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Effect of spacing and number of seedlings per hill on the performance of *aus* rice cv. NERICA 1 under dry direct seeded rice (DDSR) system of cultivation

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Abstract

An experiment was conducted at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during the period from April to August 2011 to find out the effect of spacing and number of seedlings hill^{-1} on the performance of *Aus* rice cv. NERICA 1. Four spacing viz. 25 cm × l5 cm, 20 cm × l5 cm. 20 cm × 10 cm and 15 cm × 10 cm and four number of seedlings hill^{-1} viz. 2, 3, 4 and 5 were included in the experiment. The experiment was laid out in a randomized complete block design with three replications. The highest number of total tillers m^{-2}, number of effective tillers m^{-2}, number of grains panicle^{-1}, grain yield, straw yield, biological yield and harvest index were obtained from 20 cm × 10 cm spacing. Plant height and 1000- grain weight were not significantly affected by spacing. Number of seedlings hill^{-1} exerts a significant effect on plant height. The highest value of total tillers m^{-2}, number of effective tillers m^{-2}, total grains panicle^{-1}, grain yield, straw yield, biological yield and harvest index were obtained from five seedlings hill^{-1}. The interaction between spacing and number of seedlings hill^{-1} significantly influenced yield and plant characters. The highest number of effective tillers m^{-2}, grains panicle^{-1}, grain yield, straw yield and biological yield were recorded from the interaction between 20 cm × 10 cm and five seedlings hill^{-1}.

Keywords: Spacing, Number of seedlings per hill^{-1}, Dry direct seeded rice (DDSR), NERICA

Introduction

Rice (*Oryza sativa* L.) is the staple food, of Bangladesh where it constitutes a major part of human diet. The total area and production of rice in Bangladesh are 11.35 million hectares and 31.975 million tons, respectively (BBS, 2010). *Aus* rice is cultivated on 8.9% of the total cropped area of Bangladesh (BBS, 2010). The national average yield of rice in Bangladesh is very low (2.91 t ha^{-1}) compared to that of other rice growing countries (BBS, 2010). At the same time the total rice growing area is being continuously declined at about 0.61 per annum due to urbanization and industrialization. So attempts should be made to increase the yield per unit area. Under such condition there is no way out other than the development and adoption in yield increasing technologies. Among different management practices, use of appropriate number of seedlings hill^{-1} and spacing are important.

Plant spacing has an important role on growth and yield of rice. Optimum plant density ensures the plant to grow properly with their aerial and underground parts by utilizing more solar radiation and soil nutrients (Miah *et al.,* 1990). Closer spacing hampers intercultural operations. Also in a densely populated crop, the inter-plant competition is very high for nutrients, air and light, which usually results in mutual shading, lodging and thus favours more straw yield than grain yield. On the other hand, under wider plant spacing desired hill unit^{-1} area cannot be obtained, which ultimately reduces yield unit^{-1} area. The maximum benefit can be derived from a rice field, if the crop is properly spaced between rows and within rows. Alam (2006) stated that optimum spacing gave a maximum number of total tillers m^{-2}, maximum number of fertile tillers m^{-2} which was dependent on temperature, moisture and other soil factors. Shrirame *et al.* (2000) reported that total number of tillers hill^{-1} was higher at the wider spacing. They also observed that two seedlings hill^{-1} gave significantly higher number of tillers hill^{-1} than three seedlings hill^{-1}.

