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Effect of nursery management practices on growth and yield of BRRI dhan51 under submerged condition

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Abstract: Flooding is a frequent hazard in lowland rice environments and is expected to intensify with climate change. The availability of tolerant varieties provides more opportunities for developing and validating proper management options in flood-prone areas. On contrary proper crop establishment is of considerable importance in flood-prone areas. Thus to observe the effect of nursery management practices on growth and yield of BRRI dhan51 under submerged condition, two levels of seed densities viz. 40, 25 gm^{-2}, four nutrient management viz. N_1- 50 kg N ha^{-1}, N_2 - $N:P_2O_5:K_2O$ :: 75 : 40 : 40 kg ha^{-1}, N_3 - N: P_2O_5: K_2O :: 50 : 40 : 40 kg ha^{-1}, N_4 - N: P_2O_5: K_2O :: 25 : 40 : 40 kg $ha^{-1}$and two seedling age for transplanting viz. 25, 40 day-old were used as experimental treatments. Seed densities in the nursery bed did not significantly influence all the parameters except sterile spikelets, straw yield and harvest index. 40-day-old seedling contributed the highest grain yield (5.11 t ha^{-1}), grain $panicle^{-1}$ (129.4), panicle length (21.62 cm) compared to 25-day-old seedlings. Nutrient management in the nursery showed significant differences for plant height, 1000-grain weight, grain yield and harvest index (%). Application of N: P_2O_5: K_2O:: 50 : 40 : 40 kg ha^{-1} produced the highest grain yield (5.51 t ha^{-1}) and N: P_2O_5: K_2O :: 25 : 40 : 40 kg ha^{-1} produced the lowest grain yield (4.22 t ha^{-1}).Seed density and seedling age interaction had no significant effect on most of the characters under study except effective tillers $hill^{-1}$, panicle length, sterile spikelets $panicle^{-1}$ and straw (12.53), grain yield (5.36t ha^{-1}), grains $panicle^{-1}$ (133.10) and panicle length (21.68 cm). 40-day-old seedling with 40 gm^{-2} seed density produced lowest total tillers $hill^{-1}$(14.32) and sterile spikelets $panicle^{-1}$(14.82). Seed density and nutrient management interaction had no significant effect on all of the characters under study. Seed densities at 25gm^{-2} with application of $N:P_2O_5:K_2O$::50:40:40 $kgha^{-1}$, produced highest grain yield (5.88 t ha^{-1}), total tillers (15.87), effective tillers $hill^{-1}$(13.00), non-effective tillers (3.183), sterile spikelets (50.06) and harvest index (38.96%). Seedling age and nutrient management interaction had no significant effect on most of characters under study. Highest grain yield (5.88t ha^{-1}) was obtained from 40-day-old seedling with application of $N:P_2O_5:K_2O$::50:40:40 kg ha^{-1}.In seed density, seedling age and nutrient management interaction had significant effect on most of the characters. Seedling raised from 25 gm^{-2} with 40-day-old seedling and application of $N:P_2O_5:K_2O$::50:40: 40 kg ha^{-1} produced highest grain yield (6.33 t ha^{-1}) in the field.
Key words: Seed density, nutrient management, seedling age, nursery management, submerged.

Introduction

Rice is often the only cereal that can be grown in flood prone ecosystem. Uncertainty of rainfall is a major factor affecting the rice yield in India, Bangladesh and Myanmar with flash flood affecting the plant stand seriously depending on duration of submergence stress which is considered as the third most important constraint to high yield (Sarkar *et al*., 2006).Excessive flooding poses risks to human life and is a major contributor to the poverty and vulnerability of marginalized communities especially women and children in poor families.

In recent years, there has been increasing interest to grow hybrid rice in several countries, and the potential use *of Sub1* in hybrid rice has great promise for flood-prone areas. Here, recent advances in converting additional mega varieties to submergence-tolerant varieties are reported and the role *of Sub1* in different genetic backgrounds confirmed. The importance of the *Sub1 A* and *Sub1 C* genes for tolerance is further investigated, and the potential use of *Sub1* in hybrid rice is assessed. Implications for the development of additional submergence-tolerant varieties with *Sub1*, and the development of varieties with a higher level of tolerance under longer durations of submergence are discussed.

