatty acids as a result of fertilisation with microelements and multi-component fertilisers (KOTECKI et al. 2001, SIENKIEWICZ-CHOLEWA 2002, 2005, PAŁKA et al. 2003); they most often affected polyunsaturated acids, especially linoleic acid, which could indicate their lack of stability (ROBAK, GOGOLEWSKI 2002).

A weaker effect on the values of the sum of the content of acids $C_{18:2}$ and $C_{18:3}$ in rape seeds was identified for the plant density. The highest content of acids $C_{18:2} + C_{18:3}$ (29.5%) was found in seeds from the treatments where the density was 40 plants m^{-2} , remaining unchanged for the other two densities. In none of the rape seed samples significant changes in the value of the sum of acids $C_{18:2}$ and $C_{18:3}$ depending on the plant density were found.

CONCLUSIONS

1. The significantly highest rape seed yield was ensured by a combined double application of magnesium sulphate (VI), microelement fertiliser (Solubor) and Asahi biostimulant. The plant density did not affect winter rape yielding.

2. The total nitrogen and fat in rape seeds were significantly determined by both the plant density and fertilisation. Significantly most of these nutrients were identified after a double application of magnesium sulphate (VI), Solubor and Asahi biostimulant in seeds collected from plots at the density of 40 and 30 plants m^{-2} , respectively.

3. The composition of fatty acids extracted from winter rape seeds significantly depended on fertilisation. The significantly highest content of oleic acid and an increase in its concentration, as compared with the control, was

found after a single application of magnesium sulphate (VI), Solubor and Asahi biostimulant.

4. Similarly, fertilisation significantly depressed the values of the sum of polyenic acids C_{18:2} and C_{18:3} in rape seeds, as compared with the control. A double application of magnesium sulphate (VI), microelement fertiliser (Solubor) and Asahi biostimulant were the only treatments which resulted in the accumulation of these fatty acids remaining at the level of the concentration recorded in the control seeds.

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