CHARACTERIZATION OF THE VARIABILITY OF THE STRENGTH AND ENERGY OF GRAIN-TO-EAR BINDING FOR WHEAT AND RYE

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A considerable improvement of the productivity of cereal crops can be obtained no only by the introduction of intensive varieties and proper agrotechnology, but also by the limitation to minimum the quantitative losses occuring during harvesting and threshing. The main reason for the losses — caused by different resistance of cereal plants to fall-out — is often the imadequate harvesting technology for particular species and varieties [3]. For these reasons valuable information determining indirectly the tendency of cereals to fall-out can be constituted by knowledge of the value of the grain-to-ear binding strength and energy. Particularly the value of the energy seems to be a very important physical property that can have a wide application in agricultural technology [5].

The energy of grain-to-ear binding is the minimum work necessary to break a grain off from the ear torus and to remove it completely from the surrounding glumes (with the force directed along the longest axis of the grain). The remaining of a grain in the ear depends on the strength of binding the grain with the ear torus, the force of freeing a grain of chaff (related to the degree of covering the grain by glumes), and by the way that the grain must cover from the moment of breaking off from the torus to the moment of getting out from among the glumes [1]. This way will be longer, the longer the glumes surrounding the grain.

The knowledge of the value of the grain-to-ear binding strength and energy can constitute valuable information complementing the characterization of particular species and varieties from the point of mechanical harvesting and the breeding of new varieties with favourable mechanical properties.

THE MATERIAL AND METHODOLOGY

Investigations leading to the determination of parameters characterizing the strength of grain-to-ear binding were conducted in the Institute of Agrophysics of Polish Academy of Sciences in Lublin in the period 1974—1976 on 7 varieties of winter wheat, 3 varieties of spring wheat and 5 varieties of rye, cultivated in the same agro-ecological conditions.

Measurements covered 30 ears of each variety. The grain-to-ear binding strength and energy were determined on the Instron apparatus by a direct method [2, 4, 6] consisting in the extraction of single grains from different parts of an ear [7]. On each ear 9 measurements were made, which means that for the evaluation of each variety 270 values were obtained and subjected later to statistical analysis. The apparatus allowed for the determination of the maximum strength binding a grain with an ear torus, and the strength necessary to remove a grain from the surrounding glumes. The course of the process can be analyzed on the diagram received from the recorder of the apparatus (Fig. 1). The removal

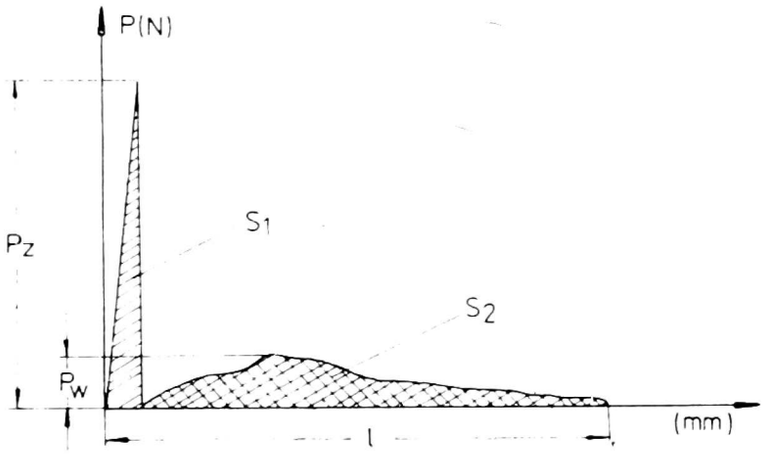

Fig. 1. Diagram from the recorder of the Instron apparatus, presenting the course of separating grain from ear: P_z — maximum force of grain-to-ear torus binding, P_w — maximum force keeping grains in glumes after breaking off from tours, l — total way a grain must cover for its complete separation from ear to occur, S_1 — energy necessary to break grain off from ear torus, S_2 — energy necessary to remove grain from among glumes (dechaffing)

of a grain from an ear was done with the velocity on 0.17 mm per sec. On the basis of the obtained diagrams the surface areas S_1 and S_2 were determined and the energy coresponding to these areas (S_1 — the breaking off of a grain from the torus, S_2 — the freeing of the grain of chaffs) calculated. The sum of these values gives the total energy necessary to remove a grain from an ear.

