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Differences among Major Rice Cultivars in Tensile Strength and Shattering of Grains during Ripening and Field Loss of Grains[1)]

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벼알의 引張強度 및 脫粒性의 登熟中 變化와 品種間 差異 및 圃場損失과의 關係[1)]

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ABSTRACT

Degree of grain shattering which is of varietal character is an important determinant for the magnitude of field loss of grains during harvest and threshing. Seven Indica x Japonica progeny varieties and four Japonica varieties were subjected to measurements of tensile strength of grains, degree of grain shattering when panicles were dropped at 1.5m above concrete floor, and moisture content of grains (wet basis) during a period 35 to 63 days after heading. In addition, two varieties were tested for the relation of tensile strength of grains to the magnitude of field loss of grains in actual binder harvest.

The 11 varieties differed conspicuously in tensile strength of grains and the degree of grain shattering: the weakest average tensile strength of grains of a variety was about 90g and the strongest about 250g with varying standard deviation of 30 to 60g. Three Indica x Japonica varieties and one Japonica variety shattered 1 to 30% of the grains under the falling test. The threshold tensile strength of grains allowing grain shattering was estimated to be 180g on average for a sampling unit of 10 panicles, but only the grains having tensile strength weaker than 98g within the samples shattered. A decrease in average tensile strength by 10g below the threshold value corresponded to an increase of 3 to 5% in grain shattering. Most varieties did not change appreciably the tensile strength of grains and degree of grain shattering with delay in time of harvest and showed a negative correlation between the tensile strength and the moisture content of grains.

The average tensile strength of grains was negatively correlated linearly with field loss in binder harvest. The average tensile strength for zero field loss in binder harvest was estimated to be 174g and a decrease in the average tensile strength by 10g corresponded to an increase of 40kg per hectare in field loss of grains.

Instead of the average tensile strength of grains, the percentage of grains having tensile strength weaker than 100g is recommended as a criterion for the estimation of field loss of grains during harvesting operations as well as a basis of variety classification for grain shattering, since the standard deviation of tensile strength of grains varies much with variety and time of harvest, and individual grains having tensile strength stronger than 98 did not shatter practically.

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INTRODUCTION

Minimizing field loss of grains during harvest is very important to increase the final yield of rice crop. Total losses under conventional harvesting condition of a Japonica variety was reported to be about 55kg/ha (*ca.* 1% of the total rice yield)[3] However, the importance of postproduction handling of rice increases with new high yielding varieties. Chung[3] observed that the field loss of grains during harvest was about 180 to 300kg/ha (3 to 5%) in recent, easily shattering Indica x Japonica progeny variety of Korea depending on harvesting system. Field loss of grains and lowered quality of milled rice often result mainly from delay in time of harvest. However, field loss of grains occurs substantially even in harvest on time. In such a case degree of grain shattering which is characteristic to variety seems to be a predominant factor for the magnitude of field loss.

Rice varieties differ in tensile strength of grains and degree of grain shattering at maturity. In general, tropic Indica varieties shatter grains easily, but Japonica varieties do not. Recently Zee and Chu[8] examined the morphology of the abscission layer of 4 Indica varieties and found that varieties with relatively larger parenchymatous cells in the abscission layer and a thinner sclerenchymatous tissue bordering the abscission layer and the central vascular bundle of the pedicel were essentially more fragile. Character of easy shattering in some of the recent Indica x Japonica varieties of Korea stemmed from their Indica parents. Korean breeders have been improving varieties for less shattering. However, the Indica x Japonica varieties occupy approximately 50% of the rice acreage and easy shattering habit of them is still a major constraint in minimizing field loss in harvest on time with binder or sickle. Moreover, the degree of grain shattering may differ by the degree of crop maturity and is known to be influenced by climatic conditions.[1] Yet only limited studies have been reported on this subject.

