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BIOLOGICAL EFFECTS OF STATIC LOADING OF WHEAT GRAIN IN MASS

Stanisław Grundas, Bogusław Szot

The mechanical damage of grain caused by the various loadings to which it is subjected during harvesting, transportation, cleaning, drying and storing plays an important role in the formation of the qualitative features of the sowing material. Damages of grain are often connected with damaging the germ, which causes the loss or lowering of the germinating ability and the deterioration of the ability to last through the winter, and of the growth and development of the plant [2]. This in turn entails difficult to evaluate losses expressed in the final effect in a considerable deterioration of crops.

The resistance of grain to loading comprises a rather wide range of measurable physical values and depends on many factors, and first of all on its moisture, size, shape and variety features [1, 4—7]. Thus the knowledge of these parameters is particularly important with the reproduction of cereals.

This paper is to present the methodology and the results of introductory investigations of the biological effects of static loading of wheat grain in mass, to which it can be subjected at mechanized technology of harvesting and storage.

MATERIAL AND METODOLOGY

Material for the investigation was constituted by representative samples of grain of two varieties of winter wheat (Dana and Helenka) originating from the riegionalization experiments carried out in 1974—1975. During the investigation the grain moisture was 11.9 to 12.5%. The forced static loading of from 10^5 to 200×10^5 N/m^2 were obtained on the resistance measuring apparatus "Instron" type 1253, at a constant deformation rate — v = 10 mm/min. The measurements were made with the help of a special cylinder of 100 cm^3 in volume, in which a mass of grain of exactly the same volume was placed. The loading of the sample was done with the help of a piston fixed to the measuring head of the apparatus (Fig. 1). For grain samples of natural granulometric composition the following loading levels were applied: 1, 2, 3, 5, 10, 20 and so on up to 200 $\times$ 10^5 N/m^2 at the intervals of every 20 $\times$ 10^5 N/m^2.

