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THE EFFECT OF THE MECHANICAL PROPERTIES OF WINTER RAPE STALKS ON THE RESISTANCE OF THE PLANTS TO LODGING

G. Skubisz

Institute of Agrophysics, Polish Academy of Sciences, Doświadczalna 4, 20-236 Lublin, Poland

A b s t r a c t. In this study the author characterizes the mechanical properties of winter rape stalks by means of the dynamic shearing energy and the bending rigidity. Lodging of the plants of Jupiter winter rape variety was provoked through increased dosage of nitrogen fertilization; a differentiation was also introduced in the number of plants per square meter. A significant, directly proportional relation was observed between the values of the mechanical parameters and the degree of lodging of the plants. It was found that plants grown at low densities per m^2 have the best mechanical parameters of stalks from the viewpoint of resistance to lodging.

K e y w o r d s: winter rape, mechanical properties of stalks

INTRODUCTION

Studies on the mechanical properties of winter rape stalks are meant to provide knowledge necessary for the estimation of the susceptibility of plants to lodging. As it is known, plant lodging makes the process of harvesting difficult and lowers the crop yields. The resistance of plants to lodging is clearly related to the mechanical properties of individual plant stalks [2,4,5,8]. The mechanical properties of stalks, characterized by means of mechanical parameters, showed heritability of properties and therefore constitute the source of information for breeders of new varieties; this fact was taken advantage of by Doliński *et al.* [1] and Jeżowski *et al.* [3].

In the present study the author determined, in dynamic tests, the shearing energy and the shearing energy per unit of cross section area of winter rape stalk, and the stalk rigidity in the process of bending, which then served for the characterization of the mechanical properties of the stalks. An assessment of the effect of the mechanical properties of winter rape stalks on the resistance of the plants to lodging was also performed.

MATERIAL AND METHOD

The studies were conducted on winter rape stalks of the Jupiter variety taken from a sowing density-fertilization experiment at the end of blooming and during the full silique filling.

An experiment was prepared, in which the number of plants per m^2 was differentiated at 20, 40, 60 and 80 plants, and a lodging provoking nitrogen fertilization dosage was applied at 120, 240 and 360 kg/ha. To ensure high accuracy and replicability of results, the experimental plots were set up in three replications. For the study, 25 plants were taken from each of the plots at a time. Measurements were performed at the characteristic spot on the stalk length, just at the first branching of the plant. The mechanical parameters were determined in the process of dynamic and static tests. In the dynamic tests the author determined the shearing energy (*Ed*) and the shearing energy per unit of stalk cross section area (*wd*), using a Dynstat type apparatus. The stalk cross section area (*S*) was determined by means of a T-areometer. The stalk rigidity (*EJ*) was determined statistically in the process of bending,

using an INSTRON strength apparatus. Stalk sample subjected to bending was freely supported at both ends and a force was applied at the middle of the distance between the support points. A detailed description of the test is provided in the paper by Skubisz [6]. The results of the tests were recorded by means of a computer system. The assessment of plant lodging was made using a ten-step scale, where 10 means no lodging, and 1 - the most advanced lodging of plants (stalk close to the ground). It was found that plant lodging resulting from heavy rain and wind (22 May, 1992) was parabolic in character.

RESULTS

The studies allowed for the formulation of a strength characteristics of winter rape stalks of the Jupiter variety, and for an assessment of the effect of the mechanical properties of winter rape stalks on the resistance of the plants to lodging (Figs 1-3). All of the parameters under analysis showed considerable variability in the course of plant growth and development.

A significant relationship was found between the mechanical properties of rape stalks and the resistance of the plants to lodging. The studies showed that the dynamic shearing energy (*Ed*) of winter rape stalks decreases as the dosage of nitrogen fertilizer is increased from 120 to 360 kg/ha. At the same time the rape stalk shearing energy decreases steadily with increasing density of plants on the plots, the differences between the mean values of the stalk shearing energy being much higher in the phase of blooming than during the stage of full silique filling. The above observations apply to all of the nitrogen fertilization levels used. It was found that the mean values of shearing energy *Ed* of winter rape stalks on plots where successive doses of nitrogen fertilization of 120, 240 and 360 kg/ha were applied varied within the ranges of 0.19 to 0.66 J, 0.14 to 0.64 J, and 0.14 to 0.64 J during blooming, and 0.36 to 0.88 J, 0.28 to 0.82 J,

