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IMPROVING SEEDLING GROWTH AND YIELD OF TRANSPLANT BORO RICE THROUGH NURSERY MANAGEMENT

F.B. Forhad[1], M.P. Anwar[1*], H.O. Rashid[2], A.K. Hasan[2], S.A. Kheya[2], S. Afrin[1], S. Yeasmin[1] and A.K.M.M. Islam[1]

[1]Agro Innovation Laboratory, Department of Agronomy, Bangladesh Agricultural University, Mymensingh

[2]Department of Agronomy, Bangladesh Agricultural University, Mymensingh

ABSTRACT

Healthy seedling is the best component of the transplant rice, which depends on its growing environment and appropriate nursery management techniques. To assess the effectiveness of various seeding densities and nutrient management in nurseries on seedling growth and yield of *Boro* rice, an experiment was conducted at the Agronomy Field Laboratory of Bangladesh Agricultural University from November 2019 to May 2020. The experiment comprised two factors, *viz*., seeding density (3): medium density (80 g m^{-2}) (control), high density (100 g m^{-2}), very high density (120 g m^{-2}); and nursery nutrient management (6): no nutrient applied, 10 g N m^{-2}, 15 g P m^{-2}, 15 g K m^{-2}, 10 g N m^{-2} + 15 g P m^{-2} + 15 g K m^{-2}, compost 2 kg m^{-2}. The experiment was replicated three times following randomized complete block design. With 80 g m^{-2} seed rate, the highest seedling dry weight, effective tillers $hill^{-1}$, grains $panicle^{-1}$ and grain yield were achieved. Regarding nutrient management, seedlings fertilized with N+P+K produced the highest shoot length, seedling dry weight, effective tillers $hill^{-1}$, grains $panicle^{-1}$ and grain yield. In case of interaction, the highest number of effective tillers $hill^{-1}$ was obtained from 80 g m^{-2} seeding density with N+P+K application, which eventually resulted in the highest grain yield. Therefore, medium seeding density of 80 g m^{-2} and application of 10 g N+15 g P+15 g Km^{-2} in nursery may be practiced for better seedling growth and higher yield of *Boro* rice.

Keywords: Nursery, Seeding density, Fertilizer management, Seedling growth, Grain yield, *Boro* rice

[*] Corresponding author: parvezanwar@bau.edu.bd

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INTRODUCTION

Rice is one of the world's most widely grown grains which accounts for an unquestionable share of cereal consumption and production (Liang et al., 2021). For more than half of the world's population, it is a vital staple diet. No other food grain is more significant from a nutritional, food security and economic standpoint than rice, which is a "Global grain" (Xu et al., 2022). It is an important cereal crop of Asia as more than 90% of rice is grown and consumed in this continent (Abdullah et al., 2008). Rice is the main food grain for Bangladesh also. Bangladesh has made incredible progress in raising rice output in last few decades. In 1971, Bangladesh produced 10.59 million tons of rice, that reached to 37.61 million tons in 2021 (BBS, 2021).

In spite of higher production, the demand for rice continues to increase owing to continued growth of population. So sustaining food security in the light of growing population is a significant challenge for the country. To fulfill the enormous population's need for food, traditional management methods alone are insufficient. Therefore, establishing new strategies and techniques will be crucial for rice production in the future. So, it is high time to search for innovative practices, which can guarantee higher yields with minimal deterioration of natural resources.

Nursery management is an integral part of transplanted rice production. Raising young plants in nurseries and then transplanting them into the main field is the usual practice of rice farming. Fertilizer management for rice nursery is an area which is traditionally overlooked in rice research, so we still lack the right fertilizer recommendations for rice nurseries. Typically, rice farmers don't use fertilizer in their nursery. So far research attention has been given to rice in the main field management only, the nursery management did not receive considerable attention. However, good nursery management will have a positive impact on crop growth in the main field (Grossnickle and MacDonald, 2018). Furthermore, fertilizer management in nursery is comparatively less expensive than the main field management.

Healthy rice seedlings may be obtained by managing the nursery's many aspects, including providing it with enough nourishment (Singh et al., 2005). Nutrient management in nursery bed influences the growth, development and yield of rice. Making a small investment in raising healthy and vigorous seedlings in the nursery, rice crop can yield an additional benefit of 1 to 2 t ha^{-1} to the farmer (Panda et al., 1991). Various research findings have showed that the seedling length, dry weight, root number, root length and seedling growth increased significantly by increasing the fertility level in the nursery (Singh and Singh, 1998; Raju et al., 2001; Singh et al., 2005).

