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Equipment for Quantitative Measurement of Shattering Habit of Paddy

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Abstract

Two kinds of testing devices, TR-I and TR-II, were developed in order to identify varietal differences of rice in shattering habit in a quantitative term. Forty-two varieties were tested with these equipment. There were close relationships between the quantitative measurements taken by means of these two devices and also between the processing losses of a combine harvester and the threshing rates with TR-I as well as the straight tensions with TR-II. The proposed method with those devices provides a quantitative basis for evaluating a degree of shattering of rice varieties without field testing and predicting losses in processing with a combine harvester.

Discipline: Agricultural machinery
Additional key words: processing losses, straight tension, threshing rate

Introduction

The performance of threshers and combine harvesters depends not only on mechanisms and operating conditions of their component units such as header, threshing and separating units, but also on physiological characteristics of paddy to be harvested, among which shattering habit of rice plants plays a principal role. In evaluating or predicting precisely the performance of a combine harvester, therefore, essential is the information on the shattering habit of each rice variety. To meet this requirement, it is necessary that the data are taken in a quantitative manner. In regard to the quantitative measurement of shattering habit of paddy, any effective method for quantification has not been established yet so far, in spite of several efforts reported, and in practice, the degree of shattering habit is expressed on the basis of an empirical and undefined ranking or grading such as easy, medium and difficult.

The objective of this study is to develop a simple method to quantitatively express the relative difficulty of shattering of paddy. Towards this end, two types of testing devices were designed, and a number of rice varieties were subjected to comparative tests of their shattering habit.

Development of testing devices

Two models of testing devices, i.e. TR–I and TR–II, were designed to evaluate shattering habit of paddy, covering a wide range of indica and japonica varieties.

1) Model: TR–I

The testing device TR–I is a modified type of the conventional thresher generally used for yield tests. It is designed so that easiness of shattering of paddy can be evaluated under running conditions. An outline of the device is shown in Fig. 1 and Plate 1. It has a threshing drum with 365 mm diameter and 440 mm width in size, which is equipped by 32 threshing teeth of 66 mm height. The concave is made of metal plate with holes of 10 mm diameter. Testing procedures to quantify the measurements of relative difficulty of shattering of paddy are as

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follows:

(1) Cut stalks bearing panicles with a length of 500 mm from the top.
(2) Divide these materials into 450 g samples each.
(3) Maintain an adequate speed of the drum so that the velocity at the top of threshing teeth is of 12 m/s. Keep the stalk disposing plate closed.
(4) Feed each sample to the testing device.
(5) After 5-second threshing, stop the motor and open the stalk disposing plate.
(6) Take out the threshed sample, and weigh the threshed grains and unthreshed grains separately.
(7) Calculate the threshing rate (P) with the following formula:

$$P = Gt/(Gt + Gut) \times 100,$$

where P : Threshing rate (%);
Gt : Total weight of threshed grains (g); and
Gut : Total weight of unthreshed grains (g).

(8) Repeat the above procedures three times for each variety, and calculate an average of the three values of P. The average value represents the threshing rate of the variety under testing.

2) Model: TR-II

The testing device TR-II is used to measure the force required for separation of a grain from the pedicel. The measurement stands for a static test of shattering habit of paddy. An outline of the TR-II is presented in Fig. 2 and Plate 2. The device consists of a pedestal, tension gauge, two holding

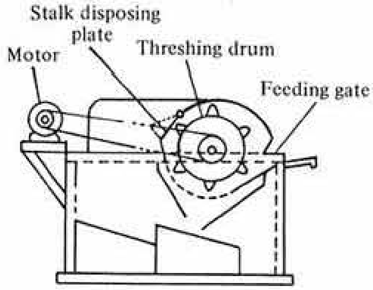

Fig. 1. Outline of the testing device on shattering habit (TR-I)