The purpose of this study was 1) to clarify the tensile strength and degree of shattering of grains of 11 major rice varieties of Korea which differ apparantly in degree of grain shattering, 2) to find out the highest value of tensile strength which allows grains to begin shattering in the falling method of shattering measurement, 3) to evaluate the effect of time of harvest on the degree of grain shattering, and 4) to interrelate the tensile strength of grains, the degree of grain shattering in the falling method, the field loss in binder harvest, and the moisture content of grains one another.

MATERIALS AND METHODS

Among the recommended varieties and important source materials in breeding 11 rice varieties were chosen for this study. They differed apparantly in the degree of grain shattering at maturity. Seven varieties were of Indica x Japonica progeny and 4 were of Japonica. They were cultured with ordinary method in Suweon in 1981.

Ten hills having 15 to 18 panicles per hill were tagged randomly in a plot for each variety at heading time. Two panicles were sampled out at random from each of tagged hills 5 times at an interval of a week from 35 days after heading (DAH) to 63 DAH. One of the two panicles from each hill was used to measure the tensile strength of grains with a rice shattering tester (Kiya No. 150, Tokyo, Japan). Randomly selected 20 grains on the 4th 5th and 6th primary branches from the top of each panicle were subjected to the measurement of tensile strength. The tensile strength values of 20 grains were averaged to represent the tensile strength of the panicle. The ten hills provided 10 replications for panicles. Pooled standard deviation (S) of tensile strength among grains for all samples at each harvest time and variety was also calculated and the lower limit of the 95% confidence interval was calculated as $X - 1.96S$.

The other panicle was used to count the number of grains detached from and remained on the panicle when it was dropped at 1.5m above ground onto the concrete floor (falling method). The ratio of the number of detached grains to the total number of grains is expressed as the degree of shattering(%).

Thus, 10 replicates were obtained for each time and variety. Moisture content of grains (wet basis) was measured with the grains left after the falling tests by standard oven drying method.

In addition, a supplementary, separate field test was carried out in a farmer's field to relate the average tensile strength of grains to the field loss of grain in binder harvest. Varieties, Milyang 23 (easy shattering) and Seokwang (non-shattering), in a farmer's field at Hwaseong-gun, Kyunggi-Province were selected. Milyang 23 headed on August 18 and Seokwang on August 23. Milyang 23 was harvested 4 times at an interval of a week from 40 DAH (moisture content of grains : 26.5% w.b) to 63 DAH, and Seokwang 3 times from 43 DAH (moisture content of grains : 26.4% w.b.) to 58 DAH. Grain loss in the field in binder harvest, tensile strength of grains and the degree of grain shattering with the falling method were measured. The field test was 3 times replicated, and laboratory tests were 10 times replicated for each field replicate. The binder used was a rice binder-harvester having 38 to 40cm binding circumference and 3 to 4kg of adjustable kicking force (Model KB 602, Kookje Machinaries Co., Pusan, Korea).

RESULTS AND DISCUSSION

Varietal Differences in Tensile Strength and Shattering of Grains:

It was found in our previous study[7] that the minimum size of sampling would be of sampling 10 panicles, one from each hill, at random in a plot and measurement of tensile strength of 20 grains at random per panicle except for the grains at topmost two primary branches for effective and economic control of experimental error in a study on the tensile strength of grains as it is related to grain shattering. The sampling method of the study was based on the previous report. Table 1 shows very conspicuous differences among varieties in the tensile strength of grains and the degree of grain shattering (%) of the panicles when they were dropped at 1.5m above ground onto the concrete floor. Three Indica x Japonica varieties, Milyang 23, Hangangchal, and Suweon 294 shattered grains to approximately 10 to 30%, and one Japonica variety, Iri 348, shattered grains to 1 to 21% with the falling method. The other varieties did not shatter appreciably. The average tensile strength of grains were in a range of 81 to 115g, 107 to 145g, 101 to 120g and 141 to 161g, respectively in the order as varieties listed. The average tensile strength of the other varieties which did not shatter grains also differed each other in a range of 140 to 286g. In general, Indica x Japonica varieties had much weaker tensile strength of grains than the Japonica varieties except for an Indica x Japonica variety, Manseok and a Japonica variety, Iri 348. Among the Indica x Japonica varieties shown shattering more than 1% of grains Keumgang had the highest value of average tensile strength of grains i.e. *ca.* 160g.

