Bot. Bull. Academia Sinica 22: 35-47 (1981)

INHERITANCE OF AMYLOSE CONTENT AND GEL CONSISTENCY IN RICE

WANG-LAI CHANG and WAN-YING LI

Chiayi Agricultural Experiment Station, Taiwan Agricultural Research Institute, Chiayi, Taiwan 600, Republic of China

(Received August 12, 1980; Accepted December 4, 1980)

Abstract

The inheritance of amylose content and gel consistency in locally developed *Indica* rices was investigated with F_1, F_2, F_3, BCF_1 and BCF_2 populations from the crosses between high and low amylose or hard and soft gel consistency parents. The results indicated that the high amylose content of Tainung-sen 12 and Chianung-sen-yu 19 was each controlled by a single incompletely dominant gene, while the hard gel consistency of Chianung-sen-yu 19 was conditioned by a single dominant gene. A two-way classification for the amylose content and gel consistency in the F_2 populations indicated that there was a close association between the two quality characters. The amylose content was negatively and highly significantly correlated with gel length which favors the breeding for an acceptable eating or processing quality of rice in Taiwan.

Introduction

Eating quality of rice (*Oryza sativa* L.) has never been a serious problem in Taiwan since nearly 90% of the rice area is planted to *Japonica* rice (TPFB, 1979) and local consumers prefer low amylose *Japonica* rice because of its stickiness, tenderness, gloss and taste. Recently, however, emphasis on the development of long-grain *Indica* rice has brought into focus the problem of eating quality in the breeding program. Newly released *Indica* rices are mostly of high amylose which cook dry and hard and are, therefore not acceptable to local consumers. As a result, the extension of these cultivars has been adversely affected, even though they generally have higher yield potential and are more resistant to major diseases and insect pests than most *Japonicas* (Chang *et al.*, 1974). This underlines the importance of incorporating acceptable eating qualities into the future long-grain *Indica* rice varieties in Taiwan.

Although amylose content is the major determinant of eating quality, it usually accounts for no more than 65% of the differences in eating quality of rice (Juliano, 1976). Differences in texture of cooked rice have been observed among rices of similar amylose content. High amylose rices differ widely in the rate of hardening of cooked rice and differences in hardness of cooked rice correlate with differences in gel consistency (Cagampang *et al.*, 1973). Cooked rice with a hard gel consistency hardens faster than that with a soft gel consistency and the latter is more tender than the former. Usually, soft gel consistency is preferred over hard gel consistency. For example, IR 5 and IR 8 have similar amylose content but IR 5 always scores higher than IR 8 for acceptability in panel tests because IR 5 has soft gel consistency while IR 8 has hard one (Khush *et al.*, 1979).

There have been several studies on the inheritance of amylose content in rice. It has been reported that high amylose content is incompletely dominant to low and is controlled by one major gene and several modifiers (Bollich and Webb, 1973; Somrith *et al.*, 1979). However, little is known on the mode of inheritance of gel consistency in rice. Additional information on the genetics of amylose content is needed on the rices developed in Taiwan. Furthermore, studies on the inheritance of gel consistency and its relation with amylose content in rice may also be useful to the selection of desirable recombinants in the progenies of parents differing in these two quality characters.

This study was, therefore, undertaken to determine the mode of inheritance of amylose content and gel consistency and their relations in two crosses of *Indica* rices recently developed in Taiwan.

Materials and Methods

Three long-grain *Indica* rices recently developed at the Chiayi Agricultural Experiment Station, including two named varieties, Chianung-sen 8 and Tainung-sen 12 and an unnamed selection, Chianung-sen-yu 19, were used as the parents in this experiment. All of them are of semi-dwarf plant type and have high yield potential. Chianung-sen 8, a selection from IR 661–140–8, has low amylose (19%) and soft gel consistency. Tainung-sen 12 originated from the cross of Peta/Ai-chueh-chien//IR 22 and has high amylose (29%) and soft gel consistency. Chianung-sen-yu 19 was selected from the cross of IR 8/Bengawan//IR 747-B_2-6–3 and has high amylose (29%) and hard gel consistency.

