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EFFECT OF PLANT DENSITY ON GRAIN YIELD AND YIELD COMPONENTS OF DIFFERENT VARIETIES AND MUTANT STRAINS OF RICE*

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Abstract

The spacings of 15 x 15cm, 20 x 20cm and 25 x 25cm between hills and rows were compared for their effect on grain yield and yield components of two standard varieties IR6 and IR8, and two mutant strains IR6-18 and IR8-5 of rice. These varieties and mutant strains possessed similar yield potential, while the increased spacing had positive linear effect on plant growth that resulted in significant increase in the number of panicles, 100 grain weight, and grain yield per hill. The 20 x 20cm spacing gave significantly higher grain yield per plot than the other two spacings and was, therefore, most suitable for obtaining maximum yields.

Introduction

Plant density is an important agronomic factor that greatly influences the microclimate of the field and eventually the yield of agricultural crops. The crop plants depend largely on the temperature, solar radiation, moisture and soil fertility for their growth and nutritional requirements. A thickly populated crop may have limitations in the optimum availability of these factors. It is therefore necessary to determine the optimum density of plant population per unit area for obtaining maximum yields. The present studies were undertaken to determine the optimum plant density for two rice varieties and two mutant strains that were developed from these varieties at this Centre.

Materials and Methods

Two standard varieties of rice (*Oryza sativa* L.) i.e. IR6 and IR8, and two promising mutant strains i.e. IR6-18 and IR8-5, that were developed from these varieties were taken for these studies which were conducted at the fields of the Atomic Energy Agricultural Research Centre, Tando Jam, in the year 1981. Both the varieties and the mutant strains possess high yield potential, have medium duration of growth, maturing within

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130 to 140 days from seeding, and are semi-dwarf in plant height, ranging from 100 to 110 cm at maturity. The grain quality of the mutant strains IR6-18 and IR8-5 is better than that of the parent varieties IR6 and IR8. The seeds were sown on 28 May for raising nursery, and the transplanting was done on 5 July, 1981. In order to have various plant densities, three different spacings i.e. 15 x 15cm, 20 x 20cm and 25 x 25cm between hills and rows were tested for their effect on grain yield and yield components.

The layout of the trial was of split plot design with four replications having varieties as main plots. The area of each plot was 3x3 meters. Five week old seedlings were transplanted with an average of three seedlings per hill in the square method of planting. The fertilizer was applied at the rate of 140N kg/ha in two equally split doses in the form of urea, and 70P kg/ha in single dose in the form of triple superphosphate. The basal dose of 70N and 70P kg/ha of the first application of fertilizer was done at the time of transplanting, while the remaining quantity of 70N kg/ha was applied as top dressing, forty days after transplanting. Standard cultural practices were carried out till the crop matured. Five hills per plot were taken at random for detailed studies of plant characters. The data on paddy yield per plot and yield components i.e. paddy yield of plants per hill, number of panicles per hill, and 100 grain weight of the rice varieties and mutant strains were recorded after the crop was harvested.

Table 1. Analysis of variance for yield and yield components of rice varieties.

Source of variation	D.F.	Mean sum of squares			
		No. of panicles per hill	100 grain weight (g)	Grain yield per hill (g)	Grain yield per plot (kg)
Replicates	3	2.2433	0.009739	5.7025	0.296919*
Varieties	3	3.3900	0.190317**	4.8547	0.176197
Error I	9	3.3100	0.003119	1.9403	0.046102
Spacings	2	203.4408**	0.071502**	975.7200**	0.715994**
VxS interaction	6	1.9308	0.006135	4.4165	0.110464
Error II	24	1.1017	0.004505	1.9134	0.083213

* Significant at 5% level of probability.
** Significant at 1% level of probability.

Table 2. Varietal performance of yield and yield components of rice varieties.

Varieties/ mutant strains	Number of panicles per hill*	100 grain weight* (g)	Grain yield per hill* (g)	Grain yield per plot* (kg)
IR6	12.18	2.46 b	15.90	3.46
IR6-18	13.25	2.49 b	17.13	3.73
IR8	13.35	2.72 a	17.33	3.71
IR8-5	13.05	2.46 b	16.65	3.61
LSD-1	NS	0.05	NS	NS
LSD-2		0.07		

* Means followed by different letters in the same column are significantly different from each other at 1% level of significance.
NS = Not significant.

Results and Discussion

The data on yield and yield components obtained from the trial were analysed statistically and the results are given in Table 1. The analysis of variance resolved the yield performance of the varieties and the mutant strains as well as the interactions between the sources of variation. The varietal performance, averaged over spacings and replicates, is presented in Table 2. The performance of varieties with respect to number of panicles, grain yield per hill and grain yield per plot was not significantly different. However, IR6-18 gave highest yield of 3.73 kg, while the yield of its parent IR6 was 3.46 kg per plot. The seed index viz., 100 grain weight of IR8 was significantly ($P \geqslant 0.01$) higher (2.72 g) than the other three genotypes in the group, where seed index was 2.46 g for IR6, 2.49 g for IR6-18 and 2.46 g for IR8-5. These results confirmed our previous studies where these genotypes gave statistically similar yields in field trials for two consecutive years at two different locations (Bari *et al.*, 1981).

