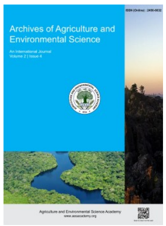
Archives of Agriculture and Environmental Science 3(1): 49-53 (2018)
https://doi.org/10.26832/24566632.2018.030106

e-ISSN: 2456-6632

This content is available online at AESA

Archives of Agriculture and Environmental Science

Journal homepage: www.aesacademy.org



ORIGINAL RESEARCH ARTICLE

CrossMark

Influence of plant nutrient management on the yield performance of transplant *Aman* rice (*Oryza sativa* L.)

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ARTICLE HISTORY

Received: 21 January 2018
Revised received: 27 January 2018
Accepted: 18 February 2018

Keywords

Nutrient management
Plant nutrient management
Transplant *Aman* rice
Variety
Yield

ABSTRACT

The experiment was conducted at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh, Bangladesh during June to December 2016 to investigate the influence of plant nutrient management on the yield performance of transplant *Aman* rice varieties. The experiment comprised four varieties *viz.*, BRRIdhan70, BRRI dhan71, BRRI dhan72 and BRRIdhan73 and six nutrient managements *viz.* poultry manure 5 t ha^{-1}, recommended dose of prilled urea, P, K, S, Zn (160, 65, 90, 70, 10 kg ha^{-1} of urea, TSP, MoP, Gypsum and Zinc sulphate, respectively), 75% of recommended dose of prilled urea and P, K, S, Zn + poultry manure 2.5 t ha^{-1}, 50% of recommended dose of prilled urea and P, K, S, Zn + poultry manure 5 t ha^{-1}, USG 1.8 g/4 hills and P, K, S, Zn recommended dose, USG 1.8 g/4 hills and P, K, S, Zn + poultry manure 2.5 t ha^{-1}. The experiment was laid out in a randomized complete block design with three replications. Number of total tillers $hill^{-1}$(10.25), number of effective tillers $hill^{-1}$(8.85), grains $panicle^{-1}$ (94.23), 1000-grain weight (27.81), grain yield (5.88 t ha^{-1}) and straw yield (8.83 t ha^{-1}) were found to be the highest in BRRI dhan72. Among the nutrient management, USG 1.8 g/4 hills and P, K, S, Zn + poultry manure 2.5 t ha^{-1} exhibited its superiority to other treatments in terms of plant height (131.0 cm), number of total tillers $hill^{-1}$(10.67), number of effective tillers $hill^{-1}$ (9.13), grains $panicle^{-1}$ (92.71), 1000-grain weight (26.82), grain yield (6.0 t ha^{-1}) and straw yield (8.35 t ha^{-1}). The highest grain yield (6.45 t ha^{-1}) was found in BRRI dhan72 combined with USG 1.8 g/4 hills and P, K, S, Zn + poultry manure 2.5 t ha^{-1} and the lowest grain yield (4.85 t ha^{-1}) was found in BRRI dhan71 fertilized with poultry manure 5 t ha^{-1}. From the study, it can be concluded that transplant *Aman* rice cv. BRRI dhan72 fertilized with USG 1.8 g/4 hills and P, K, S, Zn + poultry manure 2.5 t ha^{-1} appears as the promising practice to obtain the highest grain yield.

Citation of this article: Ali, M.I., Sarkar, M.A.R and Paul, S.K. (2018). Influence of plant nutrient management on the yield performance of transplant *Aman* rice (*Oryza sativa* L.). *Archives of Agriculture and Environmental Science*, 3(1): 49-53 DOI: 10.26832/24566632.2018.030106

