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IMPROVING PERFORMANCES OF LATE TRANSPLANT *AMAN* RICE THROUGH SPACING AND NUTRIENT MANAGEMENT OPTIONS

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Abstract

Crop and nutrient management options could improve the yield performances of late transplant *Aman* rice which is generally lower compared to optimum transplanting. To address these issues, an experiment was conducted at Bangladesh Agricultural University, Mymensingh to investigate the effect of spacing and nutrient management options on yield and yield components of late transplant *Aman* rice and to find out the better treatment combination to obtain higher yield. The experiment was laid out in two factors randomized complete block design (RCBD) with three replications consisting of three spacings *viz.* S_1 =25 cm×15 cm , S_2 =25 cm×10 cm and S_3 =20 cm×10 cm; and eight nutrient management options viz. N_0 = Control (No fertilizer), N_1 = Poultry manure @ 5 t ha^{-1} , N_2 = Vermicompost @ 3 t ha^{-1} , N_3 = Researcher's practice (Urea, TSP, MoP, Gypsum and $ZnSO_4$ @ 180,75,105, 60 and 7.5 kg ha^{-1}, respectively), N_4 = 75% N_3 + Poultry manure @ 2.5 t ha^{-1}, N_5 = 50% N_3+ poultry manure @ 5 t ha^{-1}, N_6 = 75% N_3+ Vermicompost @ 1.5 t ha^{-1} and N_7 = 50% N_3+ Vermicompost @ 3 t ha^{-1}. Pre-germinated seeds of BRRI dhan46 were sown in wet nursery bed on 16 August and 30–d–old seedlings were transplanted as per treatments on 15 September in 2017. Yield and yield components were significantly influenced by spacing, nutrient management options and their interactions. The highest yield (5.20 t ha^{-1}) was obtained the spacing 25 cm×10 cm which was at par with 25 cm×15 cm (5.12 t ha^{-1}) and the lowest (4.88 t ha^{-1}) was in 20 cm×10 cm. Statistically similar grain yield 5.85, 5.81 and 5.79 t ha^{-1} were produced in the treatments N_3, N_4 and N_6, respectively. Grain yield increased in the treatments having combination of inorganic and organic nutrient, and also in the optimum inorganic fertilizers (researcher's practice). The highest grain yield (5.98 t ha^{-1}) was obtained in the interaction S_2×N_3 which was at par with S_1 x N_3, S_1 x N_4, S_1 x N_6, S_2 x N_4 and S_2 x N_6. Performances of sole organic fertilizers were not satisfactory level. Therefore, reduced amount (75%) of inorganic fertilizers combined with organic fertilizers (poultry manure 2.5 t ha^{-1} or vermicompost 1.5 t ha^{-1}) along with closer spacing 25 cm×10 cm would be recommended to achieve better and sustainable yield performance of late transplant *Aman* rice cv. BRRI dhan46.

Introduction

Rice is the staple and primary food source for more than one-third of world's population (Karmakar *et al.,* 2004; Singh and Singh, 2008; Sharada and Sujathamma, 2018). Almost one fourth of the calories consumed by the entire world population come from rice (Subudhi *et al.*, 2006). As the primary food crop of Bangladesh, the area and production of rice were 11.61 million hectares and 36.28 million tons, respectively (BBS, 2019). Among the rice seasons, *Aman* rice covers 5.68 m ha (48.91% of total rice area) and produced 13.99 m t (38.57% of total cleaned rice production) (BBS, 2019). *Aman* rice cultivation is cost-effective utilizing rain water as the crop grown in wet season. However, sometimes the *Aman* crop damaged due flood and flash flood and some low lying areas are regularly affected by flood and flash flood. In those cases, late transplant *Aman* rice could play vital role to have good harvest. However, decreasing rate of agricultural land by 0.4% per annum (Hasan *et al.*, 2013; Karmakar and Ali, 2019) and increasing population by 1.28% (BBS, 2019) are the major limitation of horizontal expansion of rice cropping area. The rapid population growth always keeps farm and farmers as well as legislators under pressure for producing more and more rice. Moreover, in recent years frequent flash flood drastically declines the production of rice to some great extant. The loss of rice harvest costs huge sum of foreign currency due to import of rice to meet our national demand. Flood hits during the monsoon season or on the onset of monsoon season, May to July. Sometimes this flood costs the young transplanted seedlings death in some low land areas. After decreasing the water level late transplanted *Aman* rice could be cultivated. BRRI dhan46 is late transplant *Aman* rice released by Bangladesh Rice Research Institute in the year of 2007. The yield of late transplant *Aman* rice can be increased with the modern cultivation practices like proper spacing arrangement, nutrient management, seedling age etc.

