ISSN 0258-7122
Bangladesh J. Agril. Res. 39(3): 515-527, September 2014

NUTRIENT MANAGEMENT ON LEAF AREA INDEX OF POTATO-MUNGBEAN-T.AMAN RICE CROPPING PATTERN

M. A. H. S. Jahan[1], M. A. R. Sarkar[2] and M. Salim[3]

Abstract

A field experiment was conducted at Regional Wheat Research Centre of the Bangladesh Agricultural Research Institute, Joydebpur, Gazipur, Bangladesh for 2 consecutive years during 2006-07 and 2007-08. The objective was to find out the optimum nutrient management practice on leaf area index of each component crop of potato-mungbean-T.Aman rice cropping pattern. Twelve nutrient management treatments were tested in RCBD with 3 replications. Treatments combination based on cropping pattern were T_1=HYG (0-198-44-194-24-6-1.2 for potato; 0-24-40-48-24-3-1.2 for mungbean ; 0-80-16-44-12-2-0 for T.Aman rice), T_2=MYG (0-140-34-138-18-4.5-0.9 for potato; 0-20-36-40-20-2-1 for mungbean ; 0-56-12-32-8-1.5-0 for T.Aman rice), T_3=IPNS (10000-168-38-170-18-6-1.2 for potato ; 5000-9-37-36-21-3-1.2 for mungbean ; 5000-65-13-32-9-2-0 for T.Aman rice), T_4=STB (0-171-40-164-22-5-1 for potato; 0-20-36-40-22-2-1 for mungbean ; 0-68-15-37-11-2-0 for T.Aman rice), T_5=FP (0-97-16-91-0-0-0 for potato ; 0-6-5-4-0-0-0 for mungbean ; 0-39-37-12-0-0-0 for T.Aman rice), T_6=CON (0-0-0-0-0-0-0 for potato, mungbean and T.Aman rice) kg/ha CDNPKSZnB, T_7=HYG+CRI, T_8=MYG+CRI, T_9=IPNS+CRI, T_{10}=STB+CRI, T_{11}=FP+CRI, T_{12}=CON+CRI for potato-mungbean T.Aman rice cropping pattern, respectively. Average of two years data showed that HYG+CRI treatment gave maximum LAI followed by HYG, IPNS+CRI, IPNS, STB+CRI, and STB treatments at 60 days after planting (DAP) for potato, at 50 days after sowing (DAS) for mungbean, at 60 days after transplanting (DAT) for T.Aman rice, respectively. For potato, there was a significant ($p \leq 0.01$) and positive linear relation between the LAI at 60 DAP and the tuber yield. While there was a significant ($p \leq 0.01$) and positive linear relationship between the LAI at 50 DAS and seed yield of mungbean. In case of T.Aman rice, there was a significant ($p \leq 0.05$) as well as positive linear relationship between the LAI at 60 DAT and the grain yield of rice.

Keywords: Leaf area index, potato, mungbean, T.Aman rice, nutrient and crop residue management.

Introduction

Bangladesh is a small country of 0.148 million sq. km and it has to feed about 145 million people of this country (BBS, 2011). In order to produce more food

---

[1]Principal Scientific Officer, Regional Wheat Research Center, Bangladesh Agricultural Research Institute (BARI), Gazipur, [2]Professor, Department of Agronomy, Bangladesh Agricultural University (BAU), Mymensingh, [3]Professor, Department of Agronomy, BAU, Mymensingh, Bangladesh.

within a limited area, most important techniques are to be adopted, such as i) to increase the cropping intensity by producing two or more crops on the same piece of land in a year, and ii) to increase the productive efficiency of the crops depending by utilizing the basic resources like water and nutrients.

Potato is an important food crop in Bangladesh. It is a high yield potential tuber crop with yield 25-30 t/ha (Satter *et al*., 2005). It was revealed that a positive effect on dry matter production and leaf area index by application of nutrients from organic and inorganic sources and their combinations (Biswas, 2011). Previous studies have shown that nitrogen fertilizer can increase the growth parameters, such as plant height, shoot dry matter, and leaf area index (Biswas, 2011 and Najm *et al*., 2013).