RESULTS OF INVESTIGATIONS

On the basis of analyzing the obtained results, a considerable variability of the grain-to-ear binding strength and energy for winter and spring wheat and for rye was established (Table 1).

Table 1

Mean values of the grain-to-ear binding strength and energy for wheat and rye

Variety	Maximum strength binding grain with the ear torus (N)	Energy of grain with torus binding (mJ)	Maximum de-chaffing force (N)	Energy of de-chaffing grain (mJ)	Sum of energy (mJ)	Percentage of the energy of de-chaffing in relation to total energy (%)
Winter wheat						
Aria	0.92	0.07	0.10	0.27	0.35	79.12
Aurora	1.09	0.12	0.12	0.33	0.45	72.23
Grana	0.93	0.09	0.10	0.28	0.37	76.62
Helenka	0.67	0.04	0.02	0.05	0.09	54.14
Kaukaz	1.14	0.11	0.08	0.31	0.42	73.65
Ród 338	0.76	0.08	0.07	0.18	0.26	67.40
Ród 500/69	1.47	0.23	0.08	0.49	0.49	52.32
Spring wheat						
Kaspar	1.01	0.10	0.05	0.16	0.26	61.63
Kolibri	1.22	0.13	0.11	0.37	0.50	71.93
Urbanka	1.12	0.11	0.11	0.30	0.41	70.28
Rye						
Dańkowskie Nowe	0.69	0.05	0.01			
Dańkowskie Srebrne	0.77	0.05	0.01			
Dańkowskie Złote	0.63	0.03	0.01			
Pancerne	0.64	0.04	0.02			
Ród AR 3	1.03	0.10	0.04			
Mean value	0.94	0.09	0.08	0.25	0.36	67.93
The smallest significant difference (P=0.05)	0.17	0.02	0.02	0.06	0.07	7.13

The maximum strength binding grain with the ear torus for winter wheat is within the range from 0.67 N (Helenka variety) to 1.47 N (variety 500/69). The smallest variability range was found for spring wheat (from 1.01 N — Kaspar to 1.22 N — Urbanka). The lowest average values

were found for rye (from 0.63 N — Dańkowskie Złote to 1.03 N — AR 3 variety).

The maximum force necessary to remove grain from among the glumes is relatively low for wheats and varies within the range from 0.02 N (Helenka) to 0.12 N (Aurora). Minimal, or even unnoticeable values occur for rye (0.01—0.04 N).

The energy necessary to break a grain off from the ear torus forms for the investigated varieties of wheat the range from 0.04 mJ (Helenka) to 0.23 mJ (variety 500/69) and is connected with the same varieties that marked the variability range for the strength binding grain with the torus. A similar analogy was found for rye, though the values of the energy were considerably lower (0.03—0.10 mJ).

Strong chaffing of wheat grains undoubtedly results in the remaining of a grain in the ear even after its breaking off from the torus.

On the basis of the measurements it was established that the minimum of energy necessary to remove the grain from among the glumes forms the range from 0.05 mJ (Helenka) to 0.37 mJ (Kolibri) with the average of 0.23 mJ for wheats. Thus the process of removing grain from among the glumes consumes over 2/3 of the total energy. Hence the percentage of the energy of de-chaffing in relation to the total energy (necessary to remove grain from the ear) varies from 52.32% to 76.62% for winter wheats and from 61.63% to 71.93% for spring wheats. There is no such phenomenon in the case of rye, which is understandable considering the fact that a considerable part of grain is not chaffed at all. In effect, to remove grain from an ear of rye four times less energy is needed (average 0.09 mJ) than for the same process concerning wheat grain (0.36 mJ). Characteristic examples are presented in Fig. 2—4.

