

Influence of Seedling Age at Transplanting on Rice Performance¹P. A. Sanchez² and N. Larrea L.³

ABSTRACT

With the advent of high-yielding rice (*Oryza sativa* L.) varieties on the coast of Peru, the question arose as to how these short-statured plant types react to delays in transplanting, a common situation in the field because of uncertain water supply. A field experiment conducted in Lambayeque, Peru evaluated two short-statured varieties, 'IR8' and 'IR5,' with the tall, traditional 'Minabir' variety at transplanting dates from 30 to 105 days after seeding and at three seedbed growth rates. IR8 produced the highest grain yield (12.0 tons/ha) when transplanted at 30 days after seeding. Yields decreased linearly at the rate of 125 kg/ha per day of delayed transplanting beyond 30 days. Minabir showed less-pronounced yield decreases up to 75 days after seeding. Slowing seedbed growth of IR8 through water and N stress produced significant yield increases when transplanted at 75 and 90 days after seeding. Delayed transplanting reduced plant height and dry matter production, caused flowering shortly after transplanting in some cases, and decreased panicle production and the number of fertile grains per panicle. Seeding density had no effect on yields. The experiment showed that the short-statured plant types are more sensitive to delays in transplanting than the tall ones, but that the new varieties can outyield the tall varieties when transplanted up to 90 days after seeding.

Additional key words: Plant types, Physiological disturbances, Seedbed management, Seedling density, Variety-cultural practice interactions, Yield components, Panicle abortion.

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THE vast majority of the world's rice (*Oryza sativa* L.) is transplanted. About 75% of the world's transplanted rice area suffers from an unreliable water supply due to variable rainfall or irrigation patterns (2). Since transplanting usually requires puddled and flooded soil conditions, farmers without reliable water supplies are often forced to delay this operation until enough water accumulates on the fields for adequate wet land preparation. In the rainfed-dependent tropics, seedling age at transplanting may vary from 10 to more than 100 days after seeding (10, 11). Most experiment stations, however, recommend transplanting no later than 30 days after seeding (DAS) according to results from controlled irrigation experiments (10). The new short-statured, high-yielding rice varieties have initially spread in areas provided with the best water management (2). As they move toward rainfed or poorly irrigated areas, the possibility of delays in transplanting increases.

Reports from tropical areas indicate that farmers transplant traditional varieties between 45 to 65 DAS in Malaysia (3); from 25 to 45 DAS in the Philippines (4); from 35 to 55 DAS in the lower plains of Indonesia and up to 70 to 100 DAS in the mountain areas (11). In temperate regions such as Japan, Korea, and the Mediterranean, the usual range is from 40 to 60 DAS (7, 9).

The results of several studies conducted in the tropics (1, 3, 4, 5, 8, 11) show that when transplanting is delayed beyond an optimum time, an approximately linear yield decrease occurs. The optimum transplanting time ranged from 25 to 45 DAS. Yield decreases as a function of delayed transplanting were more pronounced in early maturing varieties.

In all experiments the number of days from seeding to harvest (growth duration) increased with delayed transplanting, ranging from 0.36 to 0.88 day per day of delayed transplanting. Yield decreases and growth duration increases were associated with reduction in plant height (3), in tiller production, and increases in grain sterility (8, 11). In some areas of the Philippines, farmers intentionally transplant lodging-susceptible varieties late, claiming that this practice increases yield.

The northern coast of Peru is an area of unreliable water supply, where new, high-yielding varieties such as 'IR8' are rapidly being adapted. Farmers in this region transplant the tall, traditional varieties from 45 to 120 days after seeding (DAS), depending upon increases in river flow the only source of irrigation water. In instances where serious delays are expected, some Peruvian farmers attempt to slow down their seedbed growth through water and N stress, a practice considered beneficial. When old seedlings are transplanted, plant density is increased by increasing the number of seedlings per hill. The purpose of this study was to determine the effects of transplanting age on grain yields for both traditional and improved rice plant types on the northern coast of Peru.

EXPERIMENTAL PROCEDURE

Two experiments were conducted simultaneously at the Tavera Farm of the Lambayeque Agricultural Experiment Station (6° 42'S, 79° 47'W, 24 m above sea level). Its subtropical desert climate is characterized by relatively low temperatures, high solar radiation, negligible rainfall, and low relative humidities. An alluvial clay loam soil with pH 8.3, 1.7% organic matter, 17 ppm extractable P (Olsen), and 100 ppm exch. K, considered representative of the rice-growing areas, was used. The experiments were seeded on Oct. 21, 1969. The monthly temperature, solar radiation, and irrigation water supply data appears in Table 1. Three varieties were studied: IR8, typical of the short-statured plant types with a medium growth duration at Lambayeque; 'IR5,' also a short-statured plant type but with longer growth duration, and 'Minabir 2,' the tall, late-maturing variety most commonly grown in Peru. Varietal performance under these conditions has been described elsewhere (6).

