Vol 3 No 3 September 2022 Pages 47-53 e-ISSN 2708-5694

Journal of Agriculture, Food and Environment (JAFE)

Journal Homepage: http://journal.safebd.org/index.php/jafe

https://doi.org/10.47440/JAFE.2022.3309

Original Article

Weed Growth and Yield of Transplant *Aus* Rice (cv. Binadhan-19) as Influenced by Spacing of Transplanting and Level of Nitrogen

Salam MA*, Ferdousy R and Kheya SA

Department of Agronomy, Bangladesh Agricultural University, Mymenssingh-2202

Article History

Received: 25 June 2022

Revised: 07 August 2022

Accepted: 16 August 2022

Published online: 30 September 2022

***Corresponding Author**

Salam MA, E-mail: salamma71@bau.edu.bd

Keywords

Aus rice, Binadhan-13, Nitrogen management, Plant spacing, Yield

How to cite: Salam MA, Ferdousy R, Kheya SA (2022). Weed Growth and Yield of Transplant *Aus* rice (cv. Binadhan-19) as Influenced by Spacing of Transplanting and Level of Nitrogen. J. Agric. Food Environ. 3(3): 47-53.

ABSTRACT

An experiment was conducted at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh from April to August 2019 to find out the effect of spacing of transplanting and nitrogen level on weed growth and yield performance of *aus* rice (cv. Binadhan-19). Four spacings of transplanting (25 cm × 15 cm, 25 cm × 10 cm, 20 cm × 15 cm and 20 cm × 10 cm) and four levels of nitrogen (control, 50% of RD, 100% of RD, 150% of RD and application of USG) were used in this experiment. The experiment was laid out in a randomized complete block design (RCBD) with three replications. Nine weed species belonging to five families infested the experimental field. Among the nine species three were grasses, three were broad leaves and three were sedges. *Paspalum scrobiculatum, Echinochloa crusgalli, Digitaria sanguinalis, Oxalis europaea, Monochoria vaginalis, Nymphaea nouchali, Cyperus difformis, Scirpus juncoides and Fimbristylis miliacea* were the important weeds in the experimental plots. The highest weed density at 20 DAT (14.43) and 40 DAT (17.40) were obtained from spacing of 20 cm × 15 cm and 20 cm × 10 cm, respectively. Control treatment showed maximum weed densities (15.08 and 18.41, respectively) at both sampling dates. The highest weed density (16.67) was recorded from the treatment combination of 20 cm × 10 cm spacing with control treatment at 20 DAT and the highest weed density (19.66) was recorded from treatment combination of 20 cm × 10 cm spacing with 150% of RD of nitrogen at 40 DAT. Spacing of 20 cm × 10 cm gave the highest (3.54 t ha^{-1}) grain yield compared to other spacings. The highest number of grains $panicle^{-1}$ was found in 20 cm × 10 cm spacing compared to other spacings used in the study. The highest grain yield (3.89 t ha^{-1}) was recorded from application of USG, which was significantly higher than other nitrogen levels. The 20 cm × 10 cm spacing produced the highest grain yield (4.41 t ha^{-1}) with application of USG, whereas 20 cm × 15 cm with no nitrogen (control) treatment produced the lowest grain yield (2.39 t ha^{-1}). So, it can be concluded that 20 cm × 10 cm spacing of transplanting with application of USG may be used for maximization of yield of Binadhan-19 in *aus* season.

Introduction

Rice *(Oryza sativa* L.) is one of the most important cereal crops in the world and about three billion people around the world consume it as their staple food (Koireng *et al.*, 2019). Bangladesh is one of the leading rice producing countries in the world and about 80% of the cropped areas are covered by rice. About 37.61 million metric ton of rice is produced in this country from 11.70 million hectares of land (BBS, 2021). Since independence, rice production has been increased by three-fold in Bangladesh, which jumped from about 11 million tons in 1971-72 to about 34.86 million tons in 2014-15 (AIS, 2016). This has transformed the country from so called "Bottomless Basket" to a "Full of Food Basket". In recent years, the country has not only earned self-sufficiency in rice production, but also gradually entering the export regime (BER, 2015). There are three distinct rice growing seasons in Bangladesh namely, *aus*, *aman* and *boro*. Both area and yield of *aus* rice were very low compared with other two seasons. So, among these three seasons' *aus* is the least productive season. Binadhan-19 is a drought tolerant rice variety. It is a newly released short duration *aus* rice. Cultivation of Binadhan-19 rice has been expanding every year as *aus* crop during the off season in between *boro* and *aman* cultivations to keep agriculture productions increasing despite adverse impacts of climate change to assure food security. Though the climate and soil of Bangladesh are favorable for year-round rice production, but maintaining an increased production of rice will be a challenge especially in the context of decreasing of cultivable rice land with increasing population. The important ways of increasing yield of rice per unit area are use of HYV, proper use of fertilizer especially nitrogen, optimum water management and use of proper spacing. However, the potential production of Binadhan-19 also depends on proper plant spacing and nitrogenous fertilizer management. BRRI (2000) reported that spacing of transplanting is an important factor that needs to be considered during transplanting of rice. The growth, yield and yield components of rice are also greatly influenced by plant spacing. Under field condition farmers are using variable plant spacing for rice cultivation. Some of them use very closer plant spacing and others are using wider plant spacing. Closer spacing hampered cultural operations, intra-plant competition begins among the plants for essential plant nutrients, spaces and light, as a result plant becomes weaker and thinner, thereby reduces grain yield. Again, using more wider plant spacing farmers do not get desired number of hills per unit area which ultimately reduces yield. Optimum plant spacing ensures proper growth of plants by utilizing optimum solar radiation and nutrients. The quantities of *aus* rice along with its quality might be increased by space managements. Proper spacing management may help to produce maximum LAI for light interceptions, which is better for photosynthesis. Increasing crop density by narrowing row spacing enhances crop competitiveness against weeds. High planting density of a crop develops canopy rapidly and consequently suppresses weeds more effectively, and in contrast, widely spaced plants encourage weed growth. Nitrogen is a major essential plant nutrient and key input for crop production (Dastan *et al.*, 2012). It is essential for the synthesis of protein, which is the constituent of protoplasm and chloroplast. Nitrogen is a constituent of numerous important compounds found in living cells, including amino acid, protein (enzymes), nucleic acid and chlorophyll. Nitrogen has a positive influence on growth and yield of rice. The nitrogen content of Bangladesh soil is low due to warm climate accompanied by extensive cultivation. Farmers tend to apply more nitrogenous fertilizer to get maximum production. But yield of improved rice varieties may reduce due to improper use of fertilizer, which also increases production cost of rice. Inadequate use of nitrogenous fertilizer might be the reason of low response of many high yielding improved varieties. Optimum level of nitrogen ensures proper growth and development of crop and this results higher yield. So, effective fertilizer management can ensure higher crop yield and may reduce fertilizer cost (Hossain and Islam, 1986). Therefore, it is very much essential to determine optimum dose of nitrogenous fertilizer for efficient utilization of nitrogen for reaching maximum production with minimum cost. However, both weed and rice plants compete for nitrogen and in a weed infested field weeds uptake N more rapidly than rice plant, particularly at high nitrogen levels (Nyarko and De Datta, 1993). Judicious weed management actions are essential to obtain better yields in transplant *aus* rice. The traditional methods of weed control involve huge labor and these are also tedious, time consuming and expensive. Nitrogen application may also affect weed infestation. For rice, as nitrogen level increased, the growth of weed increased resulting the higher yield reductions at higher nitrogen level (De Datta *et al.*, 1969). Under the above circumstances, a field experiment was carried out to evaluate the different spacing of transplanting and different nitrogen levels on weed growth and yield of *aus* rice cv. Binadhan-19.