A crop production system with high yield targets cannot be sustainable unless balanced nutrient inputs are supplied to soil against nutrient removal by crops (Bhuiyan *et al.*, 2007). Imbalanced and continuous application of chemical fertilizers on crop production might be disturbed soil health and microbes (Khadka *et al.,* 2008). Application of inorganic fertilizer is considered to be most effective measures for improving rice production. Mythili *et al.* (2003) reported that zinc and sulphur deficient soil with N, P, K, S as gypsum coupled with poultry manure produced the highest grain yield (5.63 t ha^{-1}). It revealed that the efficient fertilizer management gives higher yield of crop and reduces fertilizer cost (Hasan *et al.*, 2004). Organic sources of nutrients applied to preceding crop can benefit the succeeding crop. Therefore, a judicious integration of chemical fertilizer along with organic manure may help to maintained soil fertility as well as increase crop productivity. Poultry manure contains sufficient amount of nutrients especially it has enough phosphorus that very beneficial for rice crop. Fresh chicken manure is rich with 0.8% potassium, 0.4 % to 0.7 % phosphorus, and 0.9 % to 1.5 % nitrogen (Wikipedia, 2019a). Vermicompost is the product of the decomposition process using various species of worms, usually red wigglers, white worms, and other earthworms, to create a mixture of decomposing vegetable or food waste, bedding materials, and vermicompost. Vermicompost is the end-product of the breakdown of organic matter by earthworms. It improves soil aeration, enriches soil with micro-organisms (adding plant hormones such as auxins and gibberellic acid) (Wikipedia, 2019a). Average organic matter content of the soil of Bangladesh is less than 1.5% and in many cases it is less than 1% (BARC, 2018). Islam *et al.* (2015) reported that application of 50% recommended chemical fertilizers + poultry manure @ 2.5 t ha^{-1} produced the highest plant height, number of tillers $hill^{-1}$. Thus, any alternative means has to be suggested to the farmers to maintain the high level of productivity. That's why, integrated use of organic manures such as vermicompost, poultry manure and inorganic fertilizers can be an effective strategy for nutrient management in rice as well as to sustain long term productivity. So, the proper utilization of different source of nutrients in context of crop-soil productivity must be explored for the existence of the people. In some regions the soil are not only deficient in macronutrients such as N, P, K and S but also some of the micronutrients such as Zn and B. Sreelatha *et al.* (2006) found the grain yield of rice applying poultry manure @ 1 t ha^{-1} along with recommended dose of fertilizer. It may supply sufficient amount of S, Zn and B for growth of rice plants. Application of poultry manure may play an important role in rice cultivation when used alone or in combination with chemical fertilizers. Vermicompost is rich in nitrogen (2-3%), Phosphorus (1.55-2.25%) and Potash (1.85-2.25%); and other micronutrients (Wikipedia, 2019b). It is beneficial for soil microbes and also contains 'plant growth hormones & enzymes'. Vermicompost retains nutrients for long time and while the conventional compost fails to deliver the required amount of macro and micronutrients including the vital NKP to plants in shorter time. Combination of 75% of recommended inorganic fertilizers and cow-dung (5 t ha^{-1}) improves the physical, chemical and biological properties of soil and thus it helps to increase and conserves the soil productivity (Marzia*et al.,* 2016). Sustainable production of crops cannot be maintained by using only chemical fertilizers and similarly it is not possible to obtain higher crop yield by using organic manure alone (Moe *et al.,* 2019). To expand crop productivity more emphasis should be given on spacing along with integrated nutrient management. Therefore, the experiment was executed to investigate the effect of spacing and nutrient management options on yield and yield components of late transplant *Aman* rice (BRRI dhan46) and to find out the better combination of spacing and nutrient management options to obtain higher yield.

