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R. H. Dilday
USDA-ARS-SPA

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INFLUENCE OF THRESHER CYLINDER SPEED AND GRAIN MOISTURE AT HARVEST ON MILLING YIELD OF RICE

R.H. DILDAY
USDA-ARS-SPA
Stuttgart, AR 72160

ABSTRACT

The percentage of broken rice (*Oryza sativa*) kernels was determined after threshing the grain at varying cylinder speeds of the thresher and moisture contents of the grain at harvest. Moisture contents of the individual grain samples ranged from 12 to 26% and the two cylinder speeds were 600 and 1000 RPM. Significant differences between germplasm, cylinder speed and moisture content of the grain at harvest on milling yield was observed. For example, Newbonnet had the fewest broken kernels while Leah had the greatest amount of broken kernels. Lemont produced the highest total milling yield; whereas, L202 produced the lowest total milling yield. Newbonnet produced the highest and Leah produced the lowest head rice yield. Percentage of broken kernels approximately doubled when the cylinder speed was increased from 600 to 1000 RPM. Generally there was a significant increase in the percentage of broken kernels as the moisture content of the grain at harvest decreased.

INTRODUCTION

Milling yield, as defined in the United States standards for rough rice (*Oryza sativa*) and milled rice (Smith, 1972) is based on the quantity of whole kernels (head rice) and total milled rice (whole and broken kernels combined) that is produced in the milling of rough rice to a well-milled degree. The market value of rough rice is based mainly upon its milling quality or milling yield. Whole kernels (fancy), broken kernels, and total milled rice are usually expressed as a percentage of rough rice that is subjected to USDA milling procedures (Anonymous, 1982, 1983).

The effects of moisture content of the grain at harvest on milling quality of rice are well documented. In the 1930's, Smith *et al.* (1938) showed that rice harvested between 23 to 28% moisture content resulted in maximum grain yields and the highest percentage of head rice yields after drying and milling. Long-grain, 'Edith'; medium grain, 'Early Blue Rose' and 'Supreme Blue Rose'; and short-grain, 'Caloro', cultivars were evaluated in this study at a time when rice was harvested with a binder, placed in shocks for curing, and then threshed. In the 1940's and 1950's McNeal (1950) showed that the highest milling quality, after drying, occurred when the grain was threshed between 16 to 24% moisture content. Four cultivars (Zenith, Rexark, Nira, and Prelude) were evaluated and a small variation between the cultivars for optimum moisture content of the grain at harvest was noted. These data are among the earliest indications of differences in milling quality due to germplasm.

In the 1960's Kester *et al.* (1963) showed that the highest head rice yield, after drying, of 'Calrose', a medium-grain cultivar, and Caloro was obtained at moisture contents between 25 to 32% at harvest. Morse *et al.* (1967) showed that the maximum head rice yields of Caloro was obtained when the grain was between 28 to 30% moisture content at harvest. In the 1970's Calderwood *et al.* (1980) evaluated two long-grain (Lebonnet and Labelle) and two medium-grain (Brazos and Nato) cultivars and found that the percentage of total milled rice increased with delays in harvest date, but the percentage of head rice reached a maximum at an intermediate harvest date, then declined rapidly with delays in harvesting. The authors concluded that both Brazos and Lebonnet required a higher moisture content at harvest than did Labelle and Nato to maintain the same head rice yield. Conclusions were not drawn about the range in moisture content that would give maximum head rice yield because of the variation between cultivars. However, these data do indicate that a rapid decline in head rice yield occurs after the grain of Lebonnet and Brazos reaches about 17% moisture content and after Labelle and Nato reach 14% moisture content of the grain.

Obviously, grain moisture content at harvest has an influence on head

rice yield. However, a minimum amount of data are available on factors other than grain moisture at harvest which influence milling yield. Objectives of this research were to: 1) determine the influence of cylinder speed of the thresher on milling yield; 2) determine the influence of moisture content of the grain at harvest versus cylinder speed of the thresher and; 3) determine the influence of germplasm, if any, on milling quality in rice.

MATERIALS AND METHODS

Four experiments were conducted during a two-year period. Field trials with 11 cultivars were conducted in 1985 and 1986 at the Rice Research and Extension Center, Stuttgart, Arkansas, on a Crowley silt loam soil which is a fine montmorillonitic, thermic Typic Albaqualf. The experimental design for each test was a randomized block design with four replications. The tests were drill seeded in plots, 14 rows by 4.57 m, with a 0.191 m row spacing on May 2, 1985 and April 23, 1986. The seedlings emerged on May 11, 1985 and May 4, 1986, respectively. Plots of the 11 cultivars were harvested each year at 10 harvest dates. Harvesting started at a moisture content of approximately 25% and the harvest continued for twice a week for five weeks. The number of days after heading was noted for each harvest sample.