Seeding density in nursery is another important factor that determines the proper growth and vigor of rice seedlings. High seeding density in nursery bed creates competitions for light, nutrient and water among the plants, which results in production of weaker seedlings (Niraula and Timilsina, 2020). Optimum seed rate in nursery bed helps the plant to grow their aerial and underground parts efficiently by utilizing more nutrients and solar radiation (Miah et al., 1990). Yield and yield components of rice crop are affected negatively by using a higher seed rate at the nursery level (Singh et al., 1987). Even optimizing seeding rate and planting density could partially compensate the yield loss caused by prolonged seedling age (Huang, 2021).

Therefore, this research is designed to identify suitable seeding density and nutrient management in nursery bed for enhancing the growth and yields of *boro* rice in Bangladesh conditions.

MATERIALS AND METHODS

Experimental duration and site

The study was carried out during the *Boro* season from November 2019 to May 2020 at the Agronomy Field Laboratory, Department of Agronomy, Bangladesh Agricultural University, Mymensingh (90º 50' E and 24º 75' N latitude and at an altitude of 18 meter). The experimental area belongs to the non-calcareous dark grey floodplain soil under Old Brahmaputra Floodplain Agro-ecological Zone (AEZ-9). The land was well drained medium high with silt-loam textured soil. The soil almost neutral in reaction (pH 6.8), low in organic matter content (1.27%) and the general fertility level of the soil was low (1.1% total N, 25 ppm available P and 0.16 meq% exchangeable K). The experimental area characterized by subtropical monsoon climate with a humid environment. The monthly values of maximum, minimum and average temperature, relative humidity, monthly total rainfall and sunshine hours received at the experimental site during the study period were 29.2^{0}C, 15.5^{0}C, 22.4°C, 80.7%, 96.7 mm, and 175.8 hrs, respectively.

Experimental treatments and design

The experiment consisted of two factors namely, nursery seeding density and nursery nutrient management. Three seeding densities included i) 80 g seeds m^{-2} (medium seeding density) (control) ii) 100 g seeds m^{-2} (high seeding density) and iii) 120 g seeds m^{-2} (very high seeding density). While six nutrient managements treatments were i) No nutrient applied (control), ii) Nitrogen (N) 10 g m^{-2} iii) Phosphorus (P) 15 g m^{-2} iv) Potassium (K) 15 g m^{-2} v) N 10 g m^{-2} + P 15 g m^{-2} + K 15 g m^{-2} vi) Compost 2 kg m^{-2}. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Unit plot size was 4.0 m × 2.5 m.

Plant material used

A high yielding *Boro* rice variety BRRI dhan58 was used as the planting material in this study. The variety was released by Bangladesh Rice Research Institute (BRRI) in the year 2012. This variety was developed through somaclonal variation. This variant was hybridized from tissue culture of BRRI dhan29. The duration of the variety is

150-155 days and it has a yield potential of 7-7.5 tha^{-1}. Seedlings are grown in nursery bed from late November to mid-December. Harvesting time of this variety is mid-April to early May. It is medium wilt disease tolerant.

Crop husbandry

Seeds of rice variety BRRI dhan58 were collected from the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh. Seeds were immersed in a water bucket for 24 hrs. These seeds were taken out from the bucket and tightly covered by gunny bags. The seeds started sprouting after 48 hrs, which became prepared for sowing in next 72 hrs. The nursery bed was prepared by puddling with repeated ploughing followed by laddering. Sprouted seeds were sown in raised wet nursery beds size of 1.0 m length and 1.0 m width following seeding density as per treatment on 10 December 2019. Nursey beds were fertilized as per treatments in the form of urea, triple super phosphate (TSP), muriate of potash (MoP) and compost. Drainage channels were provided all along the bed to drain out the excess water.

The main field was prepared by ploughing with tractor drawn cultivators followed by cross harrowing to pulverize the soil. Then puddling was done at sufficient water level with three sequential ploughings and cross ploughings. All uprooted weeds and crop residues were removed from the field after ploughing and laddering. Well decomposed compost was applied at the rate of 5 tha^{-1} before land preparation. Fertilizers like urea, TSP, MoP and gypsum were applied at the rate of 200 (92 kg N ha^{-1}), 120 (60 kg P ha^{-1}), 60 (12.6 kg K ha^{-1}), and 60 kg ha^{-1} (10.8 kg S ha^{-1}), respectively. The entire amount of TSP, MoP and gypsum were applied just before final preparation. Urea was top dressed in three equal splits at 20, 40 and 60 days after transplanting (DAT).

Forty days old seedlings were transplanted in well puddled unit plots on 19 January 2020 with three seedlings hill^{-1} following the spacing of 25 cm × l5 cm. Weeding was done thrice manually at 20, 40 and 60 DAT. Irrigation was given as and when necessary to maintain 3-5 cm stagnant water throughout the entire period. The field was finally dried out 15 days before harvesting. There were some incidence of insects specially stem borer and brown plant hopper which was controlled by spraying Carbotaf 5G @ 2 ml L^{-1} and Regent 3GR @ 2 ml L^{-1}.