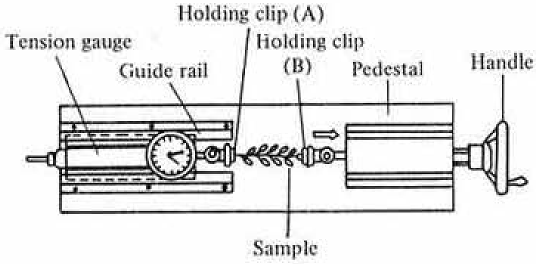

Fig. 2. Outline of the testing device on shattering habit (TR-II)

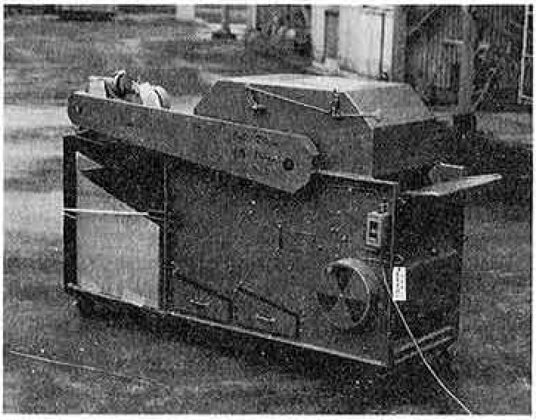

Plate 1. The testing device (TR-I)

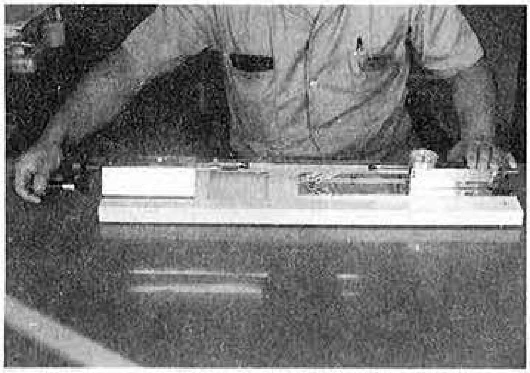

Plate 2. The testing device (TR-II)

clips and a handle. The tension gauge is fixed on the pedestal and the holding clip (A) is equipped at the top of gauge. The holding clip (B) is connected with the handle so that the clip is horizontally movable by manual operation of the handle. The procedures to measure the separating force of a grain from the pedicel are as follows:

(1) Hold a rachis on the clip (A) and a grain on the clip (B).
(2) Turn the handle at the rate of one rotation per second so that the clip (B) moves laterally with a constant speed to pull the grain.
(3) Read the measurement of the maximum force when the grain is separated from the pedicel. (The measurement of the tension gauge represents a maximum value of the given force.)
(4) Measure the maximum force of each grain on the rachis in the same manner as above.
(5) Repeat the above-noted test for at least three panicles for each variety and take an average of all the measurements, which represents the separating force of that variety.

There are three types of the holding clips (B). The separating force of a grain can be measured thereby in three directions; i.e. straight tension, tension with bend and tension with torsion as shown in Fig. 3.

The device of model TR-II is presently put on the market in Japan for practical use.

Test results

1) Test results with model TR-I

Forty-two varieties were subjected to test with TR-I in the present study. The threshing rates (P) of those varieties showed a wide range from 54% to 98%, which indicated significant differences of shattering habit of the rice varieties (Fig. 4). Among

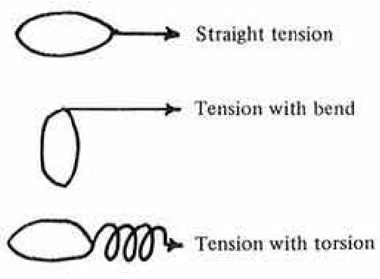

Fig. 3. Three directions of the separating forces between a grain and its pedicel

