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Optimum Plant Density for High Yield in Rice (*Oryza sativa* L.)

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Abstract; Three mutant strains Basmati 370-32, Jajai 77-30 and Sonahri Sugdasi-6 along with their respective mother varieties Basmati 370, Jajai 77, Sonahri Sugdasi and check variety Basmati 385 were evaluated under different plant population (spacings, 20 x 20 cm^2, 22.5 x 22.5 cm^2 and 25 x 25cm^2 between plant and rows) for grain yield and yield contributing parameters. An increase in spacing induced vigorous plant growth as well as increased the number of panicles per hill, grain yield per hill, filled grains per panicle and 1000 grain weight. The spacing 22.5 x 22.5 cm^2 proved more appropriate because it produced better plant stand, gave more panicle density and higher grain yield than other two spacings. The mutant strains Jajai 77-30 produced significantly higher grain yield at all spacings as compared with all other entries.

Key words : Plant density, rice mutants, high yield

Introduction

The crop plants depends largely on temperature, solar radiation, moisture and soil fertility for their growth and nutritional requirements. A thick population crop may have limitations in the maximum availability of these factors. It is, therefore, necessary to determine the optimum density of plant population per unit area for obtaining maximum yields. A number of workers have reported that maintenance of a critical level of rice plant population in field was necessary to maximize grain yields. Counce (1987) suggested that population density ranging from 159 to 304 plants per m^2 could produce maximum yield under a dry seeded and flooded rice production systems. The seeding rates from 50 to 168 kg/ha were necessary for obtaining maximum yields under direct seeded cultures depending upon planting dates (Jones and Synder, 1987a), spacing between hills and rows (Bari *et al*., 1984; Bisht *et al*., 1999) panicles per m^2 (Miller *et al*., 1991; Gravois and Helms, 1992). Number of panicles per unit area is the most important component of yield and contribute 89 % of the variations in yield. Similar results were reported by Kenneth *et al*. (1996) for an optimum plant stand in producing high rough rice yield, head rice and total milled rice. Jones and Synder (1987 b), however, reported that panicles per m^2 accounted for only 34% of yield variations in direct seeded rice crop and 85% of the yield variations in ratoon rice crop. The effect of plant density on kernel dimension were also identified during different panicle development stages (Senanayake *et al*., 1991; Karim *et al*., 1992; Banik *et al*., 1997; Wang and Luo, 1998; Gopal *et al*., 1999). The present studies were, therefore, undertaken to determine the optimum plant density for getting the maximum yield in rice.

Materials and Methods

The experiment was conducted at the Experimental Farm, Nuclear Institute of Agriculture, Tandojam. Three tall growing and late maturing aromatic varieties of rice (*Oryza sativa* L.) i.e., Basmati 370, Jajai 77, Sonahri Sugdasi and three promising mutant strains i.e. Basmati 370-32, Jajai 77-30 and Sonahri Sugdasi-6, developed at Nuclear Institute of Agriculture, Tandojam, along with a check variety Basmati 385, were taken for these studies. The three different spacings i.e., 20 x 20 cm^2, 22.5 x 22.5 cm^2 and 25. X 25 cm^2 between hills and rows were kept for growing the crop and to identify their effect on grain yield parameters. The layout of the trial was split plot design having varieties as main plots. The area of each plot was 3 x 3m^2. Four week old seedlings were transplanted with an average of three seedlings per hill in the square method of planting. The fertilizer in the form of urea and single superphosphate was applied at the ate of 80 N and 40 P (kg/ha) in two split doses. The basal dose of 40 N and 40 P (kg/ha) was applied before transplanting while the remaining quantity of 40 N (kg/ha) was applied as top dressing after 40 days of transplanting. Standard cultural practices were carried out till the crop was mature. The data on paddy yield per plot and yield parameters i.e., panicle density per m^2, 1000 grain weight (g), filled grains per panicle, grain yield per hill and number of panicles per hill were recorded. The data was analyzed according to Gomez and Gomez (1984) and mean values were compared by DMR test.