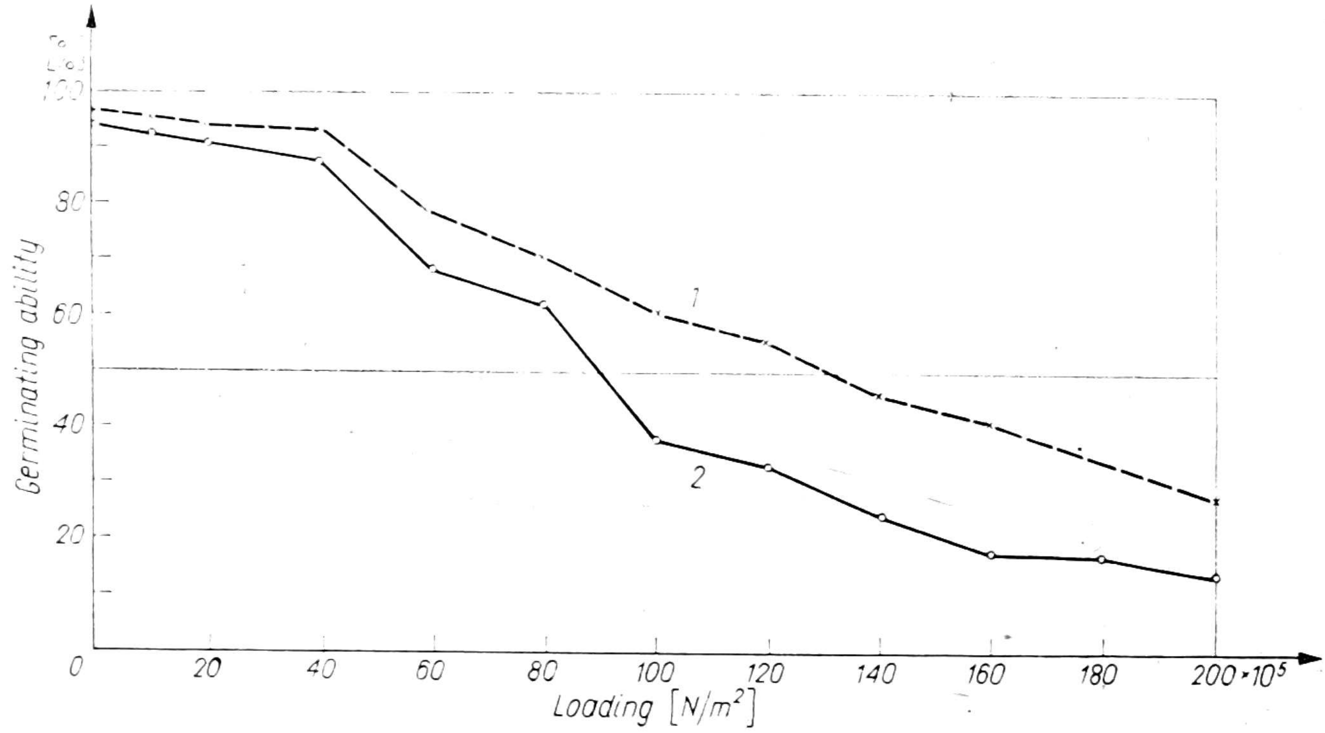

Fig. 1. Influence of loading of grain layer on their ability of germination: *1* — Helenka variety, *2* — Dana variety

A part of the material was subjected to separation process on a sieve system of Vogel's type, obtaining grain thickness classes with the exactness of 0.05 mm. Assuming that the resistance of grain to loading is related to its thickness, samples containing grains in particular classes of average sizes 2.35, 2.55, 2.75 and 2.95 mm were subjected to loadings of 40 $\times$ 10^5 and 80 $\times$ 10^5 N/m^2.

Measurements of loadings were made in three repetitions and in turn each of them was examined from the point of germinating ability on a bed prepared from sterilized sand [3], obtaining 9 repetitions for each loading level. To preserve the optimum conditions of the experiment the germination took place in an air conditioned room at the air temperature of 20°C and a constant moisture of the bed, applying a determined amount of distilled water. The germinating ability was determined considering the number of healthy and normally germinating grains after 8 days from the date of sowing. For comparative purposes the germination ability was also tested on controlling samples of grain (unloaded).

RESULTS OF INVESTIGATIONS

The obtained results characterizing the germinating ability of winter wheat grain subjected, in mass, to different static loadings, allowed for the determination of a continuous relationship between the applied loading levels and the biological effects caused by the process. Forthe controlling samples (not loaded mechanically) it was found that the germinating ability was 94.2% (Dana) and 96.1% (Helenka). Grains loaded within the range 1—40 × 10^5 N/m² lost up to 7.2% of their biological value, probably because of the micro-damage of their fruit-seed cover, the outer part of the endosperm and germ. The applied grain layer loadings of over 40 × 10^5 N/m² caused a rapid deterioration of the ability to germinate, which undoubtedly resulted from a large number of micro-damages causing, with many grains, complete loss of this most important feature of sowing material. In effect, at the loading of 200 × 10^5