Mungbean is an important grain legume crop in Bangladesh. It is used as whole or split seeds as Dal (Soup) but in other countries sprouted seeds are widely used as vegetables. It is a major source of high quality protein (26 %), carbohydrates (51 %), moisture (10%), mineral (4%), and vitamins (3 %). (Kaul, 1980), Sultana (2009) revealed that application of 20 kg N/ha as basal + 20 kg N/ha at vegetative stage with one weeding showed significantly higher values of all growth parameters viz., number of leaflets (24.27 at 20 DAS and 24.27 at 40 DAS), leaf area (23.27 cm^2 at 20 DAS and 102.17cm^2 at 40 DAS), leaf dry weight (0.30, 6.99 and 10.61gm at 10, 17 and 24 DAS, respectively. The author showed that the correlation coefficient (r) studies exhibited that number of leaves/plant (r=0.325) and leaf area (r=0.342) significantly ($p<0.05$) and positively correlated with their grain yield.

Rice is the primary source of dietary energy and protein. Fertilizers and residual benefit of crop residues incorporation is commonly assessed mainly in terms of increased grain yield, plant height, and dry matter yield. Heluf Gebrekidan and Mulugeta Seyoum, (2006) revealed that application of both N and P fertilizers have increased the magnitudes of the important plant characters and yield attributes including leaf area index, dry matter accumulation, straw yield, and plant height significantly (P = 0.01). Besides, grain yield was positively and significantly associated with leaf area index and dry matter accumulation. These indicate that N and P application increased grain yield of rice by positively affecting the important yield components of the crop growth parameters.

Most of the nutrient recommendations have been designed based on sole or mono-crop basis. But information regarding nutrient requirement and its management practices for particular cropping pattern for certain location is meagre. Therefore, the present study was undertaken with the objectives to find out the optimum nutrient management practice for leaf area index of each component crop of potato-mungbean-T.Aman rice cropping pattern.

Materials and Method

The experiment was carried out at the Regional Wheat Research Centre of Bangladesh Agricultural Research Institute, Gazipur. The experimental field of Gazipur belongs to the agro-ecological zone of Modhupur Tract (AEZ-28) Morphological characters are Grey Terrace soils, medium high land, not well drained, above flood level and grey soil clour. Physiological characters are silty loam to loam having more or less near neutral soil pH with very low to low soil fertility. The initial soil of the experimental field was analyzed for chemical properties before setting up the experiment.

Table 1. Initial soil analytical results and fertility class of experimental sites of RWRC, Gazipur.

pH	OM (%)	Total N (%)	Available P (μg/g)	Exchangeable K (meq100g^{-1})	Available S (μg/g)	Available Zn (μg/g)	Available B (μg/g)
6.48 SA	1.07 L	0.055 VL	3.76 VL	0.15 L	9.91 L	0.24 VL	0.16 L

Here, OM- Organic Matter, St. A- Strongly Acidic, SA- Slightly Acidic, N-Neutral, M-Medium, L- Low and VL- Very Low

Potato (BARI-A*lu* 8), mungbean (BARI Mung 6) and T.Aman rice (BRRI dhan39) varieties were tested during for 2006-07 and 2007-08. Twelve nutrient management treatments were tested in RCBD with 3 replications.

Here, legend is: HYG= High Yield Goal, MYG= Moderate Yield Goal, IPNS= Integrated Nutrient Management System, STB= Soil Test Base, FP= Farmers' Practice, CON= Control, CD= Cowdung, and CRI= Crop Residue Incorporated. For HYG, MYG and IPNS management recommended cowdung was adjusted into chemical nutrient and added according to the thumb rule i.e., 1 ton decomposed cowdung contains 3 kg N, 0.6 kg P, 2.4 kg K, and 0.6 kg S. (BARC, 2005). Average of two years (according to irrespective treatments), potato residues (0.42 to 2.31 t/ha dry foliage); mungbean residues (1.03 to 2.44 t/ha dry biomass); T.Aman rice residues (0.54 to 2.25 t/ha dry straws) were in-situ incorporated to the soil for crop residue incorporation plots just after harvest of each crop. Crop residue incorporation was done manually through soil pulverization by spade after chopping with knife. The crops were weeded and irrigated whenever required. The crops were harvested at full maturity. Leaf area was measured for potato and mungbean at 10 days intervals starting from 30 DAP (for potato) and 30 DAS (for mungbean) up to harvest while in case of

Table 2. Amount of organic and inorganic nutrients for different management treatments.