INTRODUCTION

Rice (*Oryza sativa* L.) crop is interwoven in the cultural, social and economic lives of millions of Bangladeshis and it holds the key for food and nutritional security of the country. It is consumed as the staple food and has been given the highest priority in meeting the demands of ever-increasing population in Bangladesh. It is the most important food crop and a primary food source for more than one-third of world's population (Singh and Singh, 2008). In Bangladesh, it is grown under irrigated, rainfed and deep water conditions in the three distinct seasons namely; *Aus*, *Aman* and *Boro*. Among the three distinct seasons *Aman* rice covers the second largest area of 56 lac hectares with a production of 131 lac tons of rice (BBS, 2016). In the recent years, crop productivity has stagnated or decreased in spite of consumption of increased rate of chemical fertilizers (Chen *et al*., 2011). As a result, agricultural ecosystems remain in a state of chemical nutrient saturation, leading to huge nutrient losses through leaching, runoff, volatilization, emissions, immobilization and subsequent low nutrient use efficiency (Sun *et al*., 2012). It is high time to search for innovative practices, which can guarantee higher yields with minimal deterioration of natural resources. Integrated nutrient management has been shown to considerably improve rice yields by minimizing nutrient losses to the environment and managing the nutrient supply, and thereby results in high nutrient use efficiency (Kumar and Yadav, 2008). Recent field experiments have demonstrated that integrated nutrient management can lead to significant increase in crop yields while substantially reducing nutrient losses (Gupta and Sharma, 2007). Strong and convincing evidence indicates that INM practice could be an innovative and environmentally friendly strategy for sustainable agriculture worldwide (Wu and Ma, 2015).Therefore, the present investigation was carried out to have a better understanding of improving nutrient management in transplant *Aman* rice for maximization of yield.

MATERIALS AND METHODS

The experiment was conducted at the Agronomy Field Laboratory, Bangladesh Agricultural University (BAU), Mymensingh, during June to December 2016 to study the influence of plant nutrient management on the yield performance of transplant *Aman* rice varieties. The land was medium high with silt-loam texture having pH 5.9. The experiment comprised four varieties *viz.* BRRIdhan70, BRRI dhan71, BRRI dhan72 and BRRIdhan73 and six nutrient managements *viz.* poultry manure 5 t ha^{-1}, recommended dose of prilled urea, P, K, S, Zn (160, 65, 90, 70, 10 kg ha^{-1} of urea, TSP, MoP, Gypsum and Zinc sulphate, respectively), 75% of recommended dose of prilled urea and P, K, S, Zn + poultry manure 2.5 t ha^{-1}, 50% of recommended dose of prilled urea and P, K, S, Zn + poultry manure 5 t ha^{-1}, USG 1.8 g/4 hills and P, K, S, Zn recommended dose, USG 1.8 g/4 hills and P, K, S, Zn + poultry manure 2.5 t ha^{-1}. The experiment was laid out in a randomized complete block design with three replications. The size of unit plot was 4.0 × 2.5 m. Poultry manure, urea, TSP, MoP, gypsum and zinc sulphate were applied at final land preparation as per treatment requirements. Urea was top dressed in three equal splits at 15, 30 and 45 days after transplanting (DAT). USG was applied at 8 DAT at the center of four hills in every alternate row. Prior to harvest, five hills plot^{-1} were randomly selected excluding border hills and central one square meter harvest area to record data on crop characters and yield components. The crop was harvested at full maturity and threshed by pedal thresher to record the fresh weight of grain and straw. Grains were cleaned and sun dried to a moisture content of 14%. Straws were also sun dried properly. Grain and straw yields were then converted to t ha^{-1}. The recorded data were analyzed statistically using Analysis of variance and the mean differences among the treatments were adjudged by Duncan's Multiple Range Test (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Effect of variety