Materials and Methods

Experimental Site

The experiment was conducted at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during the period from April to August 2019 to study the effect of spacing of transplanting and nitrogen level on weed growth and yield performance of *aus* rice (cv. Binadhan-19). The experimental field was medium high land belonging to the Sonatola Soil Series of dark grey floodplain soil under the agro-ecological zone of Old Brahmaputra Floodplain (AEZ-9) (FAO, 2009). Soil of the experimental field was low in organic matter content having pH 6.8 and its general fertility level was also low. The experimental area was under the sub-tropical climate, which is characterized by high temperature, high humidity and heavy precipitation with occasional gusty winds during April to September.

Treatments and Design

The experimental treatment consisted of two factors, Factor A- Spacing: i) 25 cm × 15 cm (S_1), ii) 25 cm × 10 cm (S_2), iii) 20 cm × 15 cm (S_3), iv) 20 cm × 10 cm (S_4) and Factor B- Nitrogen level: i) Control (N_0), ii) 50% of RD (N_1), iii) 100% of RD (N_2), iv) 150% of RD (N_3), v) Application of USG (N_4) [RD= Recommended dose]. The experiment was laid out in a randomized complete block design with three replications. Each of the replications represented a block in the experiment. Each block was divided into 20-unit plots, where the 20 treatment combinations were allocated at random. All together there were 60-unit plots in the experiment. The net size of each unit plot was 2.5 m × 2 m. The spaces between replications and between plots were 1m and 0.75 m, respectively.

Crop Husbandry

A variety of *aus* rice cv. Binadhan-19 was used in this experiment. Seedlings were raised in the wet seedbed method. Seeds were soaked for 72 hours on 8 April 2019. After incubation the seeds were sprouted. The sprouted seeds were broadcasted uniformly in a well-prepared nursery bed on 15 April 2019. The nursery bed was irrigated every 72 hours at early 15 days after broadcasting. Seedlings were ready for transplanting at 25 days after sowing when sixth or seventh leaves were formed. The land was first opened with a tractor driven plough, ploughing followed by laddering were done with a country plough and a ladder. Weeds and stubbles were removed from the field as much as possible after leveling. The lands were finally prepared and the plots were laid out on 9 May 2019. In addition to nitrogen a basal dose each of triple super phosphate, muriate of potash, gypsum at the rate of 60, 60, 60 kg ha^{-1} and zinc sulphate 6 kg ha^{-1} were applied in all plots. Nitrogen fertilizer in the form of urea was applied as per treatment used in the experiment in three equal splits at 7 DAT, 22 DAT and 36

DAT. Seedlings were transplanted in 4 different spacing (25 cm × 15 cm, 25 cm × 10 cm, 20 cm × 15 cm and 20 cm × 10 cm) as per experimental specification using 3-4 seedlings hill^{-1}. The experimental plots were irrigated and drained out as and when necessary during the growing period of the crop. The crops were found infested with some weeds and were controlled by hand weeding. The crop was harvested at full maturity. The date of harvesting was confirmed when 90% of the seed became golden yellow in color. The crop was harvested on 3 August 2019. The harvested crop of each plot was separately bundled, properly tagged and then brought to threshing floor. The grains were cleaned and sun dried to a moisture content of 14%.