Treatments	Potato							Mungbean							T.Aman rice						
	CD	N	P	K	S	Zn	B	CD	N	P	K	S	Zn	B	CD	N	P	K	S	Zn	B
	(t/ha)	(kg/ha)						(t/ha)	(kg/ha)						(t/ha)	(kg/ha)					
HYG	0	198	44	194	24	6	1.2	0	24	40	48	24	3	1.2	0	80	16	44	12	2	0
MYG	0	140	34	138	18	4.5	0.9	0	20	36	40	20	2	1	0	56	12	32	8	1.5	0
IPNS	10	168	38	170	18	6	1.2	5	9	37	36	21	3	1.2	5	65	13	32	9	2	0
STB	0	171	40	164	22	5	1	0	20	36	40	22	2	1	0	68	15	37	11	2	0
FP	0	97	16	91	0	0	0	0	6	5	4	0	0	0	0	39	7	12	0	0	0
CON	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HYG+CRI	0	198	44	194	24	6	1.2	0	24	40	48	24	3	1.2	0	80	16	44	12	2	0
MYG+CRI	0	140	34	138	18	4.5	0.9	0	20	36	40	20	2	1	0	56	12	32	8	1.5	0
IPNS+CRI	10	168	38	170	18	6	1.2	5	9	37	36	21	3	1.2	5	65	13	32	9	2	0
STB+CRI	0	171	40	164	22	5	1	0	20	36	40	22	2	1	0	68	15	37	11	2	0
FP+CRI	0	97	16	91	0	0	0	0	6	5	4	0	0	0	0	39	7	12	0	0	0
CON+CRI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Aman rice it was measured at 15-day intervals starting from 30 DAT up to harvest. Leaf area was measured from five hills for potato and T.Aman rice, while five plants for mungbean that were randomly selected for destructive sampling in each plot excluding border hills. Each time destructive samples were uprooted and washed with water. The leaf blades were separated from the leaf sheath in case of rice but in case of potato and mungbean, leaves were separated from the stem. Leaf area was measured by a Leaf Area Meter LI-300 (USA). Leaf area index (LAI) was calculated following the standard formula (Gardner *et al.* 1985) as mentioned below:

$$\text{Leaf area index (LAI)} = \frac{\text{Leaf area (cm}^2\text{)}}{\text{Ground area (cm}^2\text{)}}$$

The data were analyzed statistically and the mean comparisons of the treatments were evaluated by DMRT (Duncan's Multiple Range Test).

Results and discussion

Potato: The leaf area index (LAI) of potato, mungbean and T.Aman rice of two successive cropping cycles were statistically analyzed and were significant. Average of two years data, it was observed that LAI of potato was significantly influenced by different nutrient management treatments starting from 30 DAP up to harvest (Fig. 1). LAI increased steadily up to 60 DAP, after that it started to decline. Slow increase at an early growing period and rapid increase at the middle and decreasing trend at the later growing periods up to harvest as was expected. Among the treatments, HYG nutrient management along with crop residue incorporation showed the highest LAI followed by HYG, IPNS+CRI, IPNS, STB+CRI and STB, respectively. The lowest LAI was observed where no nutrient was added without crop residue incorporation.

In general, the LAI increased with the increasing of nutrient quantity and advancement of crop growth period. The highest LAI was obtained might be due to the effect of higher or optimum nutrient added, especially nitrogen at 60 DAP and added extra nutrient from crop residue incorporation (Table 3). After that, the LAI started decreasing that might be due to senescence of older leaves or leaf damage and leaf drop. Biswas (2011) also reported similar results in potato BARI Alu 8. The highest LAI in potato was obtained when it was fertilized with recommended fertilizer along with 100% waste water irrigated treatment. He also reported that the lowest LAI of potato was obtained when irrigated with fresh water without any fertilizer as well as 100% waste water i.e., absolute control.