Results and Discussion

The analysis of variance resolved that the yield performance of the varieties and the mutant strains as well as the interactions between the sources of variation. The performance of varieties with respect to number of panicles per hill, grain yield per hill, filled grains per panicle, 1000 grain weight (g), panicle density per M2 and yield per plot were significantly ($P<0.01$) different from each other. However, the mutant strain Jajai 77-30 gave the highest grain yield (3.45 kg/plot) followed by Sonahri Sugdasi-6 (2.95 kg/plot) and Basmati 385 (2.65 kg/plot), Basmati 370-32 (2.75 kg/plot), Sonahri Sugdasi (2.10 kg/plot), Basmati 370 (1.80 kg/plot) and Jajai 77 (1.51 kg/plot). Thousand grain weight of mutant strain Sonahri Sugdasi-6 (24.38 g) and its mother variety Sonahri Sugdasi (24.14 g) were significantly higher than the other genotypes under study. Number of filled grains (64.58), grain yield per hill (21.76 g/h) and number of panicles per hill (17.25) of mutant strain Jajai 77-30 were significantly higher than those of others genotypes. (Table 1).The effect of spacings averaged over varieties and replicates is presented in Table 2. The increased plant spacing considerably resulted in vigorous plant growth and caused a significant ($P<0.01$) increase in number of panicles per hill, grain yield per hills, filled grain per panicle and 1000 grain weight. The effects on panicle density and grain yield were highly significant ($P<0.01$). The spacing 22.5 x 22.5 cm^2 gave significantly higher grain yield of 2.95 kg/plot, while the spacings of 20 x 20 cm^2 and 25 x 25 cm^2 yielded 2.30 kg and 2.19 kg/plot, respectively.

Results indicated that wider spacing had linearly increasing effect on the performance of individual plants. The plants grown with wider spacing have more area of land around them to draw the nutrition and had more solar radiation to absorb for better photosynthetic process and hence performed better as individual plants. The reason for deviation of this linearity in case of grain yield per plot is that the yield does not entirely depend upon the performance of individual plant but also on the total number of plants per plot and yield contributing parameters within plant.The data indicates that the effect of spacings of yield and yield parameters varies within genotypes (Table 3). There is a significant interaction between varieties and spacings. This reveals that the yield of varieties will be changing if the factor of spacing is changing. The effect of spacing within entries is also significantly different. This also makes intelligible explanation that spacing modify the components that influence the final yield. Ennus and Sadeque (1974) found that the number of panicles per plant and straw yield increased with increased spacing in transplanted rice. Shahi *et al*. (1976) studied

Table 1: Varietal performance of yield parameters of rice varieties

Varieties/mutant strains	No. of panicles per hill**	Grain yield per hill (g)**	Filled grains per panicle**	1000 grain weight (g)**	Panicle density Per m^2**	Grain yield per (kg)**
Basmati. 370	10.00c	11.17d	38.00e	21.48d	252.17d	1.80d
Basmati. 370-32	14.92ab	15.38b	58.92b	22.13c	369.41b	2.75c
Jajai 77	10.42c	9.55e	41.33c	21.24d	252.92d	1.51e
Jajai 77-30	17.25a	21.76a	64.58a	23.31b	429.75a	3.45a
Sonahri Sugdasi	10.33c	12.52c	38.00e	24.14a	248.10d	2.10d
Sonahri Sugdasi-6	14.00b	16.52b	54.67c	24.38a	343.10bc	2.95b
Basmati 385	12.92b	15.45b	47.50d	22.50c	316.42c	2.65c
DMR 1%)	2.13-2.43	1.61-1.81	3.79-1.81	3.79-4.33	0.39-0.44	0.12-0.14

** = Means followed by the same letters are not significantly different from each other at 1%

Table 2: Effect of different spacings on yield and yield parameters of rice varieties

Spacing between hills and rows (cm)	No. of hills per plot	No. of panicles Per hill**	Grain yield per hill ** (g)	Filled grains per panicle**	1000 grain weight** (g)	Panicle density per M^2**	Grain yield per plot (kg) **
20 x 20	225	10.42c	13.64b	45.14b	22.46b	255.75b	2.30b
22.5 x 22.5	169	13.11b	14.86a	49.36a	22.83ab	369.43a	2.95a
25 x 25	114	14.96a	15.36a	52.05a	22.93a	316.32a	2.19c
(DMR 5%)		1.58-1.90	1.08-1.30	2.72-3.24	0.43-0.62	36.05-42.55	0.008-0.018
(DMR 5%)		2.40-2.74	1.63-1.88	4.11-4.70	0.64-0.91	54.00-60.55	0.012-0.032

* = Means followed by the same letters are not significantly different from each other at 5 %
** = Means followed by the same letters are not significantly different from each other at 1 %

Table 3: Effect of spacing on yield and yield paramenters within varietices and mutant strains of rice.

