

# Quantitative determination of the strength of rapeseed pod dehiscence\*

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## Abstract

Rapeseed pods are easy to shatter causing yield loss during harvest. Furthermore the fragile pod is not suitable for mechanical harvest. Quantitative determination of strength of rapeseed pod dehiscence is necessary for studying the mechanism of rapeseed pod shattering and breeding cultivars with shattering tolerance. A “Ripping” method was developed to determine quantitatively the pod dehiscence strength. To keep the different tests comparable, 6 pods per variety were balanced in a chamber at 25°C and at 50% relative humidity (RH) for 2 weeks, then the pods were enlaced with metallic thread at 2.5cm to the pedicel and glued onto a plate. The probe moved up to rip the pod, the maximal force that probe monitored was the pod dehiscence strength. Results of 47 tested varieties showed that the pod dehiscence strength among rapeseed lines varied greatly, hence selecting the pod shatter tolerant varieties among lines of oilseed rape for mechanical harvest was feasible. The “ripping” method of quantitative determination of the pod dehiscence strength had a potential value in rapeseed breeding and biological researches.

**Key words:** Quantitative determination, Pod dehiscence, Rapeseed, Ripping

## Introduction

Rapeseed oil is the main source of the edible oil as well as the important industrial raw material and the future reproducible biomass energy. The pod dehiscence of rapeseed is formed in the process of long term evolution. At maturity, the pod is shattered to release the seeds to ensure extension of later generations, but it has the negative effect in rapeseed production nowadays. Due to the fragile pod of *Brassica napus* which is widely cultivated, yield loss in harvest is accounted for 10% of total yield. When the climate is worse during the harvest, this loss even reaches to 50% of the yield (Kadkol et al., 1984; Child and Evans, 1989; Price et al., 1996). The loss of seeds on the earth results in the contamination of subsequent crops. To avoid the seed loss caused by the pod shattering, early harvesting is often adopted, but this lowers seed oil content and increases seed chlorophyll content and eventually reduces the oil quality. Especially, the shattering pod does not fit to harvest mechanically and restricts the improvement of the production efficiency. Quantitatively determining the strength of the pod dehiscence of different rapeseed varieties is prerequisite to understand the genetic and physiological mechanisms of pod dehiscence and select the varieties with shattering tolerance for rapeseed production.

The rapeseed breeders initially evaluate the pod dehiscence by weighing the seeds fell to the test plot after harvest (Kadkol et al., 1984). This method is valuable to evaluate the samples in the same place and the same year. With the change of test locations and time, the results from this approach would be varied and not be comparable. Other disadvantages of this approach is time consuming and laborious. Subsequently, bending pod method is developed, the pod is bended to crack and the angle which represent the pod dehiscence level when pod is shattered (Downey and Robbelen, 1989; He and Li, 1996). A low correlation is found between the maximal bending moment that the pod sustains before fracture and the percentage of shattered pods measured in field trials. The shattering angle is also affected by the pod length, diameter, moisture etc. And then the approach of VPS (Variable-speed pod splitter) is developed. The VPS is a mechanical device that provides a measure of the impact force required to trigger shattering of individual pod. Seed pods are released into the VPS at the different speed, and the speed breaking the pods is recorded. Pods remaining intact after impact at 60 Hz are considered to be non-shattering. The speed of the rotating spines is calibrated to convert Hz into revolutions per minute (RPM), and the result is reported in RPM (Timothy et al., 2003). Another quantitative method named Random Impact Testing is that 20 pods are placed together with six steel balls of 12.5mm diameter in a cylindrical container of diameter 20cm with its axis vertical. The container is then subjected to simple harmonic motion of frequency 4.98 Hz and of stroke 51mm in the horizontal plane. The pods are shaken for cumulative times of 10, 20, 40, 80s. At the end of each period, pods are removed from the container to examine the percentage of opened pods, the more percentage the opened pods, the more fragile the pods (Bruce, 2002). The two methods described above could quantitatively determine the pod dehiscence level, but the reproducibility is not good enough, and due to the nonstandard installation, the values could not be comparable among different places and time. The precise determination of pod physical character and energy release during pods shattering are reported, but the processes are too complex and the instrument are too expensive to use widely (Davies and Bruce, 1997; Morgan et al., 1998).

Here we report an approach of “Ripping” which has a good reproducibility and comparability to determine the pod dehiscence level. Method of Ripping can be widely used in shatter resistance breeding and the research on the biochemical and physiological mechanisms of pod dehiscence.

## Material and methods

**Materials:** All the materials were from the Institute of Industrial Crop, Jiangsu Academy of Agricultural Sciences, including 47 lines of *Brassica napus*, and one line of *Brassica carinata*.

**Instrument:** Texture Analyser TAXT2-HD.

**Methods:** When pods turned to the light yellow, and began to dehydrate, about 10cm of middle inflorescence of 5 plants was cut and placed at 25°C, 50% RH for 2 weeks to keep the water content identical. Six pods each plant (2 pods each part of the upper, the middle and the lower on the inflorescence) were sampled. The pod was enlaced at 2.5cm to the joint point between the pod and the pedicel with the metallic thread and glued on the plate, then the replum was paralleled to the plate (Figure 1B).

