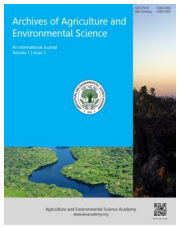
This content is available online at AESA

Archives of Agriculture and Environmental Science

Journal homepage: www.aesacademy.org

e-ISSN: 2456-6632



ORIGINAL RESEARCH ARTICLE

Variations of growth parameters in transplanted *Aman* rice (cv. BRRI dhan39) in response to plant spacing and fertilizer management

S. Jahan, M. A. R. Sarkar and S. K. Paul*

Department of Agronomy, Bangladesh Agricultural University, Mymensingh- 2202, BANGLADESH
*Corresponding author's E-mail: skpaull@gmail.com

ARTICLE HISTORY

Received: 09 Mar. 2017
Revised received: 15 Mar. 2017
Accepted: 16 Mar. 2017

Keywords

Fertilizer management
Growth
Spacing
Transplanted *Aman* rice

ABSTRACT

The experiments were carried out at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh, Bangladesh during June to December 2015 to investigate the effect of spacing and fertilizer management on the growth parameters of transplant *Aman* rice cv. BRRI dhan39. The experiment comprised of five spacing's viz. 25 cm × 5 cm, 25 cm × 10 cm, 25 cm × 15 cm, 25 cm × 20 cm, 25 cm × 25 cm, and four fertilizer treatments viz. no manure and no fertilizer (control), recommended dose of chemical fertilizer (80-60-40 kg N, P_2O_5, K_2O ha^{-1},respectively + 60 kg ha^{-1} gypsum + 10 kg ha^{-1} $ZnSO_4$), 75% recommended dose of inorganic fertilizer + cow dung at 5 t ha^{-1}, 75% recommended dose of inorganic fertilizer + poultry manure @ 2.5 t ha^{-1}. The highest and lowest plant height was found in spacing 25 cm × 15 cm, and 25 cm × 5 cm, respectively at all dates of observations. Spacing 25 cm × 15 cm, produced the highest number of tillers $hill^{-1}$ at 80 DAT. Leaf area index (LAI) and total dry matter (TDM) $hill^{-1}$ were the highest in 25 cm × 15 cm spacing and lowest in 25 cm × 5 cm spacing. The highest plant height, LAI and total TDM $hill^{-1}$ were recorded in 75% recommended dose of inorganic fertilizer + cow dung at 5 t ha^{-1} and the lowest values were observed in control treatment. In case of interaction, the highest number of tillers $hill^{-1}$, leaf area index and total dry matter $hill^{-1}$were obtained in spacing 25 cm × 15 cm fertilized with 75% recommended dose of inorganic fertilizers + cow dung at 5 t ha^{-1}.Therefore, 25 cm × 15 cm spacing combined with 75% recommended dose of inorganic fertilizers + cow dung at 5 t ha^{-1} appeared as the promising practice in transplant *Aman* rice cv. BRRI dhan39 cultivation in terms of growth parameters.

Citation of this article: Jahan, S., Sarkar, M.A.R. and Paul, S.K. (2017). Variations of growth parameters in transplanted *Aman* rice (cv. BRRI dhan39) in response to plant spacing and fertilizer management. *Archives of Agriculture and Environmental Science,* 2(1): 1-5.

INTRODUCTION

Rice (*Oryza sativa)* is the most extensively cultivated and major food grain crop of Bangladesh. Bangladesh has three rice crops/seasons within a year; the *Boro* crop, the *Aman* crop, and the *Aus* crop. The growth of rice plants is influenced genetically and environmentally. Plant spacing is an important factor, which plays a significant role on growth, development, and yield of rice at its optimum level, which provides scope to the plants for efficient utilization of solar radiation and nutrients. Closer spacing hampers intercultural operations and as such additional competition take places among the plants for nutrients, air, and light. As a result, plant becomes weaker, thinner and consequently reduces yield. A suitable combination of organic and inorganic supplies of nutrients is essential for sustainable agriculture that will provide food with superior quality. Sengar *et al*. (2000) stated that the application of chemical fertilizers in combination with manures sustained/improved the fertility status of the soil. The long term research of BRRI reveals that the addition of cow dung @ 5 t ha^{-1} yr^{-1} improves the rice productivity as well as prevents the soil resources from degradation (Bhuiyan, 1994). An upgrading and continuation of a good supply of organic matter is essential for sustenance of soil fertility and crop productivity. The growth parameter, leaf area index (LAI) is a dimensionless variable and was first defined as the total one-sided area of photosynthetic tissue per unit ground surface area (Inge *et al.,* 2004). Leaf area index (LAI) can have importance in many areas of agronomy and crop production through its influence: light interception, crop growth, weed control, crop-weed competition, crop water use and soil erosion (Sonnetag *et al.,* 2007 and Paul *et al*., 2014).Therefore, this study was undertaken

to analyze the growth parameters of transplant *Aman* rice in respect to appropriate spacing and proper fertilizer management.