Proper crop establishment is of considerable importance in flood-prone areas because rice is relatively more sensitive to flooding during germination and early seedling growth. Improved breeding lines with tolerance of submergence during germination have been developed recently (Angaji *et al*., 2010 and Ismail *et al*., 2009). For transplanted rice, proper nursery management was also found to have a significant impact on crop establishment and in further enhancing survival and recovery after flooding that occurs following transplanting. This can considerably increase grain yield if complete submergence occurs any time during the vegetative stage (Ram *et al*., 2009).

Useful nursery management options are particularly attractive to farmers since they need to apply them only on the small area occupied by the seed bed. Effective management strategies that can be applied at the nursery level include proper nutrient management, the use of organic manures, the use of a lower seeding density, proper water management, and transplanting of older seedlings when flooding is anticipated early after transplanting. Excess nutrient applications (especially N and Si) should be avoided because this results in vigorous growth and loss of stored carbohydrate reserves needed for survival during submergence. Higher soil fertility was also associated with enhanced shoot elongation and faster chlorophyll degradation during submergence (Ella and Ismail, 2006., Ella *et al*., 2011).

Seedling age is an important factor to obtain desired yield in transplant *aman* rice. Very young seedling or old seedling of transplant *aman* rice is produce less effective tiller that gives lower yield. Therefore, the study was undertaken to evaluate the effect of nursery management practices on growth and yield of BRRI dhan51 under submerged condition.

Materials and Methods

The research work was conducted at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh in the *Aman* season 2011. Geographically the experimental field is located at 24.75° N latitude and 90.50° E longitude at an average altitude of 18m above the sea level. The experimental area was located under the sub-tropical climate, which is specialized by moderately high temperature and heavy rainfall during the *Kharif* season (April-September) and low rainfall with moderately low temperature during the Rabi season (October- March).

Submerged rice variety BRRI dhan51 was used for the present study which was collected from IRRI, Bangladesh. Two levels of seed densities viz. D_1 (40 gm^{-2}), D_2 (25 gm^{-2}), four nutrient management viz. N_1-50 kg N ha^{-1}, N_2-$N:P_2O_5:K_2O$::75:40:40 kg ha^{-1}, N_3-$N:P_2O_5:K_2O$::50:40:40 kg ha^{-1} and N_4-$N:P_2O_5:K_2O$::25:40:40 kg ha^{-1} and two seedling age for transplanting T_1-25-day-old, T_2-40-day-old were the treatments of this study. The experiment was laid out in split plot design with three replications. Total number of unit plots were 48 and each plot size was 12m^2 (4m x 3m). The experimental plot was divided into three blocks each representing a replication.

A piece of medium high land was selected for raising seedlings. Sprouted seeds were sown in the nursery bed on 1 July 2011 and 16 July 2011 to get 40 and 25 day old seedlings for transplanting.. The layout of the experimental field was made on 7 August 2011. Finally, the individual plots were prepared before transplanting. Fertilizers (urea, triple superphosphate, muriate of potash and gypsum) were applied to the plots @N, P, K, S and Zn were75 kg N, 8 kg P,40 kg K, 10 kg S and 3 kg Zn ha^{-1} respectively. The whole amount of triple superphosphate, muriate of potash were applied as basal dose at the time of final land preparation and the whole amount of urea was top dressed in three equal splits, first 5 days after de-submergence (11/9/2011), second on 29/9/2011 and third on 23/10/2011. Nursery bed was made wet by watering one day before uprooting the seedlings. Forty (40) day and twenty five (25) day old seedlings were transplanted in the field as per treatment combinations. After ten days of transplanting the whole plot was submerged with water from the deep tube well up to 0.9m depth. To maintain this water depth additional water was added regularly in the plot. After 15 days of submergence, the plot was completely desubmerged by draining the water. The harvested crop of each plot (1 m × 1 m) was separately bundled; properly tagged and then brought to the threshing floor. The harvested crops were threshed by pedal thresher. The grains were cleaned and sun dried and adjusted to 14% moisture content. Straw were sun dried properly and plant height (cm), number of total tillers $hill^{-1}$, number of effective tillers $hill^{-1}$, number of non-effective $hill^{-1}$, number of grains $panicle^{-1}$,1000-grain weight (g), grain yield (t ha^{-1}), straw yield (t ha^{-1}), and harvest index were recorded. To determine grain yield (t ha^{-1}) 1 m^2 area of each unit plot were harvested and that were sun dried properly and weighed carefully and finally converted to t ha^{-1}. The harvest index was calculated with the following formula: 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 (DMRT) at 5% level of probability (Gomez and Gomez, 1984).