Number of seedlings hill^{-1} is an important factor for successful rice production because it affects plant population unit^{-1} area, availability of sunlight and nutrients, photosynthesis and respiration, which ultimately influence the yield contributing characters and yield (Chowdhury *et al.,* 1993). Optimum number of seedlings hill^{-1} may facilitate the rice plant to grow properly both in its aerial and underground parts by utilizing maximum radiant energy, nutrient, space and water and also can reduce seedling cost. Excess number of seedlings hill^{-1} may produce higher number of tillers hill^{-1} resulting in shading, lodging and thus favor the production of straw instead of grain. On the other hand, the lesser number of seedlings hill^{-1} may cause insufficient tiller number, thus keeping space and nutrients underutilized and at the end, total number of panicles unit^{-1} area may be reduced resulting in poor gain yield. It is, therefore, necessary to determine the suitable number of seedlings hill^{-1} for obtaining higher yield from a HYV of rice. Alam (2006) reported that highest number of total tillers and number of effective tillers were obtained from 2 seedlings hill^{-1}. Obulamma and Reddeppa (2002) revealed that one seedling hill^{-1} gave the highest grain yield, crop growth rate and net assimilation rate while 3 seedlings hill^{-1} had the highest dry matter prosecution, leaf area index and leaf area density. The study was undertaken to evaluate the effect of spacing and number of seedlings per hill on the performance of *Aus* rice cv. NERICA 1 under Dry Direct Seeded Rice (DDSR) system of cultivation.

Materials and Methods

An experiment was conducted at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during the period from April to August 2011. The land was medium high and the soil was silty-loam and well drained and its general fertility level was low. The soil of the experimental field was more or less neutral in reaction with p^{H} value 6.5 and low in organic matter content (1.67%). NERICA 1 was used as test crop in the experiment. The experiment consisted of four spacing viz. 25 cm × l5 cm, 20 cm × l5 cm. 20 cm × 10 cm and 15 cm × 10 cm and four numbers of seedlings hill^{-1} viz. 2, 3, 4 and 5.

The experiment was laid out in a randomized complete block design with three replications. Each block was divided into 16 unit plots and size of the unit plot was 10 m^{2} (4.0 m × 2.5 m). The experimental land was first opened with a power tiller. Then the land was prepared by ploughing and cross-ploughing with a country plough and subsequently leveled by laddering. Weeds and stubble were removed from the field before sowing the seeds. The field layout was accomplished according to the experimental design adopted on 01 May 2011. Healthy seeds were selected by specific gravity method. Seeds were then immersed in a bucket of water for 24 hours. These seeds were then taken out of water and kept in incubation for 24 hours and then were sown directly in the main field. The experimental area was fertilized with 180-125-66-60-10 kg ha^{-1} of urea, triple super phosphate, muriate of potash, gypsum and zinc sulphate respectively. The entire amounts of triple super phosphate, muriate of potash, gypsum and zinc sulphate were applied at the time of final land preparation. Urea was applied in three equal splits. The first split of urea was applied at the time of final land preparation, the second split of urea was top dressed at 20 days after sowing (DAS) and the third split of urea was top dressed at 40 days after sowing (DAS). Crop management practices such as drainage, plant protection measures were done as per requirement and three weeding were done in order to keep the crop weed free at 15, 30 and 45 DAS. Initially 6 seeds were sown hill^{-1}. After emergence, the seedling were thinned out to maintain the treatment (2, 3, 4, 5 seedlings hill^{-1}) in different plots.

At physiological maturity central 1 m^{2} area of each plot was harvested, sundried to record the data on plant height (cm), number of total tillers m^{-2}, number of effective tillers m^{-2}, number of non-effective tillers^{-2}, number of grains panicle^{-1}, number of sterile spikelets panicle^{-1}, 1000-grain weight (g), grain yield (tha^{-1}) and straw yield (t ha^{-1}) were recorded from five randomly selected hills in each unit plot from the sampling area excluding border rows. The crop was harvested at maturity from a harvest area of 2.5m x 2.0m in the middle portion of each unit plot. The grains and straws were sun dried converted to ton per hectare with 14% moisture content of grains. The biological yield and harvest index were calculated with the following formula:

Biological yield = Grain yield + straw yield
Harvest index (%) = (Grain yield/Biological yield) ×100.
Collected data were analyzed statistically using MSTAT-C programme and the means were compared by Duncan's Multiple Range Test (Gomez and Gomez, 1984).