Threshold Tensile Strength of Grains for Easy Shattering:

Figure 1 shows the relation of average tensile strength of grains to the degree of grain shattering during ripening in the easily shattering four varieties. The average tensile strength of grains was negatively linearly correlated with the degree of grain shattering. The four varieties differed a little in the degree of mutual dependency of the two parameters, but a 10g increase in the tensile strength was, on the whole, equivalent to 3 to 5% decrease in shattering of grains. Being extrapolated in the regression equations the average tensile strengths giving rise to zero in the degree of shattering were 128, 151, 162, and 181g for Suweon 294, Milyang 23, Hangangchal and Iri 348, respectively. Considering only about 1% shattering of grains in the variety Keumgang in a range of average tensile strength from 140g to 180g, the highest average tensile strength of grains which allows grains to begin shattering with the falling method appears to be about 180g.

Kwon and Shin[7] reported that the tensile strength varied among grains in a panicle, among panicles and with time of harvest and the variance increased somewhat in the late harvest, but the coeffi-

Table 1. Changes in Tensile Strength, Shattering and Moisture Content of Grains during Ripening of 11 Rice Varieties.

A) Indica x Japonica Varieties.

Variety	Time of harvest	Tensile Strength (g)			Degree of[d] shattering(%)	Moisture content (%, w.b.)	Correlation[e] coefficient
		Average	Std. dev.	Lower[c] limit			
Milyang 23	35 DAH[a]	85.8	16.0	54.4	21.9	31.1	
(Aug. 18 headed)	42	81.4	21.8	38.7	31.9	26.4	
	49	86.9	22.3	43.2	27.0	23.4	
	56	114.8	25.9	63.9	21.3	18.4	-0.560**
	63	89.2	27.2	35.9	28.1	18.0	
	F-value[b]	40.30**					
	$LSD_{.05}$	7.95					
Suweon 294	35	120.1	26.4	68.3	3.2	29.7	
(Aug. 13 headed)	42	107.1	32.6	43.2	15.9	26.4	
	49	101.4	28.6	45.3	14.9	25.8	
	56	110.8	29.8	52.4	11.7	17.8	-0.151^{NS}
	63	100.1	22.5	55.2	16.0	20.3	
	F-value	26.63**					
	$LSD_{.05}$	11.53					
Hangangchal	35	116.2	24.2	68.8	13.3	26.2	
(Aug. 20 headed)	42	107.5	23.7	61.0	15.3	22.5	
	49	128.3	31.3	66.9	14.7	23.7	
	56	144.5	33.5	78.8	13.2	16.5	-0.683**
	63						
	F-value	40.30**					
	$LSD_{.05}$	9.08					
Keumgang	35	140.6	26.9	87.9	0.9	29.5	
(Aug. 26 headed)	42	146.8	32.8	82.5	1.0	25.8	
	49	149.6	29.9	91.0	1.0	23.7	
	56	161.7	25.4	111.9	0.9	19.9	-0.736**
	63	179.9	35.1	111.1	0.7	15.5	
	F-value	19.10**					
	$LSD_{.05}$	10.84					
Taeback	35	146.5	31.1	85.5	0	27.6	
(Aug. 11 headed)	42	167.8	30.4	109.2	0	25.9	
	49	182.9	34.4	115.5	0.1	20.6	-0.504**
	56	159.4	28.9	102.7	0.1	20.0	
	63	165.9	37.2	92.9	0.2	16.7	
Iri 347	42	148.4	33.0	83.7	0	27.2	
(Aug. 4 headed)	49	146.1	26.0	95.1	0	26.0	
	56	169.9	25.8	119.3	0	23.1	-0.460**
	63	150.4	18.6	113.9	0	22.1	
	F-value	24.05**					
	$LSD_{.05}$	9.65					
Manseok	35	234.3	36.4	162.9	0	26.3	
(Aug. 10 headed)	42	263.8	59.2	147.7	0	24.5	
	49	242.8	18.8	205.9	0	22.8	
	56	264.1	26.5	212.2	0	21.4	-0.501**
	63	286.3	62.4	164.0	0	19.1	
	F-value	24.55**					
	$LSD_{.05}$	11.66					