Crop characters, yield components and yield of transplant *Aman* rice were significantly influenced by variety. BRRI dhan70 produced the tallest plant (139.9 cm) followed by BRRI dhan72 (128.0 cm) and BRRI dhan71 (122.2 cm) while the shortest one (121.8 cm) was recorded in BRRI dhan73. These differences were mostly due to the genetic variation among the varieties. These results are consistent to those of Pal *et al.* (2016) and Chowdhury *et al.* (2016) who reported variable plant height among the varieties. The highest number of total tillers hill^{-1} (10.25), number of effective tillers hill^{-1} (8.85) and number of non-effective tillers hill^{-1} (1.40) were recorded in BRRI dhan72 while the lowest values were found in BRRI dhan70. The longest panicle (26.60 cm) was found in BRRI dhan73 while the shortest one (23. 57 cm) was recorded in BRRI dhan71 which was at par with BRRI dhan70 and BRRI dhan72. The highest number of grains panicle^{-1} (88.21) and 1000-grain weight (26.66 g) were found in BRRI dhan72 whereas the lowest values were recorded in BRRI dhan70. The highest grain yield (5.88 t ha^{-1}) and straw yields (6.71 t ha^{-1}) were obtained in BRRI dhan72 followed by BRRI dhan73 while the lowest values were recorded in BRRI dhan70. The variation in number of tillers hill^{-1} as assessed might be due to varietal characters. Nuruzzaman *et al.* (2000) noticed that number of tillers hill^{-1} differed among the varieties. Varietal differences regarding grain yield was reported elsewhere (Tyeb *et al.* 2013; Jisan *et al.*, 2014; Pal *et al.*, 2016). The highest harvest index (45.00%) was recorded in BRRI dhan70, which was at par with BRRI dhan71 and the lowest one in BRRI dhan72. Variety has significant influence on harvest index was also reported elsewhere (Tyeb *et al.*, 2013; Sarkar *et al.*, 2014 and Chowdhury *et al.*, 2016).

Effect of nutrient management

Nutrient management significantly influenced crop characters, yield components and yield (Table 2). The application of USG 1.8 g/4 hills and P, K, S, Zn + poultry manure 2.5 t ha^{-1} showed its superiority in terms of plant height (131.0 cm), number of total tillers hill^{-1} (10.67), number of effective tillers hill^{-1} (9.13) and grains panicle^{-1} (92.71) to nutrient management while the lowest values for these parameters were found in poultry manure 5 t ha^{-1}. The highest grain yield (6.0 t ha^{-1}) and straw yield (8.35 t ha^{-1}) were obtained when the crop was fertilized with USG 1.8 g/4 hills and P, K, S, Zn + poultry manure 2.5 t ha^{-1}. Probably this treatment might have provided adequate nutrients to plants and due to absorption of more nutrients, the crop produced the highest grain yield. These results are in agreement with that of Pal *et al.*, 2016; Biswas *et al.*, 2016; Islam *et al.*, 2015; Roy *et al.*, 2015 and Sarkar *et al.*, 2014 who found differences in yield and yield components due to levels of nutrient management. The treatment poultry manure 5 t ha^{-1} gave the lowest values for the same parameters due to poor nutrient supply and its uptake by plant. Application of USG 1.8 g/4 hills and P, K, S, Zn + poultry manure 2.5 t ha^{-1} improved the yield contributing characters *viz.* number of effective tillers hill^{-1}, number of grains panicle^{-1} and 1000-grain weight, which ultimately resulted in the highest grain yield. The straw yield showed similar trend as that of grain yield due to nutrient management. Application of different doses of manures and fertilizers influenced the crop characters in terms of plant height and number of total tillers hill^{-1} which resulted in differences of straw yield. The highest harvest index

(44.14%) was found in 50% of recommended dose of prilled urea and P, K, S, Zn + poultry manure 5 t ha^{-1} while the lowest one (41.92%) was found in USG 1.8 g/4 hills and P, K, S, Zn + poultry manure 2.5 t ha^{-1}.