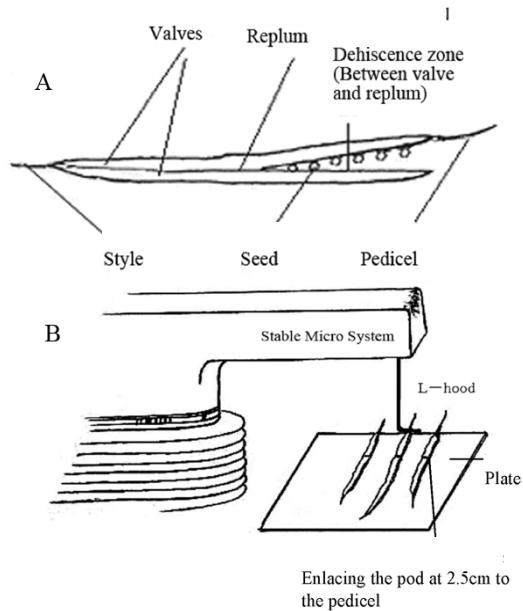


Fig 1. The structure of rapeseed pod and the installation of quantitative determination of the force for pod dehiscence.

A, Structure of a open pod. B, The installation of ripping method

## Results and discussions

### *Installation of "Ripping method" to quantitatively determine the pod dehiscence strength*

The rapeseed pod was composed of two valves, replum between two valves, dehiscence zone between the replum and the valve, style, pedicel and seeds attached to the replum. (Fig 1 A). At maturity, the pods began to dehydrate, and if the exterior forces such as mechanical, wind and so on, interacted with the pods, the valves and dehiscence zone detached resulting in the seeds release. Different varieties needed different exterior force to open the pods. We used the texture analyser to rip the rapeseed pod, and quantitatively determined the exterior forces necessary for pod opening. Before testing, all samples were put into a controlled room with 50% RH and at 25°C for two weeks. In Summer, the air-conditioned room could be easily controlled at 50% RH and temperature of 25°C. The pods with identical humidity were enlaced with metallic thread at 2.5cm to the end of pods to ensure that every test just determined the open strength at 2.5cm of the pod. Then, the pods were glued to a plate, and the replum was paralleled to the plate. One side of L-shaped hook was fixed in the probe of the Texture analyser, another side hooked the pedicel at the joint point of pod and pedicel (Figure 1 B). During the test, the plate was held in hands, the probe was moved upwards at the speed of 2 mm/min and the pod was opened. At the same time, the probe recorded the opened strength.

During the test, the probe drove the L-shaped hook moving forwards, the opening strength increased gradually before the pod opened. When the pod opened, the opening strength decreased rapidly. With the probe continued to move upwards, the opening strength increased slightly, and then decreased (Figure 2). The curve had a peak, the maximal opening strength appeared in 0.3s. The more the tolerant shattering, the higher the maximal value of opening strength. The peak value of the opening strength of each variety represented the pod dehiscence level. Fig 2 showed that the variety's pod dehiscence strength was 2.38 N. Here we used the precise and expensive instrument to determine the dehiscence strength, but in the rapeseed breeding practice, the maximal opening strength can be recorded by a cheap and simple spring balance instead of Texture Analyser.

### The dynamics of the opening strength in the course of pod opening

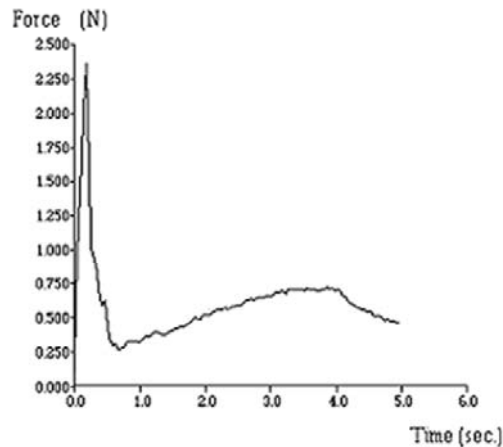


Fig. 2, The time-force curve of the tested variety under the external force in the course of the pod dehiscence.

#### Pod dehiscence strength varied among lines of *Brassica napus*

*Brassica napus* was considered to be fragile, and pod dehiscence strength varied little among different varieties (Morgan et al., 1998). Shattering tolerance germplasm existed in the wildness of *Brassica rapa*, *Brassica juncea*, *Brassica oleracea*, *Brassica carinata* and artificially synthesized *Brassica napus*. The traditional method for the development of shattering tolerant variety was interspecific cross, but some poor agronomic traits might be introduced also, thereby the breeding progress was not great.