Data Collection

Growth parameters such as plant height, number of tillers hill^{-1}, total dry matter production hill^{-1}, density and dry weight of weed were determined. One hill was marked by bamboo stick excluding boarder rows to collect data on plant height and tiller number. To determine total dry matter for plant one hill was taken from the outside of harvest area at 20 and 40 DAT and in order to determine weed density and dry weight, the weeds were counted and separated from the field at 20 and 40 DAT. The plants and weeds were washed with tap water and then they were packed separately in labeled brown paper bags and dried in the oven at 85±5ºc for 72 hours until constant weight was reached. The samples were weighed carefully after oven drying to measure the dry weight of plant and weed. Three hills (excluding border rows and central 1 m^2 area) were selected randomly from each unit plot and uprooted for recording yield contributing data. After sampling a harvest area of central 1m^2 (1m × 1m) was selected from each unit plot for recording grain and straw yield per plot and finally converted to t ha^{-1}. At harvest data on plant height (cm), total tillers hill^{-1} (no.), effective tillers hill^{-1} (no.), length of panicle (cm), sterile spikelets panicle^{-1} (no.), grains panicle^{-1} (no.), 1000-grain weight (g), grain yield (t ha^{-1}), straw yield (t ha^{-1}) and harvest index (%) were recorded. The harvest index was computed by using the following formula:

$$\text{Harvest index (\%)} = \frac{\text{Grain yield}}{\text{Biological yield}} \times 100$$

Where, Biological yield = Grain yield + straw yield

Statistical Analysis

Data on different parameters were compiled and tabulated in proper form for statistical analysis. Analysis of variance was done with the help of computer package MSTAT-C. The mean differences among the treatments were adjudged with Duncan's Multiple Range Test (Gomez and Gomez, 1984).

Results and Discussion

Effect of spacing of transplanting on plant height, tiller production and plant dry matter production

Plant height, number of total tillers hill^{-1} were not significantly influenced by plant spacing at 20 and 40 DATs. There was significant relationship between spacing treatments and plant dry weight at 20 DAT but non-significant relationship was found between spacing treatments and plant dry weight at 40 DAT. At 20 DAT the highest (0.81 g hill^{-1}) plant dry weight was obtained from 20 cm × 15 cm spacing and the lowest one (0.66 g hill^{-}) was found in 25 cm × 10 cm spacing treatment (Table 1). The higher dry matter with wider spacing was due to increased amount of photosynthate accumulation which was provided by more availability of PAR, nutrient and soil moisture compared to closely spaced plants. Villanueva *et al.* (1989) reported that closer plant spacing significantly reduced plant dry weight. This result was also in agreement with Singh *et al.* (1989) and Hasanuzzaman *et al.* (2009).

Effect of nitrogen level on plant height, tiller production and plant dry matter production

Nitrogen level had significant effect on the plant height at 20 and 40 DATs. The tallest plant (24.08 cm) was obtained from 50% of recommended dose of nitrogen from urea at 20 DAT and at 40 DAT the tallest plant (49.58 cm) was found from 150% of recommended dose of nitrogen from urea. The shortest plant (21.25 cm) was found in the control treatment (no nitrogen) at 20 DAT and at 40 DAT the shortest plant (42.00 cm) was recorded in control treatment. Number of total tillers hill^{-1} was not significantly influenced by the nitrogen management treatment at 20 and 40 DATs. There was no significant variation in the nitrogen management on the plant dry weight at 20 DAT but significant variation was found at 40 DAT. The highest (4.34 g hill^{-1}) plant dry weight was obtained from the 150% recommended dose of nitrogen from urea at 40 DAT. Growth promoting effect of N on plant can be explained on the basis of the fact that N supply increases the number and size of meristematic cells which leads to formation of new shoots that enhanced dry matter production in rice. The lowest (3.32 g hill^{-1}) dry matter was found in 50% of recommended dose of nitrogen from urea at 40 DAT (Table 2).

Interaction effect of spacing and nitrogen level on growth parameters of rice

Plant height was not significantly influenced by the interaction of spacing and nitrogen management treatment at 20 and 40 DATs. Number of total tillers hill^{-1} was not significantly influenced by the interaction effect of spacing and nitrogen management at 20 DAT but at 40 DAT total tillers hill^{-1} was significantly influenced by the interaction of spacing and nitrogen management. At 40 DAT highest number of total tillers hill^{-1} (14.00) was obtained from the spacing of 20 cm × 10 cm with application of USG and the lowest number (97.66) of total tillers hill^{-1} was found with spacing 20 cm × 15 cm with application of USG. Plant dry weight was not significantly varied due to interaction of spacing and nitrogen management at 20 DAT but at 40 DAT there was significant variation of plant dry weight due to interaction of spacing and nitrogen management. At 40 DAT numerically the highest (18.55 g hill^{-1}) plant dry weight was obtained from the treatment combination of 25 cm × 15 cm spacing with 150% of recommended dose of nitrogen from urea and the lowest one (2.72 g hill^{-1}) was found in the treatment combination of 20 cm × 10 cm spacing with application of USG (Table 3).

Effect of spacing of transplanting on weed density and dry weight

Number of weeds was significantly affected in the present study by spacing at 20 DAT. At 20 DAT the highest number of weeds (14.43) was obtained from 20 cm × 15 cm spacing and the lowest weed number (11.60) was obtained in the spacing of 25 cm × 15 cm. Weed dry weight was non-significantly influenced by the spacing treatment (Table 1).

Effect of nitrogen management on weed density and dry weight

Number of weeds was significantly varied due to nitrogen management at 20 DAT but at 40 DAT number of weeds was not significantly influenced by the effect of nitrogen level. At 20 DAT the highest number of weed (15.08) was obtained from control (no nitrogen) treatment and the lowest weed number (11.25) was obtained from 50% of recommended dose of nitrogen from urea. Weed dry weight was significantly influenced by the nitrogen management at 40 DAT. The highest weed dry weight (6.09 g) was found in application of USG at 40 DAT and the lowest one (4.17 g) was found in control (no nitrogen) treatment (Table 2).