Materials and Methods

An experiment was conducted at Agronomy field laboratory, Bangladesh Agricultural University, Mymensingh during July to December 2017. The experimental field was located at 24.75° N latitude and 90.50° E longitude at an average altitude of 18 m from above the sea level. The site belongs to the Old Brahmaputra Floodplain Agro-ecological zone (AEZ) 9 having non-calcareous dark-grey floodplain and silty loam soil. The soil of the experimental field was more or less neutral in nature (pH 6.82) and low in organic matter content (1.19%). The climate of the locality was tropical in nature characterized by high temperature, high humidity and heavy precipitation with occasional breezy winds in *Aman* season (wet season) (June-October) and scanty rainfall associated with moderate to low average air temperature (°C), relative humidity (%), rainfall (mm) and sunshine (day^{-1}) during the experimental period. The experiment was comprised two factors covering three spacings S_1 = 25 cm×15 cm, S2 = 25 cm×10 cm and S_3 =20 cm×10 cm; and eight nutrient management options viz. N_0 = Control (No fertilizer), N_1 = Poultry manure @ 5 t ha^{-1} , N_2 = Vermicompost @ 3 t ha^{-1} , N_3 = Researcher's practice (Urea, TSP, MoP, Gypsum and $ZnSO_4$ @ 180,75,105, 60 and 7.5 kg ha^{-1}, respectively), N_4 = 75% N_3 + Poultry manure @ 2.5 t ha^{-1} , N_5 = 50% N_3 + poultry manure @ 5 t ha^{-1} , N_6 = 75% N_3 + Vermicompost @ 1.5 t ha^{-1} and N_7 = 50% N_3 + Vermicompost @ 3 t ha^{-1}.The experiment was laid out in a randomized complete block design with three replications. The size of unit plot was 4 m 5 m. High yielding late transplant *Aman* rice variety BRRI dhan46 released byBangladesh Rice Research Institute (BRRI) was used in the experiment. Seeds of BRRI dhan46 were collected from BRRI, Gazipur. Pre-germinated seeds were sown in the wet nursery bed on 16 August and 30–d–old seedlings were transplanted as per the treatments on 15 September in 2017. Seeding and transplanting was purposively delayed to address the late planting effect and to find out how can overcome that adverse effect utilizing that late transplant *Aman* rice variety BRRI dahn46. For the treatment N_1, N_4 and N_5; Poultry manure @ 5, 2.5 and 5 t ha^{-1}; and for the treatment N_2, N_6 and N_7; Vermicompost@ 3, 1.5 and 3 t ha^{-1}, respectively were applied at 10 days before transplanting. All inorganic fertilizers except urea having in different treatments were applied one day before transplanting during final land preparation. Nitrogen was top dressed as per treatment in the form of urea (prilled) in three equal splits; one-third during final land preparation as basal dose, one-third at 15 days after transplanting (DAT) and the rest one-third at 30 DAT. The distance maintained between two unit plots was 0.5 m and between blocks was 1 m. The bunds around individual plots were made firm enough placing polythene sheet inside the soil up to 50 cm to control water and nutrient movement among the plots. Yield and yield parameters like panicles hill^{-1}, grains panicle^{-1}, panicle length, spikelet sterility, 1000-grain weight, grain, straw and biological yield; harvest index were recorded at harvest. Data collected on different parameters were analyzed using the statistical software MSTAT-C program and mean differences among the treatment were adjusted by using the Least Significance Test (LSD) at 5% level of significance (Gomez and Gomez, 1984).

Results and Discussion

The results of the experiment on effect of spacing and integrated nutrient management and their interaction on the growth and yield of *Aman* rice cv. BRRI dhan46 have been presented and discussed in this chapter.