Results and Discussion

Effect of spacing: Number of total tillers m^{-2}, number of effective tillers m^{-2}, number of grains spikelets^{-1}, number of sterile spikelets panicle^{-1}, grain yield, straw yield, biological yield and harvest index were significantly affected by different spacing (Table 1). The highest number of total tillers m^{-2}, number of effective tillers m^{-2}, number of grains panicle^{-1} were obtained in S_3 (20 cm × 10 cm) spacing and the lowest number of total tillers m^{-2}, number of effective tillers m^{-2}, number of grains panicle^{-1} were obtained in S_1 (25 cm × 15 cm) spacing. The highest grain yield (3.13 t ha^{-1}) was observed in S_3 (20 cm × 10 cm) spacing. The highest number of effective tillers m^{-2} and the highest number of grains panicle^{-1} were mainly responsible for this highest grain yield. Grain yield obtained in S_4 (15 cm × 10 cm) spacing was statistically identical to the spacing S_3 (20 cm × 10 cm). The lowest grain yield (1.85 t ha^{-1}) was obtained from S_1 (25 cm × 15 cm) spacing mainly because of the lowest number of effective tillers m^{-2} and the lowest number of grains panicle^{-1}. Similar results were also obtained by Moniruzzaman (2003). The highest straw yield (3.58 t ha^{-1}) was observed in S_3 (20 cm × 10 cm) spacing mainly because of the highest number of total tillers m^{-2}.On the other hand, the lowest straw yield (2.55 t ha^{-1}) was obtained from S_1 (25 cm × 15 cm) spacing caused mainly due to the lowest number of total tillers m^{-2}. The highest biological yield (6.70 t ha^{-1}) and harvest index (46.63%) were observed in S_3 (20 cm × 10 cm) spacing. On the other hand, the lowest biological yield (4.39 t ha^{-1}) was obtained from S_1 (25 cm × 15 cm) spacing (Table 1).

Effect of number of seedlings hill^{-1}: Number of seedlings hill^{-1} had significant effect on yield and yield contributing characters of *Aus* rice. The tallest plant was observed in two seedlings hill^{-1}. Five seedlings hill^{-1} produced the shortest plant. It was observed that plant height showed a decreasing trend with the increase of number of seedling hill^{-1} and became the shortest one at five seedlings hill^{-1}. The highest number of total tillers m^{-2}, number of effective tillers m^{-2} and the highest number of grains panicle^{-1} were found in five seedlings hill^{-1}. The lowest number of total tillers m^{-2}, number of effective tillers m^{-2} and the lowest number of grains panicle^{-1} were found in two seedlings hill^{-1}. The highest grain yield (3.05 t ha^{-1}) was obtained at five seedlings hill^{-1}. The highest number of effective tillers m^{-2} and the highest number of grains panicle^{-1} were mainly responsible for this highest grain yield. Grain yield decreased progressively with the decrease of number of seedlings hill^{-1}. The lowest grain yield (2.19 t ha^{-1}) was found in two seedlings hill^{-1} because mainly of lowest number of effective tillers m^{-2} and lowest number of grains panicle^{-1}. The highest straw yield (3.57 t ha^{-1}) was produced by five seedlings hill^{-1} caused mainly due to the highest number of total tillers m^{-2}. The lowest straw yield (2.75 t ha^{-l}) was obtained from two seedlings hill^{-1} because mainly of the lowest number of total tillers m^{-2}. The highest biological yield (6.63 t ha^{-1}) and harvest index (45.93%) were obtained from five seedlings hill^{-1}. Weight of 1000 grains was not significantly affected by number of seedlings hill^{-1} (Table 1).