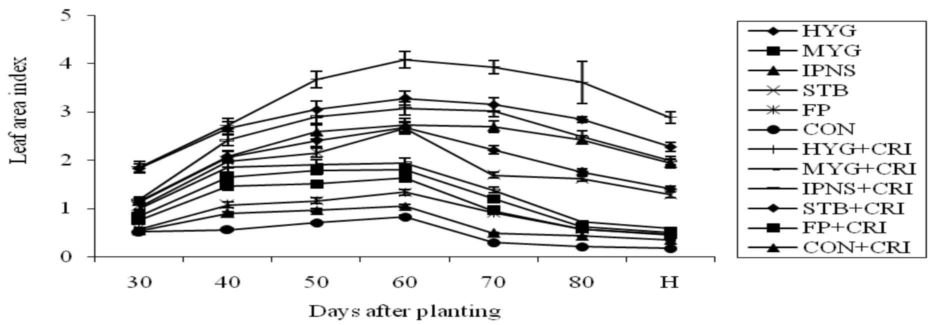

Fig. 1. Leaf area index of potato as influenced by nutrient managements (two years mean. Error Bar. I=SE(+/-) of means.

Functional relationship between LAI and tuber yield of potato

Regression analysis (two years mean data) was done to quantify the relationship between LAI at 60 DAP and tuber yield of potato. In case of potato crop, maximum LAI was noticed at 60 DAP in both the years as influenced by different nutrient management practices during the life cycle of the crop. Therefore, this stage (60 DAP) was considered to establish a functional relationship between LAI and tuber yield. It was observed that there was a positive linear relation between the LAI at 60 DAP and the tuber yield (Fig. 2). The functional relationship revealed that 70 % (R^2=0.709) of the variation of tuber yield could be explained from the variation in LAI at 60 DAP. On an average, tuber yield could be increased at the rate of 7.63 t/ha with an increase in 1 unit of LAI at 60 DAP. The result is in agreement with Biswas (2011). The authors stated that 42% variation of tuber yield could be explained by the functional relationship of LAI under fertilized and 47 % under unfertilized conditions in BARI Alu 8.

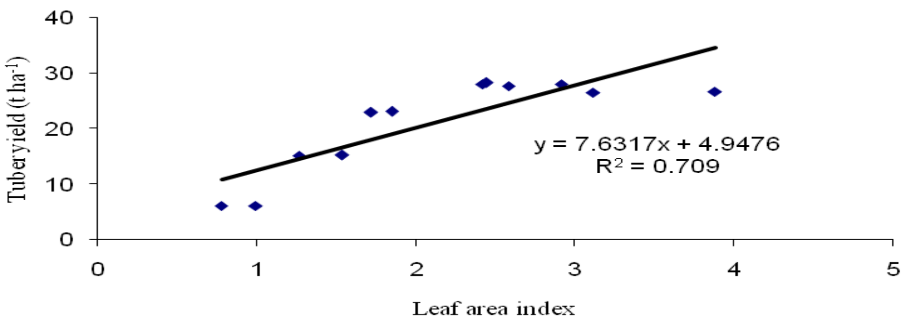

Fig. 2. Functional relationship between LAI and tuber yield of potato at 60 DAP as influenced by nutrient managements (two years mean)

Mungbean: From two years mean data, it was noticed that LAI of mungbean responded significantly to different nutrient management treatments (Fig. 3).

Irrespective of treatment, LAI was increasing up to 50 DAS. The LAI was the highest at 50 DAS, while it was reduced at harvest. Among the treatments, HYG nutrient along with crop residue incorporation showed the highest LAI during the cropping season followed by HYG, IPNS+CRI, IPNS, STB+CRI, and STB, respectively. The lowest LAI was observed where no nutrient was added without crop residue incorporation.

