emasculated spikelets of indica/japonica varieties, gave a high seed set. Thus, G39 is a case of female-sterile rice.

The F_1s in two crosses between elite male-sterile restorer lines (japonica type) and G39 showed hybrid vigor and a high seed set, whereas the F_1s in the cross between a Korean elite japonica variety, Junambyeo, and G39 produced normal seeds and showed good performance with desirable agronomic traits. Genetic analysis of the F_2 and BC_1F_1 revealed that inheritance of this female-sterile G39 was sporophytic and controlled by a single recessive gene in nuclear fertile plants (seed set >90%) and complete sterile plants (no seed set) following the ratio 3:1 in the F_2 generation (see table). Except for completely sterile plants, the average spikelet fertility of all fertile plants in the F_2 population of Junambyeo/G39 appeared to be quite normal (93.8%), which was slightly higher than the average spikelet fertility of Junambyeo (90.3%) under field conditions.

Our genetic female-sterile rice line G39 could not produce any seeds through selfing or any other method. Unlike the findings on two recessive genes controlling female-sterile rice (Yokoo 1986) and the quantitative trait in female-sterile alfalfa (Rosellini et al 1998) and soybean (Pereira et al 1997), G39 is genetically different. Currently, those female-sterile plant stocks coded G39 are maintained at the Wild Crop Germplasm Bank, CNR, Yeungnam Univeristy, Korea. These can be used as an important resource for genetic study as well as hybrid breeding in crops.

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Inheritance of a female-sterile gene in G39.

Combination/generation	Count	Plant (no.)		
		Sterile	Fertile	Total
Ansanbyeo/G39 F_2	Observed	35	125	160
	Expected	35.57	122.43	
	Chi-square	0.18	0.05	
Junambyeo/G39 F_2	Observed	23	64	87
	Expected	20.43	66.57	
	Chi-square	0.32	0.10	
Statistics	Total chi-square	0.65 ns		
	P value	0.4191		
	DF	1		

DF = degrees of freedom, ns = not significant.

Aleurone thickness and its relation to patterns of breakage of rice caryopsis during cooking

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When the caryopsis of rice is cooked with aleurone, the aleurone layer acts as a limiting factor for the lateral and vertical expansion of the endosperm. However, the pressure exerted by the components of the endosperm leads to the breakage of the aleurone. We have already reported on three specific patterns of breakage of the aleurone—longitudinal, one-end, and two-end breakage—that occur during cooking (Nadaf and Krishnan 2001). Figure 1 summarizes the percentage of breakage for each pattern in each variety. In this study, efforts were made to determine the reasons for specific patterns of breakage of the aleurone in the caryopsis of rice during cooking, with special reference to longitudinal breakage.

Among the 16 varieties studied, some varieties such as IET13549 and IET15392 recorded 100% longitudinal breakage. Hence, these varieties were chosen for the study to determine reasons for specific longitudinal breakage. The grains of these varieties were unhusked manually and soaked in water for an hour for sectioning. Freehand and microtome sections were stained with Safranin and observed under the microscope. Thickness (diameter) was measured in different regions of the aleurone us-