Results and Discussion

Effect of seeding density on grain yield and yield components: Plant height, number of total tillers $hill^{-1}$, number of effective tillers $hill^{-1}$, number of non-effective tillers $hill^{-1}$, panicle length, number of grains $panicle^{-1}$, number of total grains panicle-1, 1000-grain weight, grain yield (t ha^{-1}) except number of sterile spikelets $panicle^{-1}$, straw yield (t ha^{-1}) and harvest index (%) were not significantly affected by different seeding density in the nursery (Table 1).Result indicates that grain yield (5.26 t ha^{-1}) was higher at 25 gm^{-2} seed density than the grain yield of (4.692 t ha^{-1}) obtained with 40 gm^{-2} seed density.

Table 1. Effect of seeding density & age and nutrient management on yield and yield components of rice cv. BRRI dhan51

Treatments	Plant height (cm)	Total tillers	Effective tillers	Non- effective tillers	Panicle length (cm)	Grains $panicle^{-1}$	Sterile spikelets $panicle^{-1}$	Total grains $panicle^{-1}$	1000 grain Wt. (g)	Grain yield (t ha^{1})	Straw yield (t ha^{-1})	Harvest Index (%)
Density												
D_1	76.37	14.48	12.28	2.48	21.44	121.5	43.37b	164.9	19.74	4.69	9.63a	32.66b
D_2	75.34	14.94	12.26	2.96	21.24	127.8	47.53a	175.3	19.77	5.26	9.19b	36.29a
$LSD_{0.05}$	0.84	0.31	0.18	0.25	0.58	3.13	1.62	5.42	0.19	0.40	0.19	0.56
Sx	0.29	0.11	0.06	0.09	0.20	1.08	0.56	1.87	0.067	0.14	0.064	0.193
Level of sig.	NS	NS	NS	NS	NS	NS	*	NS	NS	NS	**	*
CV (%)	1.56	4.92	5.40	12.06	2.40	2.75	4.20	3.20	1.19	8.69	4.60	5.33
Seedling age												
T_1	75.72	14.76	12.21	2.766	21.06b	120.0b	44.97	164.9b	19.70	4.85b	9.42	33.89b
T_2	75.99	14.66	12.32	2.674	21.62a	129.4a	45.93	175.3a	19.81	5.11a	9.40	35.06a
$LSD_{0.05}$	0.699	1.35	0.391	0.194	0.302	2.02	1.13	3.21	0.139	0.255	0.255	1.08
Sx	0.241	0.467	0.135	0.067	0.104	0.700	0.389	1.11	0.048	0.088	0.088	0.374
Level of sig.	NS	NS	NS	NS	**	**	NS	**	NS	*	NS	*
CV%	1.56	4.92	5.40	12.06	2.40	2.75	4.20	3.20	1.19	8.69	4.60	5.33
Nutrient management												
N_1	75.46 b	14.72	12.23	2.804	21.32	124.0	46.62	170.6	19.67b	5.05b	9.18	35.47b
N_2	77.02 a	14.72	12.15	2.737	21.56	126.8	44.91	171.7	19.63b	5.12b	9.57	34.85b
N_3	75.52 b	14.97	12.60	2.596	21.33	124.6	45.15	169.8	19.73b	5.51a	9.30	37.11a
N_4	75.42 b	14.43	12.10	2.743	21.15	123.3	45.12	168.4	19.98a	4.22c	9.58	30.46c
$LSD_{0.05}$	0.989	1.91	0.554	0.274	0.427	2.87	1.59	4.54	0.197	0.36	0.36	1.53
Sx	0.341	0.661	0.191	0.095	0.147	0.990	0.551	1.57	0.068	0.125	0.125	0.529
Level of sig.	**	NS	NS	NS	NS	NS	NS	NS	**	**	NS	**
CV (%)	1.56	4.92	5.40	12.06	2.40	2.75	4.20	3.20	1.19	8.69	4.60	5.33