Sampling, harvesting and processing

For studying the seedling growth, twenty seedlings from each nursery bed were randomly selected and carefully uprooted at 20 and 40 days after sowing (DAS). The crop was harvested at full maturity on 30 May 2020. This was the time when about 90% of the seeds became golden yellow in color. Five hills (excluding border hills) were randomly selected from each plot and uprooted before harvesting for recording the necessary data on various growth and yield parameters. After sampling, the whole plot was harvested (yield of five hills was also added to the yield of whole plot), separately bundled, properly tagged and brought to the threshing floor. The crops were threshed manually. Grains were sun dried and cleaned. Straws were also sun dried properly, weighed and converted to ton per hectare. Finally, grain yield was adjusted to 14% moisture and converted to ton per hectare.

Observations made

Seedling growth was monitored in terms of root growth, shoot growth and seedling dry weight at 20 and 40 DAS. Plant growth was measured as plant height and tillering ability. Yield components like effective tillers hill^{-1}, grains panicle^{-1}, thousand grain weight, and grain and straw yield were measured.

Statistical analysis

The recorded data were compiled and tabulated for statistical analysis. Analysis of variance was done with the help of computer package program MSTAT-C. Collected data were analyzed using the "Analysis of Variance" technique and the mean differences were adjudged by Duncan's Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

Seedling Growth Parameters

Effect of seeding density

With the exception of root length, seeding density had substantial impact on seedling growth parameters including shoot length and seedling dry weight. Seeding density of 120 g m^{-2} performed the best (10.16 cm and 12.77 cm, respectively) in terms of shoot length, followed by 100 g m^{-2} (9.35 cm and 12.47 cm, respectively) and 80 g m^{-2} (8.37 cm and 11.97 cm, respectively) at 20 DAS and 40 DAS. The increment of shoot length at higher seeding density is probably because of competition for photosynthetically active radiation, which stimulates growth and results in stem elongation. Singh et al. (2013), revealed higher seeding density increases intra-seedling competition which resulting in tall, lanky, seedlings with poor vigour without any tiller. In line with this observation, Arif et al. (2012), also recorded maximum height not in widest spacing in Mustard.

In contrary to this result, Sharma et al. (2001), found maximum length in wider spacing and shortest length in closer spacing and explained as due to low-density plant get proper light, nutrient and space for their growth. The BRRI dhan58 seedling's dry weight was found to be highest at 80 g m^{-2} seeding density at 20 DAS and 40 DAS (33.67 mg and 84.27 mg, respectively), which was statistically similar to 100 g m^{-2} (30.86 mg and 82.01 mg, respectively). Conversely, the lowest seedling dry weight (27.31 mg and 74.92 mg, respectively) was produced by very high seeding density (120 g m^{-2}) (Table 1). This was due to competition free healthy and robust seedlings in medium density nursery. Al- Barzinjy et al. (1999), also reported an increase in dry weight per plant with a decrease in plant density; this might be due to less competition for nutrients, water, and light. De Datta, (1980) suggested increase in both inter and intra plant competition with increase in seeding density during the early stage of crop growth.

Effect of nutrient management

Nutrient management also had no significant effect on seedling root length but on shoot length and seedling dry weight at 20 DAS and 40 DAS. At 20 DAS variation of shoot length was noticed due to different nutrient management and a range of 8.28 cm to 10.54 cm long shoot was documented. And after 40 days of sowing shoot length fluctuated from 11.37 cm to 13.84 cm. In both sampling days combine application of NPK fertilizers produced the longest shoot than solo application of those nutrients, compost and all these treatments were found to be significantly superior to the control treatment.

Similarly, variation in seedling dry weight was also noticed due to differences in nutrient management. The maximum seedling dry weight was achieved by N+P+K application at 20 DAS (34.63 mg) and 40 DAS (86.90 mg), and all other treatments were shown to be considerably better than the control treatment (26.59 mg and 75.80 mg, respectively) at all sample dates (Table 1). In both sampling dates combine application of NPK fertilizers produced the longest shoot and maximum seedling dry weight than solo application of those nutrients and compost. Application of N and P

Table 1: Effect of seeding density and nutrient management in nursery bed on seedling root length at different days after sowing of *Boro* rice

