MECHANICAL PROPERTIES OF OILSEED RAPE PODS RELATING TO SEED LOSS BY DEHISCENCE AT HARVEST

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ABSTRACT

Although loss of seed during harvest operations in oilseed rape may exceed 50% in extreme cases, the physical properties of pod material and the mechanics of pod cracking have not been studied in detail. This paper presents preliminary results of a study of this topic.

INTRODUCTION

Seed loss at the point of harvest in oilseed rape is a significant problem. There are no comprehensive figures but typically 10 - 20% of the available seed may be lost and in extreme cases[1] more than 50% may be shed before the crop is inside the harvester.

Disturbance occurs both before harvest by the action of wind, heavy rain, hail etc. on the crop, and during swathing, picking up of swaths and direct cutting of the crop. Losses measured from different parts of machines for harvesting operations have been recorded[2], but this work seeks to understand the fracture process itself in quantitative terms. The objective of the present work was, therefore, to measure the mechanical properties of the individual elements making up the pod, not available in the literature, so as to aid this understanding. In the longer term, such data will be incorporated in models of the pod and used to guide genetic development towards pods which are more resistant to fracture.

EXPERIMENTAL

Materials A

Oilseed rape of variety Express was grown under farm conditions, and chemically desiccated as per normal practice. Plants were gathered once fully senesced. Samples of pod wall material were made by cutting strips, either by a fine modelling knife or a miniature high-speed circular saw, parallel to the pod longitudinal axis, between 1 and 2 mm wide and between 20 and 25 mm long. Areas of extreme curvature round seed sites were avoided to ensure the sample was not extensible as a consequence of its shape. Pod stems were prepared by cutting each one from the plant and from the pod. Each sample was glued at each end to small metal tags using rapid setting epoxy resin, which was allowed to cure for at least 12 hours.

Materials B

Pods from the same field crop of oilseed rape were cut by hand every few days from several plants as they desiccated naturally. Pods were taken from before full maturity through to the fully mature, senesced condition.

Test equipment

Tensile tests were carried out using a Nene Davenport universal test machine fitted with a load cell with a maximum capacity of 10 N for tensile tests and 0.5 N for bending tests. The cell and the base were each fitted with an attachment made from a chain link of 0.5 inch pitch, over which the metal tag to which the sample was mounted fitted closely. To test the background stiffness of the test machine, a steel rod was glued into similar metal tags and substituted for the sample in a tensile test.

Method A

To determine the tensile properties, the sample was mounted and the crosshead was driven at a speed of 1 mm/min until the sample fractured or until the load limit of the load cell was reached. Sample thickness was measured using a dial gauge of 0.2 mm full scale deflection with resolution of 0.002 mm. Sample width of the pod wall strip was measured by projecting its magnified shadow onto a scaled screen.

Method B

To determine the strength of pods in bending, the stem of each pod was gripped firmly in a pin chuck such that the pod was held horizontally, with the replum in the horizontal plane. The pod was deflected by pressing it vertically with a fine roller connected to the load cell, at a bending moment arm of 30 mm and at a speed of 8 mm/min until the pod cracked or until a deflection of 15 mm was exceeded. The load deflection curve was analyzed to determine the force required to initiate a crack in the pod and the deflection at first cracking. After testing, the moisture content of pod material without seeds was determined by oven-drying at 105°C for 12 hours.

Data analysis

After tensile testing a display of force versus crosshead displacement was used to select the linear part of the trace, the slope of which in N/mm was then recorded. From width and thickness data, area of the samples normal to the direction of force was calculated. The slope of the linear portion of the force displacement curve was corrected to take into account the stiffness of the load cell and grips using the formula

$$\text{corrected slope} = ((\text{measured slope})^{-1} - (\text{machine slope})^{-1})^{-1}$$

where machine slope = slope of the curve for a short, steel specimen.

Youngs modulus of elasticity for the material was then calculated as the product of corrected slope and sample length divided by sample cross sectional area. Ultimate strength was calculated as the maximum force sustained by the sample divided by its cross sectional area.

RESULTS

Table 1 shows values for Young's Modulus of the pericarp and pod stem material and the ultimate strength of the pericarp. The load cell reached its limit before samples of pod stem fractured so a lower limit of ultimate strength was calculated.

Figure 1 shows force versus deflection data for two pods, only one of which cracked (pod 1). The crack was initiated by a force of 0.065 N at a deflection of 2.4 mm at the loading point, and propagated in an unsteady manner along the pod as the deflection increased, as revealed by the jagged trace. In contrast the data for pod 2 shows a slow but monotonic increase in force as deflection increased, and no cracking occurred. The initial slope for pod 1 is three times that for pod 2, and the force generated by the bending never exceeds the 0.065 N which initiated cracking of pod 1. The moisture contents of pods 1 and 2 were 25.8% and 35.4% wet basis respectively. Figure 2 shows plotted against moisture the number of pods, out of each batch of five, which cracked. It is clear that as pod moisture reduced the likelihood of cracking increased. In Figure 3 the deflection at which cracking was observed is presented against pod moisture for 70 samples. For most of the pods which cracked, i.e. 80% or more for those under 25% moisture (Fig.2), the required deflection from Figure 3 was less than 15 mm, a deflection that could be readily reached in field conditions of harvest and, for 23 samples, less than 5 mm.