In a column, figures having similar letter (s) do not differ significantly whereas, figures having dissimilar letters differ significantly as per DMRT at 5% level of probability. ** = At 1 % level of probability, NS= Non-significant.T_1= 25- day- old seedlings, T_2= 40- day- old seedlings, D_1= 40 gm^{-2}, D_2= 25 gm^{-2}, N_1= 50 kg ha^{-1}, N_2= $N:P_2O_5:K_2O$::75:40:40 kg ha^{-1}, N_3= $N:P_2O_5:K_2O$::50:40:40 $kgha^{-1}$,N_4= $N:P_2O_5:K_2O$::25:40:40 kg ha^{-1}.

Effect of seedling age on grain yield and yield components: Plant height, number of total tillers $hill^{-1}$, number of effective tillers $hill^{-1}$, number of non-effective tillers $hill^{-1}$,number of sterile spikelets $panicle^{-1}$, 1000-grain weight, straw yield (t ha^{-1}) except panicle length, number of grains $panicle^{-1}$, number of total grains $panicle^{-1}$, grain yield (t ha^{-1}) and harvest index (%) were not significantly affected by different seedling age (Table 1). The highest grain yield (5.11 t ha^{-1}) was recorded from 40-day-old seedling and the lowest grain yield (4.85 t ha^{-1}) was produced by 25- day-old seedling. The highest number of grains $panicale^{-1}$and the highest number of total grains panicle^{-1}were mainly responsible for this highest grain yield. This might be due to aged plant gets more nutrients and moisture which eventually leads to the development of more grains.

Effect of nutrient management in the nursery on grain yield and yield components: Nutrient management in the nursery showed significant differences for plant height, 1000-grain weight, grain yield (t ha^{-1}) and harvest index (%) except number of total tillers hill^{-1}, number of effective tillers hill^{-1}, number of non-effective tillers hill^{-1}, panicle length, number of grains panicle^{-1}, number of sterile spikelets panicle^{-1}, number of total grains panicle^{-1} and straw yield (t ha^{-1}). Application of N: P_2O_5: K_2O:: 50 : 40 : 40 kg ha^{-1}produced the highest grain yield (5.51 t ha^{-1}) and N: P_2O_5: K_2O :: 25 : 40 : 40 kg ha^{-1} produced the lowest grain yield (4.22 t ha^{-1}) (Table 1).

Effect of interaction on grain yield and yield components: The interaction between seed density and seedling age had no significant effect on all the characters except number effective tillers hill^{-1}, panicle length, number of sterile spikelets panicle^{-1} and straw yield (t ha^{-1}) (Table 2). 40-days old seedlings with 25 gm^{-2} seed density produce the highest number of total tillers hill^{-1}, number of effective tillers hill^{-1}, panicle length, number of sterile spikelets panicle^{-1}, grain yield, and harvest index (%).

Table 2. Interaction effect of seeding density and seedling age on yield and yield component of rice cv. BRRI dhan51

