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Inheritance of Gelatinization Temperature in Rice (*Oryza sativa* L.)

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ABSTRACT

The inheritance of gelatinization temperature in five crosses of rice (Oryza sativa L.) involving intermediate and low gelatinization temperature was studied. The analysis was based on single grain in the parents, F_2,F_3 and BC1 generations. The results suggested that gene for intermediate gelatinization temperature in Basmati 370 was dominant over low gelatinization temperature in the cross KDML 105/ Basmati 370. In another low/intermediate crosses KDML105/IR 841 and KDML 105/RD 23 the gelatinization temperature tended to be controlled by more than one gene.

Key words : rice, inheritance, gelatinization temperature

INTRODUCTION

Gelatinization temperature is a physical property of starch. Juliano (1979) described the gelatinization temperature in terms of time required for cooking or the range of temperature within which the starch granules start to swell irreversibly in hot water. The observed values for rice starch gelatinization temperature ranged from 55 °C to 79 °C (Cagampang *et al.*, 1966; Juliano *et al.*, 1969).

Alkali spreading tests are commonly used by rice researchers to obtain an estimate of cooking time of the milled grain by chemical means. Alkali spreading values in turn shows a strong inverse relation to gelatinization temperature which is frequently used as a mean for placing varieties into low, intermediate and high cooking temperature classes. Rice varieties classified as low gelatinization require temperature less than 69°C, intermediate type from 70 to 74°C and froms with high gelatinization require temperature above 74°C. Gelatinization temperature is usually estimated by the simple test of the rate of disintergrate of the rice kernels in dilute alkali at 30°C for 23 hours. Thus sample with low gelatinization temperature disintegrate completely, intermediate type partially disintegrate while high gerlatinization temperature sample not affected.

Ghosh and Govindaswamy (1972) crossed high and low gelatinization temperature rice cultivars. The F_1 plants showed intermediate value. The F_2 segregation had a bimodal curve but the

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phenotypic classes could not be fitted into any conventional genetic ratio. Somrith(1974) in a study of two crosses found that the gelatinization temperature was the result of additive gene effects as well as dominant effect. Mckenzie and Rutger (1983) found that segregation pattern for gelatinization temperature in five crosses did not conform to any identifiable genetic model of the six crosses studied. Only one cross gelatinization temperature was probably controlled by a single gene. In the other crosses, one or a few additive genes of the major effect along with modifier genes were probably controlling gelatinization temperature. Heda and Reddy (1986) found that high gelatinization temperature was governed by polygenic factors. Srivantaneeyakul(1988) found that high alkali digestion values were incompletely dominant and F_2 distribution suggested that polygenes controlled this trait.

The purpose of this investigation was to obtain information on mode of inheritance of gelatinization temperature in rice.

MATERIALS AND METHODS

This study was conducted from June 1994 to February 1996 at the Department of Agronomy, Kasetsart University. The rice varieties used were KDML 105, Basmati 370, IR 841, IR 42, RD 23 and CT 9155. KDML 105 was used as a common parent in cossing with five other varieties namely Basmati 370, IR 841, IR 42, RD 23 and CT 9155. The following crosses were made:KDML 105/ Basmati 370, KDML 105/IR 841, KDML 105/IR 42, KDML 105/RD 23 and KDML 105/CT 9155. The parents and F_1 plants were grown in greenhouse at the Department of Agronomy during the 1994 wet season. The F_1 were backcrossed to both parents. Some F_1 were selfed to obtain F_2 seeds. The single crosses were also made to obtain F_1 seeds. During the 1995 wet season the parents F_1,F_2 and backcross progenies were transplanted into the field at Bangkhen Rice Experiment Station using single seedlings per hill. At maturity 100 individual plants from each F_2 cross combination were harvested randomly from the middle of plot and threshed separately. For parents 10 plants were harvested. For F_1 and BC1, all grown plants were harvested and threshed separately. All samples were stored in an incubator for 5 days to stabilize the moisture content at about 12% before analyzing. Gelatinization temperature was determined by using the procedure of Little *et al.* (1958). The procedure followed was:

- Grain samples from the individual plants of the parents, F_1,F_2 and BC_1 were dehulled by Satake dehulling machine.
- The dehulled seeds were milled in Kett milling machine for 4 seconds.
- Whole milled kernels of the individual plants were placed in small petridishes containing 10 ml of 1.7% KOH.
- The petri-dishes were covered and incubated for 23 hours at 30 C.
- The Individual grain were then classified visually according to the following spreading scale based on the degree of alkali digestion of the rice kernel.

RESULTS AND DISCUSSION

The gelatinization temperature is one of the character expressed in the endosperm which is a triploid tissue consisting of one set of chromosomes from the male parent and two sets of chromosomes from the female parent. Genotypically the seeds harvested from and F_1 plants contain an endosperm of F_2 genertion. Similarly, seeds from F2 plants will be referred as F_3 generation. The results of single seed analysis for gelatinization temperature are presented in this study.