Grain yield

Spacing had significant effect on grain yield at 1% level of probability. These results were in confirmation of the findings of Karmakar *et al.* (2014) and Obulamma and Reddeppa (2002). The results indicated that the spacing 25 cm x 10 cm (S_2) produced the highest grain yield (5.20 t ha^{-1}) that was statistically similar with 25 cm x 15 cm (5.12 t ha^{-1}) (Table 1). The lowest grain yield (4.88 t ha^{-1}) was recorded from S_3 (20 cm×10 cm). The highest grain yield from S_2(25 cm×10 cm) was due to the highest number of effective tillers hill^{-1}.The crop got less time for tillering so that the medium spacing produced the highest yield. Grain yield differences might be due to the availability of sunlight for photosynthesis inserted across the row spacing 25 cm.

Table1. Effect of spacing on yield components and yield of BRRI dhan46

Spacing	Panicles hill^{-1} (no.)	Panicle length (cm)	Grains panicle^{-1} (no.)	Sterile spikelet panicle^{-1} (no.)	1000-grain wt. (g)	Grain yield (t ha^{-1})	Harvest index (%)
S_1	8.86a	23.14	129.21	12.57	26.14	5.12ab	45.23b
S_2	9.14a	23.10	129.73	12.43	26.30	5.20a	47.88a
S_3	7.65b	22.87	127.44	13.01	26.09	4.88b	45.28b
$LSD_{(0.05)}$	0.73	0.52	5.12	0.69	0.38	0.14	0.26
F-test	**	NS	NS	NS	NS	**	**

** =Significant at 1% level of probability and, NS = Not significant.
S_1 = 25 cm×15 cm, S_2 =25 cm×10 cm, and S_3 = 20 cm×10 cm

Grain yield significantly affected by the nutrient management options at 1% level of probability. These results are in good harmony with Karmakar *et al.* (2002).The results showed that the treatment N_3 (Researcher's practice) produced the highest grain yield (5.85 t ha^{-1}), however it was at par and very close to N_4 (75% N_3 + Poultry manure 2.5 t ha^{-1}) and N_6 (75% N_3 + Vermicompost 1.5 t ha^{-1}) those yielded 5.81 and 5.75 t ha^{-1}, respectively (Fig. 1). The lowest (3.12 t ha^{-1}) grain yield was found in treatment N_0 (No fertilizer). Yield of the treatments applied sole poultry manure and sole vermicompost were significantly higher than the control plot, nevertheless, those were significantly lower than the treatments where applied the combination of organic and inorganic fertilizers. Moreover, long term effect of organic fertilizers is very much promising as nutrients release from it slowly. However, Poultry manure and vermicompost with 75% inorganic fertilizers produced similar yield with researcher's practice. It is very much helpful to get higher yield and to improve soil health. The crop was transplanted at least one month later than the optimum planting date (15 July to 15 August) (BRRI, 2019) so that the crop got less time in the monsoon to utilize the nutrient from the organic fertilizers. In this aspect, N_3 (Researcher's practice: 110% inorganic fertilizers), N4 (75% N_3+ Poultry manure 2.5 t ha^{-1}) and N_6 (75% N_3+ Vermicompost 1.5 t ha^{-1}) released nutrient sufficiently and readily which may be a strong reason for the higher yield of these treatments. Yield and yield component increased with increased nutrient levels (Salem *et al.,* 2011). Sarkar *et al.* (2014) also indicated the highest number of effective tillers $hill^{-1}$, grains $panicle^{-1}$, panicle length and grain yield were recorded in the treatment using 75% recommended dose of fertilizer. Mollah *et al.* (2011) found that cow dung had a positive effect on grain and straw yields of *Aman* rice.

Interaction of spacings and nutrient management options showed significant variation in respect of grain yield. The highest grain yield (5.98 t ha^{-1}) was produced by the combination of S_2 N_3 that at par with S_1 N_3, S_2 x N_4, S_1 x N_4 and S_2 x N_6 (Table 3). The lowest grain yield (4.05 t ha^{-1}) was produced by S_1 (25 cm×15 cm) with control (no manures and fertilizer). In general higher grain yield was observed in the interactions of the spacing 25 cm x 10 or 15 cm and researcher's practice along with reduced amount (75%) of researcher's practice. The results showed that combination of inorganic and organic fertilizers along with bit closer spacing 25 cm x 10 cm might be better to get better yield from late transplant *Aman* rice. These results are corroborated with Sarker *et al.* (2015) in BRRI dhan33 and Islam *et al.* (2007) who observed that conventional spacing of 25 cm×15 cm in combination with 50% N, P, K, S, Zn and 5 t ha^{-1} poultry manure appeared as the best practice for transplant *Aman* rice.