MATERIALS AND METHODS

The experiment was conducted at the Agronomy field laboratory, Bangladesh Agricultural University, Mymensingh, during the period from July to December 2015 to study the effect of spacing of transplanting and fertilizer management on the growth of transplant *Aman*-rice. The experimental sites belongs to the Sonatola Soil Series of Old Brahmaputra Floodplain (AEZ 9) having non calcareous dark grey floodplain soil. The land was medium high with sandy loam texture having pH 5.9. BRRI dhan39, a high yielding modern rice variety of transplant *Aman*rice, developed by the Bangladesh Rice Research Institute, has been used as the test crop. The experiment comprised five spacings *viz.,* 25 cm × 5 cm (S_1), 25 cm × 10cm (S_2), 25 cm × 15 cm (S_3), 25 cm × 20 cm (S_4), 25 cm ×25 cm (S_5) and four fertilizer treatments viz. no manure and no fertilizer (control) (N_0),recommended dose of chemical fertilizer (80-60-40 kg N, P_2O_5,K_2O ha^{-1},respectively + 60 kg ha^{-1} gypsum + 10 kg ha^{-1} $ZnSO_4$) (N_1),75% recommended dose of inorganic fertilizer + cow dung at 5 t ha^{-1} (N_2), 75% recommended dose of inorganic fertilizer + poultry manure @ 2.5 t ha^{-1} (N_3). The experiment was laid out in a Randomized Complete Block Design with three replications. There were 60 unit plots in the experiment. The size of unit plot was 4m × 2.5m. The experimental plots were fertilized according to the treatments during final land preparation. Nitrogen was applied accordingly experimental specification in the form of urea at three splits application. Five hills were randomly selected and marked with the bamboo sticks in each unit plot excluding border rows to record the data on plant height and tiller number. Plant height and number of total tillers hill^{-1}were recorded five times at 20, 35, 50, 65 and 80 days after transplanting (DAT). Leaf area index and total dry matter hill^{-1} were determined at 60 DAT. For total dry matter determination, five hills were randomly selected in each plot excluding border rows. The plant samples were destructed and packed in labeled brown paper bags and dried in the oven at 80±5°C for 72 hours until constant weight was reached. Recorded data were analyzed statistically using "Analysis of Variance Technique and the differences among treatment means were adjudged by Duncan's Multiple Range Test (DMRT) (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Plant height: The plant height was significantly influenced due to spacing at 20, 35, 50, 65 and 80 days after transplanting (DAT) (Table 1). The highest plant height was obtained at all sampling dates in 25 cm × 15 cm spacing and lowest one was found in 25 cm × 5 cm spacing. Ray *et al.* (2014) also found that closer spacing produced shorter plant in rice. This result was due to maximum number of plant population as well as higher competition for space, solar radiation, water and other resources in 25 cm × 5 cm (S_1) spacing compared to 25 cm × 15 cm (S_3) spacing. Fertilizer management had significant effect on plant height at 20, 35, 50, 65 and 80 days after transplanting (DAT) (Table 2). At all sampling dates the highest plant height was found when fertilized with 75% recommended dose of inorganic fertilizer + cow dung at 5 t ha^{-1}(N_2) and lowest one was found in control application.

Interaction between plant spacing and fertilizer management had no significant effect on plant height at different days after transplanting of T. *Aman* rice cv. BRR dhan39 (Table 3). Visually, At 20, 35, 50, 65 and 80 DAT, the highest plant height (31.67 cm, 57.33 cm, 89.00 cm, 103.30 cm and 109.20cm) was observed in S_3 × N_2 and the lowest ones (28.00 cm, 51.13 cm, 77.07 cm, 90.27 cm and 92.33 cm) was obtained from S_1 × N_0.