The treatments influenced the increment of LAI. Plants grown with adequately higher or optimum nutrient, especially added nitrogen showed higher LAI during the crop season than the plant grown without or inadequate added nutrient. An increasing trend of LAI was observed with the higher levels of nutrients as well as extra nutrient added in soil from crop residue incorporation (Table 3) which might be due to positive response to vegetative growth of mungbean. Reduction of leaf area index at harvest is associated with leaf senescence and damage of older leaves. Saha (2005) also obtained increased of LAI in BARI Mung-5 and BU Mung-2 due to higher nitrogen fertilizer application up to 50 DAS.

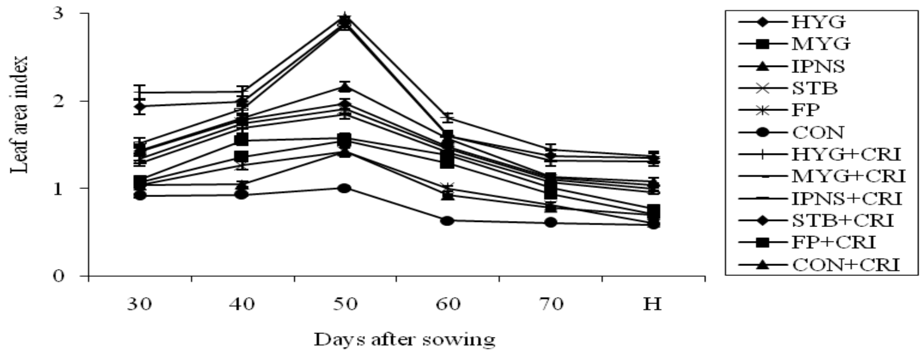

Fig. 3. Leaf area index of mungbean as influenced by nutrient managements (two years mean). Error Bar. I=SE(+/-) of means.

Functional relationship between LAI and seed yield of mungbean

Regression analysis (mean of two years' data) was done to determine the relationship between LAI at 50 DAS and seed yield of mungbean. In case of mungbean crop, maximum LAI was found at 50 DAS in both the years as influenced by different nutrient management practices during the total growth period of the crop. Therefore, this stage (50 DAS) was considered to establish a functional relationship between LAI and seed yield. There was a positive linear relationship between the LAI at 50 DAS and seed yield (Fig. 4). The relationship was significant at $p \leq 0.01$. The functional relationship between LAI and the seed yield implies that 55 % (R^2=0.5519) of the variation of seed yield could be explained from the variation in LAI at 50 DAS. On an average, seed yield could be increased at the rate of 0.61 t/ha with an increase in 1 unit of LAI at 50 DAS. Similar result was found by Biswas (2011). The authors stated that 42 % variation of tuber yield could be explained by the functional relationship of LAI under fertilized and 47 % under unfertilized conditions in BARI Alu 8.

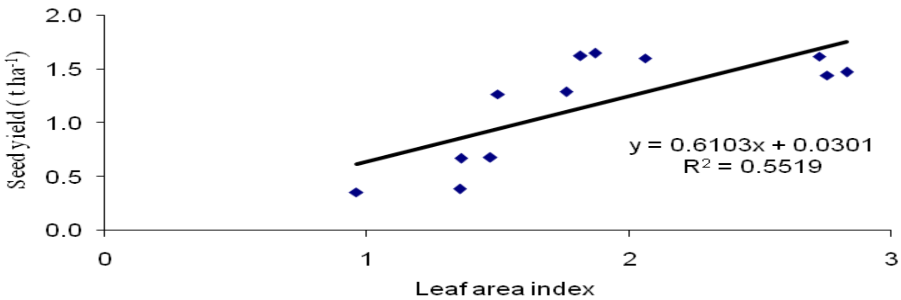

Fig. 4. Functional relationship between LAI and seed yield of mungbean at 50 DAS as influenced by nutrient management treatments (two years mean)

T.Aman rice

Two years mean data showed that LAI of transplanted *Aman* rice was significantly influenced by the nutrient management treatments during the period of plant growth (Fig. 5). Maximum LAI was observed when the crop was fertilized with HYG nutrient along with crop residue incorporation followed by HYG, IPNS+CRI, IPNS, STB+CRI, and STB, respectively. LAI increased steadily as the crop growth period advanced and reached the peak at 60 DAT and then started falling down till the final harvest. The lowest LAI was observed where no nutrient was added without crop residue.