Chianung-sen 8 was crossed with both Tainung-sen 12 and Chianung-sen-yu 19 in the second crop of 1966 at this Station. Both crosses were used in the studies of the inheritance of amylose content but only the cross of Chianung-sen 8/Chianung-sen-yu 19 was studied for the inheritance of gel consistency. The F_1, F_2, F_3, BCF_1 and BCF_2 of each cross were investigated for their amylose content and/or gel consistency. Plants of F_1 were grown in the first crop while those of F_2 and BCF_1 were grown in the second season of 1977 except that F_2 of Tainung-sen 12/Chianung-sen 8 was grown in the first crop of 1978. F_3 and BCF_2 lines were grown also in the first crop of 1978.

Grains were harvested on individual plants basis, air-dried and stored in an air-conditioned room before being subjected to chemical analysis. Amylose content of the milled rice was determined by the method of Williams *et al.* (1958) and gel consistency was measured by the procedure outlined by Cagampang *et al.* (1973). Amylose content is expressed as a percentage of milled rice on dry weight basis while gel consistency is measured by the length of the cold gel held horizontally in a test tube for half an hour. Hard gel consistency is represented by shorter gel while soft gel consistency tends to be associated with longer gel.

Results

Inheritance of amylose content

The frequency distributions of amylose content for the various populations of the crosses, Chianung-sen 8 (CNS 8)/Tainung-sen 12 (TNS 12) and CNS 8/Chianung-sen-yu 19 (CNS 19) are shown in Tables 1 and 2, respectively. It showed that the low amylose parent, CNS 8 had amylose content of 18.7% while high amylose parents TNS 12 and CNS 19 both had amylose content of 29.3%. Standard error associated with parental varieties were small, reflecting a small variability in amylose content among plants for each parent.

Table 1. *Frequency distribution of amylose for P_1, P_2, F_1, F_2, BC_1F_1, and BC_2 F_1 plants of the cross CNS 8/TNS 12*

Population	Amylose content (%)															Total	Mean (%)	S. E.
	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31			
CNS 8 (P_1)		4	26													30	18.73	±0.18
TNS 12 (P_2)												1	21	8		30	29.26	±0.53
F_1 (P_1/P_2)								2	11	2	1					16	25.10	±0.71
F_1 (P_2/P_1)								3	6	5						14	25.07	±0.86
F_2 (P_1/P_2)		17	13	16	13	5	4	16	59	63	42	37	20	6		311	24.96	±3.12
F_2 (P_2/P_1)		38	26	4			6	19	48	37	19	14	22	10	2	245	24.09	±3.89
BC_1F_1 ($P_1//P_1/P_2$)	4	2	1					2	5	4						18	22.17	±3.90
BC_2F_1 ($P_2//P_1/P_2$)									3	2	2		3	2	4	16	28.20	±2.31

The amylose of F_1 plants ranged from 24 to 27% in both crosses (Tables 1 and 2). The distributions of F_1 plants in the reciprocal crosses were similar, suggesting that there was no maternal effect. The means of F_1 were intermediate between the parental means but were slightly near the high parents, indicating that high amylose content was partially dominant to low one. Standard error for the F_1 were slightly larger than parental values, showing that F_1 plants were more variable than parental varieties.

Table 2. *Frequency distribution of amylose for $P_1, P_2, F_1, F_2, BC_1F_1$, and BC_2 F_1 plants of the cross CNS 8/CNS 19*

Population	Amylose content (%)															Total	Mean (%)	S. E.
	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31			
CNS 8 (P_1)		4	26													30	18.73	±0.18
CNS 19 (P_2)													25	5		30	29.33	±0.26
$F_1(P_1/P_2)$								2	13	1						16	25.05	±0.48
$F_1(P_2/P_1)$									6	3	1					10	25.50	±0.82
$F_2(P_1/P_2)$		6	25	19	12	4	3	10	53	63	60	21	26	5		307	24.96	±3.11
$F_2(P_2/P_1)$	1	10	19	27	13	5	5	21	53	57	41	26	25	4	3	310	24.71	±3.22
BC_1F_1 ($P_1//P_1/P_2$)		2	2	1	1				3	4		1				14	22.96	±3.63
BC_2F_1 ($P_2//P_1/P_2$)									2	7	2	4	3			18	26.92	±1.37