The effect of spacings, averaged over varieties and replicates is presented in Table 3. The increased plant spacing had positive linear effect on plant morphology and caused significant ($P \geqslant 0.01$) increase in the number of panicles, 100 grain weight, and grain yield per hill. The effect on grain yield per plot was also highly significant ($P \geqslant 0.01$)

but it was not linear. The spacing of 20x20cm gave significantly higher yield of 3.87 kg per plot, while the spacings of 15 x 15cm and 25 x 25cm yielded 3.49 kg and 3.52 kg per plot respectively. The linearly increasing significant effect of plant spacings on plant characters showed that wider spacing was better for the performance of individual plants. The reason of deviation of this linearity in case of grain yield per plot is that the yield does not entirely depend upon the performance of individual plants, but also on the total number of plants per plot.

The effect of spacing on each variety is presented in Table 4. From this table and Table 1 of the analysis of variance, it is concluded that the effect of different spacings on yield as well as yield components is similar on both the varieties and their mutants. There is no significant interaction between varieties and spacings. The effects of spacing within varieties are, therefore, not different from average spacing effects discussed earlier.

These results lead to the conclusion that the plants grown with wider spacing had more area of land around them to draw their nutrition and had more solar radiation to absorb for better photosynthetic process, and had therefore performed better as individual plants. Eunus & Sadeque (1974) also found that the number of panicles per plant and straw yield increased with increased plant spacing in transplanted rice. Shahi *et al.*, (1976) studied the effect of spacings of 20x20cm, 20x15cm and 15x15cm on the paddy

Table 3. Effect of different spacings on yield and yield components of rice varieties.

Spacing between hills and rows (cm)	Number of hills per plot	Number of panicles per hill*	100 grain weight* (g)	Grain yield per hill* (g)	Grain yield per plot* (kg)
15 x 15	400	9.01 c	2.46 b	8.72 c	3.49 b
20 x 20	225	13.91 b	2.55 a	17.21 b	3.87 a
25 x 25	144	15.95 a	2.95 a	24.32 a	3.52 b
LSD-1		0.76	0.05	1.01	0.21
LSD-2		1.04	0.07	1.37	0.29

* Means followed by different letters in the same column are significantly different from each other at 1% level of significance.

Table 4. Effect of spacing on yield and yield component within varities and mutant strains of rice.

Varieties/ mutant strains	Spacings	No. of panicles per hill	100 grain weight (g)	Grain yield per hill (g)	Grain yield per plot (kg)
	15x15	8.30	2.43	8.21	3.30
IR6	20x20	12.95	2.48	17.33	3.90
	25x25	15.30	2.47	22.16	3.19
	15x15	10.30	2.41	9.05	3.62
IR6-18	20x20	13.60	2.51	17.17	3.86
	25x25	15.85	2.56	25.16	3.70
	15x15	8.70	2.61	8.97	3.59
IR8	20x20	14.50	2.74	16.77	3.77
	25x25	16.85	2.83	26.25	3.78
	15x15	8.75	2.40	8.66	3.46
IR8-5	20x20	14.60	2.46	17.57	3.95
	25x25	15.80	2.53	23.72	3.42

yield of dwarf rice variety Jaya. Although they did not find significant differences in the yields, yet the yields in case of 20x20cm spacing tended to be higher than that of the other two spacings. Chandrakar & Khan (1981) studied the effect of spacings of 10x10cm, 15x10cm and 20x10cm on the grain yield of early, medium, and late duration tall growing indica varieties of rice, and found that the spacing of 20x10cm gave the highest yields for medium and late varieties, while the spacing of 10x10cm gave higher yield in case of early maturing varieties.

Thangamuthu & Subramanian (1983) studied the effect of plant population on the grain yield of rice variety Co 43 planted at the spacings of 15x10cm, 15x20cm, 22.5x20cm, and 30x20cm between hills with the corresponding plant population of 66, 33, 22 and 16 hills/m^2. The results indicated that the spacings of 15x20cm and 22.5x20cm gave higher yields per unit area than the narrower and the wider spacings. Singh *et al.*, (1983) studied the effect of row spacing and nutrient supply on grain yield of a semi-dwarf variety Narendra 1(IET 2232) of upland rice. The crop was grown by direct seeding in rows at three spacings of 15, 20, and 25cm with nitrogen levels of 0, 40, and 80 kg/ha. The grain yield increased sharply with increased nitrogen, and the 20cm spacing between rows produced maximum grain yields at 40 and 80 kg N/ha.

The grain yield per unit area depends evidently on the performance of individual plants as well as the total number of plants grown on that area. In the present studies, although the performance of individual plants grown with wider spacing was better as compared to the plants with narrower spacing, the total plant population per unit area in that case was less than that of narrower spacing. A balance has, therefore, to be sought between the performance of individual plants and the plant density per unit area for obtaining optimum crop yields. In the studies reported here, the number of hills per plot was 400 in 15x15cm spacing, 225 in 20x20cm spacing and 144 in case of 25x25cm spacing, and the corresponding grain yields were 3.49 kg, 3.87 kg and 3.52 kg per plot. The grain yield of 3.87 kg per plot in case of 20x20cm spacing was significantly higher ($P \geqslant 0.01$) than that of the other two spacings. On the basis of these results, it was concluded that the spacing of 20x20cm between hills and rows was most suitable for obtaining optimum grain yields in the rice crop.

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