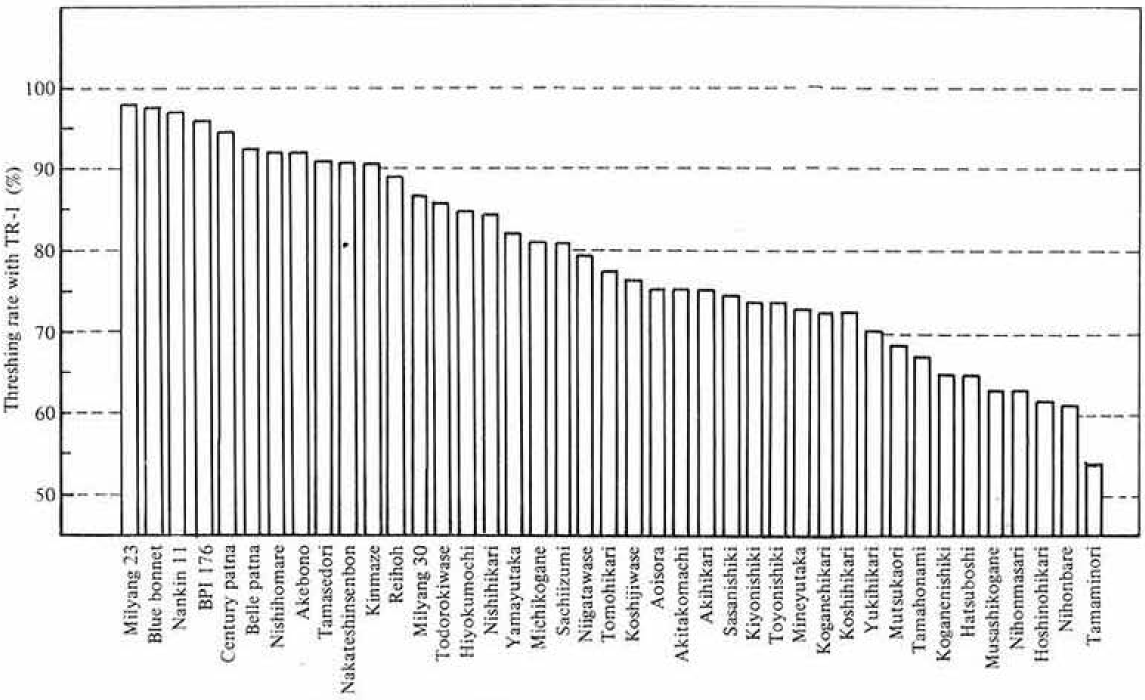

Fig. 4 Varietal differences of shattering habit in rice

the varieties tested, both of indica varieties and japonica-indica hybrid varieties showed high threshing rates exceeding approximately 90%, which confirmed that the shattering habit of these varieties was of "very easy". Since the threshing rates of japonica varieties ranged widely, the grade of shattering was classified into five ranks as shown in Table 1.

There was a tendency in the samples measured with TR-I that the number of grains attaching pedicels

Table 1. Classification of rice varieties based on shattering habit (1)*

Rank	Shattering habit	Threshing rate (%)	Rice variety
1	Very easy	90 and over	Blue Bonnet, Akebono, Milyang 23, Nakateshinsenbon, etc.
2	Easy	80 to 90	Nishihikari, Michikogane, Milyang 30, etc.
3	Medium	70 to 80	Koshihikari, Sasanishiki, Akitakomachi, Yukihikari, etc.
4	Difficult	60 to 70	Nihonbare, Hatsuboshi, Musashikogane, Hoshinohikari, etc.
5	Very difficult	below 60	Tamaminori

*Under testing with TR-I.