The F_2 populations gave a distinctly bimodal distribution in both crosses (Tables 1 and 2). The minimum frequency class between the two curves fell at 23%, dividing F_2 plants into low (below 22%) and high (above 23%) amylose groups. The numbers of F_2 plants segregating into each group gave a satisfactory fit to a 3:1 ratio of high and low amylose in both crosses (Tables 4 and 5). The F_2 ratios agreed with the hypothesis that high amylose content is controlled by one major gene.

The 60 F_3 families randomly selected from the cross of CNS 8/TNS 12 gave a satisfactory fit to the ratio of 1:2:1 when amylose content of the plants were classified into homozygous low, segregating, and homozygous high classes (Table 4). Since the classification of F_3 lines were based on the amylose content of all plants with each line rather than that of a single plant as in the case of F_2, the results should be more reliable. The data for F_3 families further support the hypothesis of monogenic inheritance of amylose content, the gene for high amylose being incompletely dominant.

The F_1 plants of CNS 8/TNS 12 and CNS 8/CNS 19 were backcrossed to their respective low and high amylose parents to produce BC_1F_1 and BC_2F_1 populations. In both crosses, the BC_1F_1 plants segregated into distinct low and high amylose groups (Tables 1 and 2) with numbers in each group fitting to the 1:1 ratio while those of BC_2F_1 all fell into high amylose classes (Tables 4 and 5). This would mean that amylose content in both parents is differentiated by a single major gene.

The distributions and means of high amylose plants in both BC_1F_1 populations were similar to those of their respective F_1 plants (Tables 1 and 2). There was also evidence of BC_2F_1 plants segregating into two groups, one with moderately high amylose with an average of 25 to 26% and the other with higher amylose of 28 to 30%. The distributions and means of BC_2F_1

plants with moderately high amylose were similar to those of high BC_1F_1 as well as F_1 plants (Tables 1 and 2). The results of backcross populations further confirm the finding that gene for high amylose was incompletely dominant to its allele.

Table 3. *Frequency distribution of amylose for BC_1F_2, BC_2F_2, and F_3 families of the crosses CNS 8/TNS 12 and CNS 8/CNS 19*

Population	Amylose content (%)																		Total	Mean (%)	S. E.
	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30			
CNS 8/TNS 12																					
CNS 8 (P_1)						24	4												28	18.08	±0.35
TNS 12 (P_2)																	13	3	16	29.15	±0.27
BC_1F_2 ($P_1//P_1/P_2$)	1			2	4	1				2	4	2	1	1					18	20.34	±3.85
BC_2F_2 ($P_2//P_1/P_2$)									1		1	1	2	1		1	7	2	16	27.10	±2.78
$F_3(P_1/P_3)$				3	6	2	1		1	4	5	7	7	2	5	4	13		60	24.61	±4.24
CNS 8/CNS 19																					
CNS 8 (P_1)						24	4												28	18.08	±0.35
CNS 19 (P_2)																3	8	3	14	28.89	±0.62
BC_1F_2 ($P_1//P_1/P_2$)					1	3	2		1		1	1	2	2	1				14	21.87	±3.59
BC_2F_2 ($P_2//P_1/P_2$)												4	3	2	1	2	4	2	18	26.76	±2.26

BCF_1 plants were selfed to produce BCF_2 families. The results are shown in Table 3. All BC_1F_2 lines from high amylose BC_1F_1 plants were segregating while those from low amylose plants were all fixed. This indicates that low amylose BC_1F_2 plants are homozygous in a gene pair for low amylose while high amylose plants are heterozygous in amylose genes. The BC_1F_2 data agreed with the 1:1 segregation for low and high amylose observed in BC_1F_1 populations (Tables 4 and 5).