Number of total tillers hill^{-1}: Spacing had significant effect on the number of tillers hill^{-1} at different sampling dates up to harvesting (Table 1). The maximum number of tillers hill^{-1} (6.00, 9.00, 12.75, 10.80 and 11.20) was observed in the spacing 25 cm × 15 cm whiles the minimum ones (4.68, 5.76, 6.50, 5.55 and 5.50) were observed in the closest spacing 25 cm × 5 cm at 20, 35,50,65 and 80 DAT. The reason might be wide spaced plants received more nutrients; moisture and light thus produced higher number of tillers hill^{-1}. Mobasser *et al*. (2007) and Ray *et al*. (2014) also reported that wider spacing produced maximum number of total tillers than closer spacing in rice. Total tillers hill^{-1} was significantly influenced due to application of manure and fertilizer (Table 2). The maximum number of tillers hill^{-1} (5.73, 8.30, 10.95, 9.46, 9.12) was observed at N_2 (75% recommended dose of inorganic fertilizer + cow dung 5 t ha^{-1}), at 20, 35, 50, 65 and 80 DAT and while the minimum ones (5.14, 6.92, 8.06, 7.62, 7.61) were observed at N_0 (Control) at 20, 35, 50, 65 and 80 DAT. The result was in agreement with that of Marzia (2015) who reported that combined application of manure with 75% recommended dose of inorganic fertilizer produced maximum number of tillers hill^{-1}.The lowest total tillers hill^{-1} occurred due to lack of proper nutrient uptake. At 20 DAT total tillers hill^{-1} was not significantly influenced by the interaction effect between spacing and manure and fertilizer (Table 3). But at 35, 50, 65 and 80 DAT total tillers hill^{-1} was significantly influenced by the interaction effect between spacing and manure and fertilizer (Table 3). At 35, 50, 65 and 80 DAT, the highest number of tillers hill^{-1} was recorded from S_3 × N_2 and the lowest number of total tiller hill^{-1} was recorded from S_1 × N_0 treatment.

Leaf area index (LAI): Spacing had significant effect on leaf area index (Table 1). At 60DAT, leaf area index was found highest (7.45) in the spacing 25 cm × 15 cm and the lowest LAI (2.80) was found in the closest spacing (25 cm × 5 cm). The result was in agreement with that of Aziz (2014) who observed that LAI reduced due closer spacing in rice. Fertilizer management had significant effect on LAI (Table 2). At 60DAT, LAI (6.16) was found highest in N_2 (75% recommended dose of inorganic fertilizer + cow dung 5 t ha^{-1}) and the lowest LAI (4.33) was found in N_0 (Control). The treatment having combination of organic

Table 1. Effect of plant spacing on plant height, number of tiller hill^{-1}, leaf area index and total dry matter production hill^{-1}.

Plant spacing	Plant height (cm)					No. of total tillers hill^{-1}					Leaf area index	Total dry matter production (g hill^{-1})
	Days after transplanting (DAT)					Days after transplanting (DAT)					Days after transplanting (DAT)	Days after transplanting (DAT)
	20	35	50	65	80	20	35	50	65	80	60	60
25cm × 5cm(S_1)	28.93b	53.38b	81.42c	95.20b	97.10c	4.68d	5.76e	6.55e	5.55e	5.50e	2.80e	14.34e
25cm × 10cm (S_2)	29.15b	54.53ab	82.15bc	97.30ab	99.20bc	5.16c	6.93d	8.03d	7.78d	7.00d	3.65d	16.34d
25cm × 15cm(S_3)	30.67a	55.68a	85.38a	99.63a	103.20a	6.03a	9.00a	12.75 a	10.80a	11.2 a	7.45a	21.01a
25cm × 20cm (S_4)	30.52a	55.27a	84.51ab	98.77a	101.90ab	5.73ab	8.64b	11.88 b	9.983b	10.0b	5.443b	18.83b
25cm × 25cm (S_5)	29.90ab	55.13a	83.83abc	97.98a	99.82bc	5.40bc	7.75c	9.450 c	8.700c	8.40c	4.27c	17.33c
S$\bar{x}$	0.383	0.492	0.838	0.906	1.06	0.13	0.10	0.17	0.10	0.12	0.08	0.156
Level of significance	**	*	**	**	**	**	**	**	**	**	**	**
CV (%)	4.45	3.12	3.48	3.21	3.68	8.45	4.78	6.40	4.24	5.01	5.60	3.06

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, * =Significant at 5% level of probability.

