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BORDER EFFECTS IN RICE EXPERIMENTAL PLOTS. II. VARIETAL COMPETITION

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SUMMARY

Three varieties of rice, selected for their differences in height and tillering ability, were grown side by side in 10-row plots to determine the effect of varietal competition on plot yields. Plants in border rows performed differently from those in the centres of plots, higher-tillering or taller varieties tending to depress the performance of adjacent plants. Comparisons among varieties based on plot yields, determined with and without excluding the border rows, gave different results. Excluding two rows on each side of a plot was sufficient to eliminate the effects of varietal competition on yield data.

The performance of plants along the sides or ends of a plot is often different from the performance of plants in the centre, this phenomenon being called the 'border effects' (Gomez and De Datta, 1971). One cause of border effects is planting different varieties in adjacent plots, which is generally referred to as 'varietal competition'. Yields of small grains are considerably influenced by plants of other varieties growing in adjacent rows (Kiesselbach, 1923; Stadler, 1921). Hartwig *et al.* (1951) concluded from their study on soybeans that varietal comparisons using one-row plots were not accurate, and Wiangco *et al.* (1924) recommended that two rows from each side of small-grain plots should be removed or left unharvested to eliminate the effect of varietal competition.

On the other hand, Love (1919) reported that only slight competition occurs among varieties of small grains, but to eliminate this effect he suggested grouping strains of similar maturity. Similar findings were reported by Springfield (1927) for oats and wheat, by Ross (1958) for grain sorghum, and by Malabuyoc and Escuro (1966) for rice. In any varietal test, relative yields rather than actual yields are most important. Hence, the critical consideration is not whether border effects exist but whether varietal comparisons are affected. We therefore undertook this study to determine the extent of varietal competition and its effects on comparisons between varieties in transplanted lowland rice (*Oryza sativa* L.).

MATERIALS AND METHODS

We planted the varieties IR8 and Peta, and the experimental selection IR127-80-1, which differ in tillering capacity and plant height (Table 1), in two experiments—one without added nitrogen and another with 120 kg./ha. nitrogen added in the form of ammonium sulphate. The experiments, conducted at IRRI in the dry and wet seasons of 1969, each included all possible pairs of the three varieties side by side in plots, at plant spacings of 20 × 20 cm. Each plot contained ten 6-m. rows and no unplanted alley was provided between plots. Grain yield was determined for each row within a plot.

Table 1. *Some agronomic characteristics of three rice varieties grown with and without added nitrogen*

Variety or selection	No added nitrogen: Plant height (cm.)	Tiller (no./m.²)	Maturity (days)	120 kg./ha. added nitrogen: Plant height (cm.)	Tiller (no./m.²)	Maturity (days)
			Dry season (January to May)			
IR8	73	273	130	82	330	130
IR127-80-1	90	193	116	98	215	116
Peta	138	245	139	165	273	138
			Wet season (July to November)			
IR8	88	176	123	96	263	125
IR127-80-1	103	114	119	113	165	119
Peta	159	171	139	—*	—	—

* Data not available due to severe lodging.

Table 2. *Effects of varietal competition on grain yield (averages of 9 replicates in t./ha.) of border rows of three varieties, 1969*

Border variety	Row position	Yield (t./ha.): Dry season: No added nitrogen	Dry season: 120 kg./ha. added nitrogen	Wet season: No added nitrogen	Wet season: 120 kg./ha. added nitrogen
			IR8		
Peta	1	3·36**	4·58**	3·54**	3·18**
	2	3·70	4·88**	3·66*	4·16**
	3	3·74	5·21*	3·92	4·86**
IR127-80-1	1	4·91**	6·33	4·97**	5·91
	2	3·95	5·83	4·47	5·72
	3	3·87	5·93	4·23	5·95
	Centre	4·04	5·89	4·13	5·73
			IR127-80-1		
IR8	1	3·82**	5·50*	4·11	5·69
	2	4·31	6·28	4·09	5·81
	3	4·57	6·14	4·33	5·72
Peta	1	3·46**	4·39**	3·86	4·17**
	2	4·34	5·43*	4·02	4·86**
	3	4·33	5·93	4·17	5·23
	Centre	4·42	6·08	4·11	5·46
			Peta		
IR127-80-1	1	5·88**	7·18**	5·99**	—
	2	4·56	5·66**	4·77**	—
	3	4·35	4·99	4·24	—
IR8	1	4·87	6·88**	4·95**	—
	2	4·80	6·40**	4·42	—
	3	4·29	5·17	4·35	—
	Centre	4·45	4·73	4·11	—

* ** Significant at P = 0·05 and 0·01 respectively.

RESULTS AND DISCUSSION

Yields of individual rows

There were no significant differences in grain yield among the four centre rows of any plot, hence we used the average yield of the four centre rows of each plot as

the control. We designated the three border rows, starting from the outermost row of a plot, as Rows 1, 2, and 3. The performance of plants in the border rows was affected by their variety as well as by the variety of the plants in the adjacent plot.