Interaction effect of spacing and number of seedlings hill^{-1}: Interaction effect of spacing and number of seedlings hill^{-1} had significant on yield and yield contributing characters of *Aus* rice except plant height (cm) and 1000-grain weight. The highest number of total tillers m^{-2} and number of grains panicle^{-1} were obtained from S_3 (20 cm × 10 cm) spacing with five seedlings hill^{-l}. The highest grain yield (3.53 t ha^{-1}) and straw yield (4.02 t ha^{-1}) were obtained from the S_3 (20 cm × 10 cm) spacing with five seedlings hill^{-1} .The lowest grain yield (1.46 t ha^{-1}) and straw yield (1.98 t ha^{-1}) were obtained from S_1 (25 cm × 15 cm) spacing with two seedlings hill^{-1}. The highest biological yield (7.55 t ha^{-l}) was recorded from S_3 (20 cm × 10 cm) spacing with five seedlings hill^{-1} and the lowest biological yield (3.44 t ha^{-1}) was obtained from S_1 (25 cm × 15 cm) spacing with two seedlings hill^{-1} (Table 2).

Results revealed that plant spacing and number of seedlings hill^{-1} have considerable role in increasing yield of rice. Optimum plant density ensures the plant to grow properly. When the plant density exceeds the optimum level, competition among plants for light above ground or for nutrients below the ground become severe, consequently the plant growth slows down and the grain yield decreases. On the other hand, optimum number of seedlings hill^{-1} influences the tiller formation, solar radiation interception, total sunshine reception, nutrient uptake and other physiological phenomena and ultimately affects the growth and development of rice plant. Therefore, it can be concluded that spacing 20 cm × 10 cm with five seedlings hill^{-1} appears as the best combination to obtain maximum grain yield of *aus* rice cv. NERICA 1 under Dry Direct Seeded Rice (DDSR) system of cultivation.

Table 1. Effect of spacing and number of seedlings hill^{-1} on yield and yield contributing characters of *aus* rice cv. NERICA1

Treatments	Plant height (cm)	Number of total tillers m^{-2}	Number of effective tillers m^{-2}	Number of non-effective tillers m^{-2}	Number of grains panicle^{-1}	Number of sterile spikelets panicle^{-1}	Number of total spikelets panicle^{-1}	1000-grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
Spacing (cm)												
S_1	92.40	138.25d	109.58c	28.67	102.78d	31.64a	134.42d	23.94	1.85c	2.55b	4.39c	42.10d
S_2	93.16	145.75c	119.42b	26.33	107.60c	28.85b	136.45c	24.53	2.47b	3.09ab	5.56b	44.38c
S_3	92.28	151.58a	123.42a	28.17	124.65a	23.79d	148.45a	24.48	3.13a	3.58a	6.70a	46.63a
S_4	92.13	149.42b	122.50ab	26.92	112.98b	25.26c	138.24b	24.50	2.97ab	3.50a	6.47a	45.82b
CV (%)	4.12	4.36	5.24	4.26	6.33	5.45	5.78	6.59	7.45	6.31	4.18	5.85
Level of sig.	NS	**	**	NS	**	**	**	NS	**	**	**	**
Number of seedlings hill^{-1}												
2	93.98a	128.33d	99.00d	29.33b	90.33d	36.75a	127.08c	24.00	2.19d	2.75c	4.94c	44.14b
3	92.41b	128.11c	103.22c	24.89c	99.27c	26.26b	125.53d	24.08	2.37c	3.06b	5.42b	43.49c
4	92.30c	147.33b	122.44b	24.89c	119.52b	23.81c	143.33b	24.63	2.80b	3.34ab	6.14a	45.38a
5	91.27d	174.11a	144.00a	30.11a	138.90a	22.73d	143.33b	24.75	3.05a	3.57a	6.63a	45.93a
CV (%)	4.12	4.36	5.24	4.26	6.33	5.45	5.78	6.59	7.45	6.31	4.18	5.85
Level of sig.	**	**	**	**	**	**	**	NS	**	**	**	**