The first experiment compared the three varieties at six transplanting dates (30, 45, 60, 75, 90, and 105 DAS) and three seedbed growth rates. The "slow" growth rate was accomplished by irrigating once every 15 days and omitting N fertilization in order to keep the seedlings alive but with minimum growth. The conventional practice of flooding every 8 days with an application of 100 kg N/ha as urea at 21 DAS was followed to achieve the "normal" growth rate. The "fast" treatment was designed to produce maximum early growth through constant flooding and an application of 200 kg N/ha applied half before planting and half at 21 DAS. The first experiment was arranged in a factorial design with varieties as main plots and seedbed growth rates as subplots with four replications for each transplanting-age treatment. The transplanting density used was six seedlings per hill spaced at 25 by 25 cm.

The second experiment compared the same varieties and transplanting ages at one, three, six, and nine plants/hill at the subplot level with three replications. Seedlings from the "normal" seedbed were used with the same spacing as above.

The puddled seedbeds were prepared in the conventional manner. Pregerminated seeds at the rate of 2,000 kg/ha of dry seed were sown in 10 m² plots on a thin water layer that was maintained for 2 weeks, after which the growth rate differentials were established. Transplanting was carried out on 15 m² plots on puddled soils. A total of 300 kg N/ha as urea was applied in three parts: at 20 days after transplanting, 30 days afterwards, and at panicle initiation. Weeds were effectively controlled and no incidence of pests or diseases was observed. The plots were intermittently flooded, averaging one flooding and drying cycle every 8.5 days. Plant height, tiller counts, and dry matter were determined at 30-day intervals; yields and the conventional yield components were measured at harvest. Grain yields were meas-

Table 1. Monthly weather data at Lambayeque, Peru. Average and 1969-70 cropping season.

Parameter	Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
Mean min-temp, C	27 yr \bar{x}	15.6	16.2	17.8	19.9	21.0	20.8	19.5	18.4	16.0
	1969-70	16.5	17.2	18.6	20.3	20.5	20.4	19.4	17.3	15.5
Mean max-temp, C	27 yr \bar{x}	24.7	26.0	27.8	30.3	31.6	31.4	29.6	27.2	25.1
	1969-70	24.3	25.6	27.0	28.7	29.4	29.4	28.5	25.6	22.9
Solar radiation*	5 yr \bar{x}	481	484	503	487	498	483	456	405	365
	1969-70	476	470	547	472	513	533	490	397	376
Irrigation water supply†	46 yr \bar{x}	15.9	16.7	18.0	25.0	44.4	67.8	70.5	39.0	20.4
	1969-70	18.4	30.3	52.0	40.6	23.0	44.4	48.9	76.4	27.3

* g-cal/cm²/day.

† river flow in m³/sec.

Table 2. Effects of seedbed growth rates on the duration of the vegetative phase in the seedbed prior to transplanting (number of days from seeding to panicle primordium initiation).

Varieties	Direct seeded control	Seedbed growth rate			Mean
		Slow	Normal	Fast	
IR8	102	104	102	85	98
IR5	107	113	104	90	103
Minabir	125	130	126	122	126
Mean	111	116	111	99	

ured from a 5 m² central area devoid of border effects and adjusted to 14% moisture.

In addition, a direct-seeded control was established in an adjacent plot and was seeded the same day. The three varieties were replicated four times at a seeding density of 90 kg/ha in 25-cm rows. Other management practices were identical to those of the transplanted plots.

RESULTS

Seedbed Growth Rates. Figure 1 shows plant height increases with time in the IR8, IR5, and Minabir seedbeds. The differences in growth rates as reflected by plant height for the slow, normal, and fast treatments in each variety were highly significant both for main effects and interactions. The almost latent nature of the slow growth rates is clearly shown; the height attained by IR8 at the latest transplanting date (105 DAS) by this treatment was inferior to that of the fast treatment at 30 DAS.

