Fredrick Udoh, Jürgen Beck and Thomas Jungbluth, Hohenheim

Measuring systems for determining the standing capability of cereal crops

As part of an investigation into the influence of different cereal fungicide treatments on straw properties, the standing capability of winter wheat was determined. For this, a measuring system was developed that allowed the direct assessment of standing capability of growing and mature cereal crops.

Legende

α	outer angle of pendulum (°)
DMS	Expansion measuring strip
F_x	Force in horizontal direction at the pendulum (N)
F_z	Force in z-direction at the pendulum (N)
h_D	Fulcrum height (m)
l_P	Length of pendulum (m)
m_{Hi}	Straw mass (kg)
m_P	Pendulum mass (kg)
v_F	Driving speed (m s^{-1})
W_{bi}	Resistance moment (Nm)
I	Flow strength (µA)

Cand. agr. Fredrick Udoh was diploma student in the specialist area of process technology in livestock production and agricultural buildings, at the Institute for Agricultural Engineering of Hohenheim University. Dr. agr. Jürgen Beck is academic supervisor at the institute (director: Prof. Dr. habil. Thomas Jungbluth), Garbenstr. 9, 70599 Stuttgart; e-mail: jafbeck@uni-hohenheim.de
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Keywords

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The improvement of cereal standing capability is very important in integrated plant production. Current crops, with their higher plant density and yields, rely still more on a dependable resistance to lodging compared with the thinner crops of earlier decades. Where lodging occurs, grain yield and quality penalties (fungus-affected and shrivelled grain) are to be reckoned with in every case. The earlier the crop lodges, the higher the losses. Even where lodging takes place late, losses must be calculated, especially through harvesting difficulties thus caused. To these must be added increased drying costs [1, 4].

Factors influencing standing capability

Relevant properties of plants which influence their standing properties are growth height, stalk wall strength and, particularly, the straw base internode areas and straw elasticity. These are dependent on cereal type and variety [1, 4]. Materials (fungicide and plant growth regulator) can be applied for retention of standing properties, the stabilising effects of which could not up until now be directly investigated on growing or mature crops.

Development of a plant resistance measuring system

The plant resistance is defined as the force (decisively influenced by mass weight and flex resistance of the plant) which the plant stalk must find in order to resist an outside force (wind gusts or driving rain); from the sum of these properties the standing capability of the plant is derived.

Method

The method chosen relied on Newton's third law "for every action there is an equal and opposite reaction". This was carried by a system used for the measuring of biomass [2,3] in which a suspended cylindrical body was moved horizontally through standing crop.

In that it is possible to keep almost constant h_D; l_P; m_P and v_F within a field area or a variety, α is dependant only on the crop parameters M_{Hi}, W_{bi}, n_H, which were introduced by the authors to describe the relative form of the biomass. From the definition of the plant resistance and the biomass properties according to [2] the following consequences were taken for the development of a system to determine plant resistance and crop stability of cereals:

From the force applied by a certain number of plants on a horizontally-moving cylin-

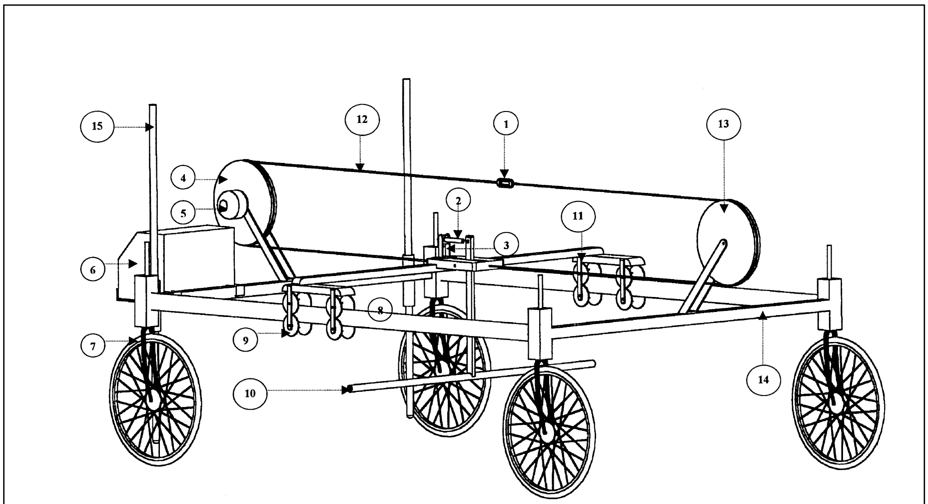

Fig. 1: Pendulum measuring device (1-cable tension clamp, 2-distance meter, 3- distance meter holder, 4-driving disc, 5- electric motor, 6- control box, 7- wheel and fork blades, 8- running tubes, 9- guide wheels, 10- pendulum, 11- pendulum carrier, 12-cables, 13- guide disc, 14- transverses, 15- pin

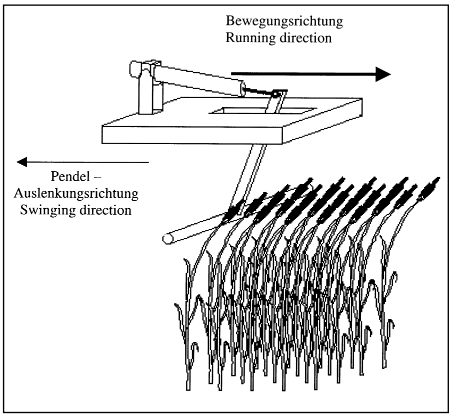

Fig. 2: Measuring the resistance of a cereal stalk, situation of unit during measurement