Seeding density (g m^{-2})	Root length (cm)		Shoot length (cm)		Seedling dry weight (mg)	
	20 DAS	40 DAS	20 DAS	40 DAS	20 DAS	40 DAS
80	2.90	9.86	8.37 c[1]	11.97 b	33.67 a	84.27 a
100	2.80	9.55	9.35 b	12.47 ab	30.86 a	82.01 a
120	2.70	9.11	10.16 a	12.77 a	27.31 b	74.92 b
Level of significance	NS	NS	**	**	**	**
CV (%)	16.85	10.55	8.15	6.46	15.12	5.46
Nutrient management						
No nutrient applied	2.57	9.18	8.28 c	11.37 c	26.59 c	75.80 c
Only N	2.69	9.25	9.63 b	12.94 b	31.78 ab	80.16 bc
Only P	2.85	9.44	9.18 b	12.20 bc	30.86 abc	80.79 b
Only K	2.92	9.64	9.26 b	12.17 bc	30.54 abc	79.47 bc
N+P+K	3.10	10.22	10.54 a	13.84 a	34.63 a	86.90 a
Compost	2.65	9.31	8.86 bc	11.88 c	29.28 bc	79.29 bc
Level of significance	NS	NS	**	**	*	**
CV (%)	16.85	10.55	8.15	6.46	15.12	5.46

[1] 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)

*= Significant at 5% level of probability; ** =Significant at 1% level of probability, NS = Not significant

in the rice nursery can produced 50% and 100% more dry matter, respectively, compared with the control treatment (Ros et al., 1997). The reason for better growth and development in the above treatments might be due to the greater availability of nutrients in soil.

Interaction effect of seeding density and nutrient management

No significant effects on shoot length, root length, and seedling dry weight were observed when seeding density and nutrition management were combined, either at 20 DAS or at 40 DAS. However, numerically the longest root at 20 DAS (3.26 cm) and 40 DAS (10.86 cm) were recorded at seeding density 80 g m^{-2} with the application of N+P+K and the shortest root at 20 DAS (2.49 cm) and 40 DAS (8.84 cm) were recorded at 120 g m^{-2} seeding density with control treatment.

Table 2: Interaction effect of seeding density and nutrient management on seedling root length at different days after sowing of *Boro* rice

Seeding density x Nutrient management		Root length (cm)		Shoot length (cm)		Seedling dry weight (mg)	
		20 DAS	40 DAS	20 DAS	40 DAS	20 DAS	40 DAS
80 g m^{-2}	No nutrient applied	2.68	9.41	7.57	10.95	29.50	79.03
	Only N	2.74	9.46	8.90	12.67	35.47	84.47
	Only P	2.94	9.81	8.11	11.86	33.87	83.50
	Only K	3.03	10.08	8.05	11.76	32.97	82.70
	N+P+K	3.26	10.86	9.48	13.17	37.70	93.17
	Compost	2.75	9.54	8.12	11.38	32.50	82.73
100 g m^{-2}	No nutrient applied	2.55	9.30	8.51	11.55	25.70	76.70
	Only N	2.70	9.36	9.86	12.92	32.20	81.47
	Only P	2.84	9.46	9.08	12.35	31.87	83.17
	Only K	2.93	9.62	8.96	12.29	31.30	82.13
	N+P+K	3.09	10.24	10.84	13.82	34.57	86.20
	Compost	2.65	9.35	8.85	11.89	29.50	82.40
120 g m^{-2}	No nutrient applied	2.49	8.84	8.76	11.61	24.57	71.67
	Only N	2.63	8.94	10.14	13.24	27.67	74.53
	Only P	2.77	9.05	10.35	12.38	26.83	75.70
	Only K	2.80	9.23	10.76	12.45	27.35	73.57
	N+P+K	2.95	9.56	11.30	14.53	31.63	81.33
	Compost	2.53	9.04	9.62	12.38	25.83	72.73
Level of significance		NS	NS	NS	NS	NS	NS
CV (%)		16.85	10.55	8.15	6.46	15.12	5.46

NS = Not significant

The interplay between 120 g m^{-2} seeding density and combine application of NPK fertilizers produced the maximum shoot length (11.30 cm) at 20 DAS. At 40 DAS, 120 g m^{-2} seeding density together with combine application of NPK fertilizers produced the longest shoot (13.82 cm). Interaction between 80 g m^{-2} seeding density and control treatment produced shortest shoot (7.57 cm and 10.95 cm, respectively) at 20 and 40 DAS. Numerically the highest seedling dry weight (37.70 mg and 93.17 mg, respectively) was recorded at 80 g m^{-2} seeding density with application of N+P+K in nursery bed at 20 and 40 DAS, respectively and the minimum seeding dry weight was produced by high seeding density with control treatment (25.59 mg and 75.80 mg, respectively) at all sampling dates (Table 2).

Yield Contributing Characters and the Yield

Effect of seeding density

Seeding density had significant effect on effective and non-effective tiller count, grains panicle^{-1} and grain yield. Number of effective tillers hill^{-1} varied due to different seeding densities. It was noticed that medium seeding density produced maximum number of effective tillers hill^{-1} (11.60) followed by 100 g m^{-2} (10.79) and 120 g m^{-2} (10.54). Conversely, maximum number of non-effective tillers hill^{-1} (2.48) was obtained with 100 g m^{-2} seeding density and minimum (1.71) was found with 80 g m^{-2} seeding density.