Seedbed growth rates also had a substantial effect on the duration of the vegetative phase (seeding to panicle initiation). Table 2 shows that panicle initiation was delayed by an average of 17 days in the slow treatment in relation to the fast. Both IR8 and IR5 fast treatments were at the reproductive stage when transplanted at 90 days and all the IR8 and IR5 treatments, except slow, had panicle initiation underway when transplanted at 105 days. Minabir 2, a late maturing variety, remained in the vegetative phase up to 122 days. The direct-seeded control plots approached the normal seedbeds in their time of panicle initiation.

Growth Pattern. Growth abnormalities were observed in IR8 when transplanted at 75 DAS or more and in IR5 at 90 and 105 DAS. The plants flowered shortly after transplanting, producing a small panicle. This is locally known as panicle abortion. Stimulated by N fertilization, they began to tiller afterwards, producing a second, ratoon-type flowering. These panicles account for most of the grain yields reported, since the original panicle had overmatured and shattered weeks before harvesting. The late-maturing variety Minabir 2 did not show any panicle abortion throughout the experiment.

The beneficial effect of the slow seedbed growth rate in IR8 transplanted at 75 and 90 DAS is asso-

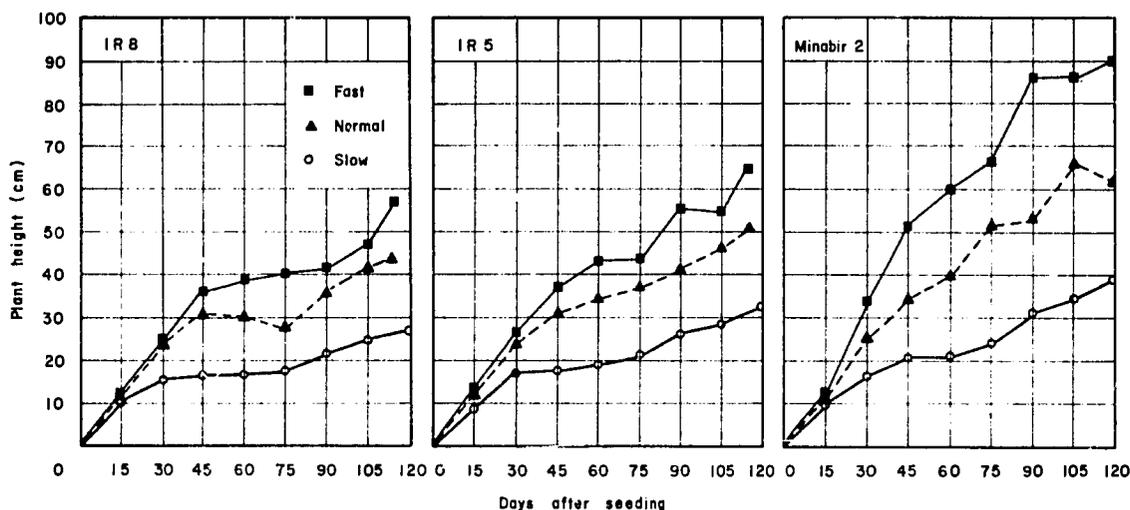


Fig. 1. Seedbed growth of the three varieties as affected by seedbed management.

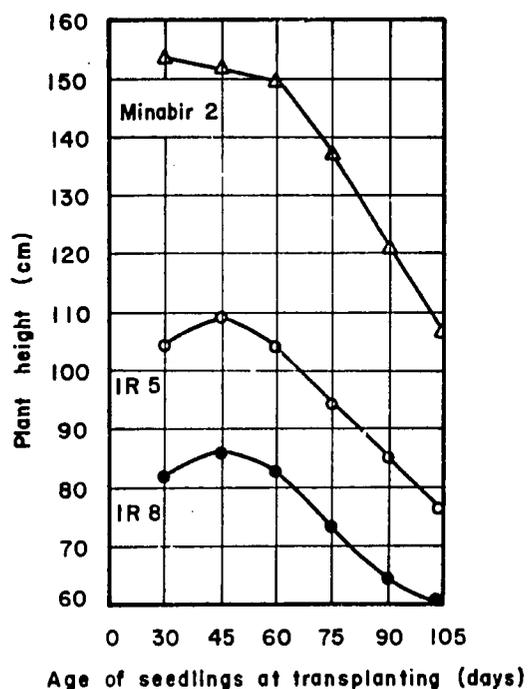


Fig. 2. Effects of age of seedlings at transplanting on plant height at harvest.