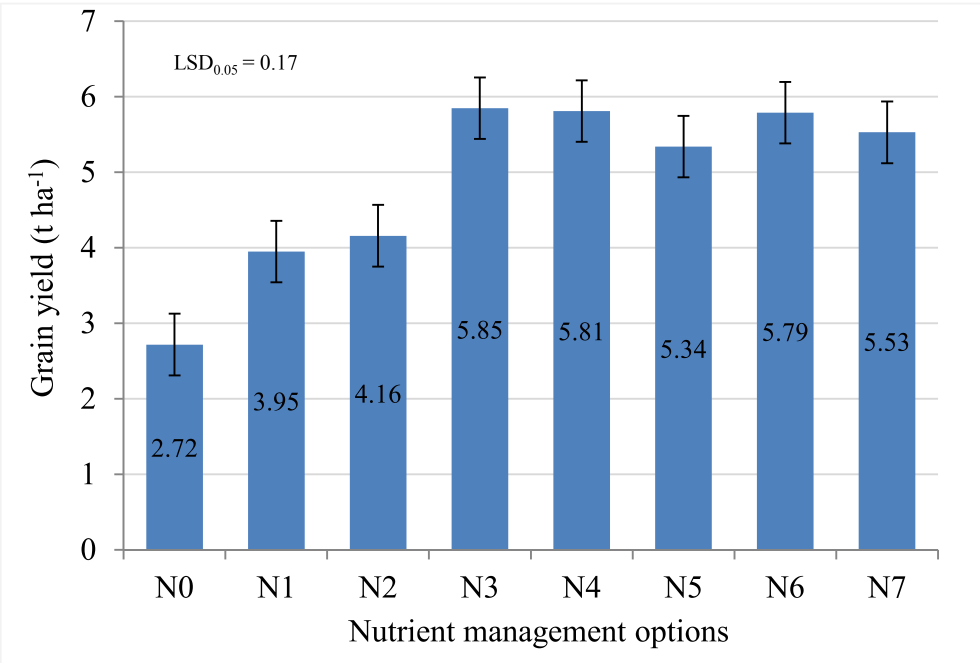

Fig.1. Effect of nutrient management options on grain yield of late transplant *Aman* rice (BRRI dhan46).

N_0 = Control, N_1 = Poultry manure @ 5 t ha^{-1}, N_2 = Vermicompost @ 3 t ha^{-1}, N_3 = Recommended dose of inorganic fertilizer, N_4 = 75% N_3 + Poultry manure @ 2.5 t ha^{-1}, N_5 = 50% N_3+ poultry manure @ 5 t ha^{-1}, N_6 = 75% N_3+ Vermicompost @ 1.5 t ha^{-1}, N_7 = 50% N_3 + Vermicompost @ 3 t ha^{-1}

Panicle production

Spacing had significant effect on number of panicles hill^{-1}. These results are in good alignment with the findings of Karmakar *et al.* (2014); Verma *et al.* (2002); Patra and Nayak (2001).The number of panicles hill^{-1}ranged from 7.65 to 9.14 among the spacings. The results indicated that S_1 (25cm×10cm)produced the highest number of panicles hill^{-1}(9.14) followed by 25 cm x 15 cm (8.86) (Table 1). In comparison with these results, Mobasser *et al.* (2007) reported that the spacing had a significant effect on the total number of tillers hill^{-1}.