Effect of interaction between variety and nutrient management

Crop characters, yield components and yield were significantly influenced by the interaction between variety and nutrient management (Table 3). The highest number of total tillers $hill^{-1}$ (12.42), number of effective tillers $hill^{-1}$ (10.20), number of non-effective tillers $hill^{-1}$ (2.17), grain yield (6.45t ha^{-1}) and straw yield (9.57t ha^{-1}) were obtained in BRRI dhan72 fertilized with USG 1.8 g/4 hills and P, K, S, Zn + poultry manure 2.5 t ha^{-1}. The lowest number of total tillers $hill^{-1}$ (7.93) was found in BRRI dhan70 fertilized with poultry manure 5 t ha^{-1} while the lowest number of effective tillers $hill^{-1}$ (6.67), grain yield (3.5 t ha^{-1}) and straw yield (4.85 t ha^{-1}) were found in the combination of BRRI dhan70 and poultry manure 5 t ha^{-1}. The highest harvest index (47.28%) was found in the combination of BRRI dhan70 and 75% of recommended dose of prilled urea and P, K, S, Zn + poultry manure 2.5 t ha^{-1}while the lowest harvest index (38.90%) was found in the combination of BRRI dhan72 and 75% of recommended dose of prilled urea and P, K, S, Zn + poultry manure 2.5 t ha^{-1}.

Table 1. Effect of variety on crop characters, yield components and yield of transplant *Aman* rice.

Variety	Plant height (cm)	No. of total tillers $hill^{-1}$	No. of effective tillers $hill^{-1}$	No. of non-effective tillers $hill^{-1}$	Panicle length (cm)	No. of grains $panicle^{-1}$	No. of sterile spikelets $panicle^{-1}$	1000- grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Harvest index (%)
BRRI dhan70	139.9a	8.74d	7.67c	1.09b	24.74b	75.52d	20.06a	21.38c	4.84d	5.89d	45.00a
BRRI dhan71	122.2c	9.06c	7.76c	1.29a	23.57b	79.99c	18.22b	26.27b	5.09c	6.28c	44.83a
BRRI dhan72	128.0b	10.25a	8.85a	1.40a	24.17b	94.23a	11.61d	27.81a	5.88a	8.83a	40.08b
BRRI dhan73	121.8c	9.7b	8.31b	1.39a	26.60a	88.21b	13.59c	26.66b	5.3b	6.71b	44.35a
Sx	1.45	0.09	0.08	0.04	0.39	0.73	0.28	0.19	0.054	0.08	0.36
Level of significance	**	**	**	**	**	**	**	**	**	**	**
CV (%)	4.83	4.25	4.19	11.85	6.81	3.68	7.50	3.10	4.41	5.12	3.55

Table 2. Effect of nutrient management on crop characters, yield components and yield of transplant *Aman* rice.

Nutrient management	Plant height (cm)	No. of total tillers $hill^{-1}$	No. of effective tillers $hill^{-1}$	No. of non-effective tillers $hill^{-1}$	Panicle length (cm)	No. of grains $panicle^{-1}$	No. of sterile spikelets $panicle^{-1}$	1000- grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Harvest index (%)
F_0	122.3b	8.21f	7.15f	1.07c	24.14	78.12d	19.38a	24.24e	4.45f	5.76e	43.76a
F_1	126.7ab	9.21d	8.02d	1.19c	25.29	84.02b	15.64c	25.16d	5.2d	6.8c	43.43a
F_2	127.8a	10.12b	8.63b	1.5a	24.43	86.03b	14.59d	26.23b	5.65b	7.26b	44.12a
F_3	129.4a	8.73e	7.58e	1.14 c	24.55	80.85c	16.84b	24.95d	4.93e	6.31d	44.14a
F_4	130.6a	9.67c	8.33c	1.33b	25.40	85.20b	15.31cd	25.79b	5.45c	7.04bc	44.02a
F_5	131.0a	10.67a	9.13a	1.54a	24.81	92.71a	13.47e	26.82a	6.0a	8.35a	41.92b
Sx	1.78	0.12	0.09	0.04	0.481	0.898	0.342	0.228	0.07	0.10	0.446
Level of significance	**	**	**	**	NS	**	**	**	**	**	**
CV (%)	4.83	4.25	4.19	11.85	6.81	3.68	7.50	3.10	4.41	5.12	3.55

