ESTIMATION OF RAPE SILIQUE RESISTANCE TO CRACKING AND RAPE SEED SHATTERING RESISTANCE FOR SOME SELECTED VARIETIES AND LINES OF SPRING RAPE

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Resistance to shedding is one of the main problems at harvesting of many Cruciferae, Papilionaceae and Gramineae plants. Because of the growing demand for plant fat and protein and thanks to the possibility of its mechanical harvest rape is one of the main agricultural crops in many countries. Especially the new varieties quarantee high oil quality and a high value of the extracted meal.

Studies on the determination of seed losses in the final phase of ripening and at harvesting conducted for several years have proved that the losses are on the average 8-12 % of the crop, and when the conditions are very unfavourable (e.g.frequent storms and rainfalls) up to 20 % (1,2). If it is possible to limit these losses rape seed may become even more attractive as it will be possible to harvest additional amounts of valuable plant materials.

Experiments and observations conducted for several years (3) have shown that the main factors influencing seed shedding are the following: a) varietal features, b) agrotechnical features, c) meteorological conditions, d) insects and diseases.

Silique cracking is a complex phenomenon, influenced by the combination of the above mentioned factors that makes the losses even greater. Hence the losses recorded in individual years vary considerably. The studies proved that there exists not only intervarietal variation within Brassica species but also variation as to the resistance of silique to cracking among the varieties belonging to the same species (4,5). To establish these differences it is necessary to use precise methods of evaluation of silique resistance to cracking. The methods consist mainly in twisting (6) or bending (7) of the siliques by means of suitable testing equipment. The resistance parameters established in this way enable comparing individual varieties and their performance in a given year or years.

The aim of the present study was to gather information on the resistance features and to estimate shedding in field conditions under the influence of the whole complex of genetic, agrotechnical and meteorological factors.

MATERIALS AND METHODS

Estimations of the resistance properties of silique and stems were conducted on 27 rape varieties and lines coming from varietal experiments of Svalof AB in Sweden.

The methodology of the studies included:

I.evaluation of the silique susceptibility to cracking conducted on the basis of: A - studies on the resistance parameters; B - visual assessment and comparison of seeds shed on individual experimental plots.

basis of: A - studies on the resistance parameters; B - visual assessment and comparison of plant lodging on individual plots.

III. morphological and biometric studies.

Ad. IA. Studies on the silique susceptibility to cracking were conducted by means of determining their resistance parameters. According to the previously established methodology (8) 50 siliques were taken from each of the studied varieties. They were then twisted in the Instron testing apparatus. The coefficient of silique resistance to twisting R was calculated from the so-obtained curve on the basis of the following equation:

$$R = -0.42 + 0.21A_1 + 1.64A_2 + 0.38\ \lambda A + 0.30\ M\ max + 2.91\ \alpha$$

where: A_1 - the energy necessary to overcome the elastic resistance of the silique; A_2 - the energy causing the cracking of the silique; λ A - the energy overcoming the silique seams adhesion; M_s - the maximum torque at which the first silique cracking occurs.

Ad. IB. Visual assessment and comparison of the shed seeds was conducted four times starting on the day full ripeness was observed (22.08, 2.09, 14.09, and 22.09). During this period plants were subjected to changeable weather conditions (rainfalls, sunshine, strong winds) that normally cause silique cracking and seed shedding. The amount of seeds was assessed visually on the basis of the amount of silique that had fallen to the ground or were cracked (characteristic white middle lamellas on plants). The amount of cracked siliques was expressed in per cent. These assessed values are not precise but still they allow for the comparison of varieties especially when they were considerable.

Ad. IIA. The evaluation of the plants susceptibility to lodging was conducted by means of determining their resistance parameters considering 50 representative stems from each of the studied varieties. In order to determine the distribution of mechanical parameters along the stem length, the stem was divided into 3 sections and the measurements were taken 5 cm above ground (section I), under the first branch (section III) and between these sites (section II). The characteristics of stem resistance was obtained by determining stem stiffness in the process of bending. The theory of bending an elastic beam empty inside with a circular section supported at both ends (9) was applied.

$$K = \frac{Fo\,l^3}{48y}$$

where: K - stem stiffness (Nm^2); F - the force that bends stem section on the tangent - w in the range of elastic deformations (N); y - deflection arrow (m); l - the length of the stem section between the points of support (m).

Ad. IIB. The assessment of the susceptibility to lodging was conducted four times starting on the day when full maturity was observed, i.e. on 24.08, 2.09, 14.09, and 22.09. using a 5-grade scale in which: 1 - totally lodged plants, 2 - slightly lodged plants, 3 - inclined, 4 - slightly inclined plants, 5 - straight standing plants.