About half of BC_2F_2 lines were classified as homozygous in high amylose while the other half fell into the segregating class. The numbers of lines in each class gave a good fit to a 1:1 segregating ratio, suggesting that half of BC_2F_1 plants are heterozygous in amylose genes (Tables 4 and 5). The results of BC_2F_2 confirmed the observation that BC_2F_1 had two groups of plants, one with moderately high amylose and the other with higher amylose. The finding that BC_2F_1 plants homozygous in a pair of genes for high amylose showed higher amylose than those heterozygous in amylose genes provides another evidence of incomplete dominance of gene for high amylose.

Distributions of BCF_2 and F_3 lines indicated that most of low amylose BCF_2 and F_3 lines had means lower than the low amylose parent in the cross of CNS 8/TNS 12 but not in the CNS 8/CNS 19 cross (Table 3). There was also no BCF_2 or F_3 lines with amylose values distributed beyond the ranges of high amylose parents in both crosses. This suggests that there was transgressive segregation for low amylose in the BCF_2 and F_3 populations of CNS 8/TNS 12 cross but not in the cross of CNS 8/CNS 19. There was also no evidence of transgressive segregation for high amylose in both crosses. The presence of transgressive segregation for low amylose in the cross of CNS 8/TNS 12 would indicate that high amylose parent, TNS 12 carries, besides the gene for high amylose content, certain modifiers for low amylose.

Table 4. *Classification of P_1, P_2, F_1, F_2, F_3, BCF_1, and BCF_2 populations from the cross of CNS 8/TNS 12 for amylose content*

Population	Number of plants or families				Expected ratio	χ^2	P value
	High	Segregating	Low	Total			
CNS 8 (P_1)			30	30			
TNS 12 (P_2)	30			30			
$F_1(P_1/P_2)$	16			16			
$F_1(P_2/P_1)$	14			14			
$F_2(P_1/P_2)$	247		64	311	3:1	3.01	0.10-0.05
$F_2(P_2/P_1)$	177		68	245	3:1	1.14	0.50-0.25
BC_1F_1 $(P_1//P_1/P_2)$	11		7	18	1:1	0.50	0.50-0.25
BC_2F_1 $(P_2//P_1/P_2)$	16			16			
BC_1F_2 $(P_1//P_1/P_2)$		11	7	18			
BC_2F_2 $(P_2//P_1/P_2)$	9	7		16	1:1	0.06	0.90-0.75
F_3	13	32	15	60	1:2:1	0.40	0.90-0.75

Table 5. *Classification of P_1, P_2, F_1, F_2, BCF_1 and BCF_2 populations from the cross of CNS 8/CNS 19 for amylose content*

Population	Number of plants or families				Expected ratio	χ^2	P value
	High	Segregating	Low	Total			
CNS 8 (P_1)			30	30			
CNS 19 (P_2)	30			30			
$F_1(P_1/P_2)$	16			16			
$F_1(P_2/P_1)$	10			10			
$F_2(P_1/P_2)$	241		66	307	3:1	1.83	0.25-0.10
$F_2(P_2/P_1)$	235		75	310	3:1	0.07	0.90-0.75
BC_1F_1 $(P_1//P_1/P_2)$	8		6	14	1:1	0.07	0.90-0.75
BC_2F_1 $(P_2//P_1/P_2)$	18			18			
BC_1F_2 $(P_1//P_1/P_2)$		8	6	14			
BC_2F_2 $(P_2//P_1/P_2)$	8	10		18	1:1	0.50	0.50-0.25

The data of backcross populations were consistent with those of F_1, F_2, and F_3 generations in supporting the hypothesis that the high amylose in rices TNS 12 and CNS 19 is controlled by a single incompletely dominant gene.

Inheritance of gel consistency

The frequency distribution of gel consistency for various populations of the cross CNS 8/CNS 19 is presented in Table 6. The cold gel of soft gel parent CNS 8 was longer, with an average of 99.5 mm while that of hard gel parent CNS 19 was shorter, with an average of only 30.6 mm. The standard error for parental varieties were small, particularly for soft gel parent CNS 8, indicating that variability of gel consistency was small among parental plants.