Density × seedling age	Plant height (cm)	Total tillers	Effective tillers	Non effective tillers	Panicle length (cm)	Grains panicle^{-1}	Sterile spikelets panicle^{-1}	Total grains panicle^{-1}	1000 grain weight(g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	HI (%)
$D_1 \times T_1$	76.42	14.63	12.45a	2.477	21.32a	117.4	43.92c	161.3c	19.66	4.533	9.775a	31.67
$D_1 \times T_2$	76.33	14.32	12.12b	2.482	21.56a	125.6	42.82c	168.5b	19.82	4.850	9.483ab	33.64
$D_2 \times T_1$	75.01	14.88	11.98c	3.054	20.81b	122.5	46.02b	168.5b	19.74	5.158	9.058c	36.11
$D_2 \times T_2$	75.66	15.00	12.53a	2.867	21.68a	133.1	49.04a	182.1a	19.80	5.367	9.317bc	36.47
$LSD_{0.05}$	0.989	0.191	0.554	0.274	0.427	2.85	1.59	4.55	0.197	0.361	0.361	1.54
Sx	0.341	0.651	0.191	0.094	0.147	0.990	0.551	1.56	0.068	0.125	0.125	0.529
Level of sig.	NS	NS	**	NS	*	NS	**	*	NS	NS	*	NS
CV (%)	1.56	4.92	5.40	12.06	2.40	2.75	4.20	3.20	1.19	8.69	4.60	5.33

*= Significant at 1% level of probability, **= Significant at 5% level of probability, NS = Not significant, D_1= 40 gm^{-2}, D_2= 25 gm^{-2}, T_1= 25- day- old seedlings, T_2- 40- day-old seedlings.

Table 3. Interaction effect of seed density and nutrient management on yield and components of rice cv. BRRI dhan51

Density× nutrient management	Plant height (cm)	Total tillers	Effective tillers	Non effective tillers	Panicle length (cm)	Grains panicle^{-1}	Sterile spikelets panicle^{-1}	Total grains panicle^{-1}	1000 grain weight(g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Harvest Index (%)
$D_1 \times N_1$	76.29	14.53b	12.33abc	2.517c	21.42	116.1c	46.21bc	162.3	19.67bcd	4.783	9.217	34.18
$D_1 \times N_2$	77.69	14.70b	12.03bc	2.667bc	21.85	127.1b	42.25d	169.4	19.86abc	4.983	9.800	33.63
$D_1 \times N_3$	76.16	14.07c	12.20abc	2.008d	21.34	124.3b	40.25d	164.6	19.57cd	5.133	9.417	35.26
$D_1 \times N_4$	75.35	14.60b	12.57ab	2.727bc	21.15	118.6c	44.77c	163.3	19.85abc	3.867	10.08	27.57
$D_2 \times N_1$	74.62	14.90b	12.13abc	3.092ab	21.23	131.9a	47.03bc	178.9	19.67bcd	5.333	9.133	36.77
$D_2 \times N_2$	76.35	14.73b	12.27abc	2.808abc	21.28	126.4b	47.57b	174.0	19.40d	5.267	9.333	36.08
$D_2 \times N_3$	74.88	15.87a	13.00a	3.183a	21.32	124.9b	50.06a	175.0	19.88ab	5.883	9.200	38.96
$D_2 \times N_4$	75.50	14.27c	11.63c	2.758bc	21.15	128.0ab	45.47bc	173.4	20.11a	4.567	9.083	33.35
$LSD_{0.05}$	1.39	2.71	0.783	0.388	0.604	4.06	2.25	6.42	0.279	0.511	0.511	2.17
Sx	0.483	0.935	0.270	0.134	0.208	1.40	0.778	2.21	0.096	0.175	0.175	0.749
Level of sig.	NS	**	**	**	NS	**	**	NS	**	NS	NS	NS
CV%	1.56	4.92	5.40	12.06	2.40	2.75	4.20	3.20	1.19	8.69	4.60	5.33

** = Significant at 1% level of probability, * = Significant at 5% level of probability, NS = Not significant , D_1= 40 gm^{-2}, D_2= 25 gm^{-2}, N_1= 50 kg N ha^{-1}, N_2= N:P_2O_5:K_2O::75:40:40 kg ha^{-1}, N_3= N:P_2O_5:K_2O::50:40:40 kg ha^{-1}, N_4= N:P_2O_5:K_2O::25:40:40 kg ha^{-1}, D_1= 40 gm^{-2}, D_2= 25 gm^{-2}, N_1= 50 kg N ha^{-1}, N_2= N:P_2O_5:K_2O::75:40:40 kg ha^{-1}, N_3= N:P_2O_5:K_2O::50:40:40 kg ha^{-1}, N_4= N:P_2O_5:K_2O::25:40:40 kg ha^{-1}