Interaction effect of spacing of transplanting and nitrogen management on weed density and dry weight

Number of weeds was significantly affected by the interaction of spacing and nitrogen management at 20 DAT but was not significantly affected at 40 DAT. The highest number of weeds (16.66) was obtained from the treatment combination of 20 cm × 10 cm spacing with control (no nitrogen) treatment at 20 DAT and the lowest weed number (8.00) was obtained from treatment combination of 25 cm × 15 cm spacing with 50% of recommended dose of nitrogen from urea. Weed dry weight was non-significantly influenced by the interaction of spacing and nitrogen management treatment at 20 and 40 DATs (Table 3).

Effect of spacing on yield and yield components of *aus* rice

Spacing of transplanting exerted significant effect on number of total tillers hill^{-1}, number of effective tillers hill^{-1}, number of grains panicle^{-1} and straw yield and non-significant effect on plant height, length of panicle, sterile spikelets panicle^{-1}, 1000-griain weight, grain yield and harvest index (Table 4). The highest number of total tillers hill^{-1} (11.41) was observed with the spacing of 25 cm × 15 cm and the lowest number of total tillers hill^{-1} (10.04) was observed at 25 cm × 10 cm spacing which was statistically similar with other spacings of transplanting. This result corroborates the findings of Sarker (2001), Jocob *et al.* (2005), Sohel *et al.* (2009) and Uddin *et al.* (2010) who obtained highest number of total tillers hill^{-1} at 25 cm × 15 cm spacing. Similar result was also reported by Akondo and Hossain (2019) who found the highest number of total tillers hill^{-1} at wider spacing of 25 cm × 20 cm. This might be due to the fact that wider space allowed the individual plants to produce more tillers. The highest number of effective tillers hill^{-1} (9.60) was found at the plant spacing of 25 cm × 15 cm which was statistically similar (9.33) with 20 cm × 10 cm spacing and the lowest number of effective tillers hill^{-1} (8.73) was obtained from the spacing of 20 cm × 15 cm. This result is in agreement with the findings of Salahuddin *et al.* (2009) who obtained highest number of effective tillers hill^{-1} at 25 cm × 15 cm spacing. The plant spacing had significant effect on grains panicle^{-1}. The highest number of grains panicle^{-1} (65.67) was obtained at the spacing of 20 cm × 10 cm which was statistically similar with 25 cm × 10 cm and 20 cm × 15 cm spacings. The lowest number of grains panicle^{-1} (60.13) was recorded at 25 cm × 15 cm spacing. But this result is in disagreement with the finding of findings of Salahuddin *et al.* (2009) who found highest number of grains panilce^{-1} in 25 cm × 15 cm spacing but they found second highest number of grains panicle^{-1} in 25 cm × 10 cm spacing. Though grain yield of rice was not significantly affected by spacing of transplanting but numerically the highest grain yield (3.54 t ha^{-1}) was recorded in 20 cm × 10 cm and the lowest grain yield was recorded from the spacing of 20 cm × 15 cm. The highest grain yield (3.54 t ha^{-1}) was recorded in 20 cm × 10 cm spacing due to the highest number of effective tillers hill^{-1} and highest number of grains panicle^{-1}. This finding corroborates the findings of Saha *et al.* (2020) who obtained the highest grain yield in 20 cm × 10 cm spacing in *boro* rice. Plant spacing also exerted significant effect on straw yield. The highest straw yield (4.82 t ha^{-1}) was obtained from 25 cm × 15 cm spacing which was resulted from the highest number of total tillers hill^{-1} in this treatment. The lowest straw yield (4.70 t ha^{-1}) was recorded from 20 cm × 10 cm plant spacing (Table 4).

Table 1. Effect of spacing on growth parameters of *aus* rice cv. Binadhan-19 and weed density and dry weight.

Spacing management	Plant height (cm)		Total tillers hill^{-1} (No.)		Number of weeds		Plant dry weight (g)		Weed dry weight (g)	
	20 DAT	40 DAT	20 DAT	40 DAT	20 DAT	40 DAT	20 DAT	40 DAT	20 DAT	40 DAT
25 cm × 15 cm	23.13*	44.86	4.60	10.00	11.60b	15.66	0.77ab	3.98	1.21	5.12
25 cm × 10 cm	22.86	44.93	4.13	9.60	11.86b	17.06	0.66b	3.86	1.03	5.15
20 cm × 15 cm	23.06	46.33	4.53	9.53	14.43a	16.26	0.81a	4.06	1.48	5.64
20 cm × 10 cm	22.80	43.93	4.46	10.46	14.00a	17.40	0.70ab	3.52	1.06	4.75
Level of sig.	NS	NS	NS	NS	0.05, 0.01	NS	0.05	NS	NS	NS
% CV	10.48	9.36	17.78	18.10	16.14	20.11	20.99	19.34	55.24	21.69

*In a column, figures having same letter(s) or without letter do not differ as per DMRT; NS = Not Significant

Table 2. Effect of nitrogen level of nitrogen on growth parameters of *aus* rice cv. Binadhan-19 and weed density and dry weight.

