

Effect of seedling age and seedling number hill⁻¹ on yield and yield attributes of hybrid rice.

Treatment	Tillers m ⁻² (no.)		Mature panicles m ⁻² (no.)		Filled grains panicle ⁻¹ (no.)		1,000-grain weight (g)		Grain yield (t ha ⁻¹)	
	1998	1999	1998	1999	1998	1999	1998	1999	1998	1999
<i>Cultivar</i>										
Pro-Agro 6201	422	419	332	335	83.2	86.0	21.74	21.64	5.6	5.5
CNRH 3	410	409	319	317	80.0	81.0	21.38	21.41	5.3	5.3
IET4786	345	349	266	268	75.4	76.7	21.16	21.33	4.2	4.1
CD ^a (5%)	9.6	8.7	7.0	6.3	2.38	2.30	0.124	0.112	0.178	0.172
<i>Age of seedling</i>										
21 d old	388	385	300	301	78.8	80.6	21.42	21.40	4.8	4.8
28 d old	402	400	311	312	80.2	82.1	21.44	21.42	5.3	5.1
CD (5%)	7.9	7.1	5.7	5.1	ns	ns	ns	ns	0.145	0.139
<i>Seedling number hill⁻¹</i>										
<i>Hybrid</i>										
1	406	408	318	320	83.3	84.0	21.60	21.50	5.3	5.3
2	424	422	333	332	79.9	83.4	21.52	21.55	5.6	5.5
<i>HYV</i>										
3	345	342	261	265	77.0	75.9	21.02	21.35	4.1	4.1
6	363	356	270	272	73.8	77.5	21.30	21.31	4.4	4.1
CD (5%)	18.5	12.3	10.0	8.9	ns	ns	ns	ns	0.251	0.221

^aCD = coefficient of determination.

other parameters in hybrid cultivars. For the HYV, no significant response was obtained by increasing the number of seedlings from

three to six (see table). Thus, it was concluded that hybrid Pro-Agro 6201 could be grown profitably, replacing IET4786 (HYV)

using 28-d-old seedlings transplanted at two seedlings hill⁻¹. Three seedlings hill⁻¹ were sufficient for growing IET4786.

Effect of cooking on aleurone in the caryopsis of indica rice

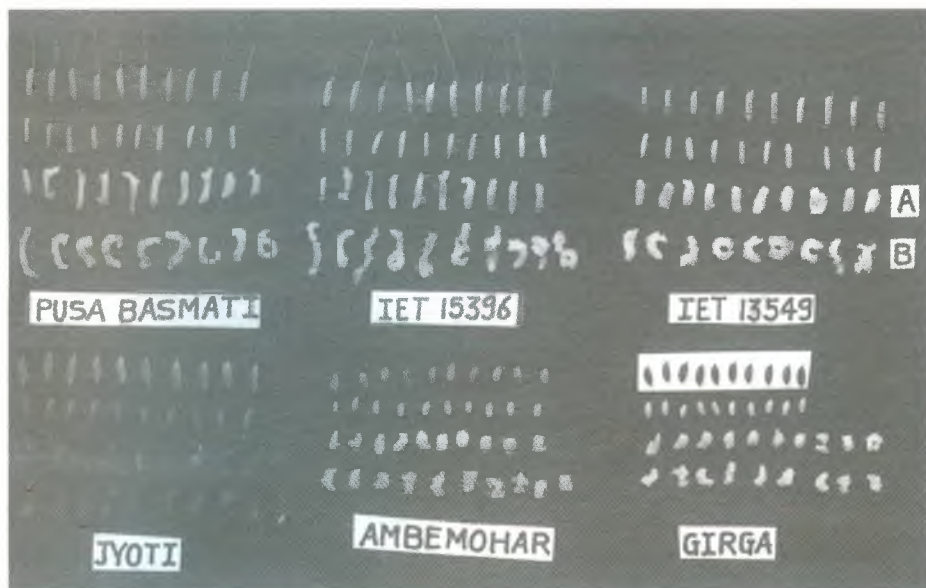
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Aleurone, the principal nourishing layer in the rice grain, consists of one to several layers of uniform, highly differentiated cells (Beteke et al 1997). In cooking, the starchy components in the caryopsis expand both laterally and vertically. This study was undertaken to determine the effect of cooking on aleurone in the rice caryopsis. Local varieties used in this study were long-, medium-, and short-grain types. Rice grains were dehusked manually and cooked in a domestic cooker with excess water, with and without aleurone. To attain a caryopsis without aleurone, the aleurone layer was manually removed. For the measurement, an average of 100 grains was used.

