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Nursery Management Influences Yield and Yield Attributes of Rainfed Lowland Rice

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A field experiment was conducted in Sundarbazar, Lamjung during May to November 2010 to understand the impact of nursery management on the yield and yield attributes of rainfed lowland transplanted rice. The experiment was conducted in three factors factorial randomized complete block with three replications. Thus a total of twelve treatments were used consisting of three levels of seeding density (600, 300 and 100 g m^{-2} of nursery bed); two levels of nitrogen fertilization (0 and 30 kg N ha^{-1} in nursery bed after 15 days after sowing) and two ages of seedlings (20 and 40 days). The results revealed that 20 days old seedlings obtained from low density seeding with nitrogen fertilization in the nursery produced the highest grain yield (6.96 t ha^{-1}) where as the 40 days old seedlings from high density seeding without nitrogen fertilization produced the lowest grain yield (5.74 t ha^{-1}). The results indicated that seedlings obtained from high seeding density (600 g m^{-2}) has the lowest durability in the nursery which is a common practice under rainfed mid hill conditions of Nepal. Nitrogen application in nursery increased the rice yield of younger seedlings as compared to older seedlings.

Key Words: Nursery management, seeding density, nursery nitrogen fertilization, seedling age

Introduction

Rice is the major crop of the Nepalese farming system. It is grown in 1.49 million ha of cultivated land in the country producing 4.46 million tons (AICC,2012). However, productivity of rice in Nepal (2.98 t ha^{-1}) (AICC, 2012) is lower compared to the world productivity of 4.36 t ha^{-1} (FAOSTAT, 2012). The major reasons for low productivity of rice in Nepal are rainfed cultivation, low input production system and crop management (AICC, 2012).

Farmers have been seen to raise rice nursery with higher seeding rates and only the application of organic manure. De Datta (1980) recommended 100 g m^{-2} of seeding density in wet and dry bed nursery. Bond *et al* (2005) also reported quadratic relationships between rice yield and seeding density, lower seeding density producing higher yield. Sarwar *et al.* (2011) exhibited significantly higher 1000- grain weight, straw and grain yield with lower seeding density of 40 g m^{-2} as compared to 160 g m^{-2}. However, Tan *et al.* (2000) reported no significant influence of increased seed rate and seeding density on the grain yield of rice as there was increase in effective tillers per m^2 but decrease in filled grains per panicle. With regards to nursery nitrogen management, Gomosta (2004) showed increase in number of tillers after transplanting when nurseries were applied with urea @ 100 kg ha^{-1} in rice nursery. Panda *et al*. (1991) reported increased rice yields up to 2.5 times as a result of various dose of nitrogen applied to rice nursery which was due to increasing trend in grain weight by transplanting seedlings grown with sufficient fertilizer application.

About 79% of the rice cultivated in Nepal is grown under rainfed conditions, 70% of which is under lowland and 9% under upland conditions (CBS, 2011). Due to non-uniform and erratic rain distribution patterns, farmers are compelled to wait for showers before transplanting resulting transplanting of older seedlings. Use of older seedlings in rice production is the major reason of lower rice yield (Mishra & Salokhe, 2008; Sarwar *et al.*, 2011) as seedling age has a tremendous effect on plant height, tiller production, panicle length, grain formation, grains per panicle, and other yield attributing characters (Ali *et al.*, 1995). Mobasser *et al.* (2007) observed that when seedlings stay for a longer period in the nursery beds, primary tiller buds on the lower nodes of the main culm become degenerated leading to reduced tiller production. Seeding density, nitrogen fertilization in nursery and age of seedlings influence seedling vigor, growth and performance of rice in the main field (Lal & Roy, 1996).

Castillo (2008), from the experiences of CURE (Consortium for Unfavorable Rice Environments) project in South Asia including Nepal explained that the use of high seeding density by the farmers were due to the shortage of available space in the highlands for the nursery and low seeding rate in the seedling nursery would not produce enough seedlings needed to plant the main field. However, he recommended the use of lower seeding density and better nutrient management for better rice production. This experiment was therefore conducted to determine the impacts of various nursery management options that is seeding density, nitrogen application, seedling age and their interaction on rice growth and yield of transplanted rice.