Spreading Scale

Score	Spreading
1	Kernel not affected.
2	Kernel swollen
3	Kernel swollen, collar incomplete and narrow.
4	Kernel swollen, collar complete and wide.
5	Kernel split or segmented, collar complete and wide.
6	Kernel dispersed, merging with collar.
7	Kernel dispersed completely and intermingled.

Classification

Score	Alkali digestion	Gelatinization temperature
1-2	Low	High
3	Low/Intermediate	High/Intermediate
4-5	Intermediate	Intermediate
6-7	High	Low

Low/intermediate gelatinization temperature
The cross KDML 105/IR 841

The mean alkali digestion index of KDML 105 was 7.00 while mean alkali digestion index of IR 841 was 4.00. The data on the distributtion of alkali digestion index in parents and different segregating populations of this cross are presented in Table 1 and Figure 1 .

In the F_2 population total 510 seeds were tested, among them 186 seeds (scores 4-5) were observed in intermediate gelatinization temperature while 324 seeds (scores 6-7) were observed in low gelatinization temperature. The mean alkali digestion index of the F_2 populations was 5.96. The F_3 population mean was close to the F_2 mean. The segregates showed a wide range of values in the F_3 generation.

The mean alkali digestion index of backcross to KDML 105 was 6.44 while the mean of backcross to IR 841 was 5.11. The mean of both backcrosses shifted to recurrent parents.

An asymmetrical F2 distribution was observed for alkali digestion index including a large proportion of the F_2 plants with high alkali digestion score. The F2 distribution showed an obvious skewnees toward the high digestion index parent indicating that dominant loci were present though significant dominance gene effect was not detected. Distribution of the F_2 population showed that gelatinization temperature was controlled by more than one gene.

The cross KDML 105/RD 23

The mean alkali digestion index of KDML 105 was 7.00 while mean alkali digestion index of RD 23 was 4.00. The data on distribution of alkali digestion index in parents and different segregating populations of the cross KDML 105/RD 23 are presented in Table 2 and Figure 2.

In the F_2 population 580 seeds were tested

Table 1 Distribution of seeds by alkali digestion index in the cross KDML 105/IR 841.

Generations	No. of seeds tested	Alkali digestion index				
		4	5	6	7	Mean
Parents						
KDML 105	500	-	-	-	500	7.00
IR 841	500	500	-	-	-	4.00
F_2						
KDML 105/IR 841	510	131	55	28	296	5.96
F_3						
KDML 105/IR 841	1120	374	231	46	469	5.54
BC_1						
KDML 105*2/IR 841	330	21	-	123	186	6.44
KDML 105/2*IR 841	270	121	63	22	64	5.11

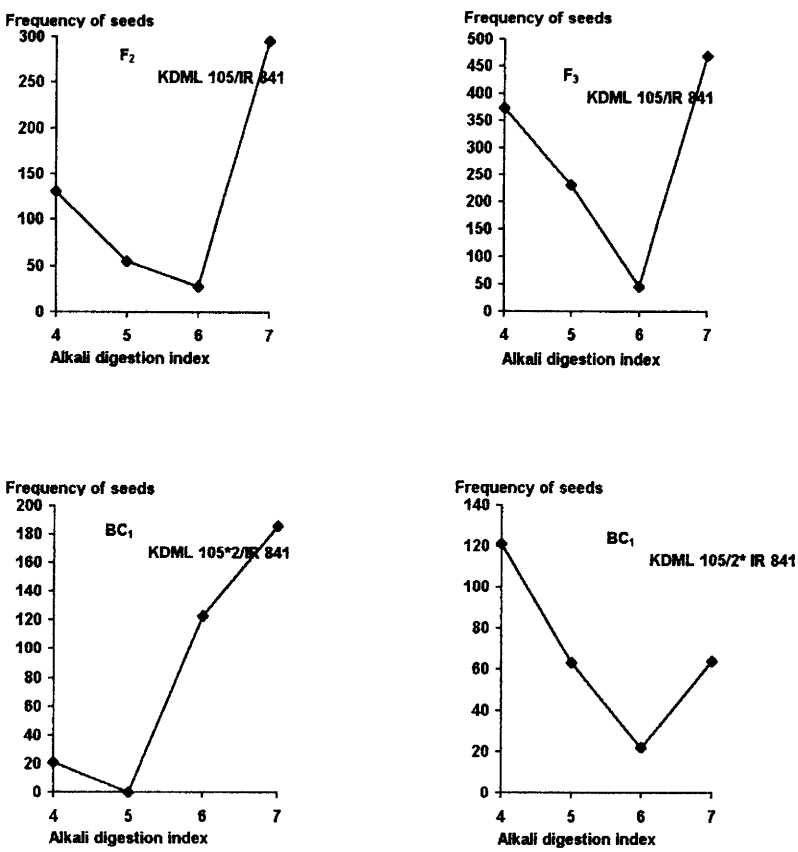

Figure 1 Distribution of seed by alkali digestion index in F_2, F_3 and BC_1 of the cross KDML 105/IR 841.