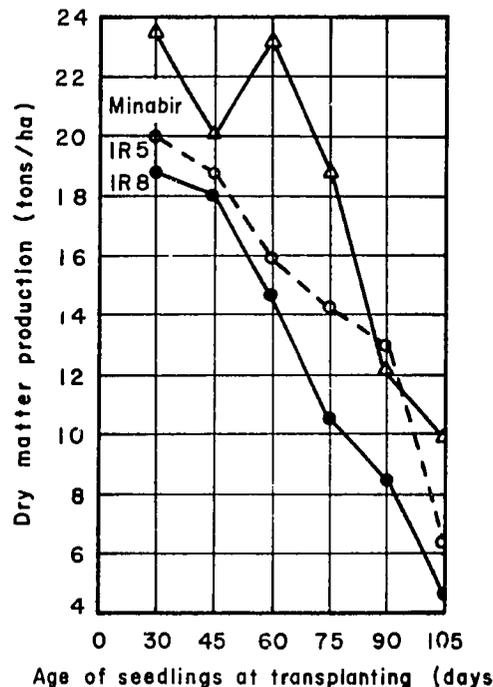


Fig. 3. Effects of age of seedlings at transplanting on total dry matter production at harvest.

ciated with a height at transplanting of 18 and 21 cm shorter than the fast treatment, delayed tillering and a physiological delay of 19 days in reaching the panicle initiation stage. These smaller seedlings recovered quickly after transplanting, had fewer aborted panicles, and produced more tillers and panicles of normal size. Since the erratic flowering pattern of these treatments made it impossible to obtain adequate samples for growth characteristics and yield components, the rest of this discussion will be limited to varietal effects only.

The influence of transplanting age on plant height at harvest (Fig. 2) was nil up to 60 DAS, but caused a rapid height decrease afterwards. The only lodging-susceptible variety in this study, Minabir, did not lodge when transplanted beyond 75 DAS. Total dry matter

production (Fig. 3) decreased rapidly with transplanting delays, but grain:straw ratios remained relatively constant.

Growth Duration. The time from seeding to maturity for IR8, IR5, and Minabir 2 averaged 176, 186, and 212 days, respectively, when transplanted at 30 DAS (Fig. 4). The direct-seeded control produced almost identical results. Growth duration beyond 30 DAS increased linearly at the rates of 0.75, 0.68, and 0.52 days per day of delayed transplanting for IR8, IR5, and Minabir 2, showing that greater delays were observed in the earlier-maturing varieties.

Seedbed management also influenced the number of days from seeding to 50% flowering. The slow treatment delayed flowering by an average of 11, 6, and 4 days in relation to fast treatment in IR8, IR5, and

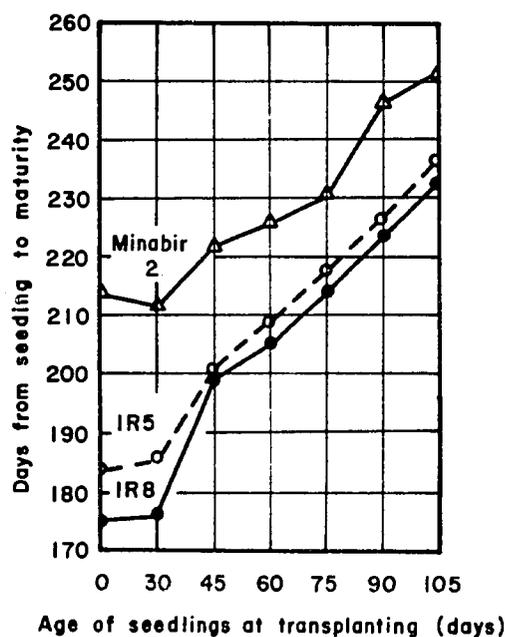


Fig. 4. Effects of age of seedlings at transplanting on the growth duration of three rice varieties (direct-seeded control plotted as 0 days).