Materials and Methods

This research was conducted in a farmer's field near Institute of Agriculture and Animal Science in Sundarbazar, Lamjung (28º 7' N, 84º 28' E), Nepal during May to November, 2010. The experiment was conducted using 3 factorial combination of treatments using randomized complete block design; each treatment replicated thrice. Thus a total of twelve treatments were used consisting of three levels of seeding density (600, 300 and 100 g m^{-2} of nursery bed); two levels of nitrogen fertilization (0 and 30 kg N ha^{-1} in nursery bed after 15 days after sowing) and two ages of seedlings (20 and 40 days). The soil texture was sandy loam (51% sand, 30% silt and 19% clay) with neutral pH (6.7), medium organic matter (3.44%), high nitrogen content (0.26%), medium phosphorus content (38 kg P_2O_5 ha^{-1}) and low potassium content (84 kg K_2O ha^{-1}). The average temperature was 30.3^0C and the total rainfall received was 1540 mm from May to October, 2010.

Radha-4 variety of rice was used in the experiment. Radha-4 variety has a high average yield (4.9 t ha^{-1}) and relatively stable crop performance (Adhikari, 2008). Twelve nursery beds, one for eac treatment were raised with dry bed method. The seeds were broadcasted in nursery bed at an interval of 20 days on 9th June and 29th June using a high seeding density of 600 g m^{-2} (D1), medium of 300 g m^{-2} (D2) and a low seeding density of 100 g m^{-2} (D3) without (N1) and with 30 kg N ha^{-1}top-dressed at 10 DAS (N2) for transplanting 40 days (A2) and 20 days (A1) seedlings respectively. Transplanting was done at crop geometry of 20 X 20 cm with 2 seedlings per hill on 18th July. Fertilizer was applied @ 60:40:30 kg N, P and K ha^{-1}. Total phosphorus and potassium and half of nitrogen were applied as basal dose while the half dose of nitrogen was top-dressed at panicle initiation stage. All plots were hand weeded twice: first weeding at 25 DAT during the active tillering stage and the second weeding at 50 days after transplanting (DAT) during the heading stage. Harvesting was done manually at harvest maturity, with approximate seed moisture content of 20%. Threshing was done separately for each treatment.

Observations regarding agronomic traits and yield attributing traits including number of effective tillers, grains per panicle and seed weight were made following standard procedures. Collected data were analyzed for ANOVA using Genstat statistical computer package. The least significant difference (LSD) was set at 5% probability level to compare the means.

Results and Discussion

Seedling characteristics

The interaction among the three factors did not significantly influence the seedling height or dry matter of the seedlings. Similarly, a decreasing trend in seedling height was recorded with the decrease in seeding density from 600 to 100 g m^{-2} but the differences were not significant. The tallest seedlings (28.7 cm) were produced at higher seeding density (600 g m^{-2}) as compared to medium (28 cm) and low seeding densities (26.7 cm) owing to comparatively serious competition for sunlight in the nursery (Table 1). High density seeding resulted in significantly higher number of emerged seedlings per unit area (210) and dry matter per unit area produced (6.23 g). Higher number of seedlings per unit area was due to higher number of seeds sown per unit area and that higher number of seedlings contributed to the higher dry matter produced per unit area. However, per seedling dry weight is seen to be higher in low density seedling. This was due to competition free healthy and robust seedlings in low density nursery. It was also observed that the seedlings from low density nursery especially with nitrogen top dressed in the nursery were more vigorous and dark green in color.

Nitrogen top-dressing in the nursery after 15 DAS did not influence significantly on plant height, number of seedlings and the dry matter production in the nursery (Table 1). The plant height was significantly higher in older seedlings of 40 days (31.5 cm) than 20 days seedlings (23.8 cm) (Table 4). Taller plant height in older seedlings is obvious because plant height increases with age. The number of seedlings per 100 cm^2 was significantly higher in younger seedlings of 20 days (154), than that of 40 days old seedlings (100) but dry matter produced per unit area was higher in older seedlings (Table 1) which was due to taller plant height that influences dry matter production.

Table 1. Effect of nursery management options on seedling characteristics at transplanting at Sundarbazar during May to October, 2010

Treatments	Seedling height (cm)	No of seedlings per 100 cm^2	Dry matter produced per 100 cm^2 (g)
Seeding density			
D1 (600g m^{-2})	28.7	210 [a]	6.23 [a]
D2 (300g m^{-2})	28.0	124 [b]	5.06 [ab]
D3 (100g m^{-2})	26.4	47 c	3.63 c
LSD (0.05)	NS	60	1.38
Sem	2.8	17.9	0.41
Nitrogen level			
N1 (control)	27.0	120	4.64
N2 (@ 30 kg/ha in nursery)	28.3	134	5.30
LSD (0.05)	NS	NS	NS
Sem	2.29	14.6	0.337
Age of seedlings			
A1 (20 days)	23.8 [b]	154 [a]	4.17 [b]
A2 (40 days)	31.5 [a]	100 [b]	5.78 [a]
LSD (0.05)	7.6	49	1.13
Sem	2.2	14.6	0.34
CV%	20.2	28.2	16.6
Grand mean	27.7	127	4.97

Treatment means are separated by Duncan's Multiple Range Test (DMRT) and the columns represented by same letter (s) are not significantly different among each other at 5% level of significance.