In a column, figures with same letter or without letter do not differ significantly whereas figures with dissimilar letters differ significantly (as per DMRT).
**= Significant at 1% level of probability. NS= Not significant.
N_1= 2 seedlings hill^{-1}, N_2= 3 seedlings hill^{-1}, N_3= 4 seedlings hill^{-1}, N_4= 5 seedlings hill^{-1}
S_1 = 25 cm × 15 cm, S_2= 20 cm × 15 cm, S_3= 20 cm × 10 cm, S_4 = 15 cm × 10 cm

Table 2. Effect of interaction of spacing and number of seedlings hill^{-1} on yield and yield contributing characters of *aus* rice cv. NERICA1

Number of seedlings hill^{-1} × spacing	Plant height (cm)	Number of total tillers m^{-2}	Number of effective tillers m^{-2}	Number of non-effective tillers m^{-2}	Numbers of grains panicle^{-1}	Number of sterile spikelets panicle^{-1}	Number of total spikelets panicle^{-1}	1000-grain wt (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
$N_1 \times S_1$	93.01	122.67j	94.00h	28.67b-f	74.30L	40.08a	114.38h	23.87	1.46h	1.98e	3.44g	42.40ef
$N_1 \times S_2$	94.00	128.00i	95.33h	32.67bc	86.16j	41.56a	127.72f	24.25	2.09f	3.07b	5.16e	40.77f
$N_1 \times S_3$	93.44	134.67h	113.67g	21.00c-g	107.57h	31.52b	139.09e	23.79	2.70cd	3.02bc	5.72cd	47.20a
$N_1 \times S_4$	95.47	134.33h	107.67f	26.67gh	93.28i	33.82b	127.11f	24.10	2.52de	2.93bc	5.44de	46.18b
$N_2 \times S_1$	93.34	118.33k	87.33i	31.00b-e	80.90k	32.59b	113.49h	24.08	1.81g	2.63cd	4.44f	40.80f
$N_2 \times S_2$	92.59	132.67h	115.33f	17.33h	92.90i	26.87cd	119.77g	24.38	2.26f	2.98bc	5.24e	43.09de
$N_2 \times S_3$	92.25	132.00h	89.00g	43.00d-g	118.09fg	21.60fg	139.69de	23.86	2.76c	3.28b	6.05bc	45.70b
$N_2 \times S_4$	91.48	133.33hi	107.00i	26.33a	105.19h	23.99def	129.18f	23.99	2.65cde	3.33b	5.97c	44.35cd
$N_3 \times S_1$	91.78	142.00g	120.00e	22.00gh	115.41g	27.91c	143.31d	24.15	1.87g	2.45d	4.32f	43.29d
$N_3 \times S_2$	93.63	147.67f	124.67d	23.00fgh	119.05f	23.18efg	142.23de	24.55	2.47e	2.97bc	5.44de	45.39bc
$N_3 \times S_3$	92.16	158.67e	140.00de	18.67b-e	126.46e	22.16fg	148.62c	25.12	3.51a	3.97a	7.48a	46.89a
$N_3 \times S_4$	91.63	152.33d	122.67bc	29.67h	117.17fg	21.99fg	139.17e	24.68	3.35a	3.95a	7.30a	45.95b
$N_4 \times S_1$	91.47	170.00c	137.00c	33.00b	140.51b	25.99cde	166.51a	23.66	2.25f	3.13b	5.38de	41.90f
$N_4 \times S_2$	92.42	174.67b	142.33b	32.33bcd	132.31d	23.78def	156.09b	24.92	3.08b	3.33b	6.41b	48.28a
$N_4 \times S_3$	91.27	181.00ab	151.00a	30.00efg	146.49a	19.89g	166.38a	25.17	3.53a	4.02a	7.55a	46.73ab
$N_4 \times S_4$	89.93	177.67a	152.67a	25.00b-e	136.28c	21.24fg	157.52b	25.24	3.35a	3.81a	7.16a	46.79a
CV(%)	4.12	4.36	5.24	4.26	6.33	5.45	5.78	6.59	7.45	6.31	4.18	5.85
Level of sig.	NS	**	**	**	**	**	**	NS	**	**	**	**

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