Table 4. Interaction effect of seedling age and nutrient management on yield and components of rice cv. BRRI dhan51

Seedling age × nutrient management	Plant height (cm)	Total tillers	Effective tillers	Non effective tillers	Panicle length (cm)	Grains panicle^{-1}	Sterile spikelets panicle^{-1}	Total grains panicle^{-1}	1000 grain weight(g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Harvest Index (%)
$T_1 \times N_1$	75.66bc	14.60	11.90	2.983a	21.10	119.7	48.13a	167.9	19.64	5.050	9.633ab	34.21c
$T_1 \times N_2$	77.46a	14.63	12.17	2.608ab	21.31	124.0	41.79d	165.8	19.54	4.917	9.167bc	34.86bc
$T_1 \times N_3$	75.32bc	15.33	12.93	2.525b	21.02	118.5	46.46ab	164.9	19.69	5.133	9.283b	35.61bc
$T_1 \times N_4$	74.42c	14.47	11.86	2.947ab	20.83	117.7	43.50cd	161.2	19.92	4.283	9.583ab	30.90d
$T_2 \times N_1$	75.25bc	14.83	12.57	2.625ab	21.55	128.2	45.11bc	173.3	19.71	5.067	8.717c	36.74ab
$T_2 \times N_2$	76.57ab	14.80	12.13	2.867ab	21.82	129.5	48.02a	177.6	19.72	5.333	9.967a	34.85bc
$T_2 \times N_3$	75.72bc	14.60	12.27	2.667ab	21.64	130.8	43.85cd	174.6	19.76	5.883	9.333b	38.61a
$T_2 \times N_4$	76.42ab	14.40	12.33	2.538b	21.47	128.9	46.73ab	175.6	20.05	4.150	9.583ab	30.02d
$LSD_{0.05}$	1.39	2.71	0.783	0.388	0.604	4.06	2.25	6.42	0.279	0.551	0.511	2.17
Sx	0.483	0.935	0.270	0.134	0.208	1.40	0.778	2.21	0.096	0.175	0.175	0.749
Level of sig.	*	NS	NS	*	NS	NS	**	NS	NS	NS	**	*
CV(%)	1.56	4.92	5.40	12.06	2.40	2.75	4.20	3.20	1.19	8.69	4.60	5.33

* = Significant at 1% level of probability, ** = Significant at 5% level of probability, NS = Not significant, T_1= 25- day- old seedlings, T_2= 40- day- old seedlings, N_1= 50 kg N ha^{-1}, N_2= N:P_2O_5:K_2O::75:40:40 kg ha^{-1}, N_3= N:P_2O_5:K_2O::50:40:40 kg ha^{-1}, N_4= N:P_2O_5:K_2O::25:40:40 kg ha^{-1}

The interaction between seed density and nutrient management showed significant effect on different characters of transplant *aman* rice except panicle length, total grains panicle^{-1}, grain yield, straw yield and harvest index (%). Application ofN:P_2O_5:K_2O::50:40:40 kg ha^{-1}with 25 gm^{-2} seed density gave the highest number of total tillers hill^{-1}, number of effective tillers hill^{-1}, number of non-effective tillers hill^{-1}, number of sterile spikelets panicle^{-1}, grain yield and harvest index (%) (Table 3).

