

Inheritance of Gelatinization Temperature in Rice

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ABSTRACT

The inconsistent nature on the genetics of cooked kernel elongation of rice was observed in the present study. Inheritance analysis was done in the crosses of three Malaysian local cultivars. Bimodal frequency distribution was observed in F₂ population of Mahsuri Mutant X Mahsuri, which indicated that more than one gene was involved and at least two loci governed the trait. But in Mahsuri Mutant X 9192, the scenario was different; the distribution was unimodal and did not fit any Mendelian inheritance pattern. The observed results identified cooked kernel elongation of rice as complex phenomenon.

Key Words: Alkali digestion value; Gelatinization temperature; Inheritance; Mahsuri Mutant; Rice

INTRODUCTION

Rice is the major food of most of the Asian countries and fine rice varieties are playing a vital role for trading (Huang *et al.*, 1991). So, it needs attention towards improvement in its cooking quality, besides several biochemical and morphological characteristics. Cooking quality of rice mainly depends on amylose content and gelatinization temperature (Juliano, 1979). Amylose contents determine the texture of cooked rice, where as gelatinization temperature determines the cooking time (Heda & Reddy, 1986). The gelatinization temperature of a plant is usually determined from a bulk sample of its seeds those are in the following generation. Such as bulk F₃ and F₄ endosperm populations represent F₂ and F₃, respectively. The alkali digestion test allows the scoring of individual rice endosperm, so observation of the F₃ endosperms from a single F₂ plant provides a progeny test allowing classification of the genotype of the F₂ plants (Maningat & Juliano, 1978; McKenzie & Rutger, 1983; Heda & Reddy, 1984). The inheritance of gelatinization temperature is not entirely clear, but it appears to be fairly simple, involving one or two major genes. Gelatinization temperature is reasonably high in heritability, although it may vary as much as 10°C within a variety in exceptional cases, depending on environment. High air temperature after flowering raises the gelatinization temperature (which lowers grain quality) and low air temperature reduces it (Jennings *et al.*, 1979). Studies on the mode of inheritance of gelatinization temperature by various workers in the past revealed inconsistency in respect of not only the number of genes controlling the trait but also the nature of dominance-recessive relationship (Kahlon, 1964; Stensel, 1965; Ghosh & Govindaswami, 1972; Hu & Choi, 1973; Puri & Siddiq, 1980). In this investigation, we made an attempt through an

extensive qualitative analysis to characterize the genetic architecture of gelatinization temperature in rice and to develop a consistent and complete reports on the genetics of rice gelatinization temperature.

MATERIALS AND METHODS

Single crosses were made in 3 Malaysian rice cultivars named Mahsuri Mutant, Mahsuri and 9192. All the crosses and 19 F₁ and all F₂ were raised at Sebarang Perai Rice Station of Malaysian Agricultural Development Research Institute (MARDI). Gelatinization temperature (GT) was measured following alkali digestion value (Anon, 1979, partially modified by the authors) and alkali digestion values of F₂ populations were determination at Universiti Kebangsaan Malaysia. About 210 plants representing F₂ generation of each cross were analyzed to study the segregation pattern of gelatinization temperature. It was not possible to test alkali digestion in F₁ seeds, because of their weak stature. MINITAB was used to analyze the data.

RESULTS AND DISCUSSION

Alkali digestion value and gelatinization temperature of different varieties and their crosses. Gelatinization temperature of Mahsuri is high and Mahsuri Mutant is intermediate (Juliano & Villareal, 1993). Gelatinization temperature of 9192 was measured as intermediate to Malaysian Agricultural Research Development Institute. The alkali digestion value and gelatinization temperatures of three crosses are presented in Table I.

Segregation pattern for alkali disintegration value. The alkali disintegration patterns were investigated in Mahsuri Mutant X Mahsuri and Mahsuri Mutant X 9192 crosses. The mean values in F₂ were found intermediate in Mahsuri

Table I. Alkali digestion value (ADV) and gelatinization temperature (GT) of different varieties of rice and their crosses

Parents and Crosses	ADV	Inference	GT ($^{\circ}$ C)	Inference
Mahsuri (M)	2.23	Low	74.5 – 80.0	High
Mahsuri Mutant (MM)	4.43	Intermediate	70 -74	Intermediate
9192	4.49	Intermediate	70 - 74	Intermediate
F ₂ of MM X 9192	4.56	Intermediate	75.6	Intermediate
F ₂ of MM X M	4.14	Intermediate	82.5	Intermediate

Table II. Frequency distribution of alkali digestion value

Parentage	Alkali digestion value class							Number of seeds	Population Mean \pm S.E
	0.5	1.5	2.5	3.5	4.5	5.5	6.5		
Mahsuri	-	-	210	-	-	-	-	210	2.23 \pm 0.03
Mahsuri Mutant	-	-	-	-	210	-	-	210	4.43 \pm 0.03
9192	-	-	-	-	210	-	-	210	4.49 \pm 0.03
MM / M	-	-	57	-	151	-	3	211	4.14 \pm 0.10
MM / 9192	-	-	1	-	207	-	3	211	4.56 \pm 0.04

Table III. Segregation pattern for alkali digestion value in the F₂ generation in three different crosses

Cross	F ₂ generations (number of plants)			χ^2 (3:1)	'P' Value
	High	Intermediate	Low		
MM X M	3	151	57	0.62	0.50 - 0.70
MM X 9192	1	207	3	-	-

MM = Mahsuri Mutant, M = Mahsuri,

Mutant X 9192 cross and also intermediate in Mahsuri Mutant X Mahsuri cross (Table II). Mahsuri Mutant X Mahsuri was representative of two different combinations of alkali value, viz., medium X low, but Mahsuri Mutant X 9192 was representative of two equal combinations of alkali value (intermediate X intermediate). However, the observed results indicated a consistent behavior of F₂ seeds in different combinations.