Nitrogen management	Plant height (cm)		Total tillers hill^{-1} (No.)		Number of weeds		Plant dry weight (g)		Weed dry weight (g)	
	20 DAT	40 DAT	20 DAT	40 DAT	20 DAT	40 DAT	20 DAT	40 DAT	20 DAT	40 DAT
N_0	21.25b*	42.00b	4.08	9.33	15.08a	18.41	0.69	3.85ab	0.97	4.17c
N_1	24.08a	43.33b	4.50	10.16	11.25c	16.50	0.75	3.32b	1.40	4.56bc
N_2	23.25ab	45.00b	4.25	9.66	11.66c	16.58	0.71	3.79ab	1.33	5.34ab
N_3	22.41ab	49.58a	4.50	9.66	13.87ab	17.00	0.83	4.34a	1.37	5.68a
N_4	23.83a	45.16b	4.83	10.66	13.00bc	14.50	0.70	3.97ab	0.90	6.09a
Level of sign.	0.01	0.01	NS	NS	0.05, 0.01	NS	NS	0.05	NS	0.01
CV (%)	10.48	9.36	17.78	18.10	16.14	20.11	20.99	19.34	55.24	21.69

*In a column, figures having same letter(s) or without letter do not differ as per DMRT; NS = Not Significant
N_0 = Control (no nitrogen), N_1 = 50% of RD, N_2 = 100% of RD, N_3 = 150% of RD, N_4 = Application of USG (180 kg ha^{-1})

Table 3. Interaction effect of spacing of transplanting and nitrogen level on growth parameters of *aus* rice cv. Binadhan-19 and weed density and dry weight.

Interaction	Plant height (cm)		Total tillers hill^{-1} (No.)		Number of weeds		Plant dry weight (g)		Weed dry weight (g)	
(S × N)	20 DAT	40 DAT	20 DAT	40 DAT	20 DAT	40 DAT	20 DAT	40 DAT	20 DAT	40 DAT
S_1N_0	20.33*	40.66	4.33	8.66c	14.66abc	17.33	0.77	10.81b-e	1.26	4.22
S_1N_1	24.33	44.66	4.66	10.00bc	8.00e	14.66	0.72	8.79de	1.72	4.36
S_1N_2	24.00	46.33	4.66	11.00abc	12.33bcd	17.66	0.60	10.45b-e	0.95	5.03
S_1N_3	23.66	51.00	4.66	10.00bc	12.33bcd	14.00	1.00	18.55a	1.25	5.73
S_1N_4	23.33	41.66	4.66	10.33bc	10.66cde	14.66	0.77	11.10b-e	0.86	6.29
S_2N_0	20.33	41.33	4.00	10.66bc	15.00ab	18.00	0.57	11.64b-e	0.63	3.97
S_2N_1	23.00	44.66	3.66	9.33bc	8.33e	13.66	0.75	8.84de	1.74	4.88
S_2N_2	22.33	41.66	4.00	8.33c	8.66de	18.33	0.70	14.45b	0.88	5.35
S_2N_3	23.33	49.33	4.00	9.00bc	13.66abc	18.00	0.60	9.12de	1.11	5.76
S_2N_4	25.33	47.66	5.00	10.66bc	13.66abc	17.33	0.70	13.88bc	0.80	5.82
S_3N_0	22.00	44.00	4.33	9.33bc	14.00abc	19.00	0.65	9.07de	1.31	4.62
S_3N_1	24.00	43.66	5.00	12.33ab	16.00ab	19.33	0.79	4.22bcd	1.28	5.08
S_3N_2	23.33	45.66	4.66	9.00bc	13.33abc	16.00	0.84	3.69b-e	1.96	5.90
S_3N_3	22.00	51.33	4.66	9.33bc	14.66abc	16.33	1.07	4.54bc	1.49	6.04
S_3N_4	24.00	47.00	4.00	7.66c	14.66abc	10.66	0.72	4.84b	1.36	6.58
S_4N_0	22.33	42.00	3.66	8.66c	16.66a	19.33	0.77	4.97b	0.68	3.89
S_4N_1	25.00	40.33	4.66	9.00bc	12.66abc	18.33	0.75	3.18cde	0.86	3.92
S_4N_2	23.33	46.33	3.66	10.33bc	12.33bcd	14.33	0.69	3.11cde	1.54	5.09
S_4N_3	20.66	46.66	4.66	10.33bc	15.33ab	19.66	0.66	3.61b-e	1.65	5.22
S_4N_4	22.66	44.33	5.66	14.00a	13.00abc	15.33	0.62	2.727 e	0.59	5.65
Level of sign.	NS	NS	NS	0.05	0.05	NS	NS	0.05, 0.01	NS	NS
CV (%)	10.48	9.36	17.78	18.10	16.14	20.11	20.99	19.34	55.24	21.69

*In a column, figures having same letter(s) or without letter do not differ as per DMRT, NS = Not Significant
S_1 = 25 cm × 15 cm, S_2= 25 cm × 10 cm, S_3 = 20 cm × 15 cm, S_4 = 20 cm × 10 cm
N_0 = Control (no nitrogen), N_1 = 50% of RD, N_2 = 100% of RD, N_3 = 150% of RD, N_4 = Application of USG (180 kg ha^{-1})

Table 4. Effect of spacing of transplanting on yield and yield contributing characters of *aus* rice

Spacing of transplanting	Plant height (cm)	Total tillers hill^{-1} (no)	Effective tillers hill^{-1} (no.)	Length of Panicle (cm)	Grains panicle^{-1} (no.)	Sterile spikelets panicle^{-1} (no.)	1000-grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Harvest index (%)
25 cm × 15 cm,	81.20	11.41a*	9.60a	19.62	60.13b	13.93	22.26	3.37	4.82a	41.29
25 cm × 10 cm	81.33	10.04b	8.76b	19.76	63.47ab	13.53	22.33	3.49	4.74b	42.30
20 cm × 15 cm	81.07	10.26b	8.73b	19.39	61.53ab	13.47	22.26	3.29	4.72b	40.94
20 cm × 10 cm	81.20	10.20b	9.33ab	19.39	65.67a	13.33	22.26	3.54	4.70b	43.42
Level of significant	NS	0.05,0.01	0.05	NS	0.05	NS	NS	NS	0.05	NS
CV (%)	3.07	10.32	11.07	5.19	9.19	14.47	2.27	17.27	23.23	13.12

