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INFLUENCE OF SOIL ACIDITY AND PERIODICAL DROUGHT ON YIELD OF WINTER OILSEED RAPE SEEDS IN RELATION TO NITROGEN RATES

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A b s t r a c t. The changes in the seed yields of the improved forms of winter oilseed rape in the arrangement depended on periodical drought in the phase of start of budding to the flowering end (determined by the precipitation difference of 135 mm), nitrogen rates of 140 and 280 kg N/ha applied once a spring in the beginning of growth period, soil acidity in the upper soil layer amounting to pH KCl 6.4, 4.9 and 4.1 of the Mar, Panter, Bolko, Ceres and Liporta cultivars were investigated in the work.

The experiment was carried out in soil containers of the surface of 0.126 m^2 and the height of 150 cm placed in the field and filled up with the soil profile consisting of loamy sand on medium loam with different acidity.

The highest differences in yields were mainly caused by nitrogen fertilization, rainfall, cultivars and soil acidity. The highest yields were obtained on soil with pH 4.9. Reduction of rainfalls led to the significant enlargement of differences due to acidity. Those differences depended also on the nitrogen rate. At a lower rate they were not significant while at a highest one they considerably increased.

The periodical drought caused a significant decrease in efficiency of the fertilizing nitrogen. As far as varieties were concerned, there were Mar and Panter cultivars which gave significantly higher yields than the others. The distinct changes in the number of lateral branches were caused by the nitrogen rate and rainfalls. The highest number of lateral branches was found in the Mar and Liporta cultivars. The seeds of the Mar variety had much lower TSW in comparison with the Panter, Bolko and Ceres cultivars. The fat and protein content depended on cultivars. The highest protein concentration and at the same time the lowest fat content were found in the Bolko cultivar seeds. The similar protein content was found in the seeds of the remaining cultivars. The highest fat concentration was in the seeds of the Mar cultivar.

K e y w o r d s: winter oilseed rape, soil acidity, nitrogen fertilization

INTRODUCTION

The winter oilseed rape in comparison with the other cultivated plants is characterized with especially high dynamics of yielding and cultivation increase. The source of the positive changes is biological progress of those species obtaining the improved and good yielding cultivar '00'.

The introduction of the new cultivars to the production needs the new experiments enriching our knowledge on those useful plant.

The rape seed hold the significant place in the structure of seeding in the Polish conditions. In practice it is frequently cultivated also on lighter soils usually with higher acidity and at the same time with lower water capacity. The rape seeds in the period of intensive growth and seed binding have especially high demand for water. That demand takes place usually in Poland from the half of April till the end of June. Within those time there is frequently periodical drought. 1992 is an example for it (Table 1).

Intensity of investigation on drought result, especially in connection with soil acidity and nitrogen fertilizing is relatively small. For

Table 1. Atmospheric precipitation at Skiemiewice

Month	Mean of 60 years sum	1991/92	Optimal precipitation for winter rape acc. to Klatt [9]
August	73.4	51.1	
September	46.8	29.8	
October	37.3	14.8	
November	38.6	55.9	
December	37.5	31.5	
January	22.0	12.9	
February	23.4	30.5	
March	23.6	44.9	
April	36.5	32.7	45
May	51.7	21.3	70
June	67.1	21.8	75
July	83.3	27.0	
Annual sum	531.2	380.2	

several years we have spent more time on that subject [1-5] mainly on winter oilseed rape experiments. In the earlier publications we have shown that Jet Neuf cultivar is in relative assessment more tolerant for drought soil in comparison with the others, especially with Bolko cultivar which reacts stronger than the others by decreasing in moisture deficiency of yield. We have also shown that variety of winter oilseed rape reacts differently on nitrogen fertilizing and that reaction appeared to be dependent on soil moisture [5].

The earlier achieved results [4,5,10,11,14] as well as investigation needs aiming at softening influence of unfavourable terms (especially periodical drought) on growth and yield of plants motivated the undertaking of experiments described below.

MATERIALS AND METHODS

The experiment had the following scheme:

Factor A - 2 moisture levels;
Factor B - 3 ranges of soil pH;
Factor C - 2 doses of nitrogen;
Factor D - 5 cultivars.