B) Japonica varieties.

Variety	Time of harvest	Tensile Strength (g) Average	Std. dev.	Lower[c] limit	Degree of[d] shattering(%)	Moisture content (%, w.b.)	Correlation[e] coefficient
Iri 348	35 DAH[a]	193.1	40.2	114.3	0.5	28.1	
(Aug. 26 headed)	42	161.4	53.8	55.9	7.6	24.5	
	49	144.5	33.9	78.0	8.3	23.4	
	56	141.0	27.5	87.1	20.4	17.7	0.295*
	63	144.8	24.2	97.4	21.0	16.2	
	F-value[b]	45.39**					
	$LSD_{.05}$	12.09					
Jinheung	35	274.6	31.8	212.3	0	27.5	
(Aug. 21 headed)	42	251.2	36.0	180.6	0	26.1	
	49	237.4	36.4	166.0	0	23.7	
	56	233.8	28.2	178.5	0	24.2	0.251[NS.]
	63	251.4	32.1	188.5	0	20.0	
	F-value	48.03**					
	$LSD_{.05}$	9.24					
Akibare	35	242.2	26.4	190.5	0	28.5	
(Aug. 27 headed)	42	221.2	37.6	147.5	0	21.3	
	49	216.4	33.9	150.0	0	25.7	
	56	261.3	37.4	187.9	0	20.5	-0.523**
	63	271.9	37.9	197.6	0	16.4	
	F-value	54.99**					
	$LSD_{.05}$	9.73					
Nackdong	35	232.0	39.7	154.2	0	30.5	
(Aug. 22 headed)	42	222.2	40.8	142.2	0	28.5	
	49	194.4	30.5	134.6	0	25.0	
	56	171.7	24.8	122.8	0	22.9	0.672**
	63	181.9	31.4	120.4	0	17.6	
	F-value	67.42**					
	$LSD_{.05}$	9.37					

a) DAH refers to days after heading.
b) F-value is from ANOVA where the times of harvest were treatments and 10 panicles were replicates in RB design.
c) Lower limit refers the value obtained from X-1.96S.
d) Degree of shattering refers the percentage of detached grains to the total number of grains when panicles were deopped at 1.5m above concrete floor.
e) Correlation coefficient was obtained for the relationship between the average tensile strength of grains and the moisture content of grains.

cient of variation was not changed significantly with time of harvest. Table 1 shows standard deviation of the tensile strength of grains for each time of harvest of all varieties tested. The standard deviation ranges from 16.0g to 62.4g. On the whole, Japonica varieties and a non-shattering Indica x Japonica variety Manseij shows greater deviation than the other varieties.

Table 1 also shows the lower limit of tensile strength with 95% confidence for each time of harvest and variety. Which was calculated as X−1.96S where S was the pooled standard deviation of tensile strength among grains for all samples. For a panicle it may be expected in general that the grains with weaker tensile strength are likely shattered firstly. The varieties shown shattering of grains under falling test had the lower limit of tensile strength in a range of 35.9 to 115.5g, and smaller the lower limit of tensile strength greater the degree of shattering on the