TABLE 1. Youngs Modulus and ultimate strength of pod elements from 11 samples of each material.

Pod element	Youngs Modulus N/mm^2		Ultimate Strength N/mm^2	
	Mean	St deviation	Mean	St deviation
Pericarp	3420	1262	48.1	13.4
Stem	3329	706	>19.4	-

From results not presented here because of space, it was noted how little force, around 0.08 N (mean), was required to initiate a crack in cantilever bending compared with a mean of 1.2 N in a bending test where the pod was supported at the ends and a load applied at the centre. Thus it is proposed that cantilever bending, where the stem of the plant is the fixed point of the system, is the mode of action which is most likely to initiate cracking of pods during handling of the plants, including by harvesting equipment.

CONCLUSIONS

1. Values for elastic modulus of components of the oilseed rape pod have been measured, to enable deformation of the pod to be modelled.

2. A force of only 0.08 N was typically required to initiate cracks in pods in cantilever bending against the resistance of the pod stem.

3. Bending is the most likely cause of crack initiation during crop handling.

REFERENCES

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ACKNOWLEDGEMENT

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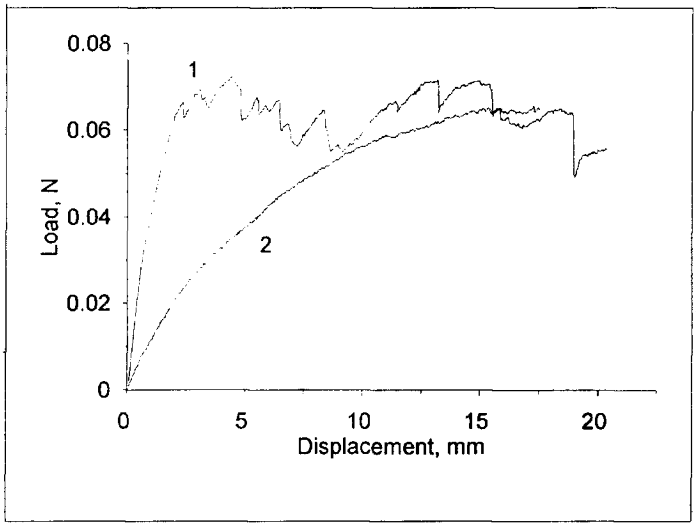

Figure 1.

Load vs. deflection curves for two pods showing contrasting behaviour (see text).

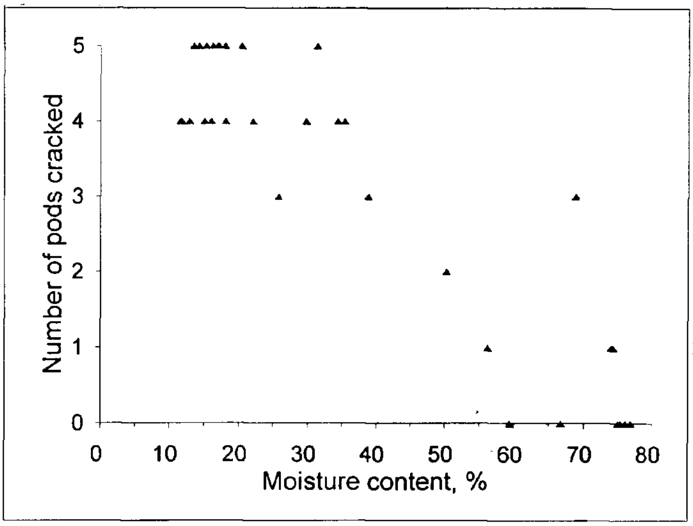

Figure 2.

The number of pods from each batch of five which cracked in cantilever bending increased as pod moisture reduced.

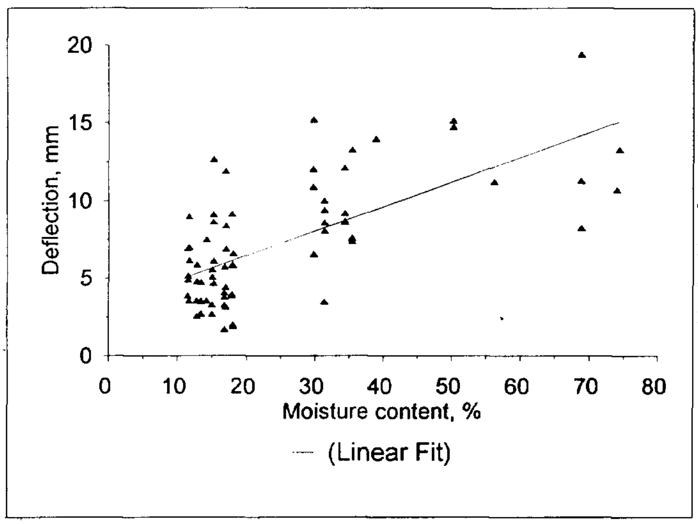

Figure 3.

The deflection to initiate a crack was correlated with pod moisture.