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ESTIMATION OF THE INFLUENCE OF NITROGEN FERTILIZATION (AMMONIUM NITRATE OR UREA) ON THE MECHANICAL PROPERTIES OF RAPE SILIQUES*

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A b s t r a c t. Two field experiments were conducted in order to evaluate the effect of nitrogen fertilization on the strength properties of rape siliques:
- on one variety (Jupiter), with nitrogen used as urea to soil in spring,
- on four varieties (Ceres, Liporta, Bolko, Mar), with nitrogen as 10 % urea water solution to leaves.

A 7 to 42 % increase in silique strength was observed for urea as compared to ammonium nitrate. 10 % water solution of urea caused a 10 to 51 % increase in silique strength, depending on variety.

K e y w o r d s: rape siliques, nitrogen fertilization, mechanical properties

INTRODUCTION

An unfavourable feature of plants from the *Cruciferae* family is the phenomenon of fruit cracking and seed shedding during ripening and harvest.

Rape silique cracking causes seed losses. Seeking for a solution to that problem, studies have been conducted on the causes and the mechanisms of silique cracking [1,2,4,5,7] and attempts have been made at limiting that problem through plant breeding or through improvements to the harvest technology [2,8].

In view of the fact rape fertilization with nitrogen is one of the main crop-increasing factors [3,6], this study was focused on the estimation of the effect of various forms of nitrogen fertilization on the mechanical properties of rape siliques.

MATERIAL AND METHOD

Two plot experiments were set up:

1. A three-year experiment with the Jupiter variety, in which nitrogen fertilization was applied in the form of ammonium nitrate (control plot) and urea.

2. A one-year experiment with four rape varieties (Ceres, Bolko, Liporta, Mar), in which ammonium nitrate was supplemented with 10 % urea water solution applied to leaves, as compared to ammonium nitrate fertilization alone.

In all the plots the nitrogen dosage was 120 kg N/ha, with P_2O_5 applied in doses of 80 kg/ha, and K_2O - 140 kg/ha.

Ammonium nitrate was applied in two doses, urea - a single application in spring, and spraying with 10 % urea was performed twice (before blooming and after blooming).

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The experiments were set up on a degraded chernozem developed from loess. The area of a single plot was 18 m^2 (1.8 m x 10 m). The plants were sown in five rows at 30 cm spacing. The experiments were conducted in five replications.

In the phase of full ripeness, from each of the combinations samples of 50 siliques were taken, in five replications, for the determination of seven strength parameters and of the coefficient of silique resistance of cracking (R).

The method used for the determination of silique resistance to cracking consisted in twisting tests in a specially designed adaptor. The operating principle of the measurement system consisted in a gradual increase of force acting, through a line and a pulley, on one of the silique ends. The other end of the silique was fixed in a grip. The adaptor was installed on a portable strength tester. The whole system was coupled to a computer, which allowed for the twisting tests to be recorded and for the calculation of the necessary strength parameters.

The parameters determined were the following: α - the angle at which the first silique cracking occurs, M_{max}- the maximum twisting moment, M_k - the ultimate twisting moment, A - energy causing total silique cracking, A' - energy elasticity, A'' - energy causing the first silique cracking, DA - energy characterizing the resistance of silique raphes, R - coefficient of silique resistance to cracking.

RESULTS

On the basis of the results obtained it was found that nitrogen fertilization in the form of urea has a limiting effect on the unfavourable phenomenon of silique cracking. Siliques from the urea combinations had higher values of the coefficient of silique resistance to cracking (R) as compared to siliques from plants fertilized with ammonium nitrate (Table 1). Increases obtained in the values of the coefficient in successive years were 28 %, 42 %, and 7 %. Mean values, compared for the three years of observations,

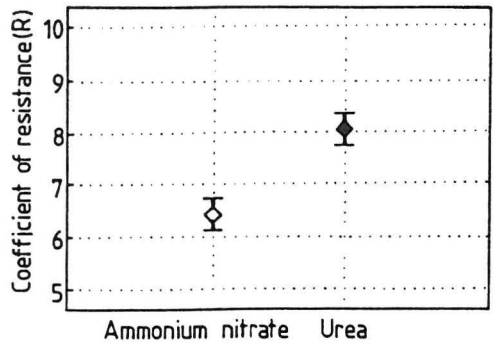

Fig. 1. 0.95 Tukey HSD intervals for factor means of total resistance coefficient (R) of v. Jupiter for three years.

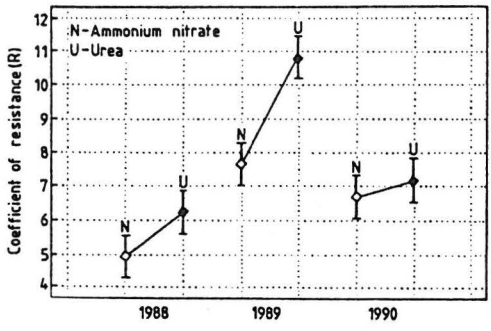

Fig. 2. 0.95 Tukey HSD intervals for factor means of resistance coefficient (R) of v. Jupiter separately for three years.

differed significantly (Fig. 1).

Analyzing the particular years of the experiment, it was found that in the third year, in spite of an increase in the value of coefficient R, the differences between the mean values were not significant (Fig. 2).

Comparing siliques from plants fertilized with urea and with ammonium nitrate it was found that siliques from the former were characterized by increased values of such strength parameters as: energy causing the first silique cracking - 1.4 mJ (urea) as compared to 1.0 mJ (ammonium nitrate); energy causing total silique cracking - 11.5 mJ (urea) and 9.2 mJ (ammonium nitrate); maximum twisting moment - 5.2 Nmm (urea) and 4.3 Nmm (ammonium nitrate) - Table 1.