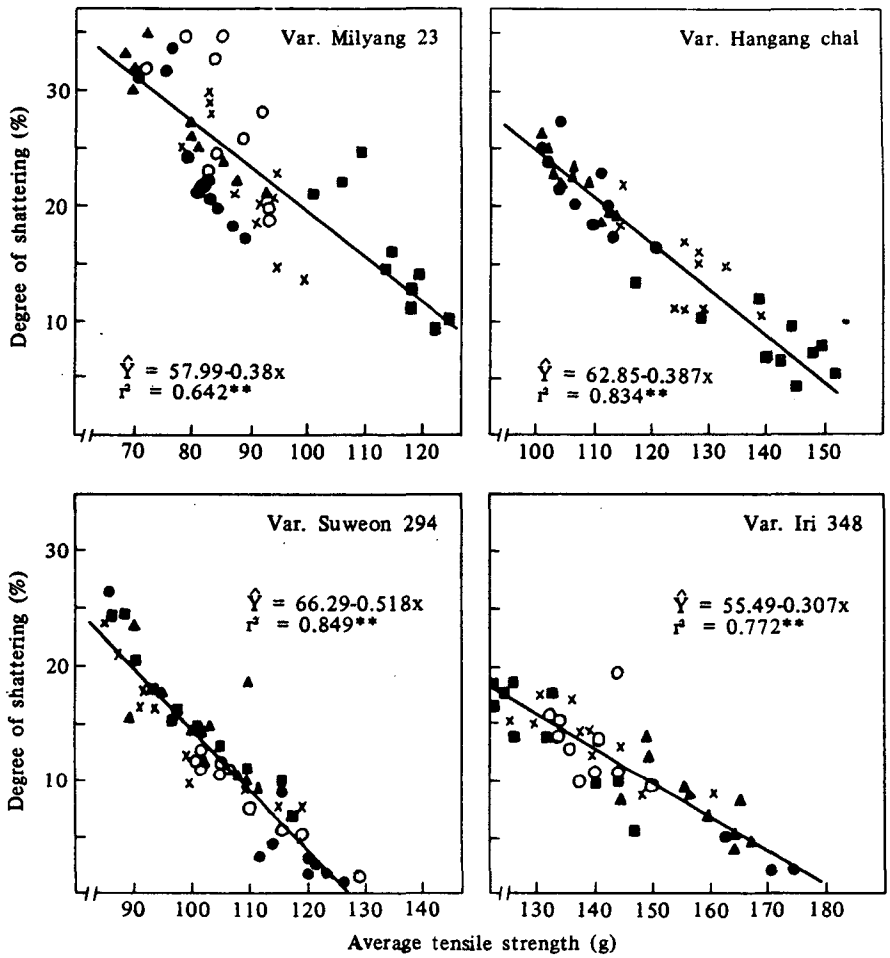

Fig. 1. Relationship between average tensile strength of grains and the degree of grain shattering. Data were evaluated with 4 shattering varieties. Different symbols are used for different time of harvest (●: 35DAH, ▲: 42 DAH, x: 49 DAH, ■:56DAH, o: 63 DAH).

whole. Figure 2 shows the relationship between the lower limit in tensile strength variation of one sampling unit and the degree of grain shattering for the unit. The degree of grain shattering is correlated negatively linearly with the lower limit of tensile strength of grains. The slope factor is about same as that obtained for the relation of average tensile strength of grains to the degree of shattering. The extrapolated value of the lower limit in tensile strength variation having no shattering of grains is 98g. This suggests that any sample of panicles having grains with tensile strength greater than 98g and average tensile strength of grains being greater than 180g will not shatter any grains.

