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Missing Hills in Rice Experimental Plots[1]

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ABSTRACT

The effects of missing hills on the performance of the surrounding plants were investigated in a series of rice (*Oryza sativa* L.) field experiments under several conditions. Plants immediately adjacent to a missing hill were found to have significantly more panicles and higher yield than plants surrounded by living hills. The magnitude of the increase, however, varied with variety, plant spacing, fertility level, crop season, and the number and the distribution of missing hills. The stand correction method is therefore not applicable to rice. To determine yields of plots wtih missing hills, only fully competitive plants should be harvested.

Additional index words: **Stand correction procedure, Yield compensation, Competitive plants, *Oryza sativa* L.**

MISSING hills are not uncommon in rice (*Oryza sativa* L.) experimental plots, even in experiments where planting and management are carefully done.

Two different methods are often used to adjust yields for missing hills in experimental plots. One is to assume that the yield of a missing hill is exactly the same as the average yield of the living hills in the plot and to adjust the plot yield accordingly. For example, if 100 hills are to be harvested from each plot, the grain yield of the plot with one missing hill is computed as:

Grain weight of 99 hills harvested $\times$ (100/99)

With the other method the researcher ignores the presence of missing hills and determines plot yield solely on the basis of area harvested.

The first procedure assumes that the presence of one or more missing hills does not affect the performance of the neighboring plants. The second assumes that the yield of a missing hill is totally compensated for by the increase in yield of the surrounding hills. Due to lack of competition from the vacant hill for soil moisture, light, nutrients, etc., it is logical to expect some increase in the yields of adjacent hills. Whether the increase totally compensates for the loss in yield due to the missing hill is unknown.

The effects of missing hills have been studied for various crops. No study has so far been reported on the effects of missing hills in rice experimental plots.

For potato (*Solanum tuberosum*), Stewart (8) reported that the increase in yields of adjoining plants compensated for part of the loss due to missing hills. To correct the yield for full stand, it is necessary to know not only the number of missing hills, but also the number of skips (a skip is a series of consecutive missing hills). He also stated that the correction factor needed probably varies with the variety, the distance between hills, the character and fertility of the soil, and the cultural and weather conditions.

The same opinion was expressed by Arceneaux and Stokes (1), who developed a formula for adjusting for gaps in sugarcane (*Saccharum officinarum*) stands with the yield reduction factor applicable to the specific conditions. Brewbaker and Immer (2) found that in a yield test on corn (*Zea mays* L.) a sizable experimental error was introduced by missing plants. Olson (7) reported a case in which corn yield was reduced in almost exactly the same ratio as the reduction in stand. He concluded that a 100% correction for stand in such cases is fully justified to bring the yield to a comparable basis. Corn breeders (3, 6) use a correction that assumes that the yield of hills surrounding a missing one increases somewhat.

On the other hand, Kiesselbach (4) suggested harvesting the same number of fully competitive hills from each plot for more precise comparisons. According to LeClerg (5), adjustments for differences in stand are seldom made for small grains, grasses, and small-seeded legumes since plots of these crops contain large plant populations.

In order to evolve procedures for coping up with missing hills in rice experimental plots, this paper aims to evaluate the effects of various types and numbers of missing hills on the growth and grain yield of adjacent plants.

MATERIALS AND METHODS

Two sets of experiments were conducted in 1969-1970 crop seasons at the IRRI experimental farm. Each set was tested in both the dry and the wet seasons. In the first set the selection IR480-5-9 was planted in both fertilized (application of ammonium sulphate at 120 kg/ha N) and unfertilized plots. Each plot had nine rows 4 m long and 25 cm apart. Plants in a row were 20 cm apart. Seven missing-hill patterns involving one to three missing hills (Table 1) were evaluated. A randomized complete block design with four replicates was used. The missing hills were established 2 weeks after transplanting in the center row of each test plot.

IR22 and IR127-80-1, which differ in tillering capacity, were used in the second set of experiments, in which only one missing hill was evaluated. There were 36 replicates for unfertilized plots and 72 replicates for fertilized (120 kg/ha N) plots. A plant spacing of 26 by 25 cm was used.

Data on grain yield and panicle number were collected for several hill positions around the missing hill or hills. In each plot four normal hills, each completely surrounded by living hills, served as control.

RESULTS AND DISCUSSION

The results from the first set of experiments consistently showed significant yield and panicle increase on all hills immediately adjacent to one or more missing hills (Table 1). Aside from the immediately adjacent hills, no other plants were significantly affected.

