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METHODS OF DETERMINING STRENGTH PROPERTIES OF THE WINTER RAPE STEMS

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A b s t r a c t. In the study the authors used a mechanical and a densitometric method for the determination of the strength properties of the stems of winter rape of the Jantar variety. They determined the dynamic shearing energy and the dynamic shearing energy per unit of stem cross section area, natural as well as after the removal of the parenchyma, and density and a number of parameters the function which was to permit the interpretation of X-ray images of the stems. A significant relationship was observed between the strength parameters obtained in the mechanical and the X-ray experiments. The simultaneous application of the mechanical and the X-ray methods for the study of the strength characteristics of stems considerably extended the scope of information concerning the strength properties of rape stems. Moreover, the study demonstrated the applicability of the densitometric method for the assessment of the strength properties of rape stems.

K e y w o r d s: winter rape stem, strength properties

INTRODUCTION

As follows from a review of the literature of the subject, the strength properties of plant stems have been widely discussed in recent years, and methods based on the assessment of the mechanical properties of the stems dominate with respect to their applicability for the assessment of the resistance of stems to lodging, as compared to other types of experiments. This is reflected in the studies by Skubisz [3-5]. The mechanical parameters of stems showed a high degree of heritability, which indicates their considerable value for the breeding of new varieties, as has been demonstrated by Doliński *et al.* [1] and by Jeżowski *et al.* [2].

To expand the scope of knowledge on the strength properties of plant stems, it seems worth while to apply the densitometric method for the study of winter rape stems. The X-ray method has been already used in the study of lignified plant seeds - a comprehensive work on the subject was written by Smirnova [6].

In the present study the authors performed an assessment of the strength properties of winter rape stems, determining the dynamic shearing energy and the dynamic shearing energy per unit of stem cross section area, stem density, as well as a number of parameters allowing for the characterization of the stems after X-ray irradiation. A comparison of the results obtained by means of the two methods was performed.

MATERIAL AND METHODS

The material for the study consisted of winter rape stems of the Jantar variety, at their full maturity. Measurements were taken on 30 representative stems, 25 cm above the ground (at the height of stem cutting during harvest). The strength characteristics were obtained through the determination of the dynamic shearing energy (*Ed*) using a Dynstat type apparatus with

pendulum velocity of v=2.1 m/s. Another parameter determined was the dynamic shearing energy per unit of stem cross section area: natural (wd) and artificial (wd'). The stem cross section area: natural (S) and after the removal of the parenchyma (S') was determined by means of a T-areometer. At the same time the density of rape stems was determined (ρ and ρ') on the basis of knowledge of the mass of 3-cm sections of the stems and the stem cross section areas (S and S'), [5]. Densitometric experiments were performed to determine a number of values (specified below) which allowed for an analysis of X-ray pictures obtained after the passage of X-rays through the stems at specific measurement spots. The values determined in the densitometric method are shown in Fig. 1.

The measurable values in the densitometric method (where a and b - the optical density of the background near the sample 1, 2, 3, 4 and 5 - indexes of the optical density along the length of the sample, and if c - ODt is the optical density of the background and x - ODp is the optical density of the sample then c-x=OD is the optical density of the X-ray picture of the sample) are as follows:

$2\Delta OD$ - difference between the optical density of the background and the sample, two walls of stem cross section considered;

ΔOD - difference between the optical density of the background and the optical density of the averaged thickness of the wall of the stem cross section;

L - circumference of the stem cross section;

$l\Delta OD$ - parameter involving the duration of the exposure of the sample tested to X-rays;