Table 6. *Frequency distribution of gel consistency for P_1, P_2, F_1, F_2, BC_1F_1 BC_2F_1 plants and BC_1F_2, BC_2F_2 lines of the cross CNS 8/CNS 19*

Population	Gel consistency (mm)															Total	Mean (mm)	S. E.
	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100			
CNS 8 (P_1)															30	30	99.5	±0.07
CNS 19 (P_2)	24	6														30	30.6	±0.13
$F_1(P_1/P_2)$		1	4	3	2		1									11	43.0	±0.77
$F_1(P_2/P_1)$	4	5		1												10	31.8	±0.44
$F_2(P_1/P_2)$	43	103	61	30	2	4	4	5	5	12	7	13	13	3	2	307	43.9	±1.87
$F_2(P_2/F_1)$	45	144	31	11	1	3	8	6	9	14	9	8	8	5	8	310	44.0	±2.02
BC_1F_1 $(P_1//P_1/P_2)$		6	1	1								1	1		4	14	59.9	±3.06
BC_2F_1 $(P_2//P_1/P_2)$		3	1	1												5	37.0	±0.46
BC_1F_2 $(P_1//P_1/P_2)$			3	3			2			1	4		1			14	59.5	±1.85
BC_2F_2 $(P_2//P_1/P_2)$	2	6	3	2	4	1										18	39.3	±0.88

The gel consistency of F_1 plants in both crosses ranged from 30 to 50 mm except one 60 mm plant in CNS 8/CNS 19 cross. The distributions of F_1 plants in the reciprocal crosses varied slightly with F_1 plants of CNS 8/CNS 19 having longer gel than those of CNS 19/CNS 8, suggesting that gel consistency was affected by the maternal parent of the cross. The means of F_1 plants were close to that of the short or hard gel parent, indicating that short or hard gel consistency was dominant to long or soft one. Standard error for F_1 plants were substantially higher than those of the parents, showing that F_1 plants were more variable than the parental varieties.

The gel consistency of F_2 populations formed a bimodal curve with the maximum frequency classes fell at 35 and 85–90 mm in the cross CNS 8/CNS 19 and at 35 and 75 mm in its reciprocal cross CNS 19/CNS 8 while the minimum frequency class fell at 50 mm in both crosses (Table 6). The difference in gel length at the second maximum frequency class provided another evidence of cytoplasmic effect on gel consistency. From the minimum frequency class of 50 mm, the F_2 plants could be divided into two groups, one with relatively short or hard gel (below 50 mm) and the other with longer or soft gel (above 55 mm). Observed frequencies of 239 hard and 68 soft gels in F_2 population of the cross CNS 8/CNS 19 and 232 hard and 78 soft gels in the F_2 population of the cross CNS 19/CNS 8 agreed satisfactorily with the assumption that a single dominant gene controls hard gel consistency in the selection CNS 19 (Table 7). Chi-square values of 1.18 and 0.02 for both crosses indicated that an assumed monogenic segregation for the inheritance of gel consistency is acceptable. A chi-square value of 3.84 is necessary to reject the theoretical ratio of 3:1 at the 0.05 probability level.

The F_1 plants of CNS 8/CNS 19 were backcrossed to their respective hard and soft gel parents to produce BC_1F_1 (CNS 8/F_1) and BC_2F_1 (CNS 19/F_1) populations. The distribution of BC_1F_1 plants into two distinct short or hard and long or soft gel groups (Table 6) gave a good fit to the 1:1 ratio of monofactorial segregation (Table 7) while all BC_2F_1 plants had short or hard gel consistency. The data of backcross populations further support the hypothesis that the inheritance of gel consistency is controlled by one pair of major genes, with short or hard gel consistency dominant.