In a column, figures with same letter (s) or without letter do not differ significantly whereas figures with dissimilar letter differ significantly (as per DMRT), ** = Significant at 1% level of probability, NS = Not significant,F_0 = Poultry manure 5t ha^{-1},F_1 = Recommended dose of prilled urea, P, K, S, Zn (100, 65, 90, 70, 10 kg ha^{-1} of urea, TSP, MoP, Gypsum, Zinc sulphate, respectively),F_2 = 75% of recommended dose of prilled urea and P, K, S, Zn + poultry manure 2.5 t ha^{-1},F_3 = 50% recommended dose of prilled urea and P, K, S, Zn + poultry manure 5 t ha^{-1},F_4 = USG 1.8 g/4 hills and P, K, S, Zn recommended dose,F_5 = USG 1.8 g hill and P, K, S, Zn + poultry manure 2.5 t ha^{-1}.

Table 3. Effect of interaction between variety and nutrient management on crop characters, yield components and yield of transplant *Aman* rice.

Interaction (Variety x Nutrient management)	Plant height (cm)	No. of total tillers hill^{-1}	No. of effective tillers hill^{-1}	No. of non-effective tillers hill^{-1}	Panicle length (cm)	No. of grains panicle^{-1}	No. of sterile spikelets panicle^{-1}	1000- grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Harvest index (%)
$V_1 \times F_0$	125.0	7.91i	6.67l	1.25efg	24.75	66.93	22.92a	20.10	3.5 j	4.85l	42.32dg
$V_1 \times F_1$	144.4	8.58 hi	7.7ghij	0.83ij	25.97	76.36	19.97bc	21.31	4.71hi	5.77gk	44.73cd
$V_1 \times F_2$	142.2	9.00fgh	7.92ghi	1.08ghi	24.42	77.31	19.03c	22.07	5.35ef	5.93hij	47.44a
$V_1 \times F_3$	142.0	8.42hi	7.25jkl	1.17gh	24.53	71.95	22.84a	20.70	4.56hi	5.52ijk	45.28bd
$V_1 \times F_4$	143.9	8.83gh	7.91fgi	0.92hij	24.13	76.50	19.58bc	21.43	5.25fg	5.86hij	47.28a
$V_1 \times F_5$	141.9	9.67def	8.33efg	1.33def	24.63	84.07	16.03e	22.67	5.59def	7.42cd	42.98def
$V_2 \times F_0$	122.5	7.93i	7.0kl	0.93hij	22.55	73.50	21.35ab	25.20	4.4 i	5.14kl	46.18ab
$V_2 \times F_1$	121.4	8.67hi	7.83hij	0.83ij	24.28	79.57	18.28cd	25.89	4.90gh	6.23fgh	44.0cde
$V_2 \times F_2$	122.6	9.83de	8.0fgh	1.75b	24.08	81.57	16.25de	z26.79	5.50def	6.7ef	44.81bd
$V_2 \times F_3$	119.2	8.5 hi	7.33ijk	1.17efgh	22.75	75.68	19.52bc	25.90	4.58 hi	5.72hijk	44.47de
$V_2 \times F_4$	121.6	9.42efg	8.0fgh	1.42cde	23.78	80.99	18.15cd	26.47	5.28fg	6.30fgh	45.58abc
$V_2 \times F_5$	125.7	10.00de	8.33efg	1.67bc	24.00	88.65	15.76e	27.39	5.88bcd	7.51cd	43.92de
$V_3 \times F_0$	124.1	8.58 hi	7.66hij	0.92hij	23.13	87.52	14.38ef	25.85	5.31efg	7.74 c	40.68gh
$V_3 \times F_1$	125.9	9.92 de	8.66cde	1.25efg	23.27	91.66	11.43gh	27.44	5.93cd	8.91 b	39.94gh
$V_3 \times F_2$	126.7	11.25b	9.41 b	1.83b	23.39	94.61	10.57 h	28.77	6.00bc	9.43ab	38.90 h
$V_3 \times F_3$	129.0	9.08gh	8.41ef	0.67j	25.46	90.57	12.00gh	27.21	5.66def	8.03 c	41.70fgh
$V_3 \times F_4$	135.4	10.25cd	8.66cde	1.58bcd	26.18	94.06	10.82gh	28.47	5.95bc	9.30ab	39.03 h
$V_3 \times F_5$	126.8	12.42 a	10.20a	2.17a	23.59	106.9	10.44 h	29.12	6.453a	9.57 a	40.2fgh
$V_4 \times F_0$	117.7	8.41 hi	7.25jkl	1.17fgh	26.13	84.53	18.8 c	25.79	4.49 hi	5.30jkl	45.86abc
$V_4 \times F_1$	114.9	9.66def	7.8hij	1.83 b	27.64	88.50	12.87fg	26.01	5.26fg	6.42fg	45.02cd
$V_4 \times F_2$	119.5	10.4cd	9.08bc	1.33def	25.82	90.64	12.5fgh	27.28	5.73bce	6.91 de	45.32cd
$V_4 \times F_3$	127.7	8.91gh	7.33ijk	1.58bcd	25.45	85.19	13.0g	25.99	4.91gh	5.97 hi	45.11cd
$V_4 \times F_4$	121.7	10.17de	8.75cd	1.42de	27.51	89.25	12.68gh	26.79	5.32efg	6.72ef	44.21de
$V_4 \times F_5$	129.4	10.58 c	9.58 b	1.00ghi	27.03	91.15	11.6gh	28.11	6.08ab	8.91 b	40.56gh
Sx	3.57	0.23	0.19	0.09	0.97	1.8	0.69	0.46	0.13	0.20	0.89
Level of sig.	NS	**	**	**	NS	NS	**	NS	*	**	**
CV (%)	4.83	4.25	4.19	11.85	6.81	3.68	7.50	3.10	4.41	5.12	3.55