Effect of Time of Harvest on Grain Shattering: Change in the degree of grain shattering with crop maturity is very important for decision of optimum time of harvest and less field loss of grains. Table 1 shows the effect of time of harvest during grain ripening from 35 DAH to 63 DAH on the tensile strength of grains and the degree of grain shattering for the 11 varieties. Three varieties, Hanhangchal, Keumgang and Akibare, tended to increase a little the tensile strength of grains with delay in time of harvest, while varieties Nackdong and Iri 348 showed a reversed

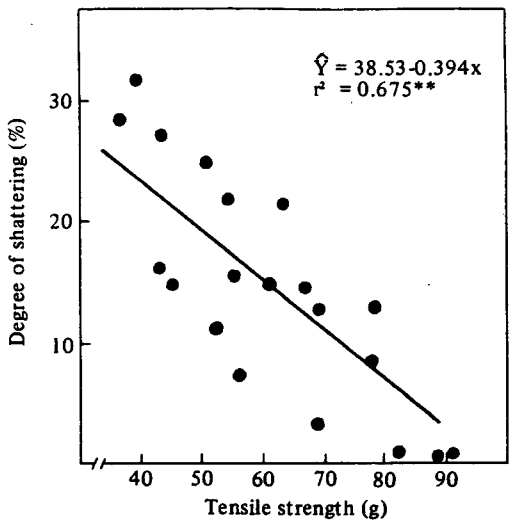

Fig. 2. Relation of the lower limit value of tensile strength of grains for a sample unit to the degree of grain shattering. The lower limit values were calculated as x-1.96S where S was the pooled variance of each sampling unit.

tendency. The other 6 varieties showed no difinite relationship between the time of harvest and the average tensile strength of grains. The degree of grain shattering was not related to the time of harvest in the easily shattering varieties, Milyang 23, Suweon 294 and Hangangchal. However, the degree of shattering increased a little in the late harvest in the easily shattering Japonica variety, Iri 348, regardless of the values of the average and minimal tensile strength of grains. Some unknown factor might have influenced on the degree of shattering in the late harvests of Iri 348. Ito *et al* (1968)[5] observed with Japonica varieties that the average tensile of grains did not change with time of harvest in the varieties having the tensile strength greater than 190g, decreased slightly with delay in time of harvest in the varieties having the average tensile strength 120 to 190g and decreased sharply in the varieties having the average tensile strength smaller than 120g. Our results are not in agreement with Ito *et al's* observation.

Agronomists tend to believe in increased shattering with delay in time of harvest. However, no evidence has been supporting the idea. The present data indicate the change in the degree of grain shattering with time of harvest depends pretty much on the characteristic of a variety and that more number of varieties are rather not much influenced by the time of harvest within a probable time limit of delay in harvest.

Relation of Grain Moisture Content to Shattering of Grains:

Kwon and Shin[6] observed the physiological maturity of on early Indica x Japonica variety Suweon 264 to be 30 days after flowering, a medium Indica x Japonica variety Milyang 23 to be 35 days after heading and a medium Japonica variety Jinheung to be 38 days after heading and the varieties had the same grain moisture content of 28% at physiological maturity. In a study on the optimum time of harvest they found that the best time of harvest for maximum yield and good grain quality was to be about 10 days after physiological maturity and the grain moisture content at this time was about 20% on wet basis. In the present study the physiological maturity of the test varieties was not determined, but the varieties were harvested from the time 35 days after heading and grain moisture content at about 28%. Table 1 shows the change in the grain moisture content during ripening and the coefficient of correlation between the tensile strength of grains and the moisture content of grains during ripening from 35 to 63 days after heading. The tensile strength of grains was well correlated negatively with the moisture content of grains except for three varieties Suweon 294, Iri 348 and Jinheung. In our another study(7) the variety Jinheung showed a negative correlation between the tensile strength of grains and grain moisture content. Addicott and Lyons[1] reported that the nutritional condition of the field affects the abscission in deciduous tree. The case of Jinheung may reflect a possible field variation. However, the reason is not clear and more documentation of variations may be worthy of.