Yield attributes

Effective tillers

Significant difference was observed in the effective tiller per square meter due to the interaction among the factors. Nitrogen application in the nursery significantly raised the number of effective tillers in both young and older seedlings only from nursery with low seeding density (100 g/m^2). Moreover, effective tillers per square meter for high density seeding were significantly higher than low seeding density when nitrogen was not applied in the nursery (Table 2). Sarwar *et al.* (2010), on the other hand, reported increased number of effective tillers with decreasing seeding density in nursery. But significantly lower number of effective tillers in low seeding density in the experiment is because the seedlings in low seeding density, specially the older seedlings produced tiller in the nursery itself, thus during transplanting the tillers were detached and transplanted @ 2 seedlings per hill.

With regard to seedling age, younger seedlings produced significantly higher number of effective tillers than older seedlings in all the factor combinations. Younger seedlings could relieve the transplanting stress in a shorter period of time compared to that of older seedlings due to the higher nitrogen content in the younger ones (Yamamoto *et al.*, 1998), and the plants' ability to faster resumption of the rate of phyllochron development. Khusrul Amin and Aminul Haque (2005) also observed production of significantly higher number of effective tillers per hill in 25 days old seedling as compared to 45 old seedlings in all the four varieties used in the experiment.

The highest number of effective tillers per m^2 recorded in treatment with medium seeding density (300 g m^{-2}) where nitrogen application did not had much influence. However, in lower (100 g m^{-2}) seeding density, nitrogen application significantly increased the effective tillers per m^2. The effective tillers per m^2 produced by medium seeding density at both control and nitrogen top dressing was significantly greater than all other treatment combinations. The interaction results revealed that under higher densities, nitrogen application in nurseries had no much effect on effective tillers per square meter, but had significant effect in nurseries with low seeding density.

Table 2. Interaction effects of nursery nitrogen management and nursery seeding density on effective tillers per m^2 of rice

Treatments	Effective tillers per square meter			
	Nitrogen level			
	N1 (Control)		N2(N top-dressed)	
	Age of seedlings			
	A1 (20 days)	A2 (40 days)	A1 (20 days)	A2 (40 days)
Seeding density				
D1 (600 g/m^2)	319.4^{bc}	266.7^{f}	327.8^{abc}	271.2^{ef}
D2 (300 g/m^2)	352.0^{a}	283.3^{d}	336.1^{ab}	302.8^{cd}
D3 (100 g/m^2)	258.3^{f}	225.0^{g}	300.0^{cde}	266.7^{f}
LSD (0.05)	30.6			
Sem	10.45			
CV%	12.4			
Grand Mean	292.4			

Treatment means are separated by Duncan's Multiple Range Test (DMRT) and the treatment means with the common letter (s) are not significantly different among each other at 5% level of significance.

Filled grains per panicle

The interactions among the factors did not significantly influence the filled grains per panicle. But, seeding density and age of seedlings solely influenced the trait. Low seeding density produced significantly higher filled grains per panicle than medium seeding density, while that produced by high seeding density was at par with both medium and low seeding density. Similarly, younger seedlings produced significantly higher filled grains per panicle than older seedlings. But, no such significant influence on filled grains per panicle was observed due to nitrogen application in the nursery.

1000- grain weight

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). Neither of the factors viz., seeding density and nursery nitrogen management or the age of seedlings had substantial differences among each other. However, interaction among the factors showed significantly higher 1000- grain weight from younger seedlings from nitrogen applied low density nursery as compared to older seedlings from high density nursery without nitrogen application.

Table 3. Interaction effects of nursery seeding density and nursery nitrogen management on 1000- grain weight of rice

Treatments	1000- grain weight (g)			
	Nitrogen level			
	N1 (Control)		N2(N top-dressed)	
	Age of seedlings			
	A1 (20 days)	A2 (40 days)	A1 (20 days)	A2 (40 days)
Seeding density				
D1 (600 g/m^2)	25.8^{b}	26.7^{ab}	27.6^{ab}	26.6^{ab}
D2 (300 g/m^2)	27.4^{ab}	26.8^{ab}	26.7^{ab}	26.5^{ab}
D3 (100 g/m^2)	27.3^{ab}	27.7^{ab}	28.0^{a}	26.3^{ab}
LSD (0.05)	2.0			
Sem	0.7			
CV%	4.5			
Grand Mean	26.95			

Treatment means are separated by Duncan's Multiple Range Test (DMRT) and the treatment means with the common letter (s) are not significantly different among each other at 5% level of significance.