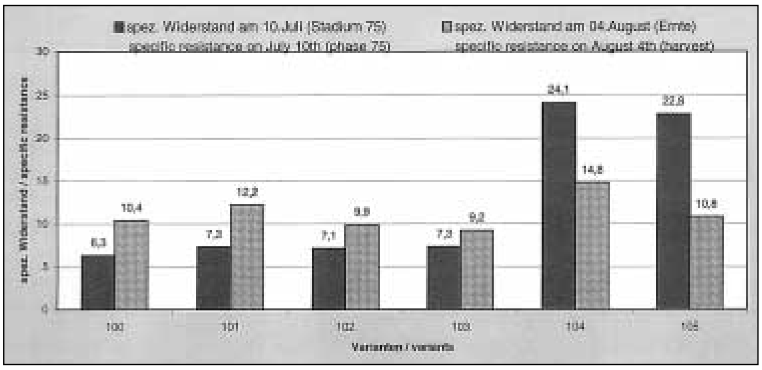

Fig. 3: Specific stalk stability during vegetation phase (75) and at harvest depending on fungicide treatment

drical body with defined mass, breadth and length, the mass inertia and stiffness of all plants that come into contact with the instrument can be determined.

If the crop plots undergo different plant protection, then it is also possible for plants of the same type and variety to display different biomass properties (specific differences in the mass per plant, in static properties, in health status). Through the strip-type testing of homogenous crop stands there appears definite relationships between the reactions of the crop (plant resistance against the pendulum) and the effect of the plant protection treatment.

- The plant stalk, which has a construction similar to that of a feather, has a specific minimum resistance against a horizontal working force.
- For efficient measurements of resistance in plant stalks, the sum of the affecting force must be less than the resultant reaction force of all the plant stalks with simultaneous pendulum contact.

Thus can the angle of the pendulum α be applied as the measurement factor for the standing capability of a crop stand.

Pendulum measurement instrument

The real measurement equipment comprises the pendulum, pendulum table, distance meter, distance meter attachment and tension measurer (*fig. 1*).

The pendulum comprises a vertical pendulum rod which swings on a horizontal axis and the horizontal plant contact surface (120 cm in length). The resistance of all plants simultaneously in contact with the contact surface is measured. The distance measurer which records the resistance force of the plant stalks against the movement of the pendulum, gives this as a change in flow force.

The plant resistance is determined from these values. The instrument is calibrated for the horizontal force component Fx as measurement of plant specific resistance. Additionally, the pendulum angle (a) with the appropriate force in direction x (Fx) is calibrated by a DMS force recorder. From this, the desired force (Fz) can be calculated. The calculation factors are then determined with help of a linear regression:

Fz = 0.2806 • I-3.296 [N]; R^2 = 0.978

Application of the instrument

At the beginning of a measurement the pendulum hangs vertically to the ground at an angle of 90° to the running rails and therefore to the surface of the crop. Thus, the plants which are to have their resistance measured are in their natural condition. When the instrument is started the measuring unit is moved horizontally at constant speed over a measurement length of 180 cm by an E-motor. As soon as the plant contact surface of the pendulum touches the plants (*fig. 2*), the pendulum continues to swing until its momentum is stopped at a certain angle – an angle which remained relatively constant right to the end of homogenous cereal stands.

Through the average movement of the pendulum (measured in µA) when moving through the crop stand, the plant resistance is determined. The final measurement value for every treatment variation was based on the average of five repetitions.

Results

The stability of a winter wheat stand was measured in growth period 75 and at harvest to determine the effect of different treatment variations. In order to minimise interference from external influences and thus measurement mistakes during both points of time, the trials were carried out during suitable weather conditions (warm, no precipitation and no special wind influences).

Definite results were determined from the specific resistance per meter breadth of the crop stand. The results have to be judged against the background of harvest losses being all the higher, the earlier lodging occurs and the larger the percentage of lodging in the entire crop.

The higher the specific resistance to the pendulum, the higher is also the resistance of the plant stalk against rain and wind. Thus a higher specific resistance can be interpreted as a measurement for better standing ability. Thus for the first time it is possible to determine the standing ability of different crops.

The results of the field trial show that, in the growth period 75, the measured resistant of the variants 104 and 105 were substantially higher than for variants 100 (control crop without treatment), 101, 102 and 103 whilst, by harvest time, significant differences could no longer be determined (*fig. 3*).

Moreover, the development of the treatment variations through the comparison of plant resistances was expressed at both periods. Whilst, from growth period 75 to harvest, the resistances of the variants 100, 101, 102 and 103 increased, they decreased for variants 104 and 105.

Conclusions for practical application

The various fungicide treatments meant the specific resistances of all treated variants against mechanical lateral stresses were different – both in the growth period 75 and at harvest. It was possible to tell through the measurement system to what extent production-technical measures such as, for instance, a fungicide treatment, influenced the stability of the cereal stand.

The specific plant resistance of a cereal stand has proved itself as directly-measurable property of plants. Through the application of this measurement system it is possible to determine cereal types and varieties, as well as fertilisers and plant protection treatments, which are suitable for specific sites under detrimental weather conditions such as driving rain and wind.

Literature

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