Table 2 Distribution of seeds by alkali digestion index in the cross KDML 105/RD 23.

Generations	No. of seeds tested	Alkali digestion index 4	5	6	7	Mean
Parents						
KDML 105	500	-	-	-	500	7.00
RD 23	500	500	-	-	-	4.00
F_2						
KDML 105/RD 23	580	361	-	32	187	5.08
F_3						
KDML 105/RD 23	1080	472	13	33	562	5.63
BC_1						
KDML 105*2/IR 23	240	84	36	60	60	5.40
KDML 105/2*IR 23	300	147	51	9	93	5.16

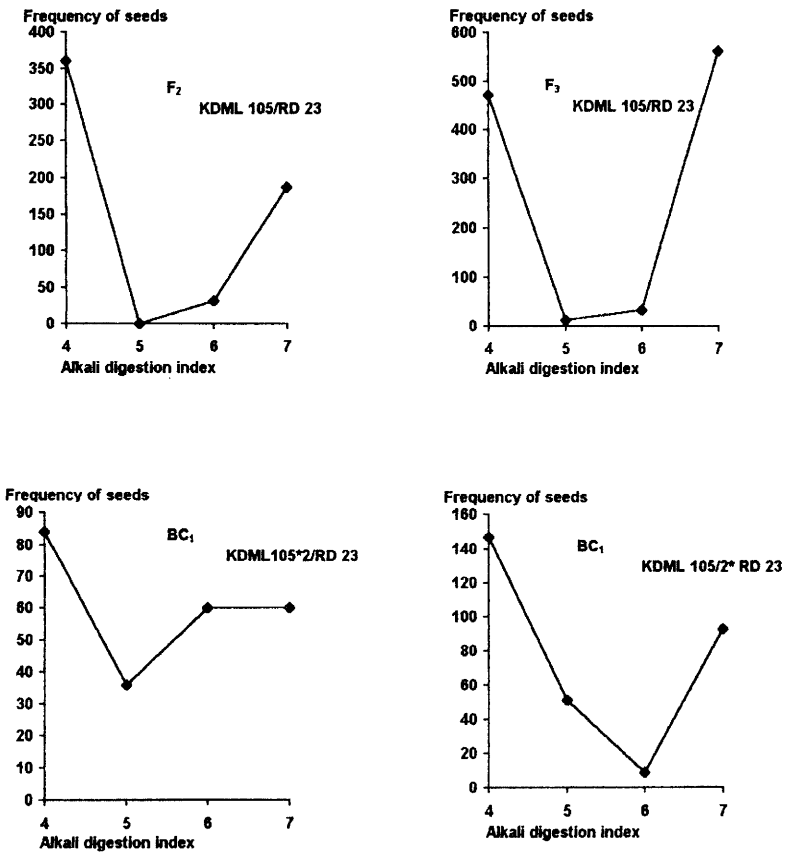

Figure 2 Distribution of seeds by alkali digestion index in F_2, F_3 and BC_1 of the cross KDML 105/RD 23.

among them 361 seeds (score 4) were observed in intermediate alkali digestion index while 219 seeds (scores 6-7) were observed in high alkali digestion index. The mean alkali digestion index of all generations were between the mean alkali digestion index of parents. An asymmetrical F_2 distribution was observed for alkali digestion index including a large proportion of F_2 plant with intermediate alkali digestion score. F_2 distribution showed as obvious skewness toward the intermediate index parent indicating that dominant loci were present though significant dominance gene effect was not detected. The data obtained showed that gelatinization temperature tended to be controlled by more than one genes.

The cross KDML 105/Basmati 370

The mean alkali degestion index of KDML 105 was 7.00 while mean alkali digestion index of Basmati 370 was 4.57. The alkali digestion index of Basmati 370 was variable ranging from scores 4-6.

The distribution of F_2 seeds for alkali digestion index showed a bimodal distribution with 407 seeds in intermediate alkali digestion category (scores 4-5) and 153 seeds in high alkali digestion index category (scores 6-7). The data showed a segregation for intermediate alkali digestion index and high alkali digestion index in a 3:1ratio. The Chi-square was 1.61 and P values were between 0.10-0.20. The backcross to KDML 105 segregated into 1:1 ratio for intermediate and high alkali digestion index. The Chi-square was 1.69 and P values were between 0.10-0.20.