In case of number of grains panicle^{-1}, seeding densities of 100 g m^{-2} (115.41) and 80 g m^{-2} (115.33) performed the best with while seeding density of 120 g m^{-2} (110.79) showed inferior performance (Table 3). The grain yield of rice was increased significantly, with the decreased seeding density. The highest grain yield (6.35 t ha^{-1}) was recorded when 80 g m^{-2} seeds were sown while, 100 g m^{-2} and 120 g m^{-2} seeding densities resulted in the grain yield of 6.17 t ha^{-1} and 6.0 t ha^{-1}, respectively (Fig. 1).

In this experiment medium seeding density performed better than high and very high seeding density. Medium seeding density produced the highest yield in the experiment comparing to high and very high seeding density. Moreover, effective tillers hill^{-1} for medium density seeding were significantly higher than high and very high seeding density. Sarwar et al. (2011), also reported increased number of effective tillers with decreasing seeding density in nursery. This might be accomplished with more light, air, nutrients and moisture that might have favored production of vigorous seedlings and eventually higher yields. Adhikari et al. (2013), also found the highest grain yield from medium seeding density. The trend clearly showed that higher seeding density can reduce the grain yield drastically.

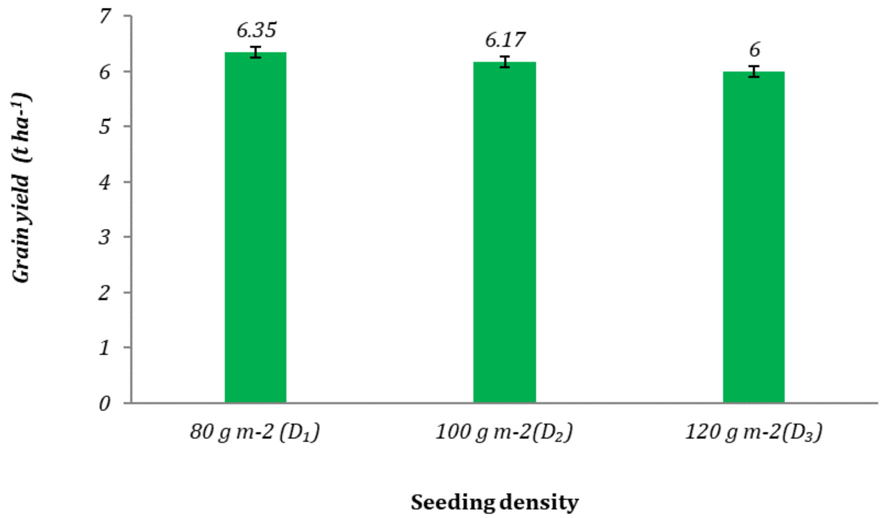

Figure 1: Effect of seeding density on grain yield of *Boro* rice

Effect of nutrient management

Nutrient management exerted significant effect on number of effective tillers hill^{-1}, grains panicle^{-1} and grain yield. Number of effective tillers hill^{-1} ranges from 10.42-11.89 where combine application of NPK produced the highest value and control treatment produced the lowest one. In case of number of grains panicle^{-1}, the treatment of N+P+K showed the best (120.77) performance and the control treatment performed the lowest (108.77), and the rest of the treatments had statistically similar effect on grains panicle^{-1}. The grain yield statistics revealed that significant differences prevailed due to the different nutrient management treatments to the rice nursery (Table 3).

The highest grain yield (6.48 tha^{-1}) was recorded when N+P+K was applied, which was at par with that of K (6.23 tha^{-1}), followed by P (6.20 tha^{-1}) treatment but significantly superior to rest of the treatments under this study (Fig. 2). In this experiment, combine application of NPK showed superior performance in terms of effective tiller count, grains panicle^{-1} and grain yield. According to Kyalo et al. (2020), nursery fertilization increases yields by 23-30% relative to the control. The judicious application of nitrogen fertilizer improves grain yield and grain protein content in rice (Ray et al., 2015). According to Rani (2012), the nursery bed with the right dose of nitrogen, FYM, and phosphorus produced the most prolific tillers m^{-2}. According to Manandhar et al. (2020), the nutrient management levels had significant influence on plant height. Roy et al. (2018), also showed a similar result on plant height. But present study showed no significance in case of plant height of BRRI dhan58.