Relation of Tensile Strength of Grains to Field Loss in Binder Harvest:

In the field test of grain loss in binder harvest Milyang 23 showed a field loss of approximately 200kg of grains per hectare and Seokwang approximately 90kg per hectare. Figure 3 shows the highly significant positive correlation between the field loss in binder harvest and the average tensile strength of grains as measured with shattering tester for the sampled panicles from the field under binder test of field loss. The variety Milyang 23 is representative of easily shattering variety and the variety Seokwang is representative of moderately less shattering variety. In obtaining the regression equation the two data from October 21 harvest in the Figure 3 were excluded, since these were from unusually late harvest. The too late harvest on October 21 was tried to check the effect of frost on the field loss of grains. However, we could not determine well the effect of frost in the present study. Extrapolation of the average tensile strength of grains for the zero field loss of grains in binder harvest gives us 174g, which is very close to the value 180g we obtained for zero shattering with 11 varieties under falling test. And, the decrease in the average tensile strength by 10g appears to increase in the field loss of grains approximately 40 kg per hectare.

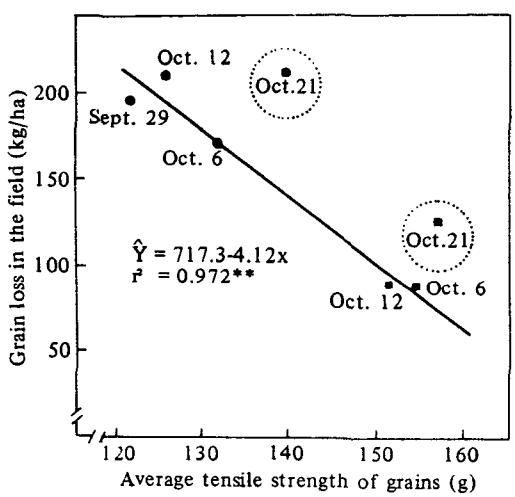

Fig. 3. Relationship between the average strength required to detach rice grains from their pedicel and the field grain loss in harvest with binder. Dates are the time of harvest. (●: Var. Milyang #23, ■: Var. Seokwang) Data with dotted circle represent abnormally too late harvest and are excluded in the regression line.

Classification of Varieties for Degree of Grain Shattering:

Plant breeders often tend to classify varieties for the character of grain shattering into 6 groups such as extremely easy, easy, moderately easy, moderate, moderately difficult, and difficult one without any reasonable, scientific basis of classification, but being based much on certain experiences.[2] Ito *et al* (1968)[5] tested tensile strength of grains for 48 Japonica varieties and found the average tensile strength of grains to be in the range of 76 to 116g in the so called extremely easily shattering varieties, 88 to 175g in the easily shattering varieties, 88 to 152g in the moderately easily shattering varieties, 150 to 215g in moderately shattering varieties, 155 to 210g in the moderately difficult varieties, and 160 to 236g in the difficult varieties. They concluded that the conventional grouping needs reevaluation. Chikai and Nishitani (1976)[2] also pointed out no clear bearing of the prevailing classification to the grain shattering in the harvest-threshing processes. They tested the average tensile strength of grains of 60g. They estimated the tensile strength of the grains shattered easily in binder operation to be 50g and the tensile strength of the grains shattered easily during carriage to the threshing place after binder operation to be 80g. And, they proposed an average tensile strength of a variety, 170g (50g + 2 x standard deviation 60g) as a criterion for easy shattering and 200g (80g +2 x standard deviation 60g) as an average tensile strength of a variety not giving shattering problem in harvesting operation. We obtained a threshold average tensile strength of grains giving rise to no shattering for varieties under the falling test as 180g and that in the field with binder harvest as 174g. The two values did not differ significantly considering the big variation in the tesile strength of grains usually greater than 30g at least. Also, the values are very close to the value of 170g which was proposed recently by Chikai and Nishitani[2] as a

threshold average tensile strength of grains not to shatter in binder harvest. Chikai and Nishitani used standard deviation value of 60g and two times of the standard deviation to have an upper limit of tensile strength variation covering 95% of variances. However, the present study shows clearly that the standard deviation of tensile strength of grains varies much with variety and time of harvest. The standard deviation of the easily shattering varieties tended to be smaller than that of the non-shattering varieties. Moreover, the determinant of the degree of shattering for any sample seems to be the proportion of the grains having tensile strength weaker than 98g, but not to be the average value. The proportion will depend not only on the average tensile strength of grains, but also on the size of the standard deviation. So, we think of that measuring tensile strength of grains and counting the proportion of grains having tensile strength weaker than 98g will reflect better the characteristic of a variety for the degree of grain shattering in harvest operation in the field, and that this must be used as a basis for classification of varieties for degree of grain shattering.