IR8. Border rows of IR8 (which is short and high-tillering) adjacent to Peta (which is tall and medium-tillering) had lower grain yields than the centre rows (Table 2). In fertilized plots, all three border rows yielded significantly less in both seasons, the greatest reduction occurring in the wet season. In both seasons, the reduction in yield was highest for Row 1, followed by Rows 2 and 3, but the effect was much less pronounced in unfertilized plots. In the dry season, the reduction in yield was significant only in Row 1, while in the wet season it was significant in both Rows 1 and 2. On average border rows of IR8 adjacent to Peta plants yielded 15 per cent less than the control rows in unfertilized plots and 33 per cent less in fertilized plots. Height differences probably accounted for the reduction in yield in IR8 rows bordering Peta. Whereas IR8 did not lodge, Peta lodged in all trials as much as 2 to 4 weeks before IR8 was harvested. In the wet season Peta lodged so severely in the fertilized plots that no data were collected. IR8 border rows produced less because Peta plants shaded them early in the season and lodged into them later in the season. On the other hand, when IR8 plots were bordered by IR127-80-1 (which is medium-short and low-tillering), yields of the outermost rows of IR8 increased, though the effect was significant only in unfertilized plots, and did not reach beyond the outermost row in either season. The increase in yield probably occurred because IR127-80-1 has a low tillering ability and so provided less competition to IR8 plants.

IR127-80-1. In the dry season, grain yields in the outermost rows of IR127-80-1 adjacent to either IR8 or Peta were consistently reduced but the reduction was greater in the outermost row adjacent to Peta. In the wet season, only fertilized plots bordered by Peta suffered significant yield reduction. Peta was both taller and slightly higher-tillering than IR127-80-1, whereas IR8 was shorter but much higher-tillering. Yield reduction of IR127-80-1 plants bordering Peta was greater than that of IR8 bordering Peta. While the height of Peta was the major cause of yield reduction in border rows of IR8, both its greater height and higher tillering capacity suppressed the yield of IR127-80-1.

Peta. The yield of the outermost row of all Peta plots was significantly higher than yield of the centre rows, with an average increase of 25 per cent when the outermost rows were adjacent to IR8 and 43 percent when adjacent to IR127-80-1.

Comparison among varieties

Varietal comparisons based on plot yields, determined with and without border rows, gave different results (Table 3). In the dry season and in fertilized plots, IR8 and IR127-80-1 significantly outyielded Peta when three border rows were excluded, but no significant differences were observed in whole-plot yields. In the wet season, on the other hand, while the three varieties showed comparable yields when the three rows were excluded, Peta significantly outyielded the other two varieties by about 9 per cent when no borders were removed. We observed

no appreciable differences, either in yields of the different varieties or in varietal comparisons, between excluding two rows on each side of the plot and excluding three rows. Excluding two rows was apparently sufficient to eliminate varietal competition.

Table 3. *Grain yields of three rice varieties grown in 10-row plots, with and without borders, 1969*

Season	Added nitrogen (kg./ha.)	Variety or selection	Yield (t./ha.) from plots: Including border rows	Excluding Row 1	Excluding Row 1 & 2	Excluding Row 1, 2 & 3
Dry	0	IR8	3·97a	3·91a	3·96a	4·04a
		IR127-80-1	4·25b	4·40a	4·43b	4·42b
		Peta	4·65c	4·47a	4·40b	4·45b
Dry	120	IR8	4·93a	4·97b	5·06b	5·16b
		IR127-80-1	5·04a	5·26b	5·36b	5·38b
		Peta	4·86a	4·50a	4·24a	4·12a
Wet	0	IR8	4·06a	4·01a	4·02a	4·08a
		IR127-80-1	4·10a	4·13a	4·16a	4·11a
		Peta	4·51b	4·26a	4·20a	4·12a

N.B. Any two variety means under the same condition having at least one common letter are not significantly different at $P = 0{\cdot}05$.

CONCLUSIONS

Plants in border rows adjacent to varieties that differed in height or tillering ability performed differently from those at the centres of plots, higher tillering or taller varieties tending to suppress the performance of adjacent plants. Competition effects due to difference in tillering ability were greater in the dry season and under unfertilized conditions, but the effects never extended further in than the outermost row. On the other hand, when shading or lodging of the taller variety was the major cause of yield reduction of border plants, the effects were greater in the fertilized plots and in the wet season. Even Row 3 was sometimes affected when tall bordering plants lodged severely and fell into the adjacent plots early in the season. Hence, varietal trials on rice should be designed to group varieties that have similar height to minimize border effects.

Comparisons among varieties were inaccurate when plot yields were determined without excluding border rows, but excluding two border rows on each side of the plot was adequate to cope with varietal competition. Exclusion of more border rows may be necessary when adjacent varieties lodge.

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