Table 1. Strength parameters of pods of winter rape v. Jupiter due to ammonium nitrate (N) and urea (U) fertilization

Parameter	Unit	1988		1989		1990		x	
		N	U	N	U	N	U	N	U
α	rad	0.32	0.35	0.41	0.55	0.66	0.68	0.46	0.53
M_{max}	Nmm	3.6	4.5	5.7	7.3	3.7	3.9	4.3	5.2
M_k	Nmm	2.8	4.0	4.5	6.4	3.7	3.8	3.7	4.7
A	mJ	7.9	10.4	11.5	15.4	8.3	8.6	9.2	11.5
A'	mJ	4.3	6.1	6.9	9.7	5.6	5.8	5.6	7.2
A"	mJ	0.6	0.8	1.2	2.0	1.2	1.4	1.0	1.4
ΔA	mJ	3.7	4.3	4.7	5.7	2.7	2.8	3.7	4.3
R		4.90	6.27	7.63	10.81	6.70	7.16	6.42	8.08
LSD for R (P=0.5)				1.2				0.5	

α - the angle at which the 1st cracking of the silique appears; M_{max} - the maximum twisting moment for a silique; M_k - the ultimate twisting moment; A - energy elasticity; A' - total cracking of the silique; A" - the first fracture of the silique; ΔA - cohesion of the silique raphes; R - the coefficient of resistance.

Table 2. Strength parameters of pods of winter rape of Ceres, Bolko, Liporta, Mar varieties due to ammonium nitrate (N) and ammonium nitrate + 10 % urea water solution

Parameter*	Unit	Ceres		Bolko		Liporta		Mar		x	
		N	N+U	N	N+U	N	N+U	N	N+U	N	N+U
α	rad	0.81	0.91	0.77	1.35	0.67	0.87	0.49	0.77	0.68	0.97
M_{max}	Nmm	4.7	4.8	4.0	4.5	3.8	4.7	3.6	3.4	4.0	4.3
M_k	Nmm	4.1	4.3	3.2	4.5	3.6	5.4	2.5	3.5	3.3	4.4
A	mJ	9.8	9.7	8.4	9.1	8.0	10.5	6.9	7.4	8.3	9.2
A'	mJ	6.1	6.6	4.7	6.7	5.5	8.2	3.8	5.3	5.0	6.7
A"	mJ	1.9	2.3	1.5	3.0	1.3	2.1	0.9	1.3	1.4	2.2
ΔA	mJ	3.6	3.1	3.6	2.3	2.5	2.3	3.1	2.0	3.2	2.4
R		9.04	9.97	7.79	11.77	6.82	9.39	5.44	6.61	7.27	9.44
LSD for R (P=0.5)				1.44						0.47	

* Nomenclature from Table 1.

Fertilization with ammonium nitrate supplemented with spraying with 10 % solution of urea applied for four rape varieties caused, as compared to simple fertilization with ammonium nitrate, the following increases in the values of the coefficient of silique resistance to cracking: Bolko - by 51 %, Liporta - by 38 %, Mar - by 21 %, and Ceres - by 10 % (Table 2). Mean increase in the value of that property for the four varieties was about 30 %. The distribution of mean values is presented in Figs 3 and 4. Mean values for the four varieties differ significantly (R=9.44 for the combination of ammonium nitrate + 10 %

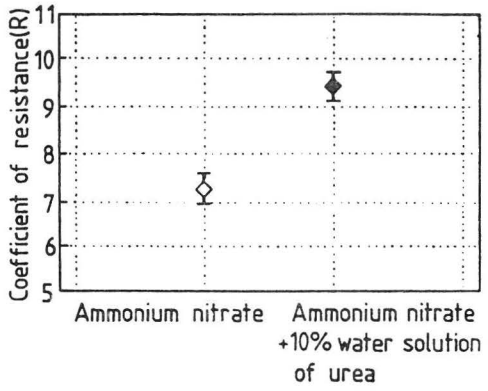

Fig. 3. 0.95 Tukey HSD intervals for factor means of resistance coefficient (R) for four varieties.

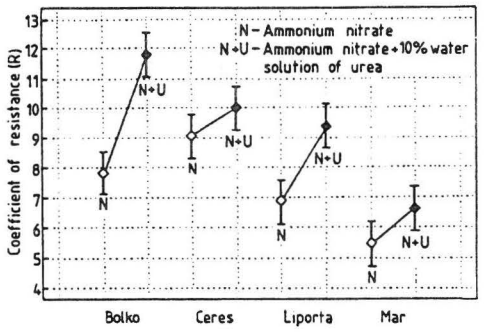

Fig. 4. 0.95 Tukey HSD intervals for factor means of resistance coefficient (R) separately for four varieties.

urea spraying, when $R=7.27$ for ammonium nitrate alone). The individual varieties respond with a differentiated increase in the value of the property under discussion.

The rape varieties under study responded with an increase in the value of the twist angle at which the first silique cracking occurs (α), as well as in the value of energy causing the first cracking ($A''=2.2$ mJ for siliques after 10 % urea spraying, while $A''=1.4$ mJ for siliques with no urea spraying) (Table 2).

CONCLUSIONS

1. As compared to fertilization with ammonium nitrate, the application of urea improved the strength properties of rape siliques. The values of the coefficient of silique resistance to cracking increased by 7 to 42 % (depending on the year of the experiments).

2. Fertilization with ammonium nitrate with additional application of spraying with 10 % water solution of urea caused an increase, by an average of about 30 %, in the values of the coefficient of silique resistance to cracking. The increases for the particular varieties were as follows: Bolko - 51 %, Liporta - 38 %, Mar - 21 %, and Ceres - 10 %.

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