摘　　要

主要 水稻品種들의 脫粒性 程度와 穀粒의 引張強度와 脫粒性 및 收穫作業時 圃場損失과의 關係를 밝히므로서 脫粒性에 관한 品種改良 및 圃場損失의 最少化에 도움을 주고자 本 硏究를 遂行하였다. 11個 品種을 供試했으며 出穗 後 35日부터 63日까지의 期間에 1週日 간격으로 品種 및 收穫期 別로 任意 抽出한 10이삭 200粒씩에 대해 穀粒의 引張強度, 脫粒程度 및 水分含量을 測定했으며, 脫粒程度는 이삭을 收穫直後 1.5m 地上에서 콘크리트바닥에 落下시켰을 때 脫粒되는 穀粒數의 全穀粒數에 대한 比率이었다. 또한 圃場損失과 穀粒의 引張強度와의 關係는 農家圃場에서 2品種을 選定하여 出穗 後 40日부터 1週日 간격으로 3~4回 binder harvester를 實際 使用하여 圃場에 脫粒된 量을 測定하고 이를 같은 材料에 대해 測定한 穀粒의 引張強度와 關係를 지었으며 3反復하였다. 그 主要結果는 다음과 같이 要約된다.

1. 供試品種들의 平均 穀粒引張強度는 90g (密陽23號) 程度부터 250g (振興) 程度까지의 範圍에서 品種 및 收穫期에 따라 差異가 있었으며, 그 標準偏差는 30~60g 程度이었는데 穀粒의 平均 引張強度가 큰 品種일수록 偏差가 컸다.

2. 落下檢定에 의한 穀粒의 脫粒程度는 密陽23號 20~30%, 水原294號 3~16%, 한강찰 13~15%, 裡里348號 1~21%, 錦江 및 太白 1% 程度로서 收穫期에 따라 多少間 差異를 보였다.

3. 落下檢定에서 脫粒하기 始作하는 平均 引張強度는 180g이었고, 供試이삭들의 穀粒들 중 引張強度가 98g 以上인 것들은 脫粒하지 않았으며 引張強度가 10g 低下하면 脫粒率은 3~5% 增加했다.

4. 洛東벼와 裡里348號는 收穫期가 늦어지면 穀粒의 引張強度가 작아지었지만 그밖의 品種들에서는 反對로 引張強度가 多少間 커지거나 별로 變化하지 않았으며, 脫粒率도 裡理348號를 除外하면 收穫期의 影響을 크게 받지 않았고, 穀粒의 引張強度는 水分含量과 대체로 逆相關關係를 보였다.

5. 穀粒의 平均 引張強度와 binder 收穫時의 圃場損失量과는 負의 相關이 있었으며, binder 收穫時 圃場損失이 일어나지 않게 되는 限界 平均引張強度는 174g이었으며 그 以下에서 平均引張強度가 10g 低下되면 圃場損失은 ha當 40kg 程度 增加하였다.

6. 現在 品種들의 脫粒性 分類基準으로 使用되고 있는 平均引張強度는 그 分散이 變異가 크고, 環境의 影響을 많이 받으며 이삭의 穀粒들 중 收穫作業時 實際로 脫粒이 잘 되는 穀粒은 引張強度가 98g 以下이었으므로 品種의 脫粒性 判定 및 圃場損失의 推定을 위해서는 標本中 引張強度가 100g 以下인 穀粒들의 全穀粒數에 대한 比率을 基準으로 할 것을 提意한다.

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