Ad. III. Morphological and biometric evaluation of plants was also conducted. It included: plant height, the height up to the first offset, the number of siliques, silique weight, silique length, number of seeds the number of siliques, silique weight, silique length, number of seeds in one silique. The above measurements were taken from 50 represenative plants of each of the studied varieties.

Statistical analyses of the results allowed for the segregation of varieties according to each of the studied features into 3 to 5 hommologous groups.

RESULTS AND DISCUSSIONS

The results proved high variability of the studied varieties and lines of spring rape as far as their morphological and biometric features were concerned (tab.1). The height of the studied plants ranged from 89 to

Tab.1. Evaluation of morphological and biometric features of spring rape

Feature	- -	-	0	+	+ +
A		1,3,10,22, 24	2,8,9,13-17 19,21,25,27	4,5,7,11,12 18,20,23,26	6
B		1-3,10,13, 21-23,26,27	4,6,8,11, 15-20,24,25	5,14	7,9,12
C	9,10	2,8,11,13, 17,19,27	1,3,5,6,16, 20,23,24,26	12,14,18,21 22,25	4,7,15
D		3,10,11,13 14,19,23	1,2,8,9,16, 17,20-22,24	4-7,12,18, 25-27	15
E		2,8-10,14	1,3,11-13, 17-19,23-27	4-7,15,16, 20-22,25	
F	3	1,2,4,6,13, 24	5,7,9,11,12 16,19,23,25	8,10,14,15, 17,18,22,27	20,21,26
A		89 - 103	107 - 113	115 - 122	126
B		22 - 25	28 - 32	35 - 38	40
C	131- 136	150 - 159	174 - 178	180 - 192	201 - 205
D		71 - 73	75 - 76	80 - 86	102
E		24 - 25	26 - 27	28 - 31	
F	103	129 - 140	150 - 158	168 - 187	198 - 215

SYMBOLS: A-plant height (cm); B-height up to the 1st offset (cm); C-silique weight (mg); D-silique length (mm); E-number of seeds per silique (szt); F-number of siliques per plant.

- - varieties and lines with very unfarourable parameters
- varieties and lines with unfarourable parameters
0 varieties and lines with average parameters
+ varieties and lines with good parameters
+ + varieties and lines with very good parameters
1-27 - successive number of individual varieties and lines:
1-Topas, 2-Korall, 3-Puma, 4-Globai, 5-Hanna, 6-Elin, 7-WW 13.9, 8-Sv 02372, 9-Sv 02367, 10-Sv 02336, 11-Sv 02368, 12-Sv 02347, 13-Sv 02355, 14-Sv 02369, 15-Drakkar, 16-Sv 02393, 17-Sv 02377, 18-Sv 02358, 19-Sv 02376, 20-Sv 02394, 21-Sv 02378, 22-Sv 02306, 23-Sv 02307, 24-Sv 02344, 25-Sv 02390, 26-Sv 02002, 27-Sv 02302

126 cm, and the length up to the first offset from 22 to 40 cm which enabled proper application of one- and two-stage technology of harvest. Silique weight ranged from 131 mg to 205 mg (172 mg on the average) and in comparison with the weight of winter rape silique (mean value for 23 varieties 221 mg) was relatively low (4).

Silique length was from 71 to 102 cm, and this feature was highly variable. The mean value of the number of seeds in one silique was from 24 to 31, and the number of siliques on one plant was from 103 to 215. The lowest number of siliques was observed on the plants from the variety No.3.

The highest values of all the analyzed features used to characterize the studied varieties in respect to their yields and usability for mechanical harvest were observed in case of the varieties Nos.5, 7, 15, as well as Nos.4, 12, 16, 17, 18, 20, 22, 25, and 26; whereas the lowest in case of Nos.2, 3, 10, 13, and 23. Silique resistance parameters and the parameters of rape stems that were used for the estimation of the silique resistance to shedding and stem resistance to lodging were even more varied (tab.2). There is no doubt that the highest resistance of

Tab.2. Characteristics of the resistance features of spring rape silique and stem