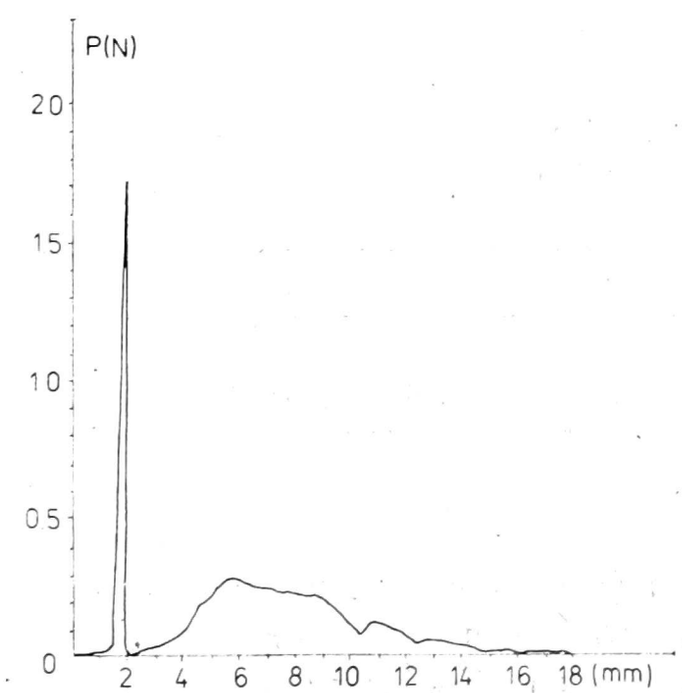

Fig. 2. The course of the process of separating grain from ear of strongly chaffed wheat

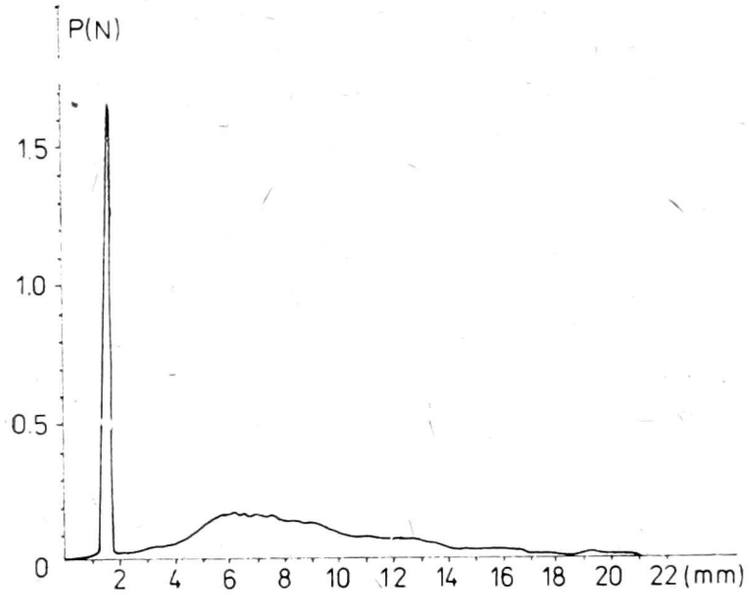

Fig. 3. The course of the process of separating grain from ear of medium chaffed wheat