Table 3. Total addition of extra nutrients into the soil through crop residues incorporation (kg/ha r^{-1}) during 2006-07 and 2007-2008 (Assuming nitrogen mineralization rate 40%).

Nutrient management	2006-2007 (kg/ha yr^{-1})						2007-2008 (kg/ha yr^{1})					
	N	P	K	S	Zn	B	N	P	K	S	Zn	B
HYG+CRI	12.74	6.02	31.55	5.40	0.15	0.09	16.46	7.01	35.53	5.75	0.18	0.10
MYG+CRI	10.75	5.33	26.74	4.91	0.14	0.08	13.15	6.18	30.04	5.55	0.14	0.08
IPNS+CRI	12.19	6.50	31.40	5.32	0.15	0.08	17.02	7.96	37.36	6.00	0.18	0.11
STB+CRI	12.15	6.91	32.91	5.98	0.14	0.09	15.84	8.02	38.75	6.92	0.18	0.11
FP+CRI	8.43	4.39	22.35	4.05	0.10	0.06	8.38	4.57	22.73	4.14	0.10	0.05
CON+CRI	5.12	2.65	14.99	2.50	0.06	0.03	5.50	2.57	16.24	2.51	0.06	0.03

Table 4. Changes in soil pH, organic matter and available nutrients in soil after completion of two cropping cycles.

Nutrient management	pH	OM%	Total N (%)	Available P (ppm)	Exchangeable K meg/100g soil	Available S (ppm)	Available Zn (ppm)	Available B (ppm)
Initial	6.48	1.07	0.055	3.76	0.15	9.91	0.24	0.16
Final								
HYG	6.52	1.10	0.064	6.95	0.167	10.60	0.32	0.21
MYG	6.58	1.02	0.060	5.44	0.142	9.86	0.30	0.18
IPNS	6.59	1.17	0.066	7.83	0.164	10.52	0.32	0.22
STB	6.52	1.08	0.062	6.74	0.158	10.11	0.31	0.20
FP	6.58	1.10	0.058	3.81	0.138	8.64	0.26	0.16
CON	6.50	1.00	0.052	3.13	0.132	7.66	0.24	0.14
HYG+CRI	6.52	1.12	0.066	7.12	0.171	10.78	0.34	0.24
MYG+CR	6.60	1.06	0.064	5.85	0.156	10.22	0.30	0.20
IPNS+CRI	6.64	1.20	0.066	7.96	0.168	10.84	0.34	0.24
STB+CRI	6.52	1.11	0.064	7.67	0.164	10.34	0.32	0.22
FP+CRI	6.44	1.14	0.060	4.13	0.144	8.72	0.28	0.18
CON+CRI	6.46	1.04	0.056	3.44	0.141	8.04	0.26	0.16

Table 5. Yield of potato, mungbean and T.Aman rice as influenced by nutrient managements during 2006-07 and 2007-08.