Table 2. Effect of fertilizer management on plant height, number of tiller hill^{-1}, leaf area index and total dry matter production hill^{-1}.

Fertilizer management	Plant height (cm)					No. of total tillers hill^{-1}					Leaf area index	Total dry matter production (g hill^{-1})
	Days after transplanting (DAT)					Days after transplanting (DAT)					Days after transplanting (DAT)	Days after transplanting (DAT)
	20	35	50	65	80	20	35	50	65	80	60	60
N_0	28.91b	52.53c	79.28c	94.75c	96.33c	5.14b	6.92d	8.06d	7.62d	7.61c	4.33d	12.48d
N_1	29.41b	54.12b	82.67b	96.59bc	99.21b	5.30b	7.43c	9.56c	8.26c	8.12b	5.10c	16.40c
N_2	31.08a	56.60a	86.59a	101.00a	105.40a	5.73a	8.30a	10.95a	9.46a	9.12a	6.16a	22.05a
N_3	29.93b	55.95a	85.31a	98.75ab	100.1b	5.42ab	7.81b	10.36b	8.89b	8.86a	5.71b	19.35b
S$\bar{x}$	0.342	0.441	0.750	0.810	0.951	0.11	0.09	0.16	0.09	0.10	0.07	0.13
Level of significance	**	**	**	**	**	**	**	**	**	**	**	**
CV (%)	4.45	3.12	3.48	3.21	3.68	8.45	4.78	6.40	4.24	5.01	5.60	3.06

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). N_0 = No manure and no fertilizer (control), N_1= Recommended dose of chemical fertilizer (80-60-40 kg N, P_2O_5, K_2O ha^{-1},respectively + 60 kg ha^{-1} gypsum + 10 kg ha^{-1} $ZnSO_4$), N_2= 75% recommended dose of inorganic fertilizer + cow dung at 5 t ha^{-1}, N_3=75% recommended dose of inorganic fertilizer + poultry manure @ 2.5 t ha^{-1}. ** = Significant at 1% level of probability.

Table 3. Interaction effect of plant spacing and fertilizer management on plant height, number of tiller hill^{-1}, leaf area index and total dry matter production hill^{-1}.

Interaction (Plant spacing x fertilizer management)	Plant height (cm) Days after transplanting (DAT)					No. of total tillers hill^{-1} Days after transplanting (DAT)					Leaf area index Days after transplanting (DAT)	Total dry matter production (g hill^{-1}) Days after transplanting (DAT)
	20	35	50	65	80	20	35	50	65	80	60	60
$S_1 \times N_0$	28.00	51.13	77.07	90.27	92.33	4.53	5.66i	6.06j	4.60 l	4.73g	2.04m	9.003l
$S_1 \times N_1$	28.93	53.40	81.67	95.27	97.80	4.60	5.73i	6.40j	5.46 k	5.53f	2.58l	12.92j
$S_1 \times N_2$	29.80	55.13	84.07	98.53	101.0	4.87	5.93hi	7.00ij	6.27j	5.87f	3.40k	18.03fg
$S_1 \times N_3$	29.00	53.87	82.87	96.73	97.27	4.73	5.73i	6.73ij	5.87jk	5.87f	3.21k	17.40gh
$S_2 \times N_0$	28.40	52.47	78.20	94.87	95.73	4.87	6.40gh	7.00ij	7.07i	6.00f	2.44lm	10.62k
$S_2 \times N_1$	29.00	53.93	82.27	96.07	98.47	5.07	7.00fg	8.20 h	7.67 hi	6.27f	3.34k	15.87i
$S_2 \times N_2$	30.07	56.07	84.33	99.73	103.9	5.53	7.20f	8.67gh	8.33gh	8.00de	4.66fgh	20.33d
$S_2 \times N_3$	29.13	55.67	83.80	98.53	98.73	5.20	7.13f	8.27 h	8.07gh	7.73e	4.18hij	18.53ef
$S_3 \times N_0$	29.73	53.80	81.00	96.53	99.07	5.60	8.07de	10.07ef	9.53de	10.0bc	7.45c	17.31gh
$S_3 \times N_1$	30.07	54.53	84.67	98.07	101.5	6.00	8.53bcd	12.40bc	10.07cd	11.2a	8.5b	18.61ef
$S_3 \times N_2$	31.67	57.33	89.00	103.3	109.2	6.33	10.2a	14.53a	12.13a	11.8a	9.2a	25.51a
$S_3 \times N_3$	31.20	57.07	86.87	100.6	103.3	6.20	9.13b	14.00a	11.47b	11.8a	8.6b	22.59b
$S_4 \times N_0$	29.60	52.67	80.13	96.40	98.60	5.53	7.30f	9.40fg	9.00ef	9.67bc	4.02ij	13.10j
$S_4 \times N_1$	29.67	54.40	82.40	97.07	99.60	5.60	8.40cd	11.40cd	9.93cd	9.73bc	5.10 f	18.13fg
$S_4 \times N_2$	32.27	57.33	88.73	102.5	107.7	6.13	9.93a	13.93a	10.53c	10.4b	6.66 d	24.90a
$S_4 \times N_3$	30.53	56.67	86.80	99.13	101.7	5.66	8.93bc	12.80b	10.47c	10.3b	5.99e	19.21e
$S_5 \times N_0$	28.80	52.60	80.00	95.67	95.93	5.20	7.16f	7.80hi	7.93h	7.66e	3.72jk	12.35j
$S_5 \times N_1$	29.40	54.33	82.33	96.47	98.73	5.26	7.53ef	9.40fg	8.20gh	7.86de	3.96j	16.48hi
$S_5 \times N_2$	31.60	57.13	86.80	101.1	105.3	5.80	8.20d	10.60de	10.07cd	9.46c	4.87fg	21.49c
$S_5 \times N_3$	29.80	56.47	86.20	98.73	99.27	5.33	8.13de	10.00ef	8.60fg	8.60d	4.53ghi	19.00ef
$S\bar{x}$	0.765	0.984	1.67	1.81	2.12	0.26	0.210	0.35	0.20	0.24	0.172	0.311
Level of significance	NS	NS	NS	NS	NS	NS	**	**	**	*	**	**
CV (%)	4.45	3.12	3.48	3.21	3.68	8.45	4.78	6.40	4.24	5.01	5.60	3.06

