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Short Communication

Effect of Planting Density on the Performance of Hybrid Rice (*Oryza sativa L.*) under Waterlogged Condition

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Abstract

The experiment was conducted to find out the effect of planting density on the performance of hybrid rice variety Aloran under water logged condition at the BRAC Agricultural Research and Development Center in Gazipur, Bangladesh during the dry (DS) and wet season (WS) of 2009. Different planting densities were maintained using different spacings and number of seedlings per hill. These include 25 cm × 20 cm, 25 cm × 10 cm, 20 cm × 10 cm, 20 cm × 15 cm with single seedling per hill and 20 cm × 15 cm with two seedlings per hill and 20 cm × 15 cm with three seedlings per hill. The experiment was laid out in a randomized complete block design with 3 replications. Density of 20 cm × 10 cm with 1 seedling hill^{-1} i.e. 50 hills m^{-2} produced the highest grain yield of 7.5 t ha^{-1} and 4.6 t ha^{-1} in DS and WS respectively, which was significantly higher than the yield with recommended density (20 cm × 15 cm with 1 seedling per hill). This yield was increased due to higher number of panicles m^{-2}. Increasing the seedling numbers hill^{-1} with the recommended planting density did not improve the yield of hybrid rice. This result suggests that higher planting density rather than increased number of seedling hill^{-1} is necessary for getting higher yield of hybrid rice in continuous water logged condition.

Key words: Water logged condition, panting density, seedlings hill^{-1}, yield

The crop plants depend largely on temperature, solar radiation, moisture and soil fertility for their growth and nutritional requirements. A thick population may have limitations in the maximum availability of these factors. A number of workers have reported that maintenance of a critical level of rice plant population in the field was necessary to maximize grain yields. The optimum planting density depends on different factors like: plant characteristics, growth duration, planting time and methods, soil fertility, plant size, available moisture, sun shine, planting pattern and situation of weeds (Shirtliffe and Johnston, 2002). Plant spacing is an important production factor in transplanted rice (Gorgy, 2010). Mohapatra *et al*. (1989) reported that plant spacing of 20 cm × 20 cm was better than those of 15 cm × 15 cm or 15 cm × 20 cm under normal soil for rice productivity. Maske *et al*. (1997) reported that plant height, leaf area index, yield and yield component of rice with plant spacing of 15 cm × 20 cm were higher than that of 15 cm × 15 cm. Number of grains per panicle and 1000 grain weight were also not

affected by spacing. Number of seedlings per hill is another important factor that can play important roles in boosting yield of rice. Because it influences tiller formation, solar radiation interception, nutrient uptake, rate of photosynthesis and other physiological phenomena and ultimately affects the growth and yield of rice plant (Bozorgi *et al*., 2011).

In densely populated rice field, the inter-specific competition among the plants is high which sometimes results in gradual shading and lodging and thus produces straw instead of grain. It is therefore, necessary to determine the optimum planting density and number of seedling hill^{-1} for high yield. Chandrakar and Khan (1981) studied the effect of spacings on the grain yields on early, medium and late - duration tall indica rice varieties and found that the spacing of 20 cm x 10 cm gave the highest yields for medium and late varieties. Faruk *et al*. (2009) reported that the highest grain yield was recorded from 2 seedlings hill^{-1} and the lowest was from 1 seedling hill^{-1}. The highest yield was observed in rice variety Ali Kazemi with planting spacing of 20 cm x 20 cm and with 7 seedlings hill^{-1} by Mohammadian *et al*. (2011).

On the other hand, under waterlogged condition, exchange of gases through soil pores might have been strongly inhibited by water content, which affects growth of roots. A slowing of oxygen influx is the principal cause of injury to roots, and the shoots they support (Vartapetian and Jackson, 1997). The maximum amount of oxygen dissolved in the floodwater in equilibrium with the air is a little over 3 % of that in a similar volume of air itself. This small amount is quickly consumed during the early stages of flooding by aerobic micro-organisms and roots. In addition to imposing oxygen shortage, flooding also impedes the diffusive escape and/or oxidative breakdown of gases such as ethylene (Arshad and Frankenberger, 1990) or carbon dioxide that are produced by roots and soil micro-organisms. This leads to accumulations that can influence root growth and function. So, considering all these, the present study was undertaken to develop appropriate plant density per unit area for hybrid variety Aloran to estimate its performance under continuous water logged condition.

The experiment was conducted at the experimental farm of BRAC Agricultural Research and Development Center, Gazipur during wet season (WS) in 2009 and dry season (DS) in 2009-10. Hybrid rice variety Aloran (140-145 days, bold grain type) developed and released by BRAC was used in this experiment as study material. Different planting densities were maintained using different spacing and number of seedlings per hill. These included 25 cm × 20 cm, 25 cm × 10 cm, 20 cm × 10 cm, 20 cm × 15 cm with single seedling per hill and 20 cm × 15 cm with two seedlings per hill and 20 cm × 15 cm with three seedlings per hill whereas 20 cm × 15 cm with single seedling per hill used as control. The experiment was conducted with randomized complete block design with three replications. The area of unit plot was 12 m^2. Thirty days - old seedlings in dry season and twenty five- days old seedlings in wet season of 2009 were transplanted.

