ZESZYTY PROBLEMOWE POSTĘPÓW NAUK ROLNICZYCH 1989 z. 378

AN INVESTIGATION ON THE RELATION BETWEEN THE GEOMETRICAL DIMENSIONS AND THE STABILITY OF WHEAT-STALK

Z. Müller

Department of Mechanics, Agricultural University, Gödöllö, Hungary

S y n o p s i s. The lodging of wheat-stalk is caused by weather factors (wind, storm, rain) which subject the stalk to compressive, shearing, bending and torsional stresses. In the respect of growing, such wheat varieties are advantageous which better tolerate stresses which means they are stable against lodging. The purpose of investigations was to gather data on the mechanical and geomertical properties of different varieties of wheat, and further to determine - on the basis of the obtained results - such a numerical value of stability of wheat which can be used for the grading of certain sorts of wheat with respect to stability.

In this paper I give an account of my investigation methods and of my measuring results. I give the relation between the average external diameter and the bending rigidity of the wheat-stalk.. I define a so-called "stability stresses factor" (st) for qualifying the stalk-stability of wheat varieties using the Euler's relationship of the deflection stress. In the respect of the stalk-stability, certain varieties of wheat can be characterized and graded by this numerical value. I can give useful information, especially for the growers and improvers of wheat.

The lodging of wheat is caused by weather-factors (wind, storm, rain) which subject the stalk to compression, shearing, bending and torsion stress. Besides lodging the stability of the wheat-stalk is influenced also by the geometric dimensions, the bending and torsional rigidity, just as by the bending and torsional strength. The purpose of my investigation is to research the geometric and mechanic features of various sorts of wheat and to determine, on the basis of the results, such a value, by which certain wheat-varieties can be graded in the respect of stability. The wheats tested derive from the institute of plant improvement in Martonvásár [1, 2].

THE MEASURING OF THE BENDING RIGIDITY

A wheat-stalk without the ear is stuck by the root end in a steel annulus-cylinder, horizontally fixed. It is loaded on the free end gradually, and the bending deflection under force is measured. A line is plotted to the measurement-points through the zero point of the coordinates by averaging. Knowing the direction factor of the equalizing line and the length of the wheat-stalk the average bending rigidity of the stalk is determined by the following relation

$$Ie = ml^3/3$$

where "m" is the direction factor of the equalizing line and "l" is the length of the stalk. Because the wheat-stalk is morphologically assymetrical, its substance inhomogeneous and anisotropic, therefore the measurement of the bending deflection is effected in two different, perpendicular, to each other directions, and the average of the two bending rigidities is formed. The measurements were effected on stalks with and without leaf sheaths.

RELATION BETWEEN THE BENDING RIGIDITY AND THE EXTERNAL DIAMETER OF THE STALK

The bending rigidity of a prismformed rod with an annulus cross-section, if the relation of the external and internal diamaters is constant, is the following

$$IE = \pi/64\ (1-d_b^4/d^4)d^4 \cdot E = ad^4,$$

where "d" means the external and "d_b" the internal diameter. The "a" factor is influenced by the elastic and cross-section features of the rod.

It can be supposed of wheat-stalks of determined sort and deriving from determined arable land that the relation of the average internal and external diameters regarding the whole stalk, and the average elastic factor, are constant. So the average bending rigidity of certain stalks is

$$IE = a_E d_k^4$$

which means that it is in proportion to the fourth power of the external diameter. The d_k average external diameter is the average of the external diameters in the middle of the internodiums of the stalk. The values of the bending rigidity of the MV-8 wheat variety with leaf sheath are shown in Figure 1 and without leaf sheath in Figure 2. The paraboles of fourth degree fitted to the measurement points on the basis of Gaussian principle of the smallest squares are also shown in the Figures. The coefficient of the parabola is a_{Em} in the case of the stalk with leaf sheath and a_{Eo} in the case of the stalk without leaf sheat. These factors contain the features of cross-sections and elastic modulus of the wheat--stalks of the said varieties, so these values can be managed as variety-features. The effect of the leaf sheath on the bending rigidity can be determined in the case of the given wheat-variety from the relation of the two factors. This rate, in the case of the wheat-sort MV-8-1984 (arable land Martonvásár), is