The caryopsis cooked with aleurone showed three specific patterns of aleurone breakage—breakage at one end, breakage at both ends, and longitudinal breakage. Longitudinal breakage was maximum in all varieties, except Ambemohar. Varieties Ghansal and Kothmirsal were followed by IET lines, Pusa Basmati, Kernal Local, Jaya, and Jyoti with one-end breakage. IET15392 and IET13549 recorded 100% longitudinal breakage of aleurone. Local short-grain varieties such as Ambemohar, Ghansal, and Kothmirsal showed maximum breakage at one end. The caryopsis cooked without aleurone showed maximum elongation in all varieties studied (see figure).

The caryopsis cooked with aleurone acted as a limiting factor to the expansion. However, the pressure exerted by the components made the aleurone layer break (see figure).

The table shows that the caryopsis cooked with aleurone, which broke at both ends, had the maximum length, whereas the grain with longitudinal breakage had maximum breadth. Among the varieties studied, IET15396 had the maximum length (2–13 cm), with breakage at two ends; maximum breadth was recorded in Jyoti (0.54 cm), with longitudinal breakage. Data show that longitudinal breakage is directly proportional to grain length.



Different varieties of rice with and without palea and lemma (upper two rows). Rice caryopsis with aleurone (A) and without aleurone (B) after cooking. Note the maximum elongation in the caryopsis cooked without aleurone (B). The aleurone layer acts as a limiting factor that minimizes elongation (A).

Dimensions of cooked grains with and without the aleurone layer in some rice varieties.^a

Variety	Grains with aleurone with breakage at									
	Before cooking		One end		Two ends		Along the furrow		Grains without aleurone	
	Length (cm)	Breadth (cm)	Length (cm)	Breadth (cm)	Length (cm)	Breadth (cm)	Length (cm)	Breadth (cm)	Length (cm)	Breadth (cm)
IET12875	0.74	0.25	1.78	0.42	1.72	0.42	1.04	0.52	1.42	0.53
IET13548	0.70	0.24	1.30	0.40	1.34	0.41	1.01	0.52	1.38	0.51
IET13549	0.72	0.25	—	—	—	—	1.09	0.52	1.26	0.51
IET14131	0.71	0.20	1.30	0.50	1.50	0.40	0.97	0.50	1.33	0.50
IET15390	0.84	0.20	1.40	0.30	1.94	0.39	1.12	0.43	1.92	0.43
IET15391	0.85	0.20	—	—	1.07	0.40	1.12	0.54	1.74	0.42
IET15392	0.92	0.20	—	—	—	—	1.10	0.50	1.71	0.42
IET15396	0.83	0.20	1.82	0.30	2.13	0.30	1.15	0.45	2.37	0.35
Pusa Basmati	0.84	0.20	1.40	0.30	1.66	0.31	1.19	0.38	1.91	0.42
Kernal Local	0.85	0.20	1.40	0.50	1.60	0.35	1.11	0.44	1.55	0.45
Ambemohar	0.48	0.25	1.18	0.37	—	—	0.72	0.52	1.12	0.41
Ghansal	0.49	0.25	0.90	0.41	—	—	0.64	0.48	0.92	0.50
Kothmirsal	0.46	0.25	1.01	0.36	—	—	0.74	0.50	0.82	0.49
Girga	0.45	0.24	0.88	0.32	—	—	0.68	0.47	0.80	0.46
Jaya	0.62	0.25	1.32	0.58	1.43	0.46	1.03	0.52	1.49	0.47
Jyoti	0.67	0.25	1.05	0.40	1.23	0.42	1.01	0.54	1.43	0.45

^a — = not recorded.

Little and Dawson (1960) recorded breakage of the aleurone layer in the ventral side, along the longitudinal fissure. They also found that splitting of bran occurs at irregular points around the surface with no fixed pattern. The study, however, clearly revealed three specific patterns of breakage of aleurone. When longitudinal breakage occurs, it takes place on one lateral side of the caryopsis, where the aleurone is thin and where the lemma and palea join,

and not on the ventral side as shown by Little and Dawson (1960). This study also clearly revealed that the caryopsis cooked without aleurone showed maximum elongation compared with that cooked with aleurone. Thus, the aleurone layer limits both vertical and lateral expansion.

References

- Beteke DC, Schuurink R, Jones RL. 1997. Hormonal signaling in cereal aleurone. *J. Exp. Bot.* 48(312): 1337–1356.

Little RR, Dawson EH. 1960. Histology and histochemistry of raw and cooked rice kernels. *Food Res.* 25:611–622.

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