Fertilizer was applied at the rate of 126, 26, 60, 13 and 4 kg ha^{-1} N, P, K, S and Zn respectively in dry season. In the wet season, 84, 16, 35, 11 and 4 Kg ha^{-1} N, P, K, S, and Zn in the form of Urea, TSP, MP, Gypsum and Zinc sulphate were applied. One fourth of urea, total TSP, MP, Gypsum and Zinc sulphate were applied as basal in dry season and one third of urea, total TSP, MP, Gypsum and Zinc sulphate were applied as basal in wet season. The rest amount of urea was applied in three splits, at 20, 40 and 60 days after transplanting (DAT) in dry season. On the other hand, in wet season, the rest amount of urea was applied in two splits, one third at 20 DAT and another one third at 35 DAT.

The first irrigation was applied at 10 DAT after the crop establishment and continued up to flowering stage to maintain 10-12 cm continuous standing water and after that irrigation was stopped. Finally, the water was drained out at dough stage. The data on plant height, number of panicles m^{-2}, number of spikelets panicle^{-1}, filled

grain (%), 1000 grain weight and grain yield at 14% moisture content were recorded. The data were analyzed following the method of Gomez and Gomez (1984) and mean values were compared by LSD test.

Yield and yield component of hybrid variety Aloran under water logged condition is shown in Table 1. For dry season, it was observed that, plant height varied insignificantly among the treatments. Number of panicles m^{-2} varied significantly and the highest number of panicles m^{-2} was found from T_6 with 293 panicles m^{-2} and it was statistically similar to T_3, T_4 and T_5. The lowest number of panicles m^{-2} (177) was recorded in T_1 that also statistically similar to T_2, T_4 and T_5. Miller *et al*. (1991) reported that number of panicles per unit area is the most important component of yield and it contributes 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. Effects of treatments on spikelets panicle^{-1}, filled grain (%) and 1000 grain weight were insignificant. However, grain yield varied significantly among the treatments. The highest grain yield was found in T_6 (7.95 t ha^{-1}) which was similar to T_5. The highest yield was recorded in T_6 which might be due to maximum number of panicles m^{-2}.

A similar experiment was repeated in the wet season 2009. The result of this trial is shown in Table 2 which shows that plant height varied insignificantly among the treatments and irrespective of all treatments plants were taller in wet season (WS) than in dry season (DS). Number of panicles m^{-2} varied significantly and the highest number of panicles m^{-2} was found in T_6 with 193 panicles m^{-2} and were statistically similar to T_2, T_3, T_4 and T_5. Moreover, it was also observed that in both wet and dry season, number of panicles m^{-2} was maximum in T_6 i.e. in 20 cm × 10 cm spacing with 1 seedling hill^{-1}. With this spacing, numbers of hills m-2 were maximum over all treatments which resulted in higher number of panicles m^{-2}. In contrast, number of spikelets panicle^{-1} was significantly higher in T_1 with 155 spikelets panicle^{-1} and was similar to T_2 and T_5. The lowest spikelet panicle^{-1} (121) was observed in T_4 which was similar to T_2, T_3 and T_6.

Table 1. Yield and yield components of hybrid rice Aloran at different planting density under continuous water logging condition during 2009 DS at Gazipur

Treatments	Plant height (cm)	Number of panicles m^{-2}	Number of spikelets panicle^{-1}	Filled grains (%)	1000 grain weight (g)	Grain yield (t ha^{-1})
T_1: 25 cm × 20 cm with 1 seedling	104	177	173	78	28.4	4.3
T_2: 20 cm × 15 cm with 1 seedling	103	213	151	73	27.9	5.5
T_3: 20 cm × 15 cm with 2 seedling	99	260	162	68	27.2	6.4
T_4: 20 cm × 15 cm with 3 seedling	100	240	162	70	27.7	5.9
T_5: 25 cm × 10 cm with 1 seedling	102	248	151	81	28.2	7.3
T_6: 20 cm × 10 cm with 1 seedling	100	293	164	66	27.3	7.5
CV (%)	3.83	16.84	9.93	14.35	3.41	7.95
$LSD_{(0.05)}$	ns	73.12	ns	ns	ns	0.89

Table 2. Yield and yield components of hybrid rice Aloran at different planting density under continuous water logging condition during 2009 WS at Gazipur

Treatments	Plant height (cm)	Number of panicles m^{-2}	Number of spikelets $panicle^{-1}$	Filled grains (%)	1000 grain weight (g)	Grain yield (t ha^{-1})
T_1: 25 cm × 20 cm with 1 seedling	120	112	155	64	25.1	2.8
T_2: 20 cm × 15 cm with 1 seedling	119	158	138	62	25.6	3.5
T_3: 20 cm × 15 cm with 2 seedling	116	176	126	65	25.7	3.8
T_4: 20 cm × 15 cm with 3 seedling	119	179	121	73	25.7	3.8
T_5: 25 cm × 10 cm with 1 seedling	115	184	143	63	26.2	4.5
T_6: 20 cm × 10 cm with 1 seedling	115	193	129	66	25.7	4.6
CV (%)	3.19	12.13	8.96	10.41	2.72	7.92
$LSD_{(0.05)}$	ns	36.87	22.07	ns	ns	0.54

Filled grain (%) and 1000 grain weight were not significantly different among the treatments. Similar results were reported by Mobasser *et al.* (2007). Grain yield varied significantly among the treatments. The highest grain yield of 4.6 t ha^{-1} was recorded ^{in} T_6 which was similar to T_5 followed by T_4, T_3 and T_2. The lowest yield of 2.8 t ha^{-1} was obtained in T_1. The highest and the lowest grain yields were might be due to maximum and minimum number of panicles m^{-2} respectively.

On the basis of above results, it can be concluded that planting density of 20 cm × 10 cm with 1 seedling $hill^{-1}$ would produce higher grain yield for hybrid variety Aloran under water logged condition in both wet and dry season.

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