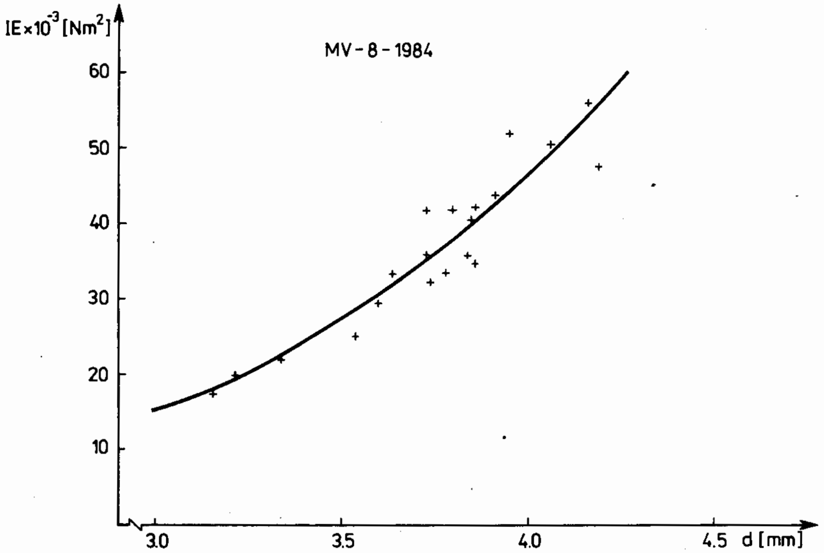

Fig. 1. The values of the bending rigidity as a function of the external diameter of the MV-8 wheat with the leaf sheath

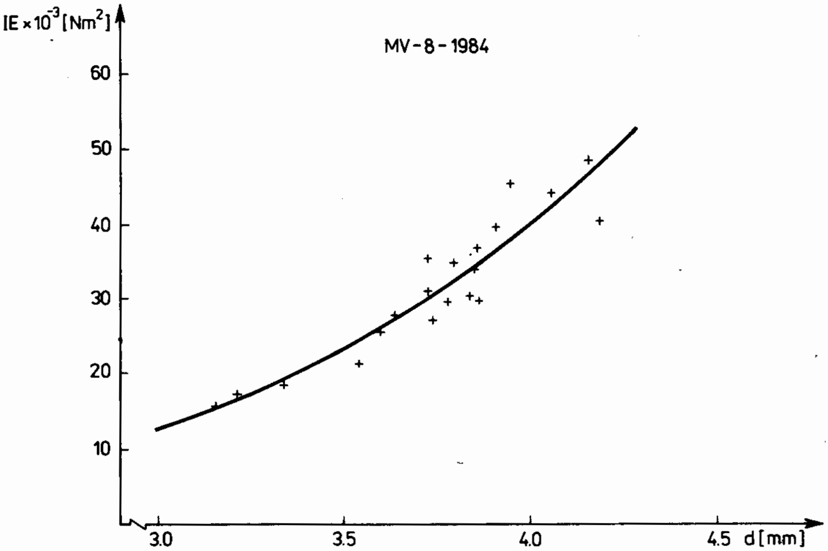

Fig. 2. The values of the bending rigidity as a function of the external diameter of the MV-8 wheat without leaf sheath

$$\frac{a_{Em}}{a_{Eo}} = \frac{180.16 \cdot 10^6 \ N/m^2}{156.01 \cdot 10^6 \ N/m^2} = 1.155$$

which means that the leaf sheath raises the value of the bending rigidity by an average of 15.5 per cent.