Variaties/mutant strains	Spacing (cm)	No. of panicles perhill**	Grain yield per hill (g)**	Filled grains per panicle**	1000 grain weight (g)**	Panicle density** per m^2	Grain yield per plot (Kg)**
Basmati 370	20 x 20	7.25	10.08	3.25	21.13	176.00	1.62
	22.5 x 22.5	10.50	11.26	37.50	21.58	312.75	2.27
	25 x 25	12.25	12.16	41.25	21.75	267.75	1.52
Basmati 370-32	20 x 20	11.50	14.76	51.75	21.85	288.75	2.58
	22.5 x 22.5	15.50	15.99	60.50	21.65	437.75	3.23
	25 x 25	17.75	15.39	64.50	22.38	374.25	2.45
Jajai 77	20 x 20	8.25	8.25	37.75	21.08	196.25	1.33
	22.5 x 22.5	10.25	9.75	41.50	21.20	313.75	1.98
	25 x 25	12.75	10.40	44.75	21.45	241.25	1.22
Jajai 77-30	20 x 20	14.75	20.72	61.00	23.15	367.75	3.27
	22.5 x 22.5	17.75	21.95	64.50	23.28	483.50	3.92
	25 x 25	19.50	22.60	68.25	23.50	430.50	3.16
Sonahri Sugdasi	20 x 20	8.25	11.49	34.75	23.88	190.75	1.90
	22.5 x 22.5	10.25	12.72	38.50	24.20	297.00	2.55
	25 x 25	12.50	13.37	40.75	24.35	249.00	1.79
Sonahri Sugdasi-6	20 x 20	12.00	15.52	51.50	24.13	297.25	2.77
	22.5 x 22.5	14.50	16.67	55.25	24.43	379.00	3.42
	25 x 25	15.50	17.35	57.25	24.60	345.50	2.66
Basmati 385	20 x 20	11.00	14.41	44.00	22.03	273.50	2.56
	22.5 x 22.5	12.25	15.87	47.75	23.00	362.25	2.84
	25 x 25	14.50	16.28	50.75	22.48	306.00	2.55

the effect of spacing 20 x 20 cm^2 and 15 x 15 cm^2 on the paddy yield of dwarf rice variety Jaya. Although they did not find significant differences in the yields, yet the yields in case of 20 x 20 cm^2 spacing tended to be higher than that of the other two spacings. Chandrakar and Khan (1981) studied the effect of spacings of 10 x 10 cm^2, 15 x 10 cm^2 and 20 x 10 cm^2 on the grain yields on early, medium and late duration tall growing indica rice varieties and found that the spacing of 20 x 10 cm^2 gave the highest yields for medium and late varieties, while the spacing of 10 x 10 cm^2 gave higher yield in case of early maturing varieties. Singh *et al.* (1983) studied the effect of row spacing in combination with nutrient supply on grain yield of semi-dwarf upland rice variety Narendra 1 (IET 2232). The crop was grown by direct seeding in rows at three spacings of 15, 20 and 25 cm. The grain yield was more with 20 cm spacing as compared to other spacings. Bari *et al.* (1984) studied the effect of plant density of 15 x 15 cm^2 and 25x 25 cm^2 between hill and rows and compared for their effect on grain yield and yield components of two standard varieties IR6 and IR8 and two mutant strains of rice Shadab and Shua-92. The plant density at spacing of 20 x 20 cm^2 was more effective and gave significantly higher grain yield per plot than the other two plant densities at other spacings and was, therefore, most suitable for obtaining maximum yields. The grain yield per unit area depends evidently on the performance of individual plants, panicle density as well as the total number of plants grown on the area. In the present studies the performance of individual plants grown with wider spacing was better as compared to the plants with narrower spacing. A balance has,

therefore, to be brought between the performance of individual plants and the plants density per unit area for obtaining optimum crop yields. In this studies reported here the number of hills per plot were 225 in 20 x 20 cm^2 spacings, 169 in 22.5 x 22.5 cm^2 spacing and 144 in case of 25 x 25 cm^2 spacing and corresponding grain yields were 2.30 kg, 2.95 kg and 2.19 kg per plot, respectively. The grain yields were 2.30 kg, 2.95 kg and 2.19 kg per plot, respectively. The grain yield of 2.95 kg per plot in case of 22.5 x 22.5 cm^2 spacing was significantly higher ($P<0.01$) than that of the other two spacings.

On the basis of these results, it is concluded that the spacing of 22.5 x 22.5 cm^2 between hills and rows most suitable for obtaining optimum grain yield in the rice crop.

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