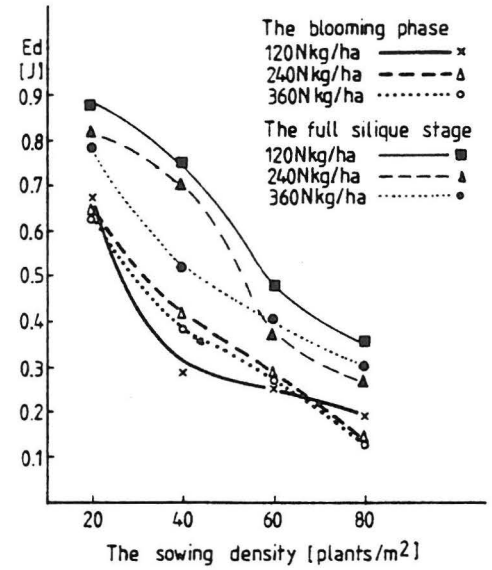

Fig. 1. The variability of shearing energy (Ed) of Jupiter winter rape stalk for different sowing density and nitrogen fertilization at two phenological phases.

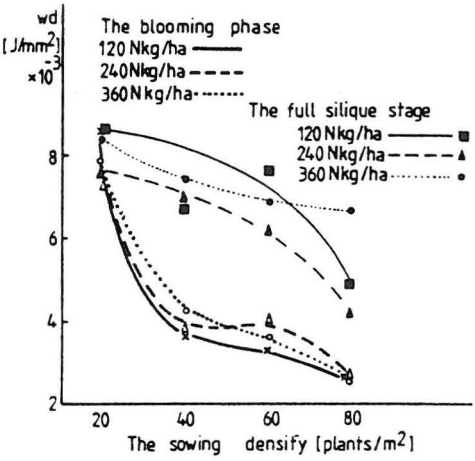

Fig. 2. The variability of shearing energy per unit of cross section area (wd) of Jupiter winter rape stalk for different sowing density and nitrogen fertilization at two phenological phases.

and 0.31 to 0.79 J during full silique filling. It was noted that an increase in the dosage of nitrogen, especially from 120 to 240 kg/ha, had a significant effect on the value of that parameter. The shearing energy per unit of

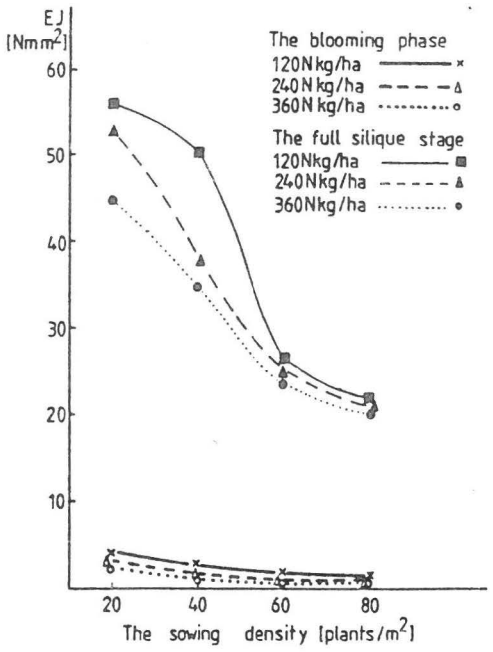

Fig. 3. The variability of rigidity (EJ) of Jupiter winter rape stalk for different sowing density and nitrogen fertilization at two phenological phases.

stalk cross section area decreased with increasing density of plants per m^2. This observation applies to all the levels of nitrogen fertilization.

The studies showed that the mean values of stalk rigidity (*EJ*) varied significantly under the effect of the dosage of nitrogen fertilization. It was found that stalk rigidity decreased in value with increasing nitrogen dosage, the differences being greater on plots with 20 and 40 plants per m^2 than in plots with 60 and 80 plants per m^2. This regularity was observed both during blooming and during the period of full silique filling. The studies showed that the mean EJ values for plants from plots where the particular nitrogen fertilization doses of 120, 240 and 360 kg/ha were applied varied within the following ranges: 0.83-3.65 J mm^2, 0.78-3.71 J mm^2 and 0.67-2.84 J mm^2 during blooming, and 23.58-56.08 J mm^2, 22.74-52.65 J mm^2 and 22.77-45.03 J mm^2 during full silique filling.