Double improved cultivars of winter oilseed rape - Mar, Panter, Bolko, Ceres and Liporta were used for investigation.

The experiment has been carried out in field conditions. In containers where plants were grown there were ceramic cylinders (150 cm high and 40 cm in diameter) without bottoms. The surface of cylinder was 0.126 m^2. The above mentioned cylinders were placed in the open space and filled with soil of different acidity in order to reconstruct full profile. The cylinders were placed in trench in such a way that their surface was on the same level as surface of the field. The open bottom in the pots ensured a natural vertical water movement. The frame of polythene tunnel was fitted over the pots. It enabled the polythene cover to be fitted during various plant growth phases in order to stimulate different rainfall doses by watering.

Soil that was used for experiment in the superficial layer had mechanical composition of light loamy sand. Subsoil mechanical composition was characteristic for the medium heavy loam. Soil acidity used for the experiment is shown in Table 2.

Before sowing the basic fertilization was applied in g per cylinder:

- 0.38 g N (30 kg N/ha) in NH_4NO_3,
- 1.01 g P_2O_5(80 kg P_2O_5/ha) in K_2HPO_4,
- 1.51 g K_2O (120 kg K_2O/ha) in K_2HPO_4 and KCl,
- 0.38 g MgO (30 kg MgO/ha) in $MgSO_4$ $7H_2O$.

The experiment was repeated five times. Winter oilseed rape was sown on 20 August,

Table 2. Acidity in grey brown podzolic soil used in experiment

pH_{KCl}	Factor (B)	
	Hw	Hh
	mmol (+)/100 g	
6.4	0.03	0.61
4.9	0.06	1.48
4.1	0.24	2.11

1991 in such a way that there were 20 seeds per cylinder. In 1992 just after beginning of vegetation 12 plants remained in each cylinder. Next on 20 March the nitrogen fertilization was applied in two doses 1.77 g (140 kg N/ha) and 3.54 g N per cylinder (280 kg N/ha). Nitrogen was applied in form of ammonium nitrate.

The experiment was carried out in open space till the beginning of budding stage of the plants. Next on 26 April the polythene film was stretched over the tunnel frame and moisture differentiation by watering began. Since that time objects described as periodical drought, i.e., with the lesser moisture have not been supplied with water. Objects with higher level of moisture have been systematically watered. Differences in watering was conducted within the period from the beginning of budding phase up to the end of flowering. The total quantity of water applied amounted to 17 liters of water what constituted equivalent of 135 mm rain precipitation. The above mentioned amount of rainfalls was slightly higher only than the average long-term one for that period. On the end of rape seed flowering taking place on 18 June the polythene film was taken off and further vegetation was continued in open air. The crop occurred in the phase of technical maturity of the seeds.

The yield of seeds as well as weight of 1000 seeds and also the number of lateral branches were determined. The content of fat in the seeds was measured by using Kielffos method while the content of protein in the seeds was measured by method of Soxlet.

RESULTS

The statistical analysis has shown that significant differences of yields were the result of the following factors occurring in the following sequence: nitrogen fertilizing, soil moisture, cultivars and soil acidity. There was also found that significant inhomogeneous of population caused by interaction of soil moisture and its acidity, nitrogen dose and soil acidity and soil moisture and nitrogen dose.

Significant cultivar interaction with other investigated factors were not proved by statistical analyses.

The Mar and Panter cultivar have yielded at the most, whereas the significantly lower seed yields were obtained from Bolko, Ceres and Liporta cultivars (Table 3).

The yield was strongly diminished by periodical drought. The 135 mm decrease in precipitation occurring in the phase from the beginning of budding up to the end of winter oilseed rape flowering have caused the drop in seed crop on an average by about 17 % however in the less extent with lower dose of nitrogen (Table 4). It was also found that in spite of drastic drought the seed rape yield in the objects with the higher nitrogen dose was significantly higher in comparison with those obtained with good moisture but with lower nitrogen fertilization (Table 4).