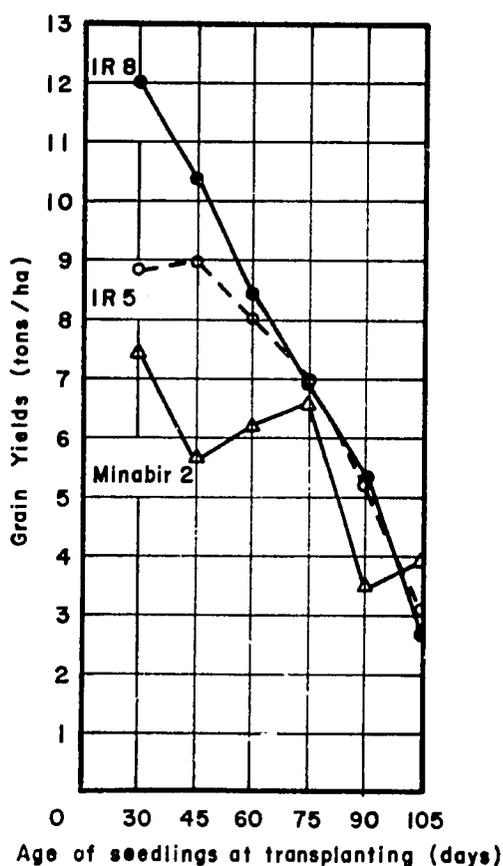


Fig. 5. Effects of age of seedlings at transplanting on the grain yield of three rice varieties. (Mean of seedbed growth rates.) LSD₀₅ for interaction: 560 kg/ha.

Minabir 2, respectively. Effects of seedbed management, therefore, were also more pronounced in the earliest-maturing variety.

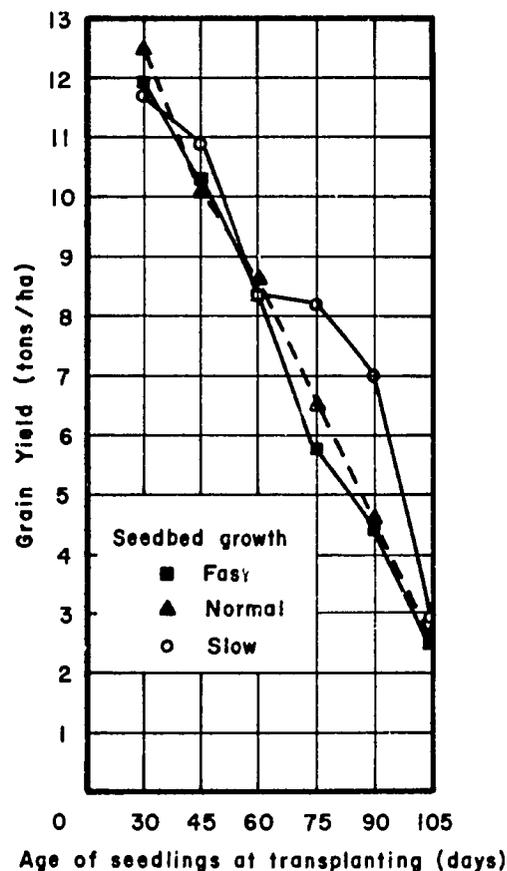


Fig. 6. IR8 yield response to transplanting age and seedbed growth rates.

Grain Yields. Figure 5 shows the main varietal effects of transplanting dates. IR8 produced the highest average yield of 12 tons/ha when transplanted at 30 days after seeding. Afterwards, yields decreased linearly at the rate of 125 kg/ha per day of delayed transplanting beyond 30 DAS. IR5 showed no yield differences between 30 and 45 DAS but suffered a similar linear decline afterwards with an approximate slope of 100 kg/ha per day. Minabir 2 showed a nonlinear but gradually decreasing pattern in which the maximum yield was obtained at 30 DAS (7.45 tons/ha), but was not drastically different from that obtained at 75 DAS (6.62 tons/ha). Both main effects and interactions resulted highly significant. The coefficient of variability was 10.87%. In spite of the dramatic yield decreases of IR8 and IR5 due to transplanting beyond their optimum transplanting dates, these varieties outyielded Minabir 2 at all but the last date.

The direct-seeded, adjacent experiment yielded 10.47, 8.58, and 5.73 tons/ha for IR8, IR5, and Minabir 2, respectively, closely resembling the yield levels obtained when transplanted at 45 DAS.