Table 7. *Classification of P_1, P_2, F_1, F_2, BCF_1, and BCF_2 populations from the cross of CNS 8/CNS 19 for gel consistency*

Population	Number of plants or families				Expected ratio	χ^2	P value
	Hard	Segregating	Soft	Total			
CNS 8 (P_1)			30	30			
CNS 19 (P_2)	30			30			
$F_1(P_1/P_2)$	10		1	11			
$F_1(P_2/P_1)$	10			10			
$F_2(P_1/P_2)$	239		68	307	3:1	1.18	0.50-0.25
$F_2(P_2/P_1)$	232		78	310	3:1	0.02	0.90-0.75
BC_1F_1 ($P_1//P_1/P_2$)	8		6	14	1:1	0.07	0.90-0.75
BC_2F_1 ($P_2//P_1/P_2$)	5			5			
BC_1F_2 ($P_1//P_1/P_2$)		8	6	14			
BC_2F_2 ($P_2//P_1/P_2$)	11	7		18	1:1	0.50	0.50-0.25

The distribution of BC_1F_2 lines was similar to that of BC_1F_1 plants (Table 6). All BC_1F_2 lines from the short or hard gel BC_1F_1 plants were all segregating while those from the long or soft gel BC_1F_1 were fixed (Table 7), suggesting that hard gel BC_1F_1 plants were heterozygous while soft gel BC_1F_1 plants were homozygous. The BC_1F_2 data thus confirm the 1:1 segregation for hard and soft gel consistency observed in BC_1F_1 population.

The distribution of all BC_2F_2 lines was within the short or hard gel classes (Table 6). About half of them were homozygous for hard gel while the others were segregating (Table 7). The numbers of lines in each group gave a satisfactory fit to a 1:1 ratio, revealing that hard gel BC_2F_1 population consisted of two genotypes in equal proportion.

The results of BCF_2 lines were consistent with those of F_1, F_2, and BCF_1 plants in assuming that hard gel consistency in rice selection CNS 19 is conditioned by a single dominant gene.

Association of characters

An attempt was also made to investigate a possible association of the two quality charactsrs in the F_2 plants of the reciprocal crosses of CNS 8/CNS 19. Each plant was classified simultaneously for its amylose content and gel consistency. The results are shown in Table 8. It showed that most F_2 plants were classified as parental types and only few plants belonged to new recombinations in each cross. Chi-square test for independence of amylose

Table 8. *Classification of F_2 plant from crosses CNS 8/CNS 19 and CNS 19/CNS 8 for amylose content and gel consistency*

Gel consistency	CNS 8/CNS 19			CNS 19/CNS 8		
	Amylose content			Amylose content		
	High	Low	Total	High	Low	Total
Hard	238	1	239	230	2	232
Soft	3	65	68	5	73	78
Total	241	66	307	235	75	310
χ^2 for independence	278.50**			268.64**		

** Significant at 1% level.

Table 9. *Phenotypic and genotypic correlation coefficients between amylose content and gel consistency in F_2 populations of CNS 8/CNS 19 and CNS 19/CNS 8*

Cross	Correlation coefficient	
	Phenotypic	Genotypic
CNS 8/CNS 19	-0.889**	-0.894
CNS 19/CNS 8	-0.858**	-0.863

** Significant at 1% level.

content and gel consistency in F_2 populations gave values of 278.50 and 268.64 with a single degree of freedom for crosses CNS 8/CNS 19 and CNS 19/CNS 8, respectively. Chi-square value of only 3.84 is enough to reject the hypothesis of independence at the 0.05 probability level. This indicates that there may be a close association between amylose content and gel consistency. Further evidence of the character association is the fact that amylose content was