*In a column, figures having same letter(s) or without letter do not differ as per DMRT, NS = Not Significant

Effect of nitrogen level on yield and yield components

Nitrogen level showed significant effect on plant height, number of total and effective tillers hill^{-1}, number of grains panicle^{-1}, grain yield and harvest index. Plant height increased with the increasing rates of nitrogen up to 150% of the recommended dose of nitrogen from urea (82.25 cm) and it was found higher from the other levels of nitrogen. The shortest plant (79.08 cm) was found in the control plot (without N). Nitrogen induced maximum vegetative growth with higher rates of nitrogen. Similar results were also reported by Siddique *et al.* (2014) who also reported that increasing N rates increased plant height up to 180 kg ha^{-1}. The highest number of total tillers hill^{-1} (11.50) was observed at 50% of recommended dose of nitrogen from urea which was statistically identical to 100% of the recommended dose of nitrogen from urea and application of urea super granule and the lowest (7.90) was obtained from control (no nitrogen) treatment. This result is in agreement with the findings of Uddin *et al.* (2013). The highest number of effective tillers hill^{-1} (9.67) was obtained when USG was applied which was statistically identical to 100% of the recommended dose of nitrogen from urea, 50% of the recommended dose of nitrogen from urea and 150% of the recommended dose of nitrogen from urea. The lowest number of total (7.90) and effective tillers hill^{-1} (7.79) was obtained from control (no nitrogen) treatment. The highest number of grains panicle^{-1} (67.83) was found from application of USG which was statistically identical to 150% of the recommended dose of nitrogen, 100% of the recommended dose of nitrogen, 50% of the recommended dose of nitrogen from urea. Similar research findings were also reported by Hasan (2007) and Islam *et al.* (2017) who recorded higher number of grains panicle^{-1} with the application urea super granule than application of prilled urea. The lowest number of grains panicle^{-1} (49.75) was found in control (no nitrogen) treatment. Nitrogen helped in proper filling of seeds which resulted higher produced plump seeds and thus the number of grains panicle^{-1}. Similar result was also reported by Salahuddin *et al.* (2009). The crop at low nitrogen level (no nitrogen) produced the lowest values of all the yield components like effective tillers hill^{-1}, grains panicle^{-1} and sterile spikelets panicle^{-1}. The influence of nitrogen on grain yield was highly significant. The highest grain yield (3.89 t ha^{-1}) was found when fertilized with USG treatment which was statistically identical to 150% of the recommended dose of nitrogen, 100% of the recommended dose of nitrogen, 50% of the recommended dose of nitrogen from urea. The lowest (2.56 t ha^{-1}) grain yield was found from control (no nitrogen) treatment. The increased grain yield with USG might be due to the cumulative effect of the highest number of effective tillers hill^{-1} and highest number of grains panicle^{-1} obtained from the supply of nitrogen for the plants. Similar result was found from the findings of Singh *et al.* (2000) and Salahuddin *et al.* (2009). Numerically the highest straw yield (4.91 t ha^{-1}) was recorded when USG was applied and the lowest one (4.63 t ha^{-1}) was obtained from the application 100% of the recommended dose of nitrogen from urea treatment (Table 5). The highest harvest index (44.30%) was recorded from application of urea super granule which was statistically identical to other treatments except control (no nitrogen) treatment (Table 5).

Table 5. Effect of nitrogen level on yield and yield contributing characters of *aus* rice.

Nitrogen management	Plant height (cm)	Total tillers hill^{-1} (no.)	Effective tillers hill^{-1} (no.)	Length of panicle (cm)	Grains panicle^{-1} (no.)	Sterile spikelets panicle^{-1} (no.)	1000-grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Harvest index (%)
N_0	79.08b*	7.90c	7.79b	19.17	49.75b	15.25a	22.16	2.56b	4.66	35.99b
N_1	82.17a	11.50a	9.42a	19.59	63.00a	13.42b	22.48	3.40a	4.65	42.51a
N_2	81.00ab	11.41a	9.58a	19.63	66.25a	12.50b	22.35	3.40a	4.63	43.08a
N_3	82.25a	10.33b	9.08a	19.45	66.67a	13.33b	22.30	3.83a	4.86	44.05a
N_4	81.50a	11.25a	9.67a	19.88	67.83a	13.33b	22.09	3.89a	4.91	44.30a
Level of sig.	NS	0.05,0.01	0.01	NS	0.01	0.05	NS	0.01	0.01	0.05, 0.01
CV (%)	3.07	10.32	11.83	5.19	9.19	14.47	2.27	17.27	23.23	13.12

* In a column, figures having same letter(s) or without letter do not differ as per DMRT, NS = Not Significant
N_0 = Control (no nitrogen), N_1 = 50% of RD, N_2 = 100% of RD, N_3 = 150% of RD, N_4 = Application of USG (180 kg ha^{-1})

Interaction effect of spacing of transplanting and nitrogen level on yield and yield contributing characters of *aus* rice

The interaction effect between plant spacing and nitrogen levels was significant on plant height, number of total tillers hill^{-1} and panicle length. The highest plant height (85.67 cm) was observed at the spacing 25 cm × 15 cm fertilized with 150% of RD and the lowest plant height (77.00 cm) was found at 25 cm × 15 cm spacing in control (no nitrogen) treatment. The highest number of total tillers hill^{-1} (13.33) was observed at the plant spacing 25 cm × 15 cm fertilized with 50% RD while the lowest total number of tillers hill^{-1} (7.56) was obtained at the spacing 25 cm × 10 cm with control (no nitrogen) treatment. The highest length of panicle (21.43) was observed at the spacing 25 cm × 10 cm fertilized with 100% of RD. The lowest length of panicle (18.46) was observed at the spacing 25 cm × 15 cm with 100% of RD. On the other hand, the interaction between plant spacing and nitrogen showed non-significant relationship with number of effective tillers hill^{-1}, number of grains panicle^{-1}, number of sterile spikelets panicle^{-1}, 1000-grain weight, grain yield, straw yield and harvest index (Table 6).