The effects of seedbed management on grain yields are shown in Fig. 6 for IR8. No significant differences between the normal and fast seedbed treatments were observed. The slow treatment significantly outyielded the other two by about 2 tons/ha when it was transplanted at 75 and 90 DAS, showing a clearly beneficial effect of delayed growth for late transplanting in this variety. Seedbed growth rates, however, had no significant effects on yields in IR5 and Minabir 2,

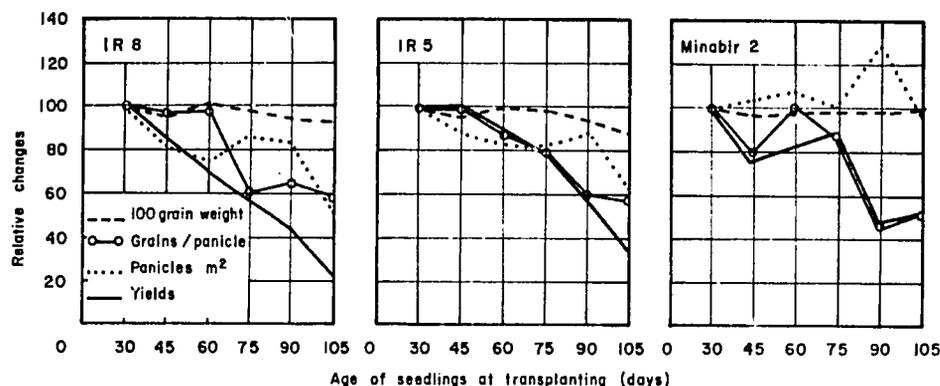


Fig. 7. Relative changes in yields and yield components as affected by age of seedlings at transplanting.

except for a significantly higher yield of the IR5 slow treatment when transplanted at 90 DAS.

The IR8 normal seedbed treatment when transplanted at 30 DAS averaged 12.5 tons/ha and one of its replicates yielded 13.5 tons/ha. These figures represent the highest treatment mean and single plot yields recorded in Peru so far at 14% moisture without border effects.

Yield Components. The influence of transplanting age on the three yield components is illustrated in Fig. 7. The IR8 yield decreases caused by delays of transplanting from 30 to 60 DAS were associated with a decrease in the number of panicles/hill from 31.6 to 23.6, while the number of filled grains per panicle and the 100 grain weight remained stable. From 60 to 75 DAS the number of grains/panicle dropped from 90 to 45 and remained stable afterwards. The sharp yield drop from 90 to 105 DAS is associated with a decrease from 26.3 to 15.8 panicles/hill. The 100 grain weight decreased very slightly with transplanting age. Grain sterility (not shown) increased from 10 to 20%. IR5 yield decreases are intimately associated with the number of filled grains per panicle. Panicle production remained stable until 90 DAS and decreased sharply thereafter. Grain sterility increased slightly from 19 to 24%. The Minabir 2 yield curve is also closely associated with the number of filled grains per panicle. Its sharp decrease after 60 DAS is related to a sharp increase in grain sterility, from 17 to 52%, probably caused by flowering at lower temperatures. Therefore, yield decreases due to delayed transplanting are associated with decreases in both panicle production and filled grains per panicle while the 100 grain weight decreased very slightly.

Effects of Seedling Density. The results of the parallel experiment in which the effect of seedling density within the range of one to nine seedlings per hill was evaluated showed no effect of this variable on yields.

DISCUSSION AND CONCLUSIONS

These results show that the detrimental effects of delaying transplanting vary widely with varieties of contrasting plant type and growth duration. Seedling age and physiological age at transplanting were more related with yields than seedling height. The tall-statured, late-maturing Minabir 2 variety was less

severely affected by delaying transplanting up to 75 days after seeding. The decrease in plant height with increasing transplanting age reduces the dangers of lodging damage in tall-statured varieties. This might be an additional reason why some farmers intentionally delay transplanting tall varieties.

In contrast, the short-statured plant types are more sensitive to transplanting delays. The high yield levels attained by IR8 when transplanted early show the remarkable yield potential of short-statured plant types with proper management under climatic conditions considered "almost ideal" for rice growth (6). The highly beneficial effect of slowing seedbed growth rates when these varieties were transplanted at 75 and 90 days after seeding is clearly shown with IR8 yields of 8 and 7 metric tons/ha. The absence of effects of the number of seedlings per hill in the second experiment indicates that the hill acts as a physiological unit even under these extreme conditions.

These experiments do not show whether varietal responses to this cultural practice are related to plant types or growth duration *per se*. They do show that more precise transplanting timing is needed to obtain the maximum yield potential of varieties like IR8, but these varieties are sturdy enough to outyield the traditional types when delays do occur. The lower air temperature regime at Lambayeque does not permit these results to be extrapolated to warmer areas. Similar experiments conducted at high temperatures in the Amazon Basin (E. Ramos, Programa Nacional de Arroz, unpublished data) show that IR varieties suffer even sharper yield losses with delaying transplanting than at Lambayeque, while tall varieties are more elastic in their response and sometimes yield better at 60 days after seeding due to less lodging than at earlier dates.

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