For the same numbers of missing hills, the effect on grain yield varied considerably with the distribution of these hills. Two factors responsible for the differences are (i) the total number of hills immediately adjacent to the missing hills and (ii) the magnitude of increase in yield of each adjacent hill. With two missing hills, for instance, four types of distribution were evaluated, namely, T_2, with the two missing hills adjacent to one another, and T_3, T_4, and T_5, with the two missing

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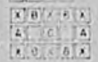
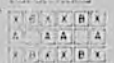
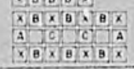
Table 1. Average* percentage increase in grain yield and panicle number of IR480-5-9 plants adjacent to the missing hills, as compared to the normal hills. IRRI, 1969.

Pattern of missing hills†		Hill position	Number of surrounding hills	Percentage increase: Grain yield	Percentage increase: Panicle number
T_1		A	2	24	30
		B	2	41	44
T_2		A	2	45	44
		B	4	34	33
T_3		A	2	39	30
		B	4	39	31
		C	1	98	52
T_4		A	4	42	27
		B	4	41	30
T_5		A	4	29	29
		B	4	40	40
T_6		A	2	38	41
		B	6	27	23
T_7		A	2	28	36
		B	6	26	32
		C	2	48	50

* Over 2 crop seasons and under 2 fertilizer levels. † Rows run horizontally—25 cm spacing between rows and 20 cm between hills within row. ☐ = Missing hill. [A] [B] and [C] = Measured hills. [x] Unmeasured living hill.

hills separated by one, two, and three living hills, respectviely. Thus, T_2 had six hills surrounding the missing hill, T_3 had seven, and T_4 and T_5 had eight. Moreover, the hill between two missing hills (hill C) gave a much larger yield increase than either hill A or hill B, each of which had only one side adjacent to a missing hill. Hence, the degree of yield compensation increased from T_2 to T_4, while yield compensation in T_4 and T_5 was about the same. A similar result was observed in T_6 and T_7, which involved three missing hills. In other words, the compensation resulting from the yield increase in plants surrounding the missing hills can be expected to be less when the missing hills are all adjacent to one another than when they are not.

The second set of experiments involving one missing hill confirmed the previous finding that all hills immediately adjacent to the missing hill had higher grain yields and more panicles than the normal hills (Table 2). The percentage increase, however, varied with variety, N level, and crop season.

The percentage increase in panicle number was much greater for the higher tillering variety, IR22, than for the lower tillering selection, IR127-80-1. A similar trend was observed in grain yield, although the differential effect was slightly less than in panicle number. With IR22, except for the fertilized plots in the wet season, the loss in yield caused by the presence of a missing hill was more than totally compensated for. This was not so in any plots of IR127-80-1.

The percentage increase in yield was much lower in the fertilized plots than in the unfertilized plots in the wet season. In the dry season no such difference was observed. Furthermore, the increase in yield was greater in the dry season than in the wet season, especially for IR22, probably because rice plants can utilize the additional nutrients provided for by the vacant hill better under the higher solar radiation of the dry season.

Of the four hills immediately adjacent to the missing hill, the two in the same row as and 20 cm away from the missing hill (position A) were affected more than the two located in the opposite row and 25 cm apart (position B). This result indicates the importance of plant spacing in the determination of the effects of a missing hill. No significant effects were observed in any other hill position measured.

Table 2. Average* percentage increase in grain yield and panicle number of hills surrounding a missing hill, for two varieties, under two fertilizer levels, and for two crop seasons.

Crop season	Hill position†	IR22: 0 kg/ha N	IR22: 120 kg/ha N	IR127-80-1: 0 kg/ha N	IR127-80-1: 120 kg/ha N
		Grain yield			
Dry	A	39**	40**	17**	26**
	B	23**	22**	19**	19**
Wet	A	29**	18**	28**	21**
	B	25**	8	19**	10
		Panicle number			
Dry	A	27**	30**	9	18**
	B	15**	12**	4	3
Wet	A	30**	24**	16**	14**
	B	21**	16**	15**	8**

* 36 replicates for unfertilized plots and 72 replicates for fertilized plots.
† See T_1 of Table 1. ** Significant at 1% level of probability.

CONCLUSIONS

Plants in hills immediately adjacent to a missing hill had more panicles and produced higher grain yield than plants in normal hills. No other hills were appreciably affected. The increases, however, varied with variety, plant spacing, fertilizer level, and crop season. The percentage increase caused by missing hills was greater in high tillering varieties, close spacings, and dry-season plantings. Application of fertilizer accentuated the effect of the missing hill in the dry season, but not in the wet season.

A stand-correction procedure, to be useful, should have a wide applicability. At best, the procedure should be appropriate under all experimental conditions, and at the very least, it should be sufficiently general to be applicable under all conditions in any one experiment. Since the effect of a missing hill was shown to be influenced by all the factors tested and since at least one of these factors is varying in most rice experiments, we believe that no procedure employing a correction factor should be used to correct plot yields for the presence of missing hills in rice field experiments. Instead, all plants immediately adjacent to a missing hill should be excluded from harvest for yield determination and from the measurement of other agronomic characters.

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