A single row 3.66 m long was hand-harvested from the center 10 rows of each plot generally between the hours of 1100 and 1400 when the kernels were free of dew and surface moisture. The outer two rows on each side of each plot were not harvested. The amount of rice harvested from the 3.66 m row generally was within the range of 450-750 g. A vogel thresher was used to separate kernels from straw. Each cultivar was threshed at a cylinder speed of 600 and 1000 RPM at each harvest date. The samples were passed through a screen to remove the larger leaves and stems. Samples were weighed in the laboratory and the moisture content was determined with a DICKEY-john Model Gac II grain analysis moisture meter. The samples were immediately placed in a zipper-top plastic bag and taken to Riceland Cooperative, Stuttgart, Arkansas the following day for analysis. Determinations of milling yield were carried out in accordance with the standard procedure of rice graders (Anonymous, 1982, 1983; Smith, 1972), except that an amount smaller (162 g) than 1,000 grams was processed.

Grain yield, head rice yield, total milled rice, and percentage of broken kernels for each variety was analyzed using the General Linear Models procedure. The LSD procedure was used for mean separation.

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RESULTS AND DISCUSSION

Harvest Moisture

Moisture content, milling quality, and cylinder speed for rice samples harvested in 1985 and 1986 are shown in Tables 1, 2, and 3. An F-test did not show significant differences between years for total milling yield, head rice yield, or percentage of broken kernels. However, there was a significant difference between cultivars, moisture content of the grain at harvest within years, and cylinder speed in the combined analysis for total milling yield, head rice yield, and percentage broken kernels. Also, there was a significant interaction affect of cultivar X moisture content for head rice yield and percentage of broken kernels. Each of these characteristics is discussed in the following sub-sections.

Grain moisture content tended to decrease with time in both 1985 and 1986. However, the moisture content of the grain at certain later harvest periods was higher than at earlier harvest periods (e.g. harvest period 5 versus harvest period 4 for Tebonnet, see Table 1). A possible explanation could be the rewetting of the grain from an extremely heavy dew or rain. Also, moisture content of the grain at harvest had an influence on the amount of broken kernels that were present after threshing at high and low cylinder speeds (Table 2). When the means from all cultivars were compared there was generally a significant inverse relationship between moisture content of the grain and percentage of broken kernels (Table 2). Also, there were significant differences between and among cultivars for percentage of broken kernels versus moisture content of the grain at harvest. Furthermore, there was a significant in-

Table 1. Change in Grain Moisture Content Over Time in 1985 and 1986 for a Long-Grain (Tebonnet), Medium-Grain (Mars) and Short-Grain (Nortai) Cultivar.

Time of Harvest ^a	Cultivars					
	Tebonnet		Mars		Nortai	
	1985	1986	1985	1986	1985	1986
1	24.1	25.9	25.0	26.4	23.8	25.8
2	20.9	23.6	22.9	24.8	22.0	25.3
3	18.6	19.2	23.9	22.5	21.1	24.3
4	17.3	18.4	19.5	22.5	18.2	23.4
5	18.5	18.4	17.4	21.5	19.4	22.4
6	14.6	17.2	16.3	22.2	15.3	21.8
7	13.8	19.9	13.9	18.1	17.8	23.4
8	13.1	14.2	13.1	16.3	13.6	19.8
9	12.5	14.7	14.5	16.3	12.8	17.3
10	12.5	13.5	12.1	15.8	12.5	17.7

^a * 2 per week beginning at about 25% moisture

Table 2. Percentage of Broken Kernels of Rice at Two Cylinder Speeds and a 2% Increment of Grain Moisture Contents at Harvest.

Variety	Cylinder Speed-600 RPM					Cylinder Speed-1000 RPM				
	-----Grain Moisture %-----					-----Grain Moisture %-----				
	14-16	16-18	18-20	20-22	>22	14-16	16-18	18-20	20-22	>22
	% Broken Kernels									
	Means									
Bond	18 ^a	14	16	11	9	29	24	26	20	20
Leah	27	28	24	20	12	37	32	35	26	24
Lebonnet	23	18	17	12	13	35	23	24	22	22
Lemont	19	16	16	12	13	30	24	23	19	21
L202	8	7	7	8	8	19	18	15	16	18
Mars	15	14	10	8	7	27	22	16	13	13
Newbonnet	5	6	6	5	6	11	11	10	10	11
Newrex	15	12	14	11	14	23	19	19	20	20
Nortai	-	7	10	9	7	12	15	13	11	12
Starbonnet	6	5	6	6	6	13	10	11	12	11
Tebonnet	13	11	11	10	11	25	21	19	22	20
Means**	16 ^a	12 ^b	12 ^b	10 ^c	10 ^c	25 ^a	19 ^b	19 ^b	17 ^c	17 ^c

+ LSD = 5.9 Within variety X cylinder speed X grain moisture
 ++ LSD = 1.8 Within grain moisture X cylinder speed
 +++ LSD = 2.5 Within variety X cylinder speed

Table 3. Influence of Cylinder Speed on Milling Quality of Rice.