ADV of Mahsuri Mutant X Mahsuri. The mean ADV of Mahsuri Mutant X Mahsuri was towards intermediate ADV parents, indicating dominance of intermediate ADV content over low ones (Table II). F₂ frequency distribution was skewed with distinct peaks at 2 to 3 (Fig. 1) in the crosses of

Mahsuri Mutant X Mahsuri, suggesting the involvement of major genes in the expression of this trait. A bimodal distribution suggesting that parents differed by one or a few pairs of genes (Kahlon 1964; Ghosh & Govindaswamy 1972). The mean ADV of F₂ generations of the cross (MM X M) was 4.14 (Table II), which denoted as intermediate ADV segregants. The F₂ populations from this crosses also showed a segregation pattern of 3 intermediate: 1 low (Table III) suggesting a single pair of dominant genes controlled high alkali digestion value in these crosses. The recovery of the plants with ADV beyond the parental range (transgressive segregants) suggested that besides a pair of major genes, several minor genes acted as modifiers. Stansel

Fig. 1. Frequency distribution of alkali digestion value of F₂ in Mahsuri mutant x Mahsuri

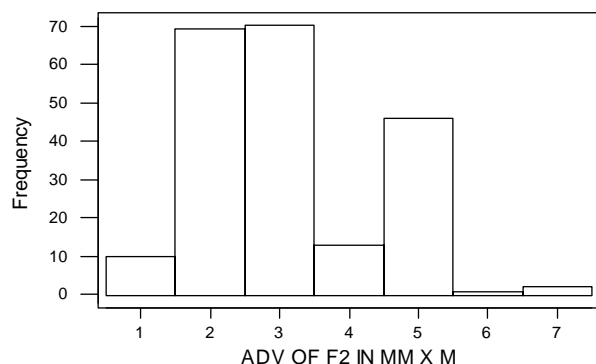
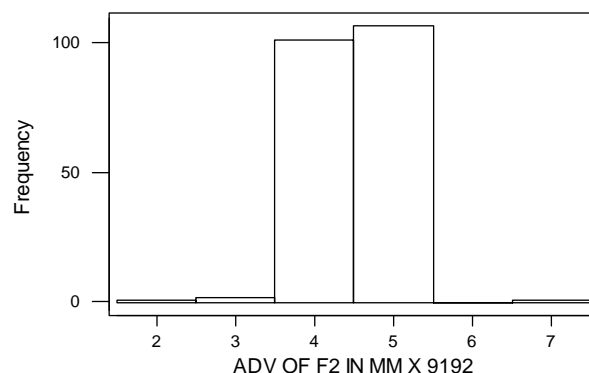


Fig. 2. Frequency distribution alkali digestion value F₂ in Mahsuri Mutant X 9192



(1965) loci governing the trait in the cross with medium X low alkali value parents stated existence of two. This statement is in the tune of this observation, where MM X M (medium X low) cross-exhibited a bimodal curve (Fig. 1). The bimodal curve indicating that one or two loci with several modifiers gene are governing the trait. Similarly, Puri and Siddiq (1980) also reported a bimodal curve in a cross with medium x low. McKenzie and Rutger (1983) also observed bimodal frequency distributions in six different crosses and they described, as mostly gelatinization temperatures seemed to indicate segregation of 1 gene of major effect.

ADV of Mahsuri Mutant X 9192. The segregation of F₂ populations with respect to range, frequency distribution pattern and the direction of transgression showed definite trends depending on the parental value. For instance, in the cross of Mahsuri Mutant X 9192 (Intermediate X Intermediate ADV) the distribution pattern was continuous and unimodal (Fig. 2). In the F₂ generation of the crosses, 1 plants with high ADV and 3 plant with low ADV were observed (Table III). This may have been due to misclassification of a few plants and sampling error. Additionally these phenotypic classes did not fit any of the Mendelian inheritance patterns even at tetragenic level. Chen *et al.* (1992) mentioned that the inheritance of gelatinization temperature is under control of two genes. Two recessive genes control two dominant genes control high gelatinization temperature of variety Hua-ai 837 with complementary effect while the low gelatinization temperature of variety Ai-mei-zao No. 3. They also added that the type of intermediate gelatinization temperature in filial generation is determined by one of two dominant genes and affected by modifying factors. Their observation is totally different compare to the present study and it can be understood that the inheritance of this character appeared to be complex.

CONCLUSIONS

The F₂ sergeants exhibited a bimodal curve in Mahsuri Mutant X Mahsuri cross, which suggested that single pair of major genes might be responsible for this character. In Mahsuri Mutant X 9192, the distribution of F₂ was unimodal

and did not fit any Mendelian inheritance pattern. So this character was identified as complex phenomenon, Puri and Siddiq (1980) also observed this type of observation in the crosses of Basmati type rice.

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