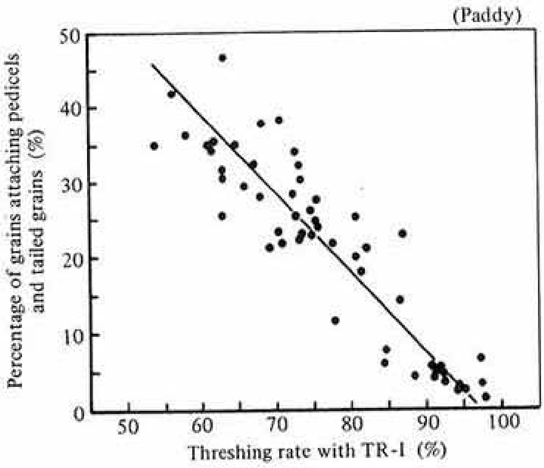

Fig. 5. Relationship between threshing rate and percentage of grains attaching pedicel and tailed grains
Under testing with TR-I.

as well as of tailed grains increased as the threshing rate decreased (Fig. 5).

2) *Test results with model TR-II*

Measurements of straight tension were taken with TR-II for 42 varieties to quantify their separating forces as were the case with TR-I. The values of straight tension showed a wide range from 71 gf to 220 gf, in which there seemed to be a tendency that higher values of the tension were corresponding to the degree of stiffness of grains in threshing operations. The results of the tests are given in Fig. 6, which shows the relationship between threshing rates with TR-I and straight tensions with TR-II for the 42 varieties. The data obtained demonstrate that the threshing rate is closely correlated with the straight tension. In other words, varieties with lower threshing rates possess higher degrees of resistance to straight tension of grain-pedicel separating force. The straight tensions of the varieties tested were classified into five ranks as shown in Table 2 referring the classification in threshing rate with TR-I.

The three types of the holding clip (B) in TR-II were employed to measure separating forces in three directions. Among the three types of tension, the straight tension indicated the highest values, followed by the tension with torsion and the tension with bend in this order (Fig. 7). Incidence of grains attaching pedicels or tailed grains occurred at a considerably high rate in case of tests by the tension with torsion, while it was rather rare in case of the straight tension and the tension with bend (Fig. 8). This result suggests that grains attaching pedicels and tailed grains be brought about in a higher degree in case where the threshing operates by tension with torsion in the threshing unit of the combine harvester.

Table 2. Classification of rice varieties based on shattering habit (2)*

Rank	Shattering habit	Strength of straight tension (gf)
1	Very easy	below 120
2	Easy	120 to 150
3	Medium	150 to 180
4	Difficult	180 to 210
5	Very difficult	210 and over

*Under testing with TR-II.

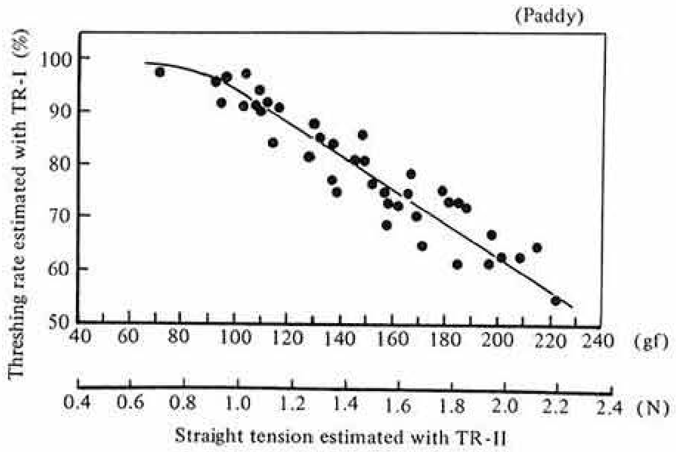

Fig. 6. Relationship between threshing rate with TR-I and straight tension with TR-II