Nutrient management	Tuber yield of potato (t/ha)			Seed yield of mungbean (t/ha)			Grain yield of T.Aman rice (t/ha)		
	2006-07	2007-08	Mean	2007	2008	Mean	2007	2008	Mean
HYG	26.12 a	27.01 a	26.57	1.41 ab	1.48 ab	1.45	4.31 ab	4.51 ab	4.41
MYG	23.55 b	22.40 b	22.98	1.24 b	1.30 b	1.27	3.50 b	3.70 b	3.60
IPNS	26.83 a	28.66 a	27.75	1.52 a	1.69 a	1.61	4.93 a	5.13 a	5.03
STB	27.10 a	28.95 a	28.03	1.54 a	1.71 a	1.63	5.02 a	5.22 a	5.12
FP	14.57 c	15.76 c	15.17	0.63 c	0.71 c	0.67	2.41 c	2.61 c	2.51
CON	6.08 d	6.11 d	6.10	0.33 d	0.38 d	0.36	1.21 d	1.31 d	1.26
HYG+CRI	26.25 a	27.15 a	26.70	1.44 ab	1.51 ab	1.48	4.35 ab	4.55 ab	4.45
MYG+CRI	23.67 b	22.52 b	23.10	1.26 b	1.32 b	1.29	3.54 b	3.73 b	3.64
IPNS+CRI	27.35 a	28.69 a	28.02	1.54 a	1.70 a	1.62	5.03 a	5.23 a	5.13
STB+CRI	27.64 a	28.98 a	28.31	1.57 a	1.73 a	1.65	5.14 a	5.34 a	5.24
FP+CRI	14.64 c	15.84 c	15.24	0.64 c	0.72 c	0.68	2.43 c	2.64 c	2.54
CON+CRI	6.11 d	6.13 d	6.12	0.36 d	0.41 d	0.39	1.26 d	1.36 d	1.31
Levl.Sig.	**	**		**	**		**	**	
CV (%)	6.39	9.29		7.51	10.27		9.76	9.29	

Green leaf area is the source of food production by green plants. An increasing trend of LAI was observed with higher levels of nutrients along with addition of extra nutrient came from crop residue incorporation (Table 3) which might be due to positive response to vegetative growth of transplanted *Aman* rice. The probable reason for increase of LAI in the HYG+CRI, treated plot is greater because of expansion of the leaf blades. The decrease of LAI at the later stages was possibly due to the senescence and abscission of the older leaves. These observations are in agreement with the findings of Islam (2008). The authors stated that they obtained maximum LAI when the crop was fertilized with 120 kg N/ha which was statistically identical to 80 kg N/ha in T.Aman rice. The lowest LAI was observed where no nitrogen (control) was added.

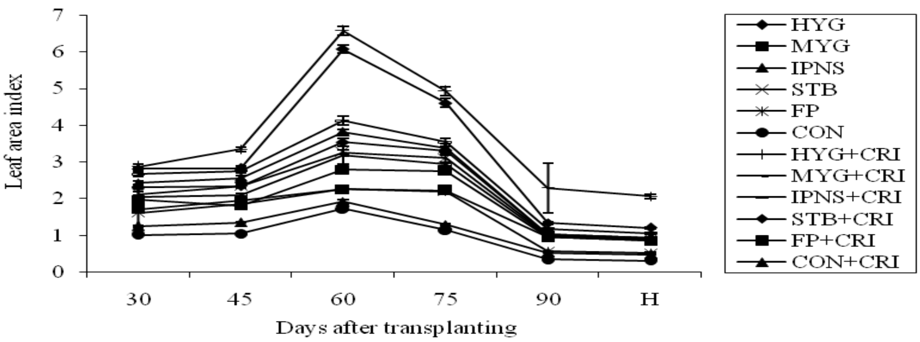

Fig. 5. Leaf area index of T.Aman rice as influenced by nutrient managements (two years mean). Error Bar, I=(+/-) of mean.

Functional relationship between LAI and grain yield of T.Aman rice

To find out the relationship between LAI at 60 DAT and grain yield of T.Aman rice regression analysis (two years mean data) was done. The maximum LAI was observed at 60 DAT in both the years as influenced by different nutrient management practices during the whole life cycle of the crop. Therefore, this stage (60 DAT) was considered to find out a functional relationship between LAI and grain yield. It was observed that there was a positive linear relationship between the LAI at 60 DAT and the grain yield (Fig. 6). The relationship was significant at $p \leq 0.05$. The functional relationship revealed that 43 % (R^2=0.432) of the variation of grain yield could be explained from the variation in LAI at 60 DAT. On an average, grain yield could be increased at the rate of 0.6614 t/ha with an increase in 1 unit of LAI at 60 DAT. The result is in agreement with Biswas (2011) who reported that 75% variation of wheat yield could be explained by the functional relationship of LAI under unfertilized and 51% under fertilized conditions.