Table 3: Effect of seeding density in nursery bed on plant height, yield contributing characters and yield of *Boro* rice

Seeding density ($g\ m^{-2}$)	Plant height (cm)	Total tillers $hill^{-1}$ (No.)	Effective tillers $hill^{-1}$ (No.)	Grains $panicle^{-1}$ (No.)	1000- grain weight (g)	Straw yield (tha^{-1})	Harvest Index (%)
80	88.08	13.31	11.60 a	115.33 a	24.30	6.95	47.74
100	88.88	13.27	10.79 b	115.41 a	24.43	6.80	47.58
120	89.82	12.81	10.54 c	110.79 b	24.73	6.62	47.56
Level of significance	NS	NS	**	**	NS	NS	NS
CV (%)	5.20	10.11	2.29	2.39	8.83	6.58	3.40
Nutrient management							
No nutrient	87.29	12.60	10.42 c	108.77 c	23.53	6.55	47.33
Only N	89.79	13.36	10.87 b	112.61 b	24.56	6.73	47.81
Only P	87.73	13.26	10.87 b	114.69 b	24.68	6.83	47.55
Only K	88.14	13.06	10.97 b	114.09 b	24.14	6.82	47.73
N+P+K	91.33	14.03	11.89 a	120.77 a	25.43	7.11	47.70
Compost	89.26	12.47	10.86 b	112.12 b	24.57	6.70	47.62
Level of significance	NS	NS	**	**	NS	NS	NS
CV (%)	5.20	10.11	2.29	2.39	8.83	6.58	3.40

In a column figure with same letters or without letters do not differ significantly whereas figures with dissimilar. DMRT. NS = Non-significant, ** =Significant at 1% level of probability,

Interaction effect of seeding density and nutrient management

The interaction of seeding density and nutrient management had a significant effect on number of effective tillers $hill^{-1}$. The maximum number of effective tillers $hill^{-1}$ (11.60) was obtained with 80 $g\ m^{-2}$ seeding density and the minimum number of effective tillers $hill^{-1}$ (10.54) was obtained with 120 $g\ m^{-2}$ seeding density. The seeding density treatments can be categorized as 80 $g\ m^{-2}$, 100 $g\ m^{-2}$ and 120 $g\ m^{-2}$ depending on the decreasing number of effective tillers. The interaction effect of seeding density and nutrient management on grain yield of BRRI dhan58 was not significant. However, numerically the maximum grain yield (6.63 tha^{-1}) was recorded in 80 g seed m^{-2} with the application of N+P+K treatment combination and the minimum grain yield (5.78 tha^{-1}) was recorded in 120 g seeds m^{-2} with no nutrient management treatment combination (Table 4).

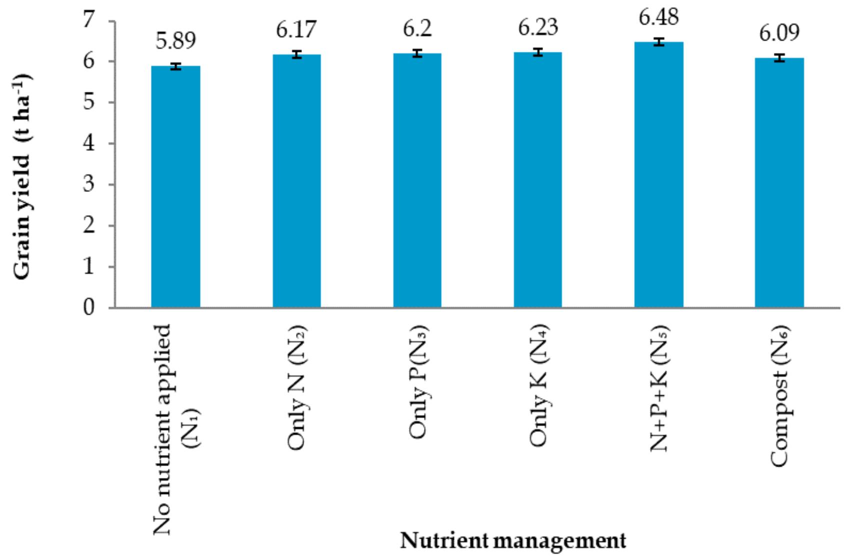

Figure 2: Effect of nursery nutrient management on grain yield of *Boro* rice

Using healthy and vigorous seedlings with sufficient fertilizers in the nursery resulted in more productive tillers and a higher grain yield, partly by better stress tolerance and decreased seedling mortality after transplanting (Panda et al., 1991). N+P+K application in the nursery significantly raised the number of effective tillers with medium seeding density. The interactions between the factors did not significantly influence the grains per panicle. 1000-grain weight is an important yield contributor that depends on genetic makeup and is the least affected by growing conditions (Ashraf et al., 1999). Interaction effect of the factors in the nursery on 1000-grain weight was non-significant at all levels of treatments.

On the other hand, Sarwar et al. (2011), reported increased 1000-grain weight from low density fertilized nursery as compared to high density unfertilized nurseries. The interactions between two factors did not significantly influence the grain yield but the highest yield obtained in the experiment was from seedlings under medium seeding (80 g m^{-2}) density with N+P+K application in the nursery. This present study shows no significant effect of seeding density and nutrient management on harvest index. Rani (2012) reported same concept for harvest index.