Table 6. The interaction between spacing of transplanting and nitrogen level on yield and yield contributing characters of *aus* rice.

Interaction	Plant height (cm)	Total tillers hill^{-1} (no)	Effective tillers hill^{-1} (no.)	Length of panicle (cm)	Grains panicle^{-1} (no.)	Sterile spikelets panicle^{-1} (no.)	1000- grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Harvest index (%)
S_1N_0	77.00e*	8.40efg	8.00	19.15b	45.33e	15.67a	21.75	2.60de	4.78	35.63
S_1N_1	81.67a-e	13.33a	11.33	19.60ab	60.33cd	14.66ab	22.48	3.48a-e	4.93	41.96
S_1N_2	79.00cde	12.67ab	10.00	18.46b	63.00bcd	12.00ab	22.40	3.54a-e	4.73	42.73
S_1N_3	85.67a	11.00bcd	9.33	20.44ab	65.33abc	13.67ab	22.47	3.68a-d	4.72	44.10
S_1N_4	82.67a-d	11.67a-d	9.33	20.44ab	66.67abc	13.66ab	22.17	3.56a-d	4.91	42.02
S_2N_0	79.67cde	7.56g	7.83	19.03b	52.67de	15.33ab	22.22	2.60de	4.40	37.57
S_2N_1	82.67a-d	10.00def	8.67	20.21ab	67.33abc	13.33ab	22.56	3.45a-e	4.57	43.25
S_2N_2	84.67ab	12.33abc	9.67	21.43a	67.00abc	12.66ab	22.50	3.54a-e	4.68	43.16
S_2N_3	79.00cde	10.00def	8.00	19.16b	65.33abc	13.33ab	22.28	4.10ab	5.06	44.39
S_2N_4	80.67b-e	10.33cde	9.67	19.11b	65.00abc	13.00ab	22.04	3.74a-d	4.97	43.11
S_3N_0	78.00de	8.00fg	8.00	19.14b	52.67de	15.00ab	22.54	2.39e	4.99	32.32
S_3N_1	81.67a-e	10.33cde	8.33	18.66b	62.33cd	12.00ab	22.14	3.27a-e	4.58	41.80
S_3N_2	80.67b-e	10.67bcd	8.67	19.37b	67.00abc	12.00ab	22.56	3.20b-e	4.21	42.90
S_3N_3	83.33abc	10.00def	9.00	19.53ab	62.00cd	13.33ab	22.19	3.78abc	4.90	43.62
S_3N_4	81.67a-e	12.33abc	9.67	20.25ab	63.67bc	15.00ab	21.83	3.85ab	4.91	43.96
S_4N_0	81.67a-e	7.667g	7.33	19.40b	48.33e	15.00ab	22.10	2.66cde	4.46	38.44
S_4N_1	82.67a-d	12.33abc	9.33	19.90ab	62.00cd	13.66ab	22.71	3.41a-e	4.52	42.94
S_4N_2	79.67cde	10.00def	10.00	19.27b	68.00abc	13.33ab	21.94	3.48a-e	4.89	33.53
S_4N_3	81.00a-e	10.33cde	10.00	18.67b	74.00ab	13.00ab	22.23	3.74a-d	4.77	44.08
S_4N_4	81.00a-e	10.67bcd	10.00	19.72ab	76.00a	11.67b	22.30	4.41a	4.85	48.11
Level of sig.	0.05	0.05	NS	0.05	NS	0.05	NS	NS	NS	NS
CV (%)	3.07	10.32	11.07	5.19	9.19	14.47	2.27	17.27	23.23	13.12

*In a column, figures with the same letter (s) or without letter do not differ significantly whereas figures with dissimilar letter differ significantly (as per DMRT), 0.01 = 1% level of significance, 0.05 = 5% level of significance, NS = Not Significant
S_1 = 25 cm × 15 cm, S_2= 25 cm × 10 cm, S_3 = 20 cm × 15 cm, S_4 = 20 cm × 10 cm
N_0 = Control (no nitrogen), N_1 = 50% of RD, N_2 = 100% of RD, N_3 = 150% of RD, N_4 = Application of USG (180 kg ha^{-1})

Conclusion

The results of present investigation indicated that a significant improvement in yield of transplant *aus* rice (cv. Binadhan-19) could be possible through application of USG with maintaining 20 cm × 10 cm plant spacing.

Acknowledgement

The authors are thankful to the Ministry of Science and Technology (MoST), Government of the Peoples Republic of Bangladesh for financial support through special allocation fund in the financial year 2018-2019.

References

AIS (Agricultural Information Service) (2016). Krishi Diary 2016, Agricultural Information Service, Khamarbari, Farmgate, Dhaka-1215, Bangladesh. pp. 23.

Akondo MRT, Hossain, MB (2019). Effect of spacing on the performance of newly developed *aus* rice var. Binadhan-19. Research in Agriculture, Livestock and Fisheries. 6(3): 373-378.