THE DETERMINATION OF THE STABILITY-FACTOR

The relation of the Eulerian deflection stability on the prismform rod fixed at one end is

$$\sigma_t = \frac{\pi^2 IE}{4Al^2}$$

where "l" is the length of the rod and "A" is the area of the cross-section of the rod. It was supposed previously that the average of the relation of the average internal and external diameters of the wheat-stalks of the same sort and deriving from the same arable land and the average elastic factor are constant, so

$$IE = a_{Em} d_o^4 \quad \text{and} \quad A = C_1 d_o^4.$$

If these are substituted,

$$\sigma_t = \frac{\pi^2 a_{Em} d_o^2}{4C_1 l_o^2} = C\left(a_{Em} \frac{d_o^2}{l_o^2}\right).$$

The relation in brackets is called stability factor, because it is proportional with the deflection stability, and marked with "st", it means

$$st = a_{Em} d_o^2 / l_o^2$$

where "d_o" is the average of the average external diameters and "l_o" is the average length of the stalk. The value of the stability factor on the wheat-sort MV--8-1984/ (arable land Martonvásár) is:

$$st = 180.16 \cdot 10^6 \cdot 3.73^2 / 916.4^2 = 2.9879 \cdot 10^3 \ \mathrm{N/m^2}.$$

If the value of "st" is greater, the stalk-stability is also greater. The value of "st" characterizes the wheat-stalk in the respect of the stalk-stability and it is suitable to grade the wheat-varieties.

REFERENCES

1. Müller Z.: A consideration of strength features in standing ability complex test of cereals. Zesz. Probl. Post. Nauk Roln., 1984, 245, 103-109.
2. Müller Z.: Bending test and internal damping measurement of stalk of straw. Zesz. Probl. Post. Nauk Roln., 1985, 304, 147-154.

Translator: Author

Z. Müller

BADANIE ZWIĄZKU MIĘDZY GEOMETRYCZNYMI WYMIARAMI I STABILNOŚCIĄ ŹDŹBŁA PSZENICY

Streszczenie

Wyleganie pszenicy jest związane z wieloma czynnikami (wiatr, burza, deszcz), które powodują zgniecenie łodyg, skręcenie lub złamanie. Ze względów uprawowych są pszenice bardziej odporne na naprężenia co oznacza, że są też bardziej odporne na wyleganie.

Celem badań było uzyskanie mechanicznych i geometrycznych własności różnych rodzajów pszenicy i następnie oznaczenie - na podstawie uzyskanych wyników - liczbowych wartości stabilności pszenicy, które mogą być użyte do klasyfikowania rodzajów pszenicy pod względem stabilności. Przedstawiono metodę badań oraz uzyskane wyniki. Pokazano zależność zewnętrznej średnicy i modułu sztywności łodygi pszenicy. Wprowadzono „współczynnik stabilności naprężeń" (st) do kwalifikowania stabilności łodygi pszenicy, wykorzystując zależność Eulera. Przedstawiono informacje praktyczne dla uprawiających i użytkujących pszenicę.

З. Мюллер

ИССЛЕДОВАНИЕ СВЯЗИ МЕЖДУ ГЕОМЕТРИЧЕСКИМИ РАЗМЕРАМИ И ВЛАЖНОСТЬЮ ПШЕНИЧНОГО СТЕБЛЯ

Резюме

Полегание пшеницы связано с многими факторами (ветер, буря, дождь), вызывающими сдавление стеблей, скручение и перелом. По соображениям обработки пшеницы более устойчивы к напряжению, что обозначает, что они тоже более устойчивы к полеганию. Цель исследований состояла в получении механических и геометрических свойств разных видов пшеницы и затем определении на основе полученных результатов числовых величин стабильности пшеницы, которые могут быть использованы для классификации видов пшеницы по их стабильности. В этой работе представлены метод исследований и полученные результаты. Показана зависимость внешнего диаметра и модуля жесткости стебля пшеницы. Введено „коэффициент стабильности напряжений" (st) для квалифицирования стабильности стебля пшеницы, используя зависимость Эйлера. Представлено практические информации для возделывателей и потребителей пшеницы.