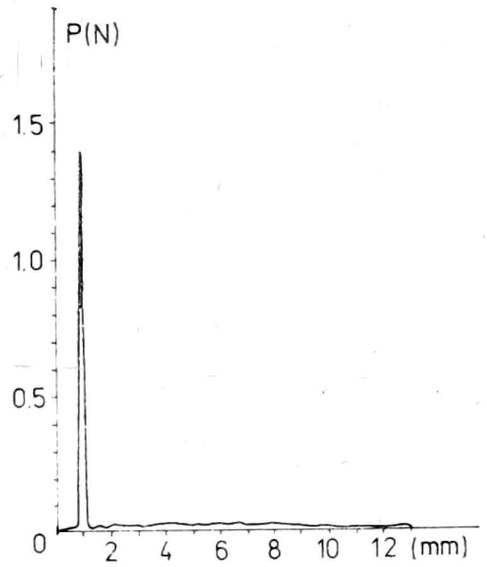

Fig. 4. The course of the process of separating grain from ear of rye

RECAPITULATION

Variability of the grain-to-ear binding strength and energy in cereals has a very wide range, determined by the species and variety properties. Such a considerable differentiation of values must have its reflection in the productivity of cereals, because on the one hand even the mutual collisions among ears or the work of the raker of a combined harvester (in the case of e.g. rye) can cause the fall-out of grain before harvesting, and on the other an improper choice of parameters of the threshing systems (for some varieties of wheat) will cause the remaining of some grain in the ears after threshing. In both cases there are losses that are difficult to evaluate. That is why the knowledge of both the strength and energy of grain-to-ear binding that is necessary for its release creates a possibility of optimizing the processes connected with harvesting and can constitute valuable information for breeders of new cereal varieties of a narrowed index of the variability of their physical properties, that is suitable for mechanical harvesting with a known resistance to fall-out. It seems that a detailed examination of this problem should lead to the minimization of the quantitative losses of grain.

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CHARAKTERYSTYKA ZMIENNOŚCI SIŁY I ENERGII ZWIĄZANIA ZIARNA Z KŁOSEM U PSZENICY I ŻYTA

Streszczenie

Badania siły i energii związania ziarna z kłosem obejmowały 7 odmian pszenicy ozimej, 3 pszenicy jarej i 5 odmian żyta. Pomiary przeprowadzono na aparaturze wytrzymałościowej „Instron", określając maksymalną siłę związania ziarna z osadką kłosową, maksymalną siłę potrzebną do usunięcia ziarna z otaczających go plewek (tzw. wyplewienie ziarna), energię związania ziarna z osadką i energię niezbędną do wyplewienia ziarna.

Na podstawie uzyskanych wyników stwierdzono, że siła związania ziarna z kłosem u pszenicy ozimej zróżnicowana jest w zależności od odmian i wahała się od 0,72 N do 1,47 N, u pszenicy jarej od 1,04 N do 1,16 N, a u żyta od 0,62 N do 1,03 N.

Wartości energii potrzebnej do oderwania ziarna od osadki kłosowej były stosunkowo niewielkie (0,04—0,23 mJ), lecz usunięcie ziarna z plewek u pszenic wymagało znacznie więcej pracy (0,16—0,32 mJ). Wartości te stanowią 55—85% energii użytej do całkowitego usunięcia ziarna z kłosa.

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ХАРАКТЕРИСТИКА ИЗМЕНЧИВОСТИ СИЛЫ И ЭНЕРГИИ СВЯЗЫВАНИЯ ЗЕРНА С КОЛОСОМ У ПШЕНИЦЫ И РЖИ

Резюме

Исследованиям силы и энергии связывания зерна с колосом подвергли 7 сортов озимой пшеницы, 3 сорта яровой пшеницы и 5 сортов ржи. Измерения провели на аппаратуре для прочностных исследований „Инстрон", определяя максимальную силу связывания зерна с колосовым стержнем, максимальную силу, необходимую для удаления зерна из окружающих его чешуй (т.наз. выче-

шуивание зерна), энергию связывания зерна с колосовым стержнем и энергию, необходимую для вычешуивания зерна.

На основании полученных результатов констатировали, что сила связывания зерна с колосом у озимой пшеницы дифференцируется в зависимости от сорта и колеблется от 0,72 до 1,47 Н, у яровой пшеницы — от 1,04 до 1,16 Н, а у ржи — от 0,62 до 1,03 Н.

Значения энергии, необходимой для отрыва зерна от колосового стержня, были сравнительно невелики (0,04-0,23 мдж), но удаление зерна из чешуй у пшениц требовало значительно больше труда (0,16-0,32 мдж). Эти величины составляют 55-85% энергии, употребленной для полного удаления зерна из колоса.

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