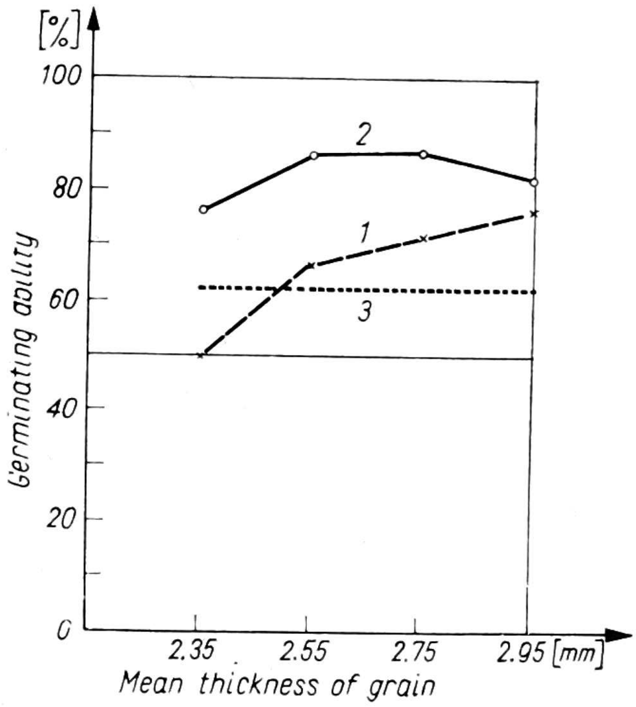

Fig. 3. Influence of grain thickuess on their ability of germination at unit loading of 40.10⁵ N/m²: *1* — Helenka variety, *2* — Dana variety, *3* — mean value

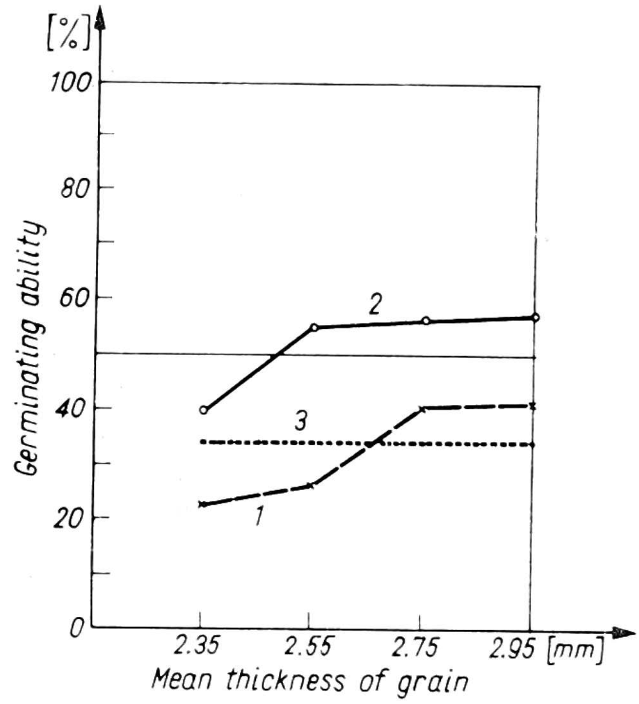

Fig. 3. Influence of grain thickuess on their ability of germinating at unit loading of 80.10⁵ N/m²: *1* — Helenka variety, *2* — Dana variety, *3* — mean value

N/m² the germinating ability was only 13.2% for the Dana variety and 27.0% for the Helenka variety. Thus, there is a very close negative correlation between loading and the biological value of the material. From the two investigated varieties Helenka is characterized by a higher resistance than Dana. This follows from the fact that the Dana variety has a smaller grain (average thickness of 2.45 mm) than the Helenka variety

(2.75 mm). Thus the previous investigations indicating that the thicker the grains the greater their resistance to mechanical loading [6, 7] are confirmed.

Analyzing the results of investigations of grain of a determined thickness, it was found that there occurs a very clear lowering of the average germinating ability at the loading of 40×10^5 N/m^2 and a very rapid increase of the process at the loading of 80×10^5 N/m^2 (Fig. 2 and 3) in comparison with the results obtained for material of natural granulometric composition at analogous loadings. On this basis we can suppose that the grain mass obtained during harvesting is more resistant to mechanical loading than the separated thickness classes. This probably follows from the specific placement of grains against one another in the measuring cylinder — creating different structures of the grain mass at various granulometric compositions. This hypothesis is partly confirmed by the results characterizing the influence of indentical static loadings on the germinating ability of grains of differentiated thickness classes. The smaller grains showed a greater degree of damage than the bigger ones. At the loading of 40×10^5 N/m^2 grains of the Helenka variety of the average thickness in class of 2.35 mm germinated only in 49%, while thicker grains (2.95 mm) in 76%. Also the intervariety differences became more distinct. Grains of the Dana variety showed a considerably greater resistance to damage, particularly in classes of smaller average sizes. Hence their ability of germination was by 27% higher than the Helenka variety.