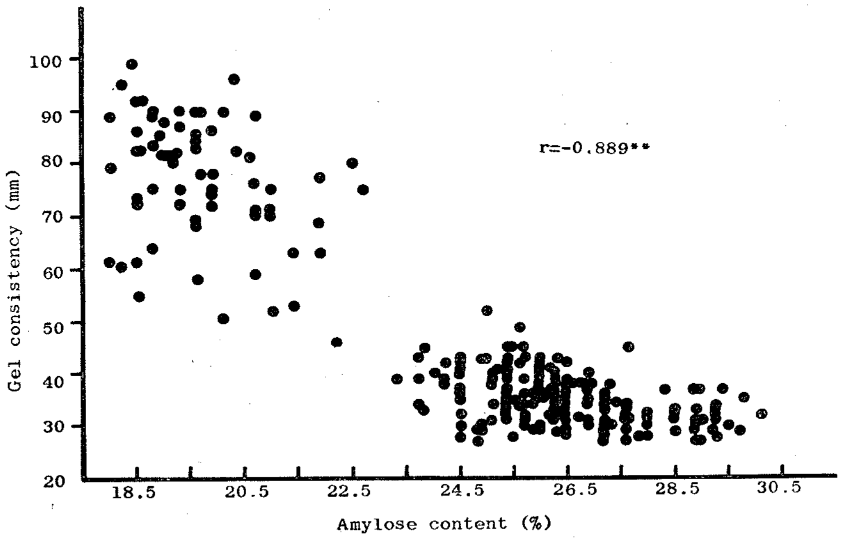

Fig. 1. Relationship between amylose content and gel consistency in F_2 population of the cross CNS 8/CNS 19

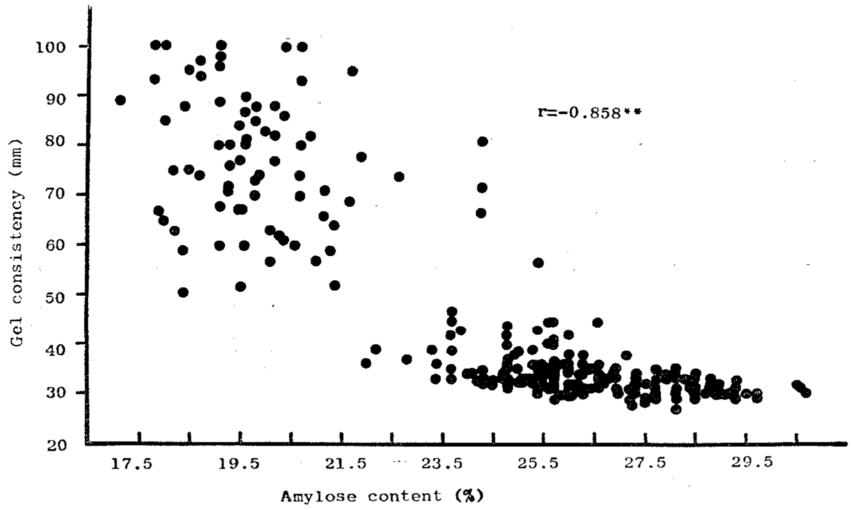

Fig. 2. Relationship between amylose content and gel consistency in F_2 population of the cross CNS 19/CNS 8

negatively correlated with gel consistency (Figs. 1 and 2) and the correlations were of large magnitude and highly significant in both crosses (Table 9).

Discussion

The results of this experiment indicate that the high amylose content in locally developed *Indica* variety, TNS 12 and selection, CNS 19 is each controlled by a single incompletely dominant gene while the hard gel consistency of CNS 19 is conditioned by a dominant gene. In addition, there was evidence of modifiers involved in the inheritance of amylose in the cross CNS 8/TNS 12, as reported by others (Bollich and Webb, 1973; Somrith *et al.*, 1979). The presence of modifiers was, however, not detected in another cross CNS 8/CNS 19, although the inheritance of gel consistency might be affected by the maternal effect.

The simple mode of inheritance for amylose content and gel consistency is most encouraging to rice breeders who wish to improve eating quality of the *Indica* rice. Selection for amylose and gel consistency in the early segregating generations of the crosses between the high and low amylose or hard and soft gel consistency parents would be effective and a breeding program aimed at combining acceptable eating quality with improved plant type could also be easily carried out. As a result, the number of promising low amylose selections has greatly increased in recent years. For instance, none of the 10 entries in the island-wide regional yield trial had low amylose in 1974 while 7 out of 9 or 78% of the entries in the 1980 trial were of low amylose selections (TPDAF, 1980). These low amylose selections are likely to be more acceptable to local consumers when they become available for commercial production.