Feature	- -	-	0	+	+ +
H	2,8-10,19	6,11,13, 16,25	1,3-5,15,18, 20,21,23,24	7,12,17, 22,26,27	14
I	6,10,13, 19,20,25	2-4,15, 16	1,5,11, 12,18	7,9,17, 21,27	8,14,22-24,26
J	6	5,7,8,11, 21,22	1,2,4,9,14, 23,24,26,27	13,15-19	3,10,12, 20,25
L		2,8,11	1,4,5,9,10 15-19,21, 22,25-27	3,7,12-14 20,23,24	6
H	4,7 - 5,0	5,8 - 6,2	6,9 - 7,2	8,0 - 9,4	12,3
I	80 - 90	60 - 70	50	30 - 40	10 - 20
J	1,2	1,5 - 1,6	2,1 - 2,7	3,2 -3,9	4,3 - 5,0
L		848 - 998	1125-1260	1301-1460	1595

SYMBOLS: H-coefficient of silique resistance -R, I-shed siliques (%), J-stem stiffnes (1-5), L-coefficient of stem stiffness K x 10^{-4} (Nm^2).

For the remaining symbols see Tab. 1.

Tab.3. Correlation table:

Shed siliques	x	R	- 0,67
Shed siliques	x	Stem stiffnes	0,45
Stem stiffnes	x	K	0,63

Coefficcient of the significance level 95 %

silique to cracking evaluated by means of the parameter R was observed in the variety No. 14 (R - 12.3), slightly lower values were observed in the varieties Nos.7, 12, 17, 22, 26 and 27 (R from 8.0 to 9.4). The weakest silique were observed in the varieties Nos.6, 11, 13, 16, and 25 (R from 5.8 to 6.2) and the varieties Nos.2, 8, 9, 10, and 19 (R from 4.7 to 5.0). The values of the coefficient of resistance R estimated for the winter rape had similar values as the ones established for the spring rape studied. And only the Górczański variety was characterized by the higher R value (R - 14.5) (11).

During the provocative stay of the studied plants on field till the belated harvest the lowest (up to 20 %) cracking and shedding was observed in case of the varieties Nos.8, 14, 22, 23, 24, and 26 as well as Nos.7, 9, 17, 21, and 27 (from 30 to 40 % of shed seeds). The highest values were observed in case of the varieties Nos.6, 10, 13, 19, 20, and 25.

Estimating plants stiffness on field it was established that the best-standing plants belonged to the varieties Nos.3, 10, 13, 12, 20, and 25. Varieties Nos.13, and 15 to 19 were a little worse in this respect. Totally lodged plants belonged to the variety No. 6, and slightly lodged plants to the varieties Nos.5, 7, 8, 11, 21, and 22. The highest stiffness of stems evaluated by the coefficient of stiffness K was observed in the variety No.6 ($K = 1595 \times 10^{-4}\ Nm^2$) and the varieties Nos.3, 7, 12, 13, 14, 20, 23 and 24 for which the values of the coefficient K ranged from 1301 to 1460 x $10^{-4}\ Nm^2$) The lowest values were observed for the varieties Nos. 2, 8, and 11 (K from 848 to 998 x x $10^{-4}\ Nm^2$). Variety No.6, though it had the highest value of the coefficient of stiffness K, was totally lodged in the field conditions. It may result from the fact that the plants from this variety were the highest (126 cm). Because of that strong winds instead of swinging the plants caused their lodging (breaking) just above ground over the root system. It leads to the conclusion that evev seemingly favourable plant features (high stem siffness) may appear to be very unfavourable in combination with other features, plant height in this case. Winter rape plants had a similar range of K coefficient values (9). Higher values were observed only when special fertilization and irrigation techniques were applied (10).

The calculated coefficient of correlation (tab.3) showed a strong dependence between resistance to cracking and the number of seeds shed on field. Varieties Nos 14, 22, 26, 27 may be given as an example of this relation as they had the best values of the resistance parameter R, i.e. from 8 to 12.3, and the lowest percentage of seeds shed on field (10 to 40 %). On the other hand, however, some varieties such as No.8, shed relatively few seeda though their resistance parameter was rather low (from 4 to 5). It resulted from the early lodging of plants caused by their low lodging resistance. It seems that the most important factors influencing silique cracking and seed shedding were not only silique resistance parameters but also canopy inclination and habit. The calculated coefficient of correlation between the number of shed seeds and the canopy inclination and the coefficient of stem stiffness K showed that there existed a strong relation between these features (tab.3). Hence these varieties that had high siliqe resistance (but with plants standing and subjected to strong winds) had a high percentage of shed seeds (e.g. variety No.20). Whereas lines and varieties that had sightly inlined canopies shed only unsubstantial amounts of seeds in the same conditions even if their siliques were not of very high resistance to cracking (e.g.variety No.6).

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