There was no significant effect of seeding density at both levels of nitrogen application in the nursery and seedling age on 1000- grain weight. Similarly, the effect of nitrogen application in the nursery on 1000-grain weight was non-significant at all levels of seeding density. The interaction results are in line with that of Sarwar *et al*. (2011). They also reported increased 1000- grain weight from low density fertilized nursery as compared to high density unfertilized nurseries.

Grain Yield

The interaction among the three factors significantly influenced the grain yield. High seeding density with older seedlings with or without nitrogen application produced the lowest yield (5.74 t ha^{-1}) in the experiment (Table 4).

It was significantly lower than the yield obtained from the younger seedlings of high and medium seeding density without nitrogen applied in the nursery and also the younger seedlings of all (high, medium and low) seeding density with nitrogen application in the nursery. However, it was statistically similar to older seedlings of all seeding density either with or without nitrogen application. Similar interaction results were observed by Mishra and Salokhe, 2008; Khusrul Amin and Aminul Haque (2009). Sarwar *et al.* (2011) also observed significantly higher yields form 20 days old seedlings (3.2 t ha^{-1}) than 40 days older (2.3 t ha^{-1}) and concluded that younger seedlings after transplanting because they suffer less root damage during uprooting, with minimum transplanting shock and mortality rate, which increases all yield attributes of transplanted rice. The younger seedlings also aid to better phyllochron development and better tillering and thus, increase the final grain yield (De Datta, 1980).

Table 4. Interaction effects of age of seedling, nursery nitrogen management and nursery seeding density on grain yield of rice

Treatments	Grain yield (t/ha)			
	Nitrogen level			
	N1 (Control)		N2(N top-dressed)	
	Age of seedlings			
	A1 (20 days)	A2 (40 days)	A1 (20 days)	A2 (40 days)
Seeding density				
D1 (600 g/m^2)	6.71^{ab}	5.74^{d}	6.48^{abc}	5.76^{d}
D2 (300 g/m^2)	6.64^{ab}	6.29^{bcd}	6.47^{abc}	5.90^{cd}
D3 (100 g/m^2)	6.27^{bcd}	6.28^{bcd}	6.96^{a}	6.02^{cd}
LSD (0.05)	0.619			
Sem	0.211			
CV%	5.8			
Grand Mean	6.295			

Treatment means are separated by Duncan's Multiple Range Test (DMRT) and the treatment means with the common letter (s) are not significantly different among each other at 5% level of significance.

The trend clearly showed that the older seedlings of higher seeding density can reduce the grain yield drastically. This indicated that the longer stay of seedlings in the nursery affected the seedling growth pattern in response to high competition (Mandel *et al.*, 1984). De Datta (1980) also suggested increase in both inter and intra plant competition with increase in seeding density during the early stage of crop growth.

The highest yield obtained (6.96 t ha^{-1}) in the experiment was from younger (20 days) seedlings under low seeding (100 g m^{-2}) density with nitrogen application in the nursery. When nitrogen was applied to the nursery bed, younger seedlings produced better yield at both high and low seeding density. The interaction table (Table 4) suggests that nursery nitrogen application has more pronounced effects in younger seedlings in low densities and older seedlings in high density seeding.

These effects resulting from the interaction of nursery seeding density, nursery nitrogen application and seedling age gives the implications of the study in rainfed lowland rice cultivation. Under rainfed condition, there is no certainty of rainfall, therefore it is obvious that the farmers may have to transplant older seedlings if rainfall is delayed. In such conditions, it would be better to manage nursery with lower seeding density as yield reduce due to late transplanting was lower.

Conclusions

The seedlings obtained from high seeding density (600 g m^{-2}) should not be transplanted at older age because it reduced the yield of rice drastically. Therefore, in the rainfed condition of mid hills where farmers generally transplant older seedlings due to uncertainty of rainfall are suggested to raise seedlings in low seeding density. The higher yield of rice could be obtained if seedlings were transplanted at younger age obtained with low seeding density (100 g m^{-2}) using recommended nitrogen fertilization in the nursery.

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