Cultivar	Broken		Head Rice		RPM	Total		Moisture	
	600	1000	600	1000		600	1000	600	1000
	Tebonnet	12.4	22.0	55.8		48.2	68.2	70.2	18.4
Newbonnet	5.7	11.0	60.5	57.5	66.2	68.5	19.9	20.5	
Bond	16.7	25.4	49.9	42.7	66.6	68.2	16.7	17.4	
Starbonnet	5.9	12.0	60.2	54.2	66.2	66.2	19.0	19.5	
Mars	10.1	16.8	57.0	50.7	67.1	67.5	20.3	21.0	
Nortai	7.8	11.8	60.5	56.9	68.3	68.8	22.3	22.6	
Lemont	15.2	23.8	54.3	46.8	69.5	70.6	19.6	20.2	
Lebonnet	17.5	26.3	49.1	43.1	66.7	69.4	18.5	19.4	
Newrex	13.4	20.4	52.1	44.1	65.6	64.5	17.3	17.9	
L202	8.0	16.8	55.4	49.5	63.3	66.2	19.4	20.0	
Leah	22.6	30.6	44.8	37.6	67.3	68.2	18.8	19.4	
Grand Mean +	12.6 ^a	19.8 ^b	54.4 ^a	48.3 ^b	67.0 ^a	68.2 ^b	19.1 ^a	19.7 ^b	
LSD ++	1.0		1.9		0.9		0.4		

+ Means followed by different letters indicate differences between cylinder speeds for the respective characteristics based on the F-test.

++ LSD for comparing differences between cylinder speed and between varieties.

crease in the moisture content of the grain as the cylinder speed increased (Table 3). This was possibly due to the nature in which grain drying occurs. The moisture in the grain moves from the kernel to the hull and then to the atmosphere in the normal drying process. An increase in the amount of hulling of the grain occurs when the cylinder speed increases from 600 to 1000 RPM. Consequently, there are more hulled-moist kernels present at the 1000 RPM cylinder speed which results in an increased moisture reading.

Milling Yield and Cylinder Speed

Delayed harvesting, which resulted in lower moisture content, and cylinder speed were associated with a wide variation in the head rice yield and broken kernels (Tables 2-3). There was a significant increase in head rice yield, moisture content of the grain, total milling yield, and percentage of broken kernels as the cylinder speed increased from 600 to 1000 RPM. For example, the percentage of broken kernels approximately doubled in Bond (9-18%), Leah (12-27%), Lebonnet (12-23%), and Mars (7-15%) at a cylinder speed of 600 RPM when the moisture content of the grain at harvest changed from below 16% to 22% or greater. There was essentially no change in the percentage of broken kernels in L202 (7-8%), Newbonnet (5-6%), Starbonnet (5-6%), Newrex (11-15%), Nortai (7-10%), and Tebonnet (10-13%) at a cylinder speed of 600 RPM as the moisture content of the grain changed from below 16% to 22% or greater (Table 2). Also, when all factors were held constant except cylinder speed the percentage of broken kernels approximately doubled when the cylinder speed was increased from 600

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to 1000 RPM. This is probably due to the grain hitting the cylinder and cylinder walls at a higher force which results in more broken kernels at higher RPM. Consequently, head rice yields decreased about 6-7 percent as cylinder speed was raised from 600 to 1000 RPM. Total milling yield increased about 1-2 percent for all cultivars except Starbonnet and Newrex. A decrease in foreign matter is one explanation for an increase in total milling yield; or explained another way, a sample with less foreign matter will result in an apparent higher total milling yield. Consequently, a higher cylinder speed will result in better removal of foreign matter and total milling yield will appear greater.

Germplasm

There were significant differences between the cultivars for total milling yield, head rice yield, and percentage of broken kernels. For example, Newbonnet had the fewest broken kernels at both cylinder speeds, 5.7 and 11.0%, respectively; while Leah had the greatest amount of broken kernels at both 600 and 1000 RPM, 22.6 and 30.6%, respectively. Lemont produced the greatest total milling yield at both 600 and 1000 RPM, 69.5 and 70.6%, respectively; whereas, L202 produced the lowest total milling yield at 600 RPM (63.3%) and Newrex produced the lowest at 1000 RPM (64.5%). Newbonnet produced the highest and Leah produced the lowest head rice yield at both 600 and 1000 RPM, 60.5 and 57.5% and 44.8 and 37.6%, respectively (Table 3). These data indicate that advancements can be made within the existing rice germplasm for improvements in milling quality either through genetic manipulation or selection.

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