Soil acidity caused important changes in the seed crop. The essential effect of interaction taking place between that factor and soil moisture was proved. It means that yield differences caused by soil acidity depended on amount of precipitation (Table 5). It worth to add that they were slight and fitting in the range of experiment error when the soil moisture was higher. On the other hand they were high and significantly essential in the objects with periodical drought. The highest yield was obtained on a soil with pH 4.9. The pH decrease (from 4.9 up to 4.1) and also pH increase (from 4.9 up to 6.4) caused the significant yield drop.

The yield decrease caused by pH drop to 4.1 can be explained by influence of unfavourable terms of metal compounds especially aluminum and manganese which occur in the soils

Table 3. Yield of seed of winter oil seed rape in g per pot with a surface of 0.126 m^2 and percentage concentration fat and protein depending on soil moisture (A), soil acidity (B), nitrogen doses (C) and cultivars (D)

Factors investigated	Seed yield	Fat dry	Protein seed wt.
	mg/pot	% of seed wt.	
Soil moisture (A)			
A_1 - higher level	47.3	48.3	17.6
A_2 - lower level	39.3	48.2	17.5
LSD (P = 0.05)	1.58		
Soil acidity (B) pH_{KCl}			
6.4	43.2		
4.9	45.7	48.1	17.7
4.1	40.9	48.5	17.5
LSD (P = 0.05)	1.94	48.4	17.4
Nitrogen doses (C)			
C_1	35.8	48.7	17.0
C_2	50.8	47.9	18.1
LSD (P = 0.05)	1.58		
Cultivars (D)			
Mar	47.0	48.8	17.1
Panter	46.5	48.0	16.6
Bolko	39.9	47.6	19.0
Ceres	42.2	48.6	17.1
Liporta	40.8	48.4	17.7
LSD (P = 0.05)	2.49		

A_1-A_2 - difference of moisture was equal to the 135 mm precipitation, C_1 - 140 kg N/ha, C_2 - 280 kg N/ha.

Table 4. Effect of moisture (A) on the seed yield of oilseed rape in g per pot with a surface of 0.126 m^2 depending on nitrogen doses (C), means within cultivars and soil acidity

Nitrogen dose (C)	Moisture of soil			
	A_1	A_2	A_1	A_2
C_1	38.8 (100)	32.9 (100)	100	85
C_2	55.8 (144)	45.8 (139)	100	82
Mean	47.3	39.3	100	83

LSD (P=0.05) for interactions: A/C - 2.24, C/A - 2.24.

in excess concentration when pH is lowered. The seed yield drop in taking place in objects with lowered moisture caused by change of soil pH from 4.9 up to 6.4 suggests the following reason of the betterment of soil acidity. Namely, the lowering of moisture enables the process of soil oxidation. Therefore the oxidation of microelements, especially of manganese might have been facilitated resulting in the limitation of the forms of element available for the plants to the level reducing rape seed crop.

Table 5. Effect of soil acidity (B) on the seed yield of winter oilseed rape in g per pot with a surface of 0.126 m^2 depending on nitrogen doses (C) and moisture (A) means over all cultivars

Soil moisture (A)	Nitrogen doses (C)	Soil acidity pH_{KCl} (B)		
		6.4	4.9	4.1
Means within nitrogen doses				
A_1		47.3	48.4	46.1
A_2		39.1	43.1	35.7
Means within soil moisture				
	C_1	35.7	37.1	34.7
	C_2	50.8	54.4	47.1

LSD (P=0.05) for interactions: A/B - 2.70, B/C - 3.22, B/A - 3.22, C/B - 2.70.

The statistical analysis has indicated significant dependence between soil interaction and dose of nitrogen. It results from the fact that interaction effect is smaller when dose of nitrogen is low. On the other hand while dose of nitrogen is higher it is distinct and statistically significant. Thus the effects of experiment show and confirm the existence of significant correlation between those factors.

Moreover the experiment was expected to determine the influence of the investigated factors on TSW as well as on the number of the lateral branches. The significant changes have been caused by moisture and nitrogen dose. It was also found that they depend on the kind of cultivar (Table 6). It allowed to come into conclusion that decrease in moisture of soil caused the drop in TSW and in the number of the lateral branches, whereas dose of nitrogen raised those features.