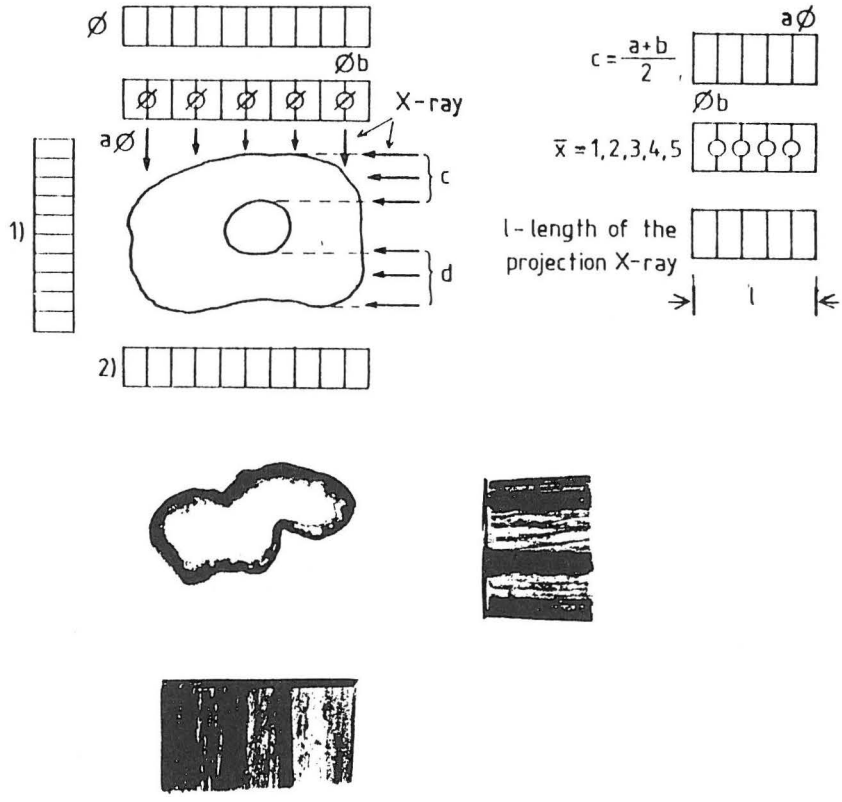

Fig. 1. X-ray description in the densitometric method.

LΔOD - parameter involving the circumference of the stem cross section.

RESULTS

The method developed by the authors, and the study presented herein, allowed for the determination of the dynamic shearing energy, the shearing energy per unit of stem cross section area, the stem density, the surface area of stem cross sections: natural and after the removal of the parenchyma, as well as of a number of values allowing for the assessment of the structure of stems of winter rape of the Jantar variety in the densitometric method after X-ray irradiation. The present study, combining two methods: a mechanical and a densitometric ones, allowed for the obtaining of a broad strength characterization of winter rape stems (Tables 1 and 2).

It was found that the dynamic shearing energy correlates with all the parameters determined in the densitometric method. The authors obtained very high coefficients of correlation between the shearing energy and the densitometric parameters, the closest correlation being observed between *Ed* and *LΔOD* and between *Ed* and *lΔOD*. At the same time the study showed a significant relation, of the direct proportion type, between the shearing energy per unit of stem cross section area (parenchyma removed) and the parameters of the densitometer X-ray picture, i.e., the values which allow for stem strength characterization. The study showed that stems characterized by high strength, i.e., stems with high values of mechanical parameters, had the brightest X-ray pictures. Therefore, a direct proportion-type

Table 1. Mean values, median and coefficients of variability of parameters determining structural-mechanical properties of winter rape stems of the Jantar variety

Parameters	Unit	Average	Median	W (%)
2ΔOD		0.8237	0.855	0.23
ΔOD		0.410	0.425	0.23
l	mm	9.3656	9.6	0.19
L	cm	2.8094	2.9	0.21
lΔOD		3.9125	3.79	0.37
LΔOD		1.1878	1.18	0.39
Ed	J	0.6134	0.445	0.76
wd	J/m^2	$11.40 \cdot 10^2$	$9.70 \cdot 10^2$	0.52
wd'	J/m^2	$12.20 \cdot 10^2$	$12.10 \cdot 10^2$	0.48
ρ	kg/m^3	$2.41 \cdot 10^2$	$2.30 \cdot 10^2$	0.28
ρ'	kg/m^3	$2.60 \cdot 10^2$	$2.60 \cdot 10^2$	0.27