The interaction between seedling age and nutrient management showed no significant effect on different characters of BRRI dhan51 except plant height, number of non-effective tillers hill^{-1}, number of sterile spikelets panicle^{-1}, straw yield and harvest index (%) (Table 4). 40- days- old seedling with application of $N:P_2O_5:K_2O$::50:40:40 kg ha^{-1}gave higher grain panicle^{-1}, grain yield and harvest index (%). 25- days- old seedling with application of $N:P_2O_5:K_2O$::25:40:40 kgha^{-1} produce lower plant height, number of total tillers hill^{-1}, number of effective tillers hill^{-1}, number of grains panicle^{-1}, grain yield and harvest index. On the other hand 25-day-old seedling with application of $N:P_2O_5:K_2O$::75:40:40 kg ha^{-1} produced higher plant height but lower grain yield (4.92 t ha^{-1}). The interaction among seed density, seedling age and nutrient management showed no significant effect on different characters of BRRI dhan51 except number of effective tillers hill^{-1}, number of grains panicle^{-1}, number of sterile spikelets panicle^{-1}, grain yield and harvest index (%). 40- days- old seedling with 40 gm^{-2} seed density and application of $N:P_2O_5:K_2O$::25:40:40 kg ha^{-1} produced lower grain yield (3.27 t ha^{-1}). 40- days- old seedling with 40 gm^{-2} seed density and application of 50 kg N ha^{-1} produced lower straw yield (8.67 t ha^{-1}). Forty days old seedling with 25 gm^{-2} seed density and application of $N:P_2O_5:K_2O$::50:40:40 kg ha^{-1} produced the highest grain yield (6.33 t ha^{-1}) (Table 5).

Table 5. Interaction effect of seed density, seedling age and nutrient management on yield and components of rice cv. BRRI dhan 51

density × Seedling age × nutrient management	Plant height (cm)	Total tiller	Effective tillers	Non-effective tillers	Panicle length (cm)	Grains panicle^{-1}	Sterile spikelets panicle^{-1}	Total grains panicle^{-1}	1000 grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Harvest Index (%)
$D_1 \times T_1 \times N_1$	76.69	14.60	12.33bcd	2.633	21.29	115.3e	49.33ab	164.6cdef	19.63	4.333ef	9.767	30.72f
$D_1 \times T_1 \times N_2$	78.59	14.73	12.33bcd	2.400	21.63	116.9de	40.87e	157.7ef	19.73	4.500def	9.500	32.14def
$D_1 \times T_1 \times N_3$	76.15	13.73	12.07bcd	1.783	21.31	124.6c	42.87e	167.5cde	19.46	4.833cdef	9.667	33.32cdef
$D_1 \times T_1 \times N_4$	74.23	15.47	13.07ab	3.093	21.03	112.9e	42.60e	155.5f	19.80	4.467def	10.17	30.53f
$D_1 \times T_2 \times N_1$	75.88	14.47	12.33bcd	2.400	21.54	116.9de	43.09de	160.0ef	19.72	5.233bcd	8.667	37.64ab
$D_1 \times T_2 \times N_2$	76.79	14.67	11.73cde	2.933	22.07	137.4a	43.62cde	181.0ab	19.99	5.467bc	10.10	35.11bcd
$D_1 \times T_2 \times N_3$	76.17	14.40	12.33bcd	2.233	21.38	124.1c	37.62f	161.7def	19.67	5.433bc	9.167	37.21ab
$D_1 \times T_2 \times N_4$	76.47	13.73	12.07bcd	2.360	21.27	124.2c	46.93bc	171.1bcd	19.91	3.267g	10.00	24.61g
$D_2 \times T_1 \times N_1$	74.63	14.60	11.47de	3.333	20.90	124.2c	46.93bc	171.1bcd	19.64	5.767ab	9.500	37.69ab
$D_2 \times T_1 \times N_2$	76.33	14.53	12.00bcd	2.817	20.99	131.2b	42.71e	173.9bc	19.35	5.333bc	8.833	37.58ab
$D_2 \times T_1 \times N_3$	74.48	16.93	13.80a	3.267	20.74	112.4e	50.05ab	162.4def	19.91	5.433bc	8.900	37.90ab
$D_2 \times T_1 \times N_4$	74.62	13.47	10.65e	2.800	20.62	122.4cd	44.40cde	166.8cde	20.04	4.100f	9.000	31.26ef
$D_2 \times T_2 \times N_1$	74.62	15.20	12.80abc	2.850	21.55	139.6a	47.13bc	186.7a	19.71	4.90cdef	8.767	35.84bc
$D_2 \times T_2 \times N_2$	76.36	14.93	12.53bcd	2.800	21.57	121.6cd	52.42a	174.1bc	19.45	5.200 bcd	9.833	34.58bcde
$D_2 \times T_2 \times N_3$	75.27	14.80	12.20bcd	3.100	21.91	137.5a	50.07ab	187.6a	19.86	6.333 a	9.500	40.01a
$D_2 \times T_2 \times N_4$	76.38	15.07	12.60abcd	2.717	21.68	133.6ab	46.53bcd	180.1ab	20.18	5.033bcde	9.167	35.44bcd
$LSD_{0.05}$	1.97	3.83	1.11	0.549	0.854	5.73	3.19	9.09	0.395	0.723	0.723	3.07
Sx	0.683	1.32	0.382	0.189	0.295	1.98	1.10	3.14	0.135	0.249	0.249	1.06
Level of sig.	NS	NS	**	NS	NS	**	**	**	NS	**	NS	**
CV (%)	1.56	4.92	5.40	12.06	2.40	2.75	4.20	3.20	1.19	8.69	4.60	5.33