Above it the Mar variety was stated to have had lower TSW and simultaneously higher number of the lateral branches in comparison with the Panter, Bolko and Ceres cultivars.

Table 6. Effect of moisture (A), nitrogen doses (C) and cultivar (D) on number of lateral branches of oilseed rape and 1000 seed weight (TSW)

Factors investigated	Number of lateral branches	1 000 seed weight (TSW)
Moisture (A)		
A_1	3.82	4.43
A_2	3.55	4.31
LSD (P = 0.05)	0.20	0.06
Nitrogen doses (C)		
C_1	3.45	4.32
C_2	3.93	4.43
LSD (P = 0.05)	0.21	0.06
Cultivars (D)		
Mar	4.04	4.27
Panter	3.46	4.42
Bolko	3.30	4.41
Ceres	3.35	4.42
Liporta	4.08	4.35
LSD (P = 0.05)	0.46	0.13

Explanations: see Table 3.

The content of fat and protein were changed relatively slight according to the factors investigated. The moisture of soil and its acidity did not cause important changes in concentration of those components (Table 3). Intensification of nitrogen fertilization caused slight drop in percentage content of fat and at the same time increase in content of protein. The smallest content of fat was noticed in the seeds of Bolko variety. Those seeds had also the highest content of protein.

CONCLUSIONS

1. The periodical drought determined by decrease in precipitation by 135 mm occurring within the phase of initial budding of winter oilseed rape up to the end of April caused the drop in the seed crop on an average by 17 % to the smaller extent with the smaller nitrogen dose.

2. The decrease in precipitation deepens the differences in yields that result from the change of soil interaction. While periodical drought the highest crops of the winter oilseed rape were achieved on the soil with pH 4.9. The decrease in soil pH up to 4.1 and increase in it up to 6.4 reduced significantly the crops of seeds.

3. The nitrate fertilization causes differences in yields of the winter oilseed rape resulting from the different acidity.

4. The Mar and Panter varieties yield significantly higher than the others.

5. The smallest content of fat and simultaneously the highest content of protein occur in the seeds of rape of Bolko cultivar. The content of fat and protein in another varieties are similar.

6. The Mar and Liporta cultivars in comparison with the remaining ones are characterized with higher number of the lateral branches. While the Mar cultivar is characterized with the smaller TSW in comparison with the others.

REFERENCES

1. **Barszczak Z., Barszczak T. Kot A.:** Wrażliwość odmian i rodów rzepaku ozimego na zakwaszenie i okresowy niedobór wody w glebie. Zesz. Probl., Rośliny Oleiste, Wyniki badań 1986, I, 182-190, 1989.
2. **Barszczak Z., Barszczak T., Górczyński J., Kot A.:** Wpływ wilgotności, zakwaszenia gleby i dawki azotu na cechy morfologiczne roślin i plon odmian rzepaku ozimego. Zesz. Probl., Rośliny Oleiste, Wyniki Badań 1989, I, 173-182, 1990.
3. **Barszczak Z., Barszczak T., Górczyński J., Kot A.:** Wpływ okresowej suszy, zakwaszenia gleby i dawki azotu na masę i skład chemiczny nasion rzepaku ozimego. Zesz. Probl., Rośliny Oleiste, Wyniki badań 1990, I, 221-229, 1991.
4. **Barszczak Z., Barszczak T., Górczyński J., Kot A.:** Effect of moisture, nitrogen doses and soil acidity on seed yield, chemical composition, thousand seed weight of some winter oilseed rape cultivars. Proc. 8th Int. Rapeseed Cong., Sascatoon, 4, 1181-1185, 1991.
5. **Barszczak Z., Barszczak T., Foy C.D.:** Effects of moisture, nitrogen rates and soil acidity on seed yield and chemical composition of winter oilseed rape cultivars. *J. Plant Nutr., 16(1), 85-96, 1993.*
6. **Dembińska H.:** Wpływ jesiennych i wiosennych niedoborów wody na rozwój i strukturę plonu rzepaku ozimego. Rocz. Nauk Rol., A, 96, 73-96, 1979.
7. **Foy C.D.:** *Physiological effects of hydrogen aluminum and manganese toxicities in acid soil. In: Soil*