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). N_0 = No manure and no fertilizer (control), N_1= Recommended dose of chemical fertilizer (80-60-40 kg N, P_2O_5, K_2O ha^{-1},respectively + 60 kg ha^{-1} gypsum + 10 kg ha^{-1} $ZnSO_4$), N_2= 75% recommended dose of inorganic fertilizer + cow dung at 5 t ha^{-1}, N_3=75% recommended dose of inorganic fertilizer + poultry manure @ 2.5 t ha^{-1}. ** = Significant at 1% level of probability.

and inorganic fertilizers showed significant improvement of LAI. The result agreed with that of Paul *et al.* (2014). Usman *et al.* (2003) reported that maximum leaf area index (LAI) of rice obtained through application of inorganic fertilizer and manure. The interaction effect between plant spacing and fertilizer management on LAI was significant at 60 DAT (Table 3). The highest LAI was observed in the spacing 25 cm × 15 cm when fertilized with 75% recommended dose of inorganic fertilizer + cow dung5.0 t ha^{-1} and the lowest one was found in the closest spacing (25 cm × 5 cm) with control application.

Total dry matter (TDM): Spacing had significant effect on TDM (Table 1). At 60 DAT, total dry matter was found highest (21.01 g $hill^{-1}$) in the spacing 25 cm × 15 cm and the lowest total dry matter (14.34 g $hill^{-1}$) was found in the closest spacing (25 cm × 5 cm). Total dry matter production $hill^{-1}$ reduced in closer spacing was reported by Tyeb *et al.* (2013). Total dry matter production increased at wider spacing due to less competition for water, nutrient and more accumulation in plant. The result was in agreement with that of Murty and Murty (1980). Fertilizer management had significant effect on TDM (Table 2). At 60DAT, total dry matter (22.05 g $hill^{-1}$) was found highest in N_2 (75% recommended dose of inorganic fertilizer + cow dung at 5 t ha^{-1}) and the lowest total dry matter (12.48 g $hill^{-1}$) was found in N_0 (Control). The result was in agreement with that of Marzia (2015) who mentioned that integration of manure with 75% recommended dose of inorganic fertilizer increased TDM of rice. The interaction effect between plant spacing and fertilizer management on TDM $hill^{-1}$ was significant at 60 DAT (Table 3). The highest total dry matter (25.51 g $hill^{-1}$) was observed in the spacing 25 cm × 15 cm when fertilized with 75% recommended dose of inorganic fertilizer + cow dung at 5 t ha^{-1} and the lowest one(9.00 g $hill^{-1}$) was found in the closest spacing (25 cm × 5 cm) with control application.