The probable reasons of difference in producing the number of panicles hill^{-1} was mainly the spacing. The lowest number (7.65) was recorded in S_3 (20cm×10cm) which is statistically identical to S_3 (20cm×10cm). Wang *et al.* (2006) found that greater light interception by middle and lower layer leaves, equal row spacings were appropriate for cultivars with erect and semi erect panicles. Nutrient management exerted significant effect on the number of panicles at 5% level of probability. Sarker *et al.* (2015) reported that number of effective and tillers hill^{-1} influenced by organic and inorganic fertilizers. It was found that N_3 (Recommended dose of inorganic fertilizer) produced the highest number of panicles hill^{-1}(8.92) followed by N_4 (8.88) (Table 2). Probably this treatment provided adequate nutrients to the plants and as a result produced the highest number of panicles hill^{-1}. Where N_2 (Vermicompost @ 3 t ha^{-1}), N_4 (75% Researcher's practice+ Poultry manure @ 2.5 t ha^{-1}), N_6 (75% Researcher's practice+ Vermicompost @ 1.5 t ha^{-1}) and N_7 (50% Researcher's practice+ Vermicompost @ 3 t ha^{-1}) were statistically identical with N_3. The lowest number of panicles hill^{-1}(7.50) was obtained in N_0 (Control). Number of effective tillers hill^{-1} was not significant due to the interaction of spacing and nutrient management options. Number of panicles hill^{-1} ranged from 7.00 to 9.88 (Table 3).

Panicle length

Spacing, nutrient management options and their interactions had no significant influence on panicle length. In contrast, Tyeb *et al.* (2013) and Karmakar *et al.* (2002) observed that spacing has significant effect on panicle length. Tyeb *et al.* (2013) reported that the highest panicle length was obtained from 25 cm×20 cm spacing while the lowest panicle length was obtained from 20 cm×10 cm, among the spacings of 25 cm×15 cm, 25 cm×20 cm, 20 cm×20 cm and 20 cm×10 cm used for4 varieties of rice viz. BRRI dhan41, BRRI dhan46, BRRI dhan51 and BRRI dhan52. Panicle length was significantly affected by nutrient management options. Kandil *et al.* (2010) and Mannan *et al.* (2010) reported similar results. The longest panicle was produced in N_4 (8.96 cm) followed by N_3 (8.92 cm) and the shortest was in N_0 (7.25 cm).

Grains panicle^{-1}

Spacing had insignificant effect on the number of grains production per panicle. In contrast, Pol *et al.* (2005) reported that rice crop transplanted with 20 cm×20 cm spacing produced significantly more number of panicle hill^{-1}. Nutrient management options had significant effect on the number of grains panicle^{-1} at 5% level of probability (Table 2). These findings collaborate with those reported by Sarker *et al.* (2015) reported that grains panicle^{-1} significantly influenced by organic and inorganic fertilizers. The results indicated that the treatment, N_2 (Vermicompost @ 3 t ha^{-1}), N_4 (75% Researcher's practice+ Poultry manure @ 2.5 t ha^{-1}), N_5 (50% Researcher's practice+ poultry manure @ 5 t ha^{-1}), N_6 (75% Researcher's practice+ Vermicompost @ 1.5 t ha^{-1}) and N_7 (50% Researcher's practice+ Vermicompost @ 3 t ha^{-1}) were statistically identical with highest number of grains panicle^{-1}. The lowest number of grains panicle^{-1} was found inN_0 (Control) followed by N_1 (Poultry manure @ 5 t ha^{-1}). Interaction of spacing and nutrient management had insignificant variation in terms of grains panicle^{-1} at 5% level of probability.

Table 2. Effect of integrated nutrient management options on yield components and yield of late transplant *Aman* rice BRRI dhan46

Nutrient management options	Panicles hill^{-1} (no.)	Panicle length (cm)	Grains panicle^{-1} (no.)	Sterile spikelet panicle^{-1} (no.)	1000-grain wt. (g)	Harvest index (%)
N_0	7.25b	20.2	102.88c	12.6	25.7	43.33f
N_1	7.62b	21.32	120.57b	13.1	26.0	46.60c
N_2	7.9ab	22.51	126.52ab	12.7	26.1	46.47e
N_3	8.92a	23.26	131.68a	12.4	26.3	48.10b
N_4	8.96a	23.05	131.73a	12.2	26.3	48.15de
N_5	7.61b	23.1	130.58a	12.6	26.1	45.54c
N_6	8.47ab	23.0	128.02ab	12.1	26.3	46.23cd
N_7	8.40ab	23.3	129.15ab	12.2	26.2	45.69a
$LSD_{(0.05)}$	1.2	1.8	8.35	1.1	0.73	0.42
F-test	*	*	*	NS	NS	**