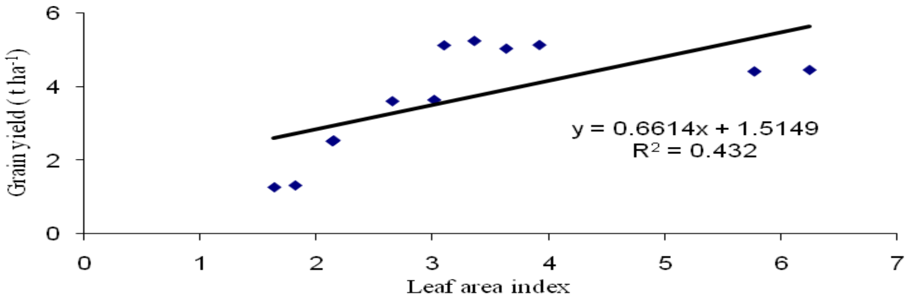

Fig. 6. Functional relationship between LAI and grain yield of T.Aman rice at 60 DAT as influenced by nutrient managements (two years mean).

The entire parameters showed slightly increasing trend might be due to the application of optimum nutrient management. However, the trend was shown a little bit higher in residue incorporated plots than non-incorporated plots might be due to crop residue incorporation (Table 3). The decreasing trend was observed in control plots from its initial value might be due to no addition of nutrients into the soil.

Conclusion

HYG+CRI treatment gave the highest LAI at 60 DAP for potato, while at 50 DAS for mungbean and at 60 DAT for T.Aman followed by HYG, IPNS+CRI, IPNS, STB+CRI and STB, respectively, rice in both the years. There were significant and positive linear relation between LAI and the tuber yield of potato, seed yield of mungbean and the grain yield of T.Aman rice at 60 DAP, 50 DAS and 60 DAT, respectively.

References

BBS (Bangladesh Bureau of Statistics). 2011. Statistical Year Book of Bangladesh. Bangladesh Bur. Stat., Plan. Div., Minis. Plan., Govt. People's Repub, Bangladesh Dhaka, Bangladesh, Pp. 27-29.

Biswas, S. K. 2011. Effect of irrigation with municipal waste water on wheat and potato cultivation. Ph D Dissertation. Department of Irrigation and Water Management, Bangladesh Agricultural University, Mymensingh, Bangladesh, Pp. 217.

Gardner, F. P., R. B. Pearce and R. L. Mithchel. 1985. Physiology of crop plants. The IOWA state Univ. Press, IOWA 50010, Pp. 156-186.

Heluf Gebrekidan and Mulugeta Seyoum. 2006. Effects of mineral N and P fertilizers on yield and yield components of flooded lowland rice on vertisols of Fogera Plain, Ethiopia. *Journal of Agriculture and Rural Development in the Tropics and Subtropics* **107**(2): 161–176

Islam, M. S. 2008. Effect of some green manuring crops and levels of nitrogen on the growth, yield and nitrogen uptake in transplanted Aman Rice and subsequent Wheat crop. Ph D Thesis. Institute of Biological Sciences. Rajshahi University, Rajshahi, Bangladesh, Pp. 296.

Kaul, A. K. 1980. Annual Report, Plant Breeding Division. BARI, Gazipur, Bangladesh.

Najm, A. A., M. R. H S. Hadi, M. T. Darzi and F. Fazeli. 2013. Influence of nitrogen fertilizer and cattle manure on the vegetative growth and tuber production of potato. *Intl J Agri Crop Sci.* **5** (2), 147-154.

Saha, R. R. 2005. Ph D Thesis. Physiological aspects of yield and seed quality of mungbean (*Vigna radita* (L.) WILCZEK). Department of Agronomy. Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur, Bangladesh, Pp.158.

Satter, M. A, M. A. Rahman, H. U. Rashid, M. S. Ali and M. S. Alom. 2005. Krishi Projukti Hatboi (Handbook on Agro-technology), 3rd edition, Bangladesh Agricultural Research Institute, Gazipur-1701, Bangladesh, Pp. 1-559.

Sultana Shamima, Jafar Ullah, Fazlul Karim and Asaduzzaman. 2009. Response of Mungbean to Integrated nitrogen and weed managements. *American-Eurasian Journal of Agronomy* **2** (2): 104-108.