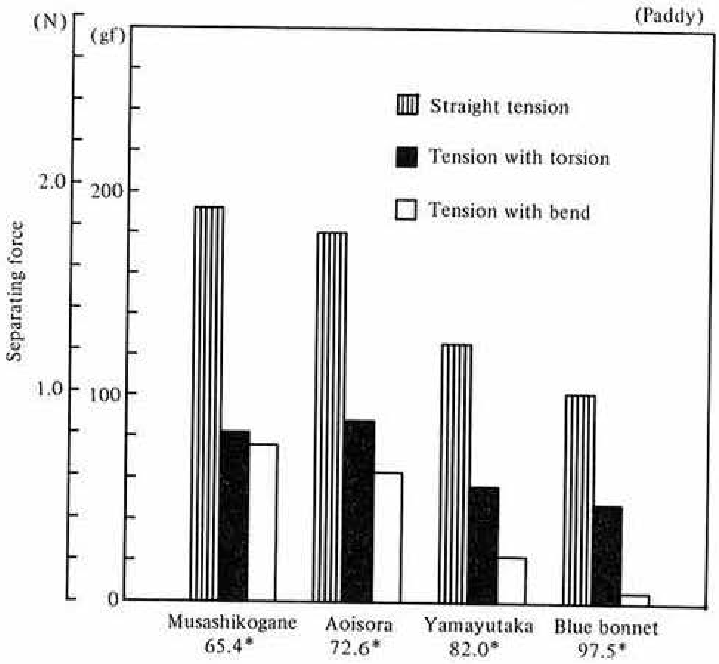

Fig. 7. Three types of separating forces in paddy
*Threshing rate under testing with TR-I.

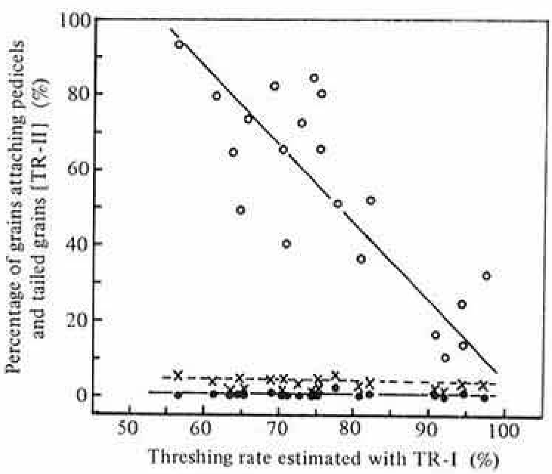

Fig. 8. Relationship between threshing rate with TR-I and percentage of grains attaching pedicels and tailed grains with TR-II

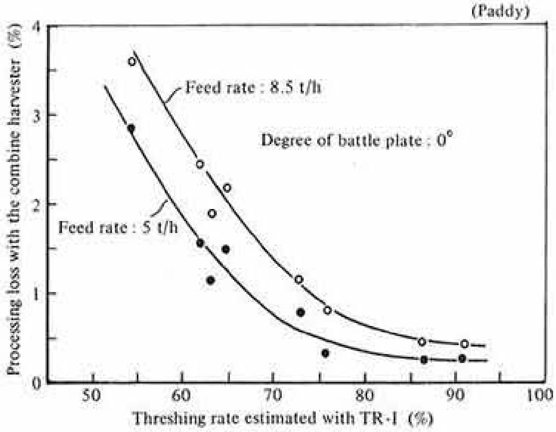

Fig. 9. Relationship between threshing rate with TR-I and processing loss with the combine harvester developed by IAM-BRAIN

Relation between shattering habit of paddy and processing losses of a combine harvester

Relationships between shattering habit and processing losses of a combine harvester were investigated[3]. The present study finds that the processing losses are highly correlated with the threshing rates and straight tension which are both measured with the use of the above two testing devices. An example of the relationship between the threshing rate with TR-I and the processing losses with a combine harvester in the same variety is presented in Fig. 9. This example clearly demonstrates that the processing losses with a combine harvester are affected by the stiffness of shattering or the grade of threshing rate.

In conclusion, even without field tests, processing losses of any rice varieties can be readily predicted from Fig. 9, only if data on their threshing rates obtained with TR-I are available. The same type of prediction is also possible on the basis of data with TR-II, since they are closely associated with threshing rates with TR-I.

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