Table 2. Values of the correlation coefficients characterizing the relationships between the mechanical and densitometer parameters of winter rape stems of the Jantar variety. Limit values $r_{0.05}=0.3246$

	LΔOD	lΔOD	L	2ΔOD	ΔOD	l	ρ	ρ'	wd'	wd
Ed	0.6519 +	0.6527 +	0.5659 +	0.5481 +	0.5479 +	0.5384 +	0.4089 +	0.3262 +	0.7192 +	0.7139 +
LΔOD		0.9858 +	0.8447 +	0.8589 +	0.8597 +	0.8124 +	0.1355 +	0.1573 0	0.3703 +	0.2391 0
lΔOD			0.8434 +	0.8580 +	0.8578 +	0.8329 +	0.1349 0	0.1733 0	0.3713 +	0.2319 0
L				0.5095 +	0.5077 +	0.9710	0.0116 0	0.0368 0	0.3205 +	0.2221 0
2ΔOD					0.9997 +	0.4582 +	0.2600 0	0.3885 +	0.3700 +	0.1931 0
ΔOD						0.4552 +	0.2682 0	0.3901 +	0.3675 +	0.1938 0
l							0.0362 0	0.0831 0	0.1826 0	0.1854 0
ρ								0.7285 +	0.5473 +	0.6390 +
ρ'									0.5625 +	0.4286 +
wd										0.9507 +

relationship was found between the mean values of the mechanical parameters of rape stems under analysis and the stems density, and the degree of brightness of X-ray photographs of the stems.

On the other hand, the study did not show any significant correlation between the dynamic shearing energy per unit of natural stem cross section area and the stem density, and the results obtained according to the densitometric method. These results illustrate the fact that X radiation is traceable only when it passes through mechanical tissues.

The results obtained from the combination of the mechanical method and the densitometric method provided a broad strength characterization of the stems of winter rape of the Jantar variety. The conclusions resulting from the study suggest a necessity of testing a larger number of varieties in order to acquire a deeper knowledge of the mechanical structure of rape stems.

CONCLUSIONS

1. A significant relationship was observed between the strength parameters obtained in the mechanical experiments and those from the densitometric experiments.

2. A direct proportion was observed between the mean values of the dynamic shearing energy, the dynamic shearing energy per unit of stem cross section area, and stem density, and the degree of brightness of X-ray photography of the stems.

3. The dynamic shearing energy per unit of natural stem cross section area as well as natural stem density did not show any significant correlation with the parameters of the densitometric method. This means that X radiation is traceable only when it passes through lignified fragments of the stems.

4. The results obtained from a comparison of the two methods indicated the applicability of the densitometric method for the study of the strength properties of rape stems.

REFERENCES

1. **Doliński R., Tarkowski C., Bichta J.**: Badania nad odziedziczalnością wybranych cech fizycznych źdźbła pszenicy ozimej. Zesz. Probl. Post. Nauk Roln., 383, 133-142, 1989.
2. **Jeżowski J., Surma M., Adamski T.**: Diallel analysis of characters determining lodging resistance of barley (Hordeum vulgare L.) III. A genetic analysis of lodging grade and physical properties of the stem. Genet. Pol., 29, 275-280, 1988.
3. **Skubisz G.**: Zagadnienie sprężystości źdźbła zbóż. Probl. Agrofizyki, 38, 1982.
4. **Skubisz G.**: Determination of the mechanical properties of winter rape stalks. Zesz. Probl. Post. Nauk Roln., 389, 165-173, 1991.
5. **Skubisz G.**: The variability of mechanical properties of winter rape stems during plant vegetation period. 8th Int. Rapeseed Cong., Saskatoon, Canada, 1795-1800, 1991.
6. **Smirnova N.G.**: Rentgenograficheskoie izuchenie siemian listviennych dreviesnych rastienii. Nauka, Moskwa, 1978.