47 lines of *Brassica napus* and 1 line of *Brassica carinata* were tested to evaluate the pod dehiscence level. The results showed that the pod dehiscence strength varied greatly among *Brassica napus* (Figure 3), with the maximum value 3.77N, the minimum value 0.77N. The pod dehiscence strength of *Brassica carinata* was 4.6N. It was feasible to breed *Brassica napus* cultivars with shattering tolerance by selecting the shattering resistant lines as parents. But the materials with much high pod dehiscence strength might be valueless in breeding. For example, the pods of *Brassica carinata* with dehiscence strength of 4.6N were hardly dehisced. Based on the data above, we proposed that the suitable pod dehiscence strength for mechanical harvest was 2N to 3N.

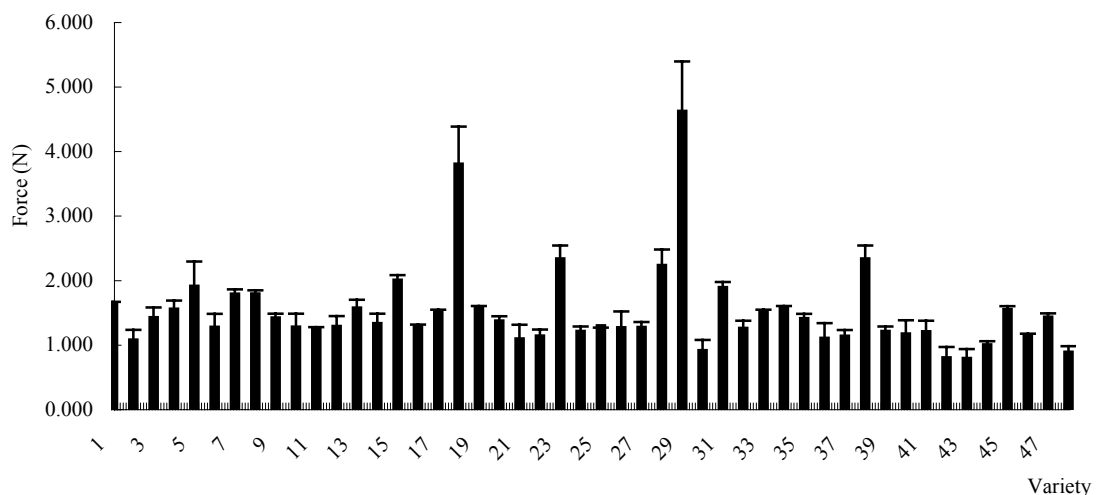


Fig.3 Determination of the dehiscence force of different rapeseed varieties

47 varieties of *B. napus*, and 1 *B. carinata* (Number 30) were determined, the dehiscence force varied greatly. The value is the mean of 6 replications, the bar above the histogram is SE.

#### Reference

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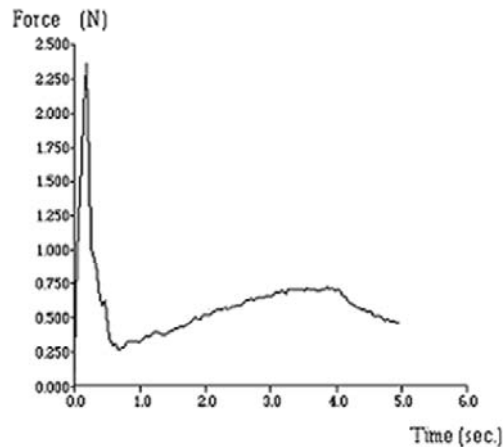


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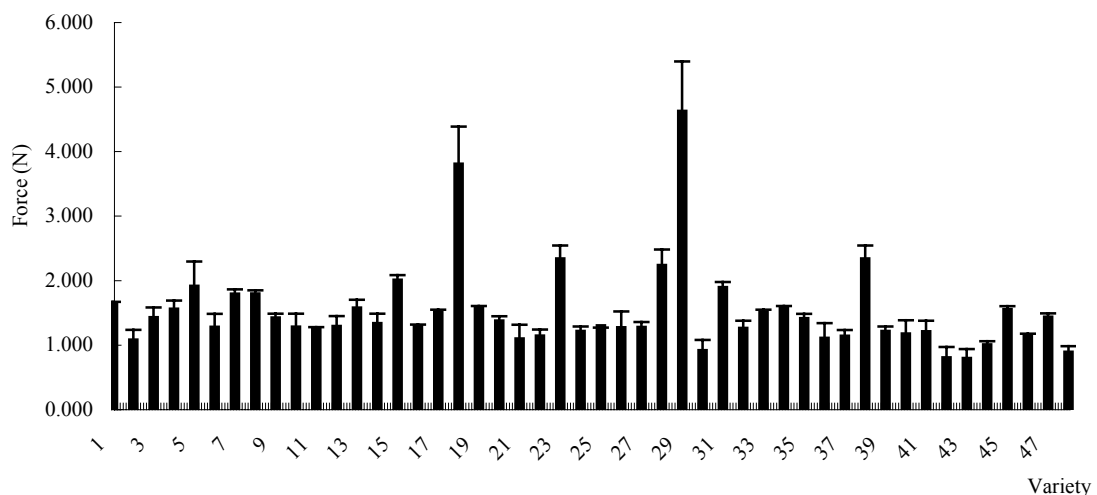


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