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

N_0 = Control, N_1 = Poultry manure @ 5 t ha^{-1}, N_2 = Vermicompost @ 3 t ha^{-1}, N_3 = Researcher's practice, N_4 = 75% N_3 + Poultry manure @ 2.5 t ha^{-1}, N_5 = 50% N_3+ poultry manure @ 5 t ha^{-1}, N_6 = 75% N_3+ Vermicompost @ 1.5 t ha^{-1}, N_7 = 50% N_3 + Vermicompost @ 3 t ha^{-1}

Sterile spikelet panicle^{-1}

Number of sterile spikelet panicle^{-1} was not significantly influenced by spacing and nutrient management options and their interactions (Table 3).Karmakar *et al.* (2014) also found that spacing had no significant effect on spikelet sterility. However, the highest sterile spikelets panicle^{-1} (13.69) was found in the interaction of S_3 x N_1 while it was the lowest (11.53) in S_2 x N_4).

Table 3. Interaction effect of spacing and nutrient management options on yield components and yield of late transplant *Aman* rice BRRI dhan46.

Interaction S×N	Panicles hill^{-1} (no.)	Panicle length (cm)	Grains panicle^{-1} (no.)	Sterile spikelet panicle^{-1} (no.)	1000-grain wt. (g)	Grain yield (t ha^{-1})	Harvest index (%)
$S_1 \times N_0$	7.00	22.21	121.6cd	14.0	26.13	4.05l	43.00k
$S_1 \times N_1$	7.77	23.27	133.7abc	13.44	26.29	5.07ghi	46.41fg
$S_1 \times N_2$	9.08	23.33	137.2a	12.04	26.14	5.00i	43.67k
$S_1 \times N_3$	9.81	23.49	140.7a	15.40	26.27	5.95a	48.45a
$S_1 \times N_4$	9.67	23.46	138.4a	15.15	26.31	5.88a	47.52ab
$S_1 \times N_5$	8.11	22.59	126.9abcd	12.75	26.07	5.47de	46.37fg
$S_1 \times N_6$	9.55	23.55	137.7a	13.91	26.24	5.74ab	45.56ij
$S_1 \times N_7$	8.78	23.44	133.2abcd	12.15	26.26	5.57cd	47.28de
$S_2 \times N_0$	7.11	23.79	120.9d	15.64	26.32	3.71m	43.45k
$S_2 \times N_1$	8.10	22.95	127.9abcd	13.06	26.30	4.74j	47.09def

Interaction S×N	Panicles hill^{-1} (no.)	Panicle length (cm)	Grains panicle^{-1} (no.)	Sterile spikelet panicle^{-1} (no.)	1000-grain wt. (g)	Grain yield (t ha^{-1})	Harvest index (%)
$S_2 \times N_2$	8.51	22.84	129.4abcd	12.29	26.24	5.16gh	46.12ghi
$S_2 \times N_3$	9.22	23.61	139.1a	16.02	26.43	5.98a	48.54a
$S_2 \times N_4$	9.00	23.48	136.3a	15.53	26.25	5.86a	47.25ab
$S_2 \times N_5$	6.78	23.69	130.6abc	13.02	26.27	5.08ghi	44.98j
$S_2 \times N_6$	8.55	23.26	135.9ab	15.26	26.41	5.81a	45.57bc
$S_2 \times N_7$	8.33	23.91	138.5a	12.60	26.18	5.13gh	47.30ab
$S_3 \times N_0$	7.44	23.07	120.1d	16.19	26.30	4.25k	43.55k
$S_3 \times N_1$	7.00	23.64	126.1abc	13.69	26.29	5.05hi	46.29bc
$S_3 \times N_2$	6.66	23.21	128.6abc	12.75	26.31	5.34f	46.63efg
$S_3 \times N_3$	9.44	23.17	133.2ab	12.95	26.22	5.77ab	47.10abc
$S_3 \times N_4$	8.78	23.51	136.5ab	12.98	26.31	5.63c	48.08a
$S_3 \times N_5$	7.88	22.97	131.1abcd	13.89	26.35	5.48de	48.26a
$S_3 \times N_6$	8.40	23.13	128.4abcd	12.22	26.19	5.11ghi	47.56bcd
$S_3 \times N_7$	8.00	22.27	123.8bcd	13.91	26.37	5.00i	48.18a
LSD $_{(0.05)}$	4.06	1.56	14.5	5.96	0.62	0.22	0.72
F-test	NS	NS	*	NS	NS	**	**