Conclusions

From the findings of the experiment it can be concluded that tallest plant, highest number of total tiller $hill^{-1}$, highest leaf area index and total dry matter production $hill^{-1}$were obtained in 25 cm × 15 cm spacing. The highest number of tillers $hill^{-1}$, leaf area index and total dry matter $hill^{-1}$ were observed in 75% recommended dose of inorganic fertilizer + cow dung at 5 t ha^{-1}. In case of interaction, growth parameters gave the highest values in spacing 25 cm × 15 cm fertilized with 75% recommended dose of inorganic fertilizers + cow dung at 5 t ha^{-1}. Therefore, application of 75% recommended dose of inorganic fertilizer + cow dung at 5 t ha^{-1}in plant spacing 25 cm × 15 cm appeared as the promising practice in respect of growth of transplant *Aman* rice (cv. BRRI dhan39).

REFERENCES

Aziz, A.B. (2014). Effect of spacing of transplanting and combined application of manure and fertilizer on the growth and yield of transplant Aman rice cv. BRRI dhan56.MS Thesis. Department of Agronomy Bangladesh Agricultural University, Mymensingh. pp: 27.

Bhuiyan, N.I. (1994). Crop production trends and need of Sustainability in Agriculture, Paper presented at the workshop on Integrated Nutrient Management of Sustainable Agriculture held at SRDI, Dhaka. Bangladesh, during June 26-28, 1994.

Gomez, K. A. and Gomez, A. A. 1984. Statistical Procedure for Agricultural Research. International Rice Research Institute, Philippines, John Wiley and Sons. New York, Chichester, Brisbane, Toronto, Singapore. pp: 680.

Inge, J.S., Fleack, K., Nackaerts, B., Muys, P., Coppin, M.W. and Baret, F.(2004). Review of methods for in situ leaf area index determination. Agricultural and Forest Meteorology, 121: 19-95.

Marzia, R. (2015). Effect of row arrangement and integrated nutrient management on the growth and yield of aromatic fine rice cv. BRRI dhan34.MS Thesis. Department of Agronomy Bangladesh Agricultural University Mymensingh. pp: 41-50.

Mobasser, H.R., Tari, D.B., Vojdani, M., Abadi, R.S. and Eftekhar, A. (2007). Effect of seedling age and planting space on yield and yield components of rice (cv. Neda). *Asian Journal Plant Sciences,* 6(2): 438-440.

Murty, P.S.S. and Murty, M.S. (1980). Effect of spacing on the physiological attributes of two high yielding long duration rice cultivars (*Oryza sativa* L.).*Oryza,* 17(2): 148-150.

Paul, S. K., Islam, S. M. M., Sarkar, M. A. R., Alam, A. and Zaman, F. (2014). Physiological parameters of transplant *Aman* rice (cv. BRRI dhan49) as influenced by weeding regime and integrated nutrient management. *Journal of Agroforestry and Environment*, 8 (2): 121-125.

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

Sengar, S.S., Wade, L.J., Baghel, S.S., Singh, R.K. and Singh, G. (2000). Effect of nutrient management on rice in rainfed lowland of southeast Madhya Pradesh. *India Journal of Agronomy,* 45 (2): 315-322.

Sonnetag, O., Chen, J. M. and Roulet, N.T. (2007).Using direct and indirect measurement of leaf area index to characterize the shrub canopy in an ombrotophic peat land. Agricultural and Forest Meteorology, 144: 200-212.

Tyeb, A., Samad, M. A. and Paul, S. K. (2013). Growth of transplanted *Aman* rice as affected by variety and spacing. *Journal of Agroforestry and Environment*, 24: 103-108.

Usman, M., Ullah, E., Wareiach, E. A., Faruq, M. and Liaqat, A. (2003).Effect of organic and inorganic manures on growth and yield of rice variety "Basmati-2000". *Journal of Bioscience and Agriculture Research*, 5(4): 481-483.

Walles, J.M. (1990). Some indirect methods of estimating canopy structure. *Remote Sensing Reviews,* 5:31-43.