* = Significant at 1% level of probability, ** = Significant at 5% level of probability, NS = Not significant, D_1= 40 gm^{-2}, D_2= 25 gm^{-2}, T_1= 25- day- old seedlings, T_2= 40-day- old seedlings, N_1= 50 kg N ha^{-1}, N_2= $N:P_2O_5:K_2O$::75:40:40 kg ha^{-1}, N_3= $N:P_2O_5:K_2O$::50:40:40 kg ha^{-1}, N_4= $N:P_2O_5:K_2O$::25:40:40 kg ha^{-1}

Result of the experiment showed that, 40-day-old seedling with 25 gm^{-2} seed density and application of $N:P_2O_5:K_2O$::50:40:40 kg ha^{-1} in the nursery bed was found to be the best possible combination for seedling raising of BRRI dhan51 and their best field performance for achieving higher grain yield under submerged condition.

References

Angaji, S.A., Septiningsih, E.M., Mackill, D.J. and Ismail, A.M. 2010. QTLs associated with tolerance of flooding during germination in rice (*Oryza sativa* L.). Euphytical 72, 159-168.

BBS (Bangladesh Bureau of Statistics). 2004. Year Book of Statistics Bangladesh. Bur. Stat, Div., Minis. of Plan. Gov.t People's Repub. of Bangladesh.

BBS (Bangladesh Bureau of Statistics). 2009. Year Book of Statistics Bangladesh. Bur. Stat, Div., Minis. of Plan. Gov.t People's Repub. of Bangladesh.

Ella, E.S. and Ismail, A.M. 2006. Seedling nutrient status before submergence affects survival after submergence in rice. Crop Sci. 46, 1673-1681.

Ella, E.S., Dionisio-Sese, M.L. and Ismail, A.M. 2011. Application of silica at sowing negatively affects growth and survival of rice following submergence. Phil. J. Crop Sci. 36, 1-11.

Gomez, K.A. and Gomez, A.A. 1984. Statistical Procedure for Agricultural Research. Second Ed., John Wiley and Sons, New York. 680 p.

Ismail, A.M., Ella, E.S., Vergara, G.V. and Mackill, D.J. 2009. Mechanisms associated with tolerance of flooding during germination and early seedling growth in rice (*Oryza sativa*). Ann. Bot. 103, 197-209.

Ram, P.C., Mazid, M.A., Ismail, A.M., Singh, B.N., Singh, V.N., Haque, M.A., Singh, U., Ella, E.S. and Singh, B.B. 2009. Crop and resource management in flood –prone areas: Farmer' strategies and research development. In "Natural Resource Management for Proverty Reduction and Environmental Sustainability in Rice-Based Systems. Proceeding No. 15" (S. Haefele and A.M. Ismail, Eds.), pp. 82-94.

Sarker, R.K., Bhattacharya, B., Chakrabarty, A., Raha, S. and Satpathy, C. 2006. Response of rice to nitrogen and potassium application in Gangetic alluvial soils of West Bengal. J. Potassium Res: 11 (3/4): 297-301.