In a column, figures with same letter (s) or without letter do not differ significantly whereas figures with dissimilar letter differ significantly (as per DMRT), ** = Significant at 1% level of probability, NS = Not significant, V_1 = BRRI dhan70, V_2 = BRRI dhan71, V_3 = BRRI dhan73, V_4 = BRRI dhan74, F_0 = Poultry manure 5t ha^{-1}, F_1 = Recommended dose of prilled urea, P, K, S, Zn (100, 65, 90, 70, 10 kg ha^{-1} of urea, TSP, MoP, Gypsum, Zinc sulphate, respectively), F_2 = 75% of recommended dose of prilled urea and P, K, S, Zn + poultry manure 2.5 t ha^{-1}, F_3 = 50% recommended dose of prilled urea and P, K, S, Zn + poultry manure 5 t ha^{-1}, F_4 = USG 1.8 g/4 hills and P, K, S, Zn recommended dose, F_5 = USG 1.8 g hill and P, K, S, Zn + poultry manure 2.5 t ha^{-1}.

Conclusion

Result revealed that the highest grain yield was produced in BRRI dhan72 compare to other tested varieties. In case of nutrient management, the highest grain yield was obtained when the crop was fertilized with USG 1.8 g/4 hills and P, K, S, Zn + poultry manure 2.5 t ha^{-1}. BRRI dhan72 fertilized with USG 1.8 g/4 hills and P, K, S, Zn + poultry manure 2.5 t ha^{-1} showed the best performance in respect of grain yield. It can be concluded that transplant *Aman* rice BRRI dhan72 fertilized with USG 1.8 g/4 hills and P, K, S, Zn + poultry manure 2.5 t ha^{-1} appeared as the promising practice in terms of grain yield.

REFERENCES

BBS, Bangladesh Bureau of Statistics (2016). The Yearbook of Agricultural Statistics of Bangladesh Stat. Div., Minis. Plan. Govt. People's Repub., Bangladesh, Dhaka.pp.54.