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

S_1 = 25 cm × 15 cm, S_2 =25 cm×10 cm and S_3 = 20 cm × 10 cm

N_0 = Control, N_1 = Poultry manure @ 5 t ha^{-1}, N_2 = Vermicompost @ 3 t ha^{-1} , N_3 = Researcher's practice, N_4 = 75% N_3 + Poultry manure @ 2.5 t ha^{-1} , N_5 = 50% N_3+ poultry manure @ 5 t ha^{-1} , N_6 = 75% N_3+ Vermicompost @ 1.5 t ha^{-1} , N_7 = 50% N_3 + Vermicompost @ 3 t ha^{-1}

1000-grain weight

Spacing and nutrient management exerted insignificant effect on 1000-grain weight. Grain weight is mostly genetic characteristics so that it did not affected by spacing (Karmakar *et al.,* 2014), nutrient management options and their interactions. Islam *et al.* (2015) also reported that the interaction effect of date of transplanting and spacing was found significant for yield and plant characters except 1000-grain weight. In contrast, Subhendu *et al.* (2003) found that 1000-grain weight significantly affected by nutrient management options. Interaction effect between spacing and nutrient management options under the study exerted insignificant effect on 1000-grain weight (Table 3).

Harvest index

Spacing had significant influence on harvest index at 1% level of probability (Table 1). These results are in good harmony with Karmakar *et al.* (2014). The spacing S_2 (20cm 10cm) gave the highest harvest index (47.88%). Nutrient management also showed significant influence on harvest index (Mondal and Swamy, 2003). The highest harvest index (48.15%) was found in the treatment $N_4$and the lowest (43.33%) was in treatment N_0 (no manures and fertilizer (Table 2).The effect of interaction of spacing and nutrient management options on harvest index was significant at 1% level of probability (Table 3). Interaction of S_2 N_3showed the highest harvest index (48.54%), which was statistically identical with S_2 x N_4, S_1 x N_3, S_1 x N_4, S_3 N_5 and S_3 N_4. The lowest harvest index (43.00%) was found in the interaction of S_1 N_0 (25cm 15cm Spacing no fertilizer and manure).

Conclusion

Nutrient management options, spacings and their interaction had significant influence on yield and yield components of late transplant *Aman* rice cv. BRRI dhan46. Statistically similar yield were produced in the spacings25 cm x 10 cm and 25 cm x 15 cm, and the treatment combinations of poultry manure (2.5 t ha^{-1}) and vermicompost (1.5 t ha^{-1}) with 75% of the researcher's practice (Urea, TSP, MoP, Gypsum and $ZnSO_4$ @ 180,75,105, 60 and 7.5 kg ha^{-1}, respectively). Yield performance of the researcher's practice was also statistically similar with organic and inorganic fertilizers treatments. Moreover, yield performances of sole organic fertilizers were not satisfactory level. Moreover, long term effect of organic fertilizers is very much promising as nutrients release from it slowly. It could be recommended that combination of reduced amount (75%) of inorganic fertilizers and organic fertilizers (poultry manure 2.5 t ha^{-1} or vermicompost 1.5 t ha^{-1}) along with 25 cm x 10 cmor 25 cm x 15 cm spacingwould be recommended to accomplish higher yield and sustainable performances of late transplant *Aman* rice cv. BRRI dhan46.

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