RECAPITULATION

The investigations of the influence of static loading of wheat grain in mass on the germinating ability indicated that the applied method of measurement can be fully applicable for prediciting biological effects resulting from mechanical damage of grain. It was also found that permanent deformations resulting from loadings exceeding the elasticity limit caused irreversible negative effects manifest in the clear lowering of the percentage of germinating grains with the increase of the applied force loading the mass of grain. The changeability of this important property of sowing material was also dependent on the sizes of grains, their shapes and situation in mass. Smaller grains were more susceptible to damage, which can be exemplified by the course of germination changeability for the Dana variety. The separated thickness classes of grain subjected to loading show much lower germinating ability than the initial non-classified mass.

The obtained information, of mainly methodological character, suggests the possibility of developing this type of investigations for the fuller understanding of processes having influence on the formation of the qualitative parameters of sowing material.

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S. Grundas, B. Szot

BIOLOGICZNE SKUTKI OBCIĄŻEŃ STATYCZNYCH MASY ZIARNA PSZENICY

Streszczenie

Przeprowadzono badania wpływu obciążeń statycznych warstwy ziarna na ich zdolność kiełkowania. Próbki ziarna pszenicy o znanej zdolności kiełkowania poddawano obciążeniom statycznym i relaksacyjnym na aparaturze wytrzymałościowej „Intron" w zakresie od 0 do 2000 N/cm^2.

Uzyskane wyniki wskazują jednoznacznie, że w miarę wzrostu obciążeń warstwy ziarna zdolność kiełkowania zdecydowanie maleje. Gwałtowny spadek wartości biologicznej ziarna następuje już przy obciążeniach 200 N/cm^2, a przy obciążeniach 1000 N/cm^2 zdolność kiełkowania utrzymuje się poniżej 40%. Większe obciążenia powodują niemal zupełny zanik wartości siewnej nasion. Obciążenia relaksacyjne (w czasie $t = 1$ godz.) obniżają dodatkowo zdolność kiełkowania o dalsze 10—30%.

Ujemne skutki biologiczne wywołane obciążeniami statycznymi warstwy ziarna pszenicy powstają przede wszytkim na skutek mechanicznych uszkodzeń ziarniaków oraz ich zarodków.

С. Грундас, Б. Шот

БИОЛОГИЧЕСКИЕ СЛЕДСТВИЯ СТАТИЧЕСКИХ НАГРУЗОК СЛОЯ ЗЕРНА ПШЕНИЦЫ

Резюме

Были проведены исследования влияния статических нагрузок слоя зерна на его способность прорастания. Пробы зерна пшеницы с известной способностью прорастания подвергали статическим нагрузкам, а также и релаксационным, на аппаратуре для исследования прочности „Инстрон" в пределах 0-2000 Н/см^2.

Полученные результаты однозначенным образом указывают на то, что с ростом нагрузок слоя зерна способность прорастания решительно понижается. Резкое падение биологических качеств зерна обнаруживается уже при нагрузках 200 Н/см^2, а при нагрузках 1000 Н/см^2 способность прорастания удерживается на уровне ниже 40%. Большие нагрузки вызывают почти полную потерю посевных качеств зерна. Релаксационные нагрузки (в течение $t = 1$ час) понижают дополнительный образом способность прорастания на дальнейших 10-30%.

Отрицательные биологические эффекты, вызыванные статическими нагрузками слоя зерна пшеницы, возникают прежде всего вследствие механических повреждений зернок и их зародышей.

Address of the authors

Mgr Ing. Stanisław Grundas, Doc. Dr Bogusław Szot,
Institute of Agrophysics, Polish Academy of Sciences,
ul. Krakowskie Przedmieście 39, 20-076 Lublin, Poland