BBS (Bangladesh Bureau of Statistics) (2021). The Yearbook of Agricultural Statistics of Bangladesh. Statistics Division, Ministry of Planning, Government of the People's Republic of, Bangladesh, Dhaka.

BER (Bangladesh Economic Review) (2015). Bangladesh Economic Review 2015, Ministry of Finance, Government of the People's Republic of Bangladesh, Bangladesh Secretariat, Dhaka, Bangladesh. pp. 120.

BRRI (Bangladesh Rice Research Institute) (2000). Annual Report for 1997. Bangladesh Rice Res. Inst. Pub. No. 134, Joydebpur, Gazipur, Bangladesh. pp. 88-256.

Dastan S, Siavoshi M, Zakavi D, Ghanbaria-malidarreh A, Yadi R, Ghorbannia Delavar E, Nasiri AR (2012). Application of nitrogen and silicon rates on morphological and chemical lodging related characteristics in rice (*Oryza sativa* L.) north of Iran. Journal of Agricultural Science, 4(6):12-18.

De Datta SK, Moomaw JC, Bantilan RT (1969). Effects of varietal type, method of planting and nitrogen level on competition between rice and weeds. In Proceeding 2nd Asian-Pacific Weed Control Inter. pp. 152-153.

FAO (Food and Agriculture Organization) (2009). Production Year Book. Food and Agric. Organ of the United Nations, Rome. pp. 72-73.

Gomez KA, Gomez AA (1984). Statistical Procedure for Agricultural Research Intl. Rice Res. Inst., John Wiley and Sons. New York, Chickester, Brisbane, Toronto, Singapore. pp. 1-34.

Hasan SM (2007). Effect of level of urea super granules on the performance of *boro* rice. MS thesis, Department of Agronomy, Bangladesh Agricultural University, Mymensingh.

Hasanuzzaman M, Nahar K, Roy TS, Rahman ML¸ Hossain MZ, Ahmed JU (2009). Tiller dynamics and dry matter production of transplanted rice as affected by plant spacing and number of seedling per hill. Academic Journal of Plant Sciences 2(3):162-168.

Hossain SMA, Islam MS (1986). Fertilizer management in Bangladesh. Adv. Agron. Res. in Joydebpur, Gazipur. pp. 48-54.

Islam MA, Islam MF, Rahman J, Sarkar MAR, Rahman MR (2017). Effect of variety and depth of placement of urea super granule on the yield and yield components of *boro* rice. International Journal of Applied Research, 3(1):1-6.

Jacob D, Syriac EK (2005). Performance of transplanted scented rice (*Oryza sativa* L.) under different spacing and weed management regimes in southern Kerala. Journal of Tropical Agriculture, 43(1-2):71-73.

Koireng RJ, Devi NM, Devi KP, Gogoi M, Anal PSR (2019). Effect of variety and spacing on the productivity of direct seeded rice (*Oryza sativa* L) under Manipur condition. Indian journal of Pure and Applied Biosciences, 3(5):335-341.

Nyarko AK, De Datta SK (1993). Effect of light and nitrogen and their interaction on the dynamics of rice-weed competition. Weed Research, 33:1-8.

Saha KK, Paul SK, Sarkar MAR (2020). Influence of spacing of planting on the yield performance of some aromatic rice varieties in *boro* season. Sustainability in Food and Agriculture, 1(1):10-14.

Salahuddin KM, Chowhdury SH, Munira S, Islam MM, Parvin S (2009). Response of nitrogen and plant spacing of transplanted *aman* rice. Bangladesh Journal of Agricultural Research, 34(2):279-285.

Sarker MAH, Samad MA, Amin MR, Pandit DB, Jahan MAHS (2001). Effect of nitrogen levels and ear size on the grain development and yield of Rice. Bangladesh Journal of Agricultural Sciences, 28(2):303-310.

Siddique MA, Islam N, Islam MZ, Islam SMM, Hussain J (2014). Effect of n level on growth and yield of T. *aman* rice cv. Surjomoni. International Journal of Sustainable Crop Production, 9(2):33-37.

Singh MK, Thakur R, Verma UN, Upasani RR, Pal SK (2000). Effect of Planting time and nitrogen on production potential of Basmati rice (*Oryza sativa*). Cultivars in Bihar Plateau. Indian Journal of Agronomy**,** 45(2):300-303.

Singh S, Prasad R, Sharma SN (1989). Growth and yield of rice as affected by spacing, time and depth of placement of urea briquettes. Fertilizer Research, 19(2):99-101.

Sohel MAT, Siddique MAB, Asaduzzaman M, Alam MN, Karim MM (2009). March varietal performance of transplanted *aman* rice under different hill densities. Bangladesh Journal of Agricultural Research, 34(1):33-39.

Uddin MJ, Ahmed S, Hasan MM (2010). Effect of spacing on morphology and yield response of different. aman rice cultivars under coastal high land ecosystem. Indian Journal of Agricultural Research, 44 (4):251-258.

Uddin S, Sarkar MAR, Rahman MM (2013). Effect of nitrogen and potassium on yield of dry direct seeded rice cv. NERICA 1 in *aus* season. International Journal of Agronomy and Plant Production, 4(1):69–75.

Villanueva JD, Jamilarin LL, Daguro P, Pablico K, Moody EL, Cabayao, JM, Osana JM (1989). Effect of plant spacing and Salvini molesta on yield of transplanted rice (*Oryza sativa* L.). Conference on Pest Control Council of the Philippines, Baguio City (Philippines), May 1989. International Rice Research Inst., Los Banos, Laguna Philippines. pp. 9-12.