Table 4: Interaction effect of seeding density and nutrient management on plant height, yield contributing characters and yield of *Boro* rice

Seeding density× Nutrient management		Plant height (cm)	Total tillers hill^{-1} (No.)	Effective tillers hill^{-1} (No.)	Grains panicle^{-1} (No.)	1000-grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Harvest Index (%)
80 g seed m^{-2}	No nutrient	87.00	12.27	10.87 de*	108.93	23.34	6.51	47.84	5.98
	Only N	88.87	14.27	11.40 bc	113.50	24.46	6.76	48.24	6.33
	Only P	87.13	13.50	11.57 bc	119.60	24.69	7.00	47.91	6.43
	Only K	87.20	13.13	11.73 b	115.23	24.13	7.07	47.53	6.40
	N+P+K	90.20	14.03	12.80 a	123.20	25.08	7.33	47.54	6.63
	Compost	88.07	12.63	11.23 cd	111.50	24.07	7.00	47.40	6.31
100 g seed m^{-2}	No nutrient	86.07	12.87	10.33 fgh	112.33	23.13	6.63	47.09	5.91
	Only N	89.47	13.53	10.93 de	113.17	24.38	6.69	47.87	6.13
	Only P	86.20	13.17	10.67 efg	115.03	24.92	6.87	47.49	6.21
	Only K	88.67	13.63	10.57 efg	116.13	24.00	6.93	47.34	6.23
	N+P+K	92.27	14.17	11.70 b	121.67	25.41	7.20	47.59	6.53
	Compost	90.60	12.23	10.53 efg	114.10	24.74	6.50	48.08	6.02
120 g seed m^{-2}	No nutrient	88.80	12.67	10.07 h	105.03	24.13	6.50	47.06	5.78
	Only N	91.03	12.27	10.27 gh	111.17	24.84	6.73	47.33	6.05
	Only P	89.87	13.10	10.37 fgh	109.43	24.42	6.63	47.26	5.94
	Only K	88.57	12.40	10.60 efg	110.90	24.27	6.47	48.33	6.05
	N+P+K	91.53	13.90	11.17 cd	117.43	25.80	6.80	47.97	6.27
	Compost	89.10	12.53	10.80 def	110.77	24.89	6.60	47.39	5.94
Level of significance		NS	NS	**	NS	NS	NS	NS	NS
CV (%)		5.20	10.11	2.29	2.39	8.83	1.72	6.58	

*In a column figures with same letters or without letters do not differ significantly whereas figures with dissimilar. DMRT. NS = Non-significant, ** =Significant at 1% level of probability

CONCLUSION

In conclusion, present findings confirm the potentiality of seeding density and nutrient management in nursery bed for seedlings growth and the yield improvement of *Boro* rice. Among the different seeding densities and nutrient managements in nursery, seeding density of 80 g m^{-2} with application of 10 g N m^{-2} + 15 g P m^{-2} + 15 g K m^{-2} resulted in better seedling growth and eventually higher yield of *Boro* rice. Further detailed studies are needed to confirm and establish the suitable nursery management package for *Boro* rice.

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REFERENCES

Abdullah, A., Kobayashi, H., Matsumura, I. and Ito, S. (2008). World rice demand towards 2050: Impact of decreasing demand of per capita rice consumption for China and India. 1-17.

Adhikari, B.B., Mehera, B. and Haefele, S. (2013). Impact of rice nursery nutrient management, seeding density and seedling age on yield and yield attributes. *American Journal of Plant Sciences,* 4: 146-155.

Al-Barzinjy, M., Stolen, O., Christiansen, J.L. and Jensen, J. (1999). Relationship between plant density and yield for two spring cultivars of oilseed rape (*Brassica napus* L.). *Acta Agriculturae Scandinavica B-Plant Soil Sciences*, 49(3):129-133.

Arif, M., Shehzad, M.A. and Mushtaq, S. (2012). Inter and intra row spacing effects on growth, seed yield and oil contents of white Mustard (*Sinapis alba* L.) under rainfed conditions. *Pakistan Journal of Agricultural Science*, 49(1): 21-25.

Ashraf, M., Khalid, A. and Ali, K. (1999). Effect of seedling age and density on growth and yield of rice in saline soil. *Pakistan Journal of Biology Science,* 2: 860-862.

BBS. (2021). Statistical Yearbook of Bangladesh. Bangladesh Bureau of Statistics. Ministry of Planning, Govt. People's Republic. Bangladesh. pp. 32-41.

De Datta, S.K. (1980). Principles and practices of rice production. Wiley & Sons, Singapore.

Grossnickle, S.C. and MacDonald, J.E. (2018). Why seedlings grow: influence of plant attributes. *New forests,* 49(1): 1-34.