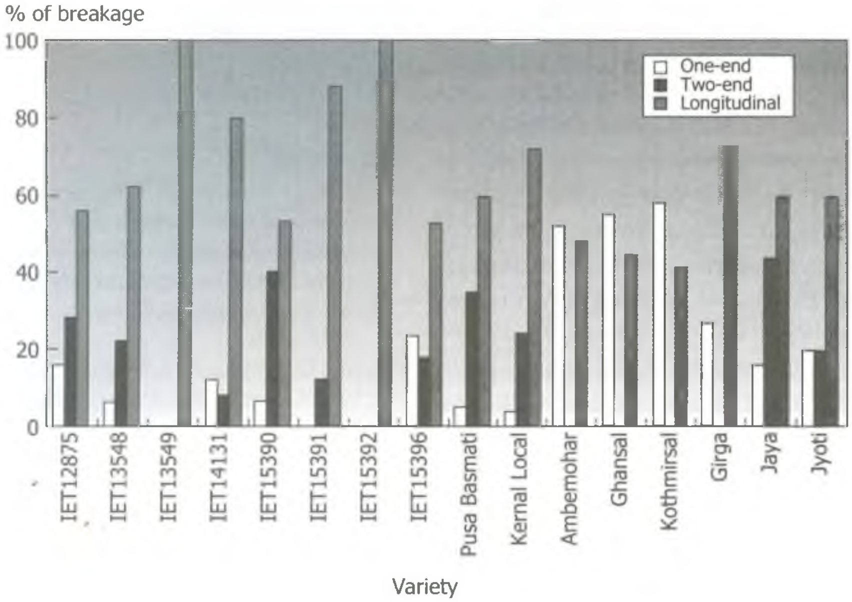

Fig. 1. Percentage of three types of aleurone breakage in different rice varieties after cooking.

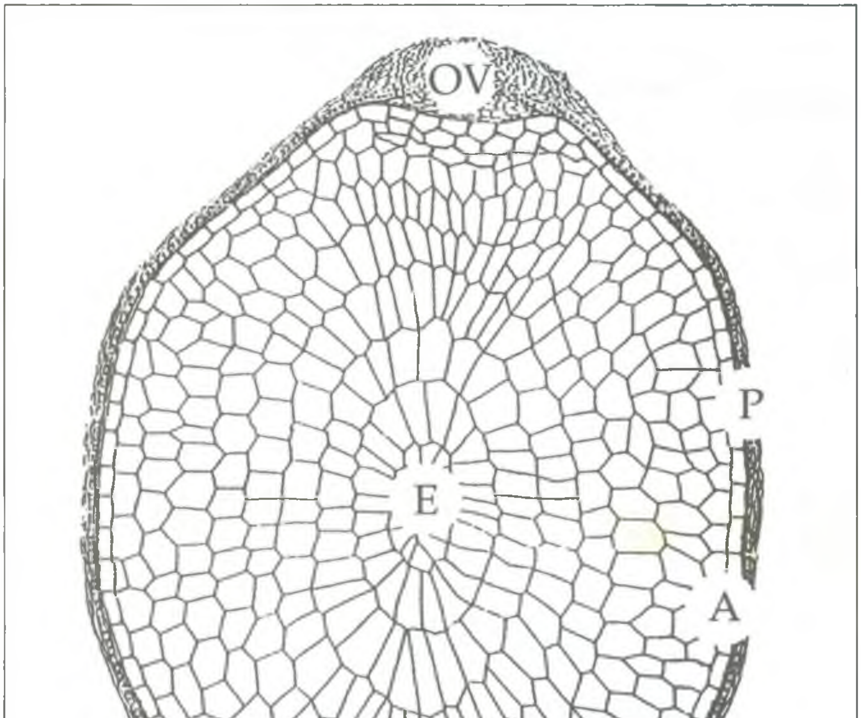

Fig. 2. Schematic diagram of transverse section of the mature caryopsis of rice showing the presence of a thin aleurone on the lateral side (arrow). A = aleurone, E = endosperm, OV = ovular vascular bundle, P = pericarp.

ing a micrometer scale. For the measurement, an average of 25 grains were studied.

IET15392 and IET13549 showed the presence of a distinct thin aleurone region at the lateral side of the caryopsis (Fig. 2). The thin aleurone region of IET15392 recorded an average diameter of 15 mm, whereas IET13549 recorded an average of 13 mm. Measurements made in three other different regions recorded an aleurone thickness from 25 to 38 mm, that is, double the diameter of the thin aleurone region. Thus, the presence of a thin aleurone region on the lateral side of the caryopsis is responsible for the longitudinal breakage of the caryopsis during cooking. It is interesting to note that this is the region where the palea and lemma join. However, the varieties that showed one- or both-end breakage did not show the presence of a thin aleurone region. This indicates that the presence or absence of a thin aleurone region plays an important role in determining the breaking patterns of the rice caryopsis. This study clearly indicates that the thin aleurone region is present only on the lateral side of the rice caryopsis where the palea and lemma join and not on the side opposite the ovular vascular bundle as described by Little and Dawson (1960).

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