Acidity and Liming (ed. F. Adams). 2nd Edition, Soil Sci. Soc. Am., Madison, WJ., 57-97. 1984.
8. **Foy C.D.:** Soil chemical factors limiting plant growth. In: Adv. in Soil Science (ed. J.L. Hatfield). Springer Verlag, New York, 19, 97-149, 1992.
9. **Klatt P.:** Technic und Technologie der Beregnung. Ltd., Berlin, 320-326, 1970.
10. **Krizek D.T., Foy C.D.:** Role of water stress in differential aluminum tolerance of two barley genotypes grown in acid soil. J. Plant Nutr., 11, 351-367, 1988.
11. **Krizek D.T., Foy C.D.:** Role of water stress in differential aluminum tolerance of six sunflower cultivars grown in acid soil. J. Plant Nutr., 11, 387-408, 1988.
12. **Marska E., Seidler M.:** Wpływ zróżnicowanej wilgotności gleby na morfologiczne cechy uszlachetnionych odmian rzepaku ozimego. Zesz. Probl., Rośliny Oleiste, Wyniki badań 1988, I, 162-168, 1989.
13. **Marska E., Seidler M.:** Wybrane parametry gospodarki wodnej podwójnie uszlachetnionych odmian rzepaku ozimego w warunkach zróżnicowanej wilgotności gleby. Zesz. Probl., Rośliny Oleiste, Wyniki badań 1988, 1, 152-161, 1989.
14. **Mc Pherson H.R., Scarth S.R., Rirner S.R., Mc Vetty P.B.E.:** The effect of drought stress on yield determination in oilseed rape. 7th Int. Rapeseed Congress, Poznań, 3, 822-827, 1987.
15. **Szukalski H., Sikora H., Szukalska-Gołąb W.:** Reakcja różnych odmian rzepaku na wilgotność gleby. Zesz. Probl., Rośliny Oleiste, Wyniki Badań 1988, I, 146-151, 1989.

WPŁYW ZAKWASZENIA GLEBY I OKRESOWEJ SUSZY NA PLON NASION RZEPAKU OZIMEGO ZALEŻNIE OD DAWKI AZOTU

W pracy badano zmiany plonów nasion podwójnie ulepszonych form rzepaku ozimego w układzie zależnym od okresowej suszy w fazie od początku pąkowania do końca kwitnienia (określonej różnicą 135 mm opadu), dawki azotu 140 i 280 kg N na ha stosowanego jednorazowo wiosną w okresie ruszenia wegetacji, zakwaszenia gleby w warstwie wierzchniej pH_{KCl} 6.4, 4.9 i 4.1, odmian Mar, Panter, Bolko, Ceres i Liporta.

Doświadczenie wykonano w wazonach gruntowych o powierzchni 0.126 m^2 i wysokości 150 cm, które zostały zlokalizowane w polu i napełnione profilem gleby, piaskiem gliniastym na glinie średniej o różnym zakwaszeniu. Największe plony uzyskano na glebie o pH 4.9. Obniżenie opadów istotnie zwiększało różnice powodowane zakwaszeniem. Różnice te były też zależne od dawki azotu. Przy mniejszej dawce były one niewielkie, natomiast przy wyższej uległy istotnemu zwiększeniu. Okresowa susza spowodowała istotne zmniejszenie efektywności azotu nawozowego. W doświadczeniu istotnie wyżej od pozostałych plonowały odmiany Mar i Panter. Wyraźne zmiany w liczbie pędów bocznych powodowała dawka azotu i opady. Największą liczbę pędów bocznych stwierdzono u odmian Mar i Liporta. Odmiana Mar tworzyła nasiona o istotnie mniejszej MTN w porównaniu do odmian Panter, Bolko i Ceres. Zawartość tłuszczu i białka była zależna od odmian. Największą koncentrację białka i równocześnie najmniejszą tłuszczu stwierdzono w nasionach odmiany Bolko. Nasiona pozostałych odmian zawierały zbliżone zawartości białka. Największą koncentrację tłuszczu stwierdzono w nasionach odmiany Mar.

S ł o w a k l u c z o w e: nasiona rzepaku ozimego, zakwaszenie gleby, nawożenie azotowe