Biswas, T., Paul, S.K., Sarkar, M.A.R. and Sarkar, S.K. (2016). Integrated use of poultry manure with prilled urea and urea super granules for improving yield and protein content of aromatic rice (cv. BRRI dhan50). *Progressive Agriculture*, 27 (2): 86-93.

Chowdhury, S.A., Paul, S.K. and Sarkar M.A.R. (2016).Yield performance of fine aromatic rice in response to variety and level of nitrogen. *Journal of Environmental Science and Natural Resources*, 9 (1): 41-45.

Chen, X.P., Cui, Z.L., Vitousek, P.M., Cassman, K.G., Matson, P. A., Bai, J.S., Meng, Q.F., Hou, P., Yue, S.C., Römheld, V. and Zhang, F.S. (2011). Integrated soil crop system management for food security. *Proceedings of the Natural Academy of Sciences USA*, 108(16): 6399-404.

Gomez, K.A. and Gomez, A.A. (1984). Statistical Procedure for Agricultural Research. Int. Rice Res. Inst., John Wiley and Sons. New York, Chichester, Brisbance. Toronto, Singapore, pp. 139-240.

Gupta, V. and Sharma, R.S. (2007). Saving of costly fertilizers through long term application of INM in rice (*Oryza sativa* L.)-wheat (*Triticum aestivum* L.) *Cropping Research on Crops*, 8: 41-5.

Islam, S.M.M., Paul, S.K. and Sarkar, M.A.R. (2015). Effect of weeding regime and integrated nutrient management on yield contributing characters and yield of BRRI dhan49.

Journal of Crop and Weed, 11: 193-197.

Jisan, M.T., Paul, S.K. and Salim, M. (2014).Yield performance of some transplant *aman* rice varieties as influenced by different levels of nitrogen. *Journal of the Bangladesh Agricultural University*, 12 (2): 321-324.

Kumar, J. and Yadav, M.P. (2008). Effect of integrated nutrient management on growth, yield attributes, yield and economics of hybrid rice (*Oryza sativa* L.). *Research on Crops*, 9: 10-3.

Nuruzzaman, M., Yamamoto, Y., Nitta, Y., Yoshida, T. and Miyazaki, A. (2000). Varietal differences in tillering ability of fourteen Japonica and Indica rice varieties. *Soil Science and Plant Nutrition*, 46 (2): 381-391.

Pal, S., Paul, S.K., Sarkar, M.A.R and Gupta, D.R. (2016). Response on yield and protein content of aromatic fine rice varieties to integrated use of cowdung and inorganic fertilizers. *Journal of Crop and Weed*, 12(1): 01-06.

Roy, B., Sarkar, M.A.R and Paul, S.K. (2015). Effect of integrated nutrient management in *Boro* rice cultivation. *SAARC Journal of Agriculture*, 13 (2): 131-140.

Sarkar, S.K., Sarkar, M.A.R., Islam, N. and Paul, S.K. (2014). Yield and quality of aromatic fine rice as affected by variety and nutrient management. *Journal of the Bangladesh Agricultural University*, 12 (2): 279-284.

Singh, Y. and Singh, U.S. (2008). Genetic diversity analysis in aromatic rice germplasm using agro- morphological traits. *Indian Journal of Plant Genetic Resources*, 21(1): 32-37.

Sun, B., Zhang, L., Yang, L., Zhang, F., Norse, D. and Zhu, Z. (2012). Agricultural Non-Point Source Pollution in China: Causes and Mitigation Measures. *Ambio*, 41(4): 370–379. http://doi.org/10.1007/s13280-012-0249-6

Tyeb, A., Paul, S. K. and Samad, M.A. (2013). Performance of variety and spacing on the yield and yield contributing characters of transplant *Aman* rice. *Journal of Agroforestry and Environment*, 7(1): 57-60.

Wu, W. and Ma, B. (2015). Integrated nutrient management (INM) for sustaining crop productivity and reducing environmental impact: A review. *Science of the Total Environment*, 512-513: 415-42, DOI. 10.1016/j.scitotenv.2014.12.101.