Huang, L., Wang, F., Liu, Y., Tian, X. and Zhang, Y. (2021). Can optimizing seeding rate and planting density alleviate the yield loss of double-season rice caused by prolonged seedling age? *Crop Science*, 1-16.

Kyalo, G., Chemining'wa, G., Nhamo, N. and Mussgnug, F. (2020). Effects of Improved Nursery Management, Seedling Transplanting Age and Split Nitrogen Fertilizer Application on Growth and Yield of Lowland Rice in Eastern Uganda. *Journal of Agricultural Science,* 12(8): 144-151.

Liang, H., Gao, S., Ma, J., Zhang, T., Wang, T., Zhang, S. and Wu, Z. (2021). Effect of nitrogen application rates on the nitrogen utilization, yield and quality of rice. *Food and Nutrition Sciences,* 12: 13-27.

Manandhar, S., Chaudhary, B., Srivastava, A.K., Singh, S., Singh, U.S. and Haefele, S.M. (2020). Nutrient Management for Higher Productivity of Swarna Sub1 under Flash Floods Areas. *Journal of Nepal Agricultural Research Council,* 6: 101-114.

Miah, M.H.N., Karim, M.A., Rahman, M.S. and Islam, M.S. (1990). Performance of Nizersail mutants under different row spacing. *Bangladesh Journal of Training and Development*, 3(2): 31-34.

Niraula, N. and Timilsina, A. (2020). Effects of seeding density on growth attributes of broadleaf mustard in nursery bed. *International Journal of Applied Sciences and Biotechnology*, 8(1): 65-70.

Panda, M.M., Reddy, M.D. and Sharma, A.R. (1991). Yield performance of rainfed lowland rice as affected by nursery fertilizer under conditions of intermediate deep water (15-50 cm) and flash floods. *Plant and Soil*, 132(1): 65-71.

Raju, R.A., Reddy, M.N. and Gangwar, B. (2001). Nursery fertilization of rice (*Oryza sativa*) with native weed vegetation. *Indian Journal of Agronomy*, 46(1): 94-100.

Rani, A.S. (2012). Rice Yield as Affected by Seedling Vigour Through Nutrient Management Techniques in Nursery, MS Thesis, Department of Agronomy, Acharya NG Ranga Agricultural University, India.

Ray, S., Sarkar, M.A.R., Paul, S.K., Islam, A.K.M.M. and Yeasmin, S. (2015). Variation of growth, yield and protein content of transplant Aman rice by three agronomic practices. *Agricultural and Biological Sciences Journal*, 1(4): 167-176.

Ros, C., Bell R.W. and White, P.F. (1997). "Effect of Nursery Applications of N and P on Rice Yield," *Kasetsart Journal: Natural Science*, 31: 96-105.

Roy, A., Sarkar, M.A.R. and Paul, S.K. (2018). Effect of age of seedlings at staggered transplanting and nutrient management on yield performance of aromatic fine rice (cv. BRRI dhan38). *SAARC Journal of Agriculture*, 16(1): 49.

Sarwar, N., Maqsood, M., Wajdi, A.S. and Anwar-ul-Haq, M. (2011). Impact of nursery seeding density, nitrogen, and seedling age on yield and yield attributes of fine rice. *Chilean Journal of Agricultural Research*, 71(3): 343-349.

Sharma, D., Chaudhary, D. and Pandey, D. (2001). Growth and yield of lettuce cv. Alamo-1 as influenced by dates of planting and plant density. *IOSR Journal of Agriculture and Veterinary Science*, 10(6): 62-71.

Singh, K.N. Singh, B. Hassan, B., Kanday, A. and Bhat, A.K. (2005). Effect of Nursery Fertilization on Seedling Growth and Yield of Rice. *Indian Journal of Agronomy*, 50(3): 187-189.

Singh, O.P., Pal, D. and Om, H. (1987). Effect of seed rate in nursery and seedlings/hill on the yield of transplanted rice. *Indian Journal of Agronomy*, 32: 96-97.

Singh, R.S. and Singh, S.B. (1998). Response of rice (*Oryza sativa* L.) to age of seedlings, and level and time of application of nitrogen under irrigated condition. *Indian Journal of Agronomy*, 43(4): 632-635.

Singh, T., Satapathy, B.S., Pun, K.B., Lenka, S. and Bhakta, N. (2013). Influence of seeding density on seedling vigour of rice (*Oryza sativa* L.). ARRW Golden Jubilee Int. Symposium on sustainable rice production and livelihood security: Challenges and Opportunities. Cuttak, Odisha, India. 141.

Xu, Y., Guan, X., Han, Z., Zhou, L., Zhang, Y., Asad, M., Wang, Z., Jin, R., Pan, G. and Cheng, F. (2022). Combined effect of nitrogen fertilizer application and high temperature on grain quality properties of cooked rice. *Frontiers in plant science*, 13: 874033.