The close relationship between amylose content and gel consistency observed in the reciprocal crosses of CNS 8/CNS 19 would also be of great help in the development of *Indica* rices with acceptable eating or processing quality. In Taiwan, rices with low amylose and soft gel consistency are preferred for eating while high amylose and hard gel consistency are required for processing purpose. Since amylose content was correlated negatively with gel length, selection for high or low amylose is likely to be accompanied with hard or soft gel consistency and *vice versa*, indicating that simultaneous improvement of these two quality characters can be made with selection of either one but not both of them. Obviously, the favorable association of the two characters not only saves labors and times needed in the chemical analysis but also facilitates a rapid screening for acceptable qualities in the early segregating generations, thereby raising the efficiency of selection.

Of the two quality characters, manual analysis of amylose appears more laborous and time consuming than that of gel consistency. The number of samples each technician can handle may never exceed 100 a day for amylose content, but with gel consistency he may easily finish 200 or even 300 samples daily. Thus, it would be more effective to make an initial selection on the basis of gel consistency followed by the identification of amylose content on the basis of eating or processing purpose. As shown in Figs. 1 and 2, there were high and intermediate amylose plants in both hard and soft gel consistency groups which make it possible for rice breeders to select desirable recombinants having met their quality requirement. A similar approach has also been proposed by Huang (1979).

Acknowledgements

This experiment was supported in part by a grant from the Council for Agricultural Planning and Development (formerly JCRR) and the Choung-Cheng Science and Technological Research Foundation. The paper was published with the approval of the Director, Taiwan Agricultural Research Institute (Research Paper No. 960).

Literature Cited

Bollich, C. N. and B. D. Webb. 1973. Inheritance of amylose in two hybrid populations of rice. Cereal Chem. **50**(6): 631-636.

Cagampang, G. B., C. M. Perez and B. O. Juliano. 1973. A gel consistency test for eating quality of rice. J. Sci. Food Agr. **24**: 1589-1594.

Chang, W. L., C. H. Cheng and C. N. Chao. 1974. Adaptability of some newly developed lines of long-grain *Indica* rice. Taiwan Agr. Quart. **10**(1): 48-82.

Huang, C. S. 1979. Acreage drop and its causes of *Indica* rice in Taiwan. J. Agr. Assoc. China. **106**: 52-61.

Juliano, B. O. 1976. Biochemical studies. Rice Postharvest Technology. Intern. Develop. Res. Centre. Ottawa, Canada. 13-18.

Khush, G. S., C. M. Paule and N. M. de Cruz. 1979. Rice grain quality evaluation and improvement at IRRI. Chemical Aspects of Rice Grain Quality. 21-31.

Somrith, B., T. T. Chang and B. R. Jackson. 1979. Genetic analysis of traits related to grain characteristics and quality in two crosses of rice. IRRI. Res. Paper Series No. 15. 14 p.

Taiwan Provincial Department of Agriculture and Forestry. 1980. Conference Materials for Rice Breeding Technical Committee. (mimeograph). 14 p.

Taiwan Provincial Food Bureau. 1979. Taiwan Food Statistics Book. 1979 ed. 160 p.

Williams, V. R., W. T. Wu, H. Y. Tsai and H. G. Bates. 1958. Varietal differences in amylose content of rice starch. J. Agr. Food Chem. **8**: 47-48.

水稻顆粒性澱粉含量與膠體軟硬度之遺傳

張萬來 李婉瑩

臺灣省農業試驗所嘉義農業試驗分所

本試驗係以高與低顆粒性澱粉含量及硬與軟膠體親本什交後裔，F_1, F_2,, F_3, BCF_1，與 BCF_2 等集團爲材料分析上述兩性狀之遺傳現象。初步結果顯示本分所育成之臺農秈12號與嘉農秈育19號之高顆粒性澱粉含量係各由一對不完全顯性基因所控制，而嘉農秈育19號之硬膠體係受一對顯性基因所支配。獨立性測驗結果顯示兩性狀之間關係密切，顆粒性澱粉之含量與膠體之長度成極顯著之負相關，即高含量者膠體硬（短）而低含量者膠體軟(長)。此相關有利於選拔符合本地需要食用或加工品質之水稻品種。