A significant relationship was observed between the dosage of nitrogen fertilization and the susceptibility of rape plants to lodging and the variability of the mechanical properties of rape stalks as expressed by the shearing energy (*Ed*), work necessary to shear a unit surface area of stalk cross section (*wd*) and stalk rigidity (*EJ*). Determinations of the mechanical properties of winter rape stalks performed for stalks of plants from different sowing density per m^2 showed a significant effect of nitrogen fertilization on the variability of the mechanical properties of the stalks. At the same time it was found that both nitrogen fertilization and plant density per m^2 differentiate plants with respect to their resistance to lodging. The assessment of the degree of plant lodging showed that the most resistant to lodging were those plants which were characterized by high mean values of the mechanical parameters under analysis. As follows from the literature of the subject, a similar direct proportion-type relationship between the degree of lodging of cereal plants and the stalk rigidity was observed by many authors, as was described by Pinthus [4].

The author found that the most resistant to lodging were the plants from plots with 20 plants/m^2, while the plants from plots with 80 plants/m^2 lodged the most extensively. It was observed that an increase in the nitrogen fertilization dosage intensified the process of plant lodging, and resulted in a strong bending to the ground of the maximum of the parabola. The studies also showed that plant lodging intensified with increasing sowing density. This relationship was observed for plants grown on plots on which the levels of nitrogen fertilization were applied, and the degree of lodging at 120 kg N/ha was 6-7 for 20 and 40 plants/m^2, 5 for 60 and 80 plants/m^2; at 240 kg N/ha - 4-6 for 20 plants/m^2, 3-4 for 40 plants/m^2, 2 for 60 and 80 plants/m^2; at 360 kg N/ha - 5 for 20 plants/m^2, 2-3 for 40 and 60 plants/m^2, and 2 for 80 plants/m^2.

It was found that at high sowing densities (60 and 80 plants per m^2) an increase in nitrogen dosage above 240 kg/ha had only a slight effect on the mean values of some mechanical parameters, i.e., the dynamic shearing energy (*Ed*) and stalk rigidity (*EJ*). At the same time it was observed that the plants were subjected to very intensive lodging and the process deepened only slightly when the dosage was increased above 240 kg N/ha.

The studies showed that those plants which were highly resistant to lodging were characterized by very high values of stalk rigidity *EJ* (0.69-3.71 J mm^2 at full blooming and 35.27-56.08 J mm^2 at full silique filling) as compared to those plants which were susceptible to lodging (0.67-1.47 J mm^2 at full blooming and 22.77-27.3 J mm^2 at full silique filling), and by large stalk cross section areas *S* (resistant stalks: 80.58-93.54 mm^2 at full blooming, 69.70-111.99 mm^2 at full silique filling; susceptible stalks: 45.08-84.46 mm^2 at full blooming, 55.63-71.92 mm^2 at full silique filling), as well as by high values of dynamic shearing energy *Ed* (resistant stalks: 0.29-0.65 J at full blooming, 0.51-0.88 J at full silique filling; susceptible stalks: 0.13-0.29 J at full blooming, 0.27-0.47 J at full silique filling).

The studies allowed for an assessment of the mechanical properties of the stalks of winter rape plants of the Jupiter variety grown in an experiment of differentiated dosage of nitrogen fertilization and of differentiated number of plants per square meter and showed a significant effect of the mechanical properties of rape stalks on the resistance of the plants to lodging.

CONCLUSIONS

1. It was found that there is a strict relation between the mechanical properties of rape stalks affected by various doses of nitrogen fertilization and differentiated sowing density, and the resistance of the plants to lodging.

2. The studies showed that increasing nitrogen fertilization dosage as well as increasing the number of plants per square meter had a decreasing effect on the mean values of the mechanical parameters under analysis and a magnifying effect on the degree of plant lodging.

3. It was found that plants resistant to lodging were characterized by very high values of stalk rigidity and by high values of dynamic shearing energy.

4. The studies showed that plants growing at the lowest sowing density (20 plants/m^2) had the most favourable mechanical properties from the viewpoint of their resistance to lodging, and that they were characterized by the highest mean values of the mechanical parameters.

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