Two distinct classes of intermediate and high alkali digestion index were obtained in 3:1 ratio in F_2 population. The result suggested that intermediate alkali digestion index was dominant over high alkali digestion index and was governed by a single major gene.

The data on distribution of alkali digestion index in parents and different segregating populations are presented in Table 3 and Figure 3.

Table 3 Distribution of seeds by alkali digestion index in the cross KDML 105/Basmati 370.

Generations	No. of seeds tested	Alkali digestion index					Chi-square		P-value
		4	5	6	7	Mean	3:1	1:1	
Parents									
KDML 105	500	-	-	-	500	7.00	-	-	-
Basmati 370	500	238	237	25	-	4.57	-	-	-
F_2									
KDML 105/Basmati 370	560	148	259	24	129	5.24	1.61	-	0.10-0.20
F_3									
KDML 105/Basmati 370	960	438	122	80	320	5.29	-	-	-
BC_1									
KDML 105*2/Basmati 370	340	44	138	10	148	5.77	-	1.69	0.10-0.20
KDML 105/2*Basmati 370	360	239	48	17	56	4.69	-	-	-

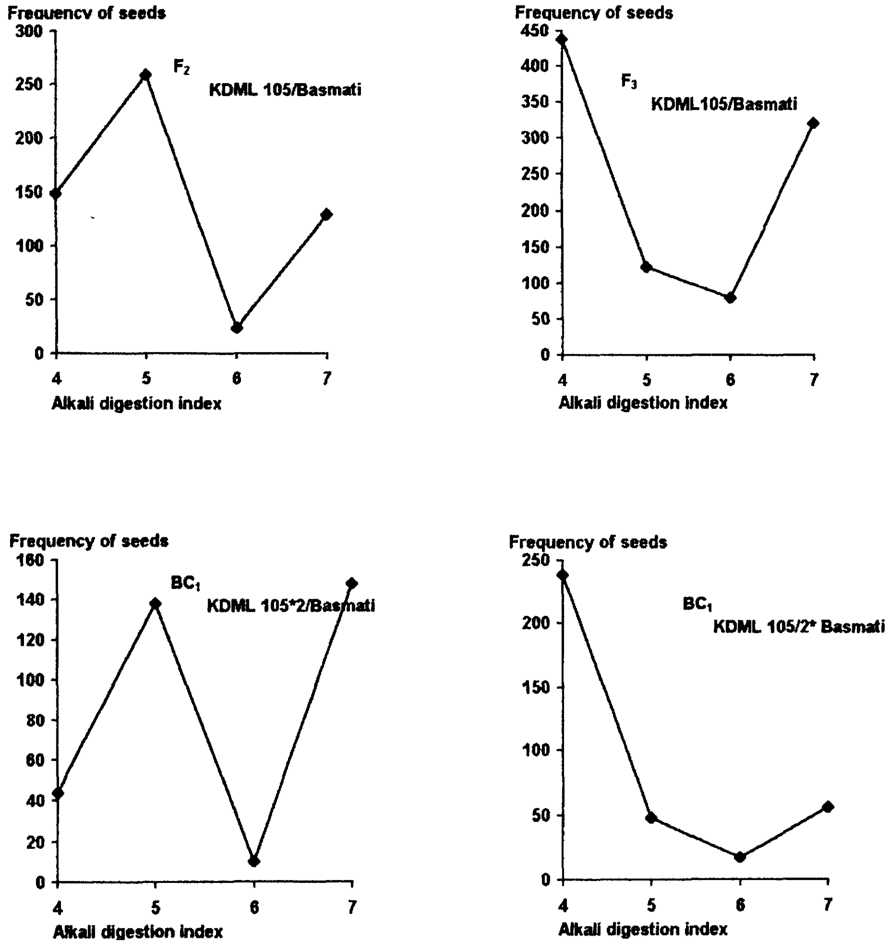

Figure 3 Distribution of seeds by alkali digestion index in F_2, F_3 and BC_1 of the cross KDML 105/ Basmati 370.

Low/low gelatinization temperature

The croes KDML 105/CT 9155 and KDML 105/ IR 42

The gelatinization temperature as measured by alkali digestion index were low in all parents. The alkali digestion index in all the different populations of the crosses KDML 105/CT 9155 and KDML 105/IR 42 were high. There was no segregation for alkali digestion index in the F_2 population of these crosses showing genes for gelatinization temperature from both the parents were allelic. The result obtained from this experiment agreed with the results of those from Mckenzie and Rutger (1983) and Somrith (1974).

CONCLUSION

The result indicated that gene for intermediate gelatinization temperature in Basmati 370 was dominant over low gelatinization temperature. In the other low/intermediate crosses KDML 105/IR 841 and KDML 105/RD 23 the gelatinization temperature tended to be controlled by more than one gene. The information suggests that selection for desirable gelatinization temperature can be done in F_3 and onward generations.

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