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Physiological Traits of Wheat as Affected by Nitrogen Fertilization and Pattern of Planting

M. S. Alam

Department of Agronomy and Agricultural Extension, Faculty of Agriculture, University of Rajshahi, Rajshahi-6205, Bangladesh

Abstract The experiment was conducted to physiological traits of wheat as affected by nitrogen fertilization and pattern of planting. The experiment consisted of two methods of planting viz. conventional and bed planting, four wheat varieties namely Protiva, Sourav, Shatabdi and Prodip and four levels of nitrogen viz. 0, 60, 110 and 160 kg N ha^{-1}. Physiological traits increased at early stages and decreased at later stages of plant growth. The maximum leaf area ratio, specific leaf area and leaf weight ration were noticed in prodip. Protiva produced the highest net assimilation rate at crown root initiation to tillering stage. Net assimilation rate differed significantly due to nitrogen level. The highest net assimilation rate, leaf area ratio, specific leaf area and leaf weight ratio was recorded from 160 kg N ha^{-1} and the lowest one from the control treatment. Significantly the higher value for physiological traits was noticed in bed planting system compared to conventional one.

Keywords NAR, LAR, SLA, LWR, Planting method, Nitrogen, Wheat

1. Introduction

Wheat is one of the most important food grain crop grown in the world. It ranks first in the world cereal crops accounting for 30% of all cereal food worldwide and is a staple food for over 10 billion people in as many as 43 countries of the world. It provides about 20% of the total food calories for the human race [10]. In Bangladesh, wheat is one of the most important food grain crop. In Bangladesh among total food grain production in the 2010-11 was 34.5 mmt. in which the contribute of wheat was 0.97 mmt respectively [3] and in 2011-12 production of wheat 2.780 mt ha^{-1} [2]. Nitrogen occupies a conspicuous place in plant metabolism. All vital processes in plant are associated with protein, of which nitrogen is an essential constituent. Consequently to get more crop production, nitrogen application is essential in the form of chemical fertilizer. Nitrogen fertilizer is known to affect the number of tillers m-2, number of spikelet's spike-1, number of Grains spike-1, spike length and 1000- grain weight [1]. Bed planting systems have been used in cultivation for centuries. The origin of raised bed cultivation has traditionally been associated with water management issues either by providing opportunities to reduce the impact of excess water in rainfed conditions or to more efficiently deliver irrigation water in high production irrigated systems [11]. Nitrogen use efficiency could be improved by 10% or more in furrow irrigated bed-planting systems because of improved N placement possibilities [4]. Also, the microclimate within the field was changed to the orientation of the wheat plants in rows on the beds, which reduced crop lodging and decreased the incidence of some wheat diseases. This was explained by the reduction in canopy humidity that is conducive to reduced disease pressure and enhanced healthy wheat growth. Variety also plays a vital role in increasing yield as recent developing variety has inherent capability to improve their product. In considering the above factors the present experiment was undertaken to study the physiological traits of wheat as affected by nitrogen fertilization and pattern of planting.

* Corresponding author:
sami_ratan@yahoo.com (M. S. Alam)
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2. Materials and Methods

The research work was carried out at Agronomy Field Laboratory, Department of Agronomy and Agricultural Extension, University of Rajshahi during the winter season. The experiment consisted of two methods of sowing viz. conventional planting (S_1) bed planting (S_2) and four wheat varieties namely Protiva (V_1), Sourav (S_2), Shatabdi (S_3) and Prodip (V_4) and four levels of nitrogen viz. 0 (N_0), 60 (N_1), 110 (N_2) and 160 (N_3) kg N ha^{-1}. The experiment was laid out in a split-split plot design with three replication. The plot size was 3m x 4m. Triple super phosphate (TSP), muriate of potash (MoP) and gypsum were applied to the plots at the rate of 180, 50, 120 kg ha^{-1} during final land preparation. Nitrogenous fertilizer was applied as per treatment in two installments; two-third at the time of final land preparation and one-third at 27 days after sowing . Seeds were sown in 25 cm apart rows opened by specially made an iron hand tine.

Intercultural operation was done as and when necessary. Plant samples were collected from each plot using six rows for collecting data on growth parameters. Five plants per plot were carefully uprooted randomly at each growth stage. Leaf, stem and spike (when appeared) were separated from each plant sample. The samples were packed separately in labelled brown paper bags. Then the samples were oven dried for 72 hours at 70-80℃ and weights were taken separately with an electrical balance. Leaf dry weight, stem dry weight and panicle dry weight was recorded carefully. From the dry weight of different plant parts and leaf area data net assimilation rate, leaf area ratio, specific leaf area and leaf weight ratio were calculated by classical technique of growth analysis [8]. After harvesting, crop of each plot was dried separately for four days. After that, threshing, cleaning and drying of grains were done plot-wise. Then the yields of grain and straw of each plot were recorded and the yields were then converted to hectare basis. The data recorded were compiled and tabulated for statistical analysis. The data were analyzed statistically using the analysis of variance technique and the mean differences among the treatments were adjudged by new Duncan's Multiple Range Test (DMRT) [5] with the help of MSTAT software.

3. Results and Discussion

Net assimilation rate (NAR)

It was established that net assimilation rate become higher during early vegetative phase and it declined rapidly as growth progressed [6]. This might be due to mutual shading of leaf and increased number of aged leaves which lost Photosynthetic efficiency [7]. Probably decreased leaf area and increased photosynthesis resulted in the increase of net assimilation rate at later stages of growth. Variety significantly influenced net assimilation rate at all the harvest stages. All the genotypes showed highest value for net assimilation rate at early stage of growth period. Significantly the highest net assimilation rate was observed in Protiva followed by Shotabdi and Sourav at crown root initiation to tillering stage. Significantly the lowest net assimilation rate value was observed in Prodip at heading to grain filling stages. Net assimilation rate differed significantly due to nitrogen level. The highest net assimilation rate was observed at crown root initiation to tillering stage with the application of 160 kg N ha^{-1} and the lowest one from the control treatment (0 kg N ha^{-1}) (Table 1). This might be due to maximum uptake of nitrogen and its use efficiency with more interception of solar radiation. Net assimilation rate varied significantly due to method of planting. Net assimilation rate decreased with the increasing growth period. The highest net assimilation rate was obtained in plants under bed planting system at crown root initiation to tillering stages followed by conventional planting system. The second highest net assimilation rate was recorded at booting to heading stages in bed planting system compared to conventional planting system (Fig. 1). Net assimilation rate varied significantly due to the interaction of sowing method and variety. Significantly the highest net assimilation rate was obtained within the period of crown root initiation to tillering stages by the treatment combination of $S_1 \times V_1$. The interaction effect between planting method and nitrogen level on net assimilation rate was statistically significant. The maximum net assimilation rate was observed in bed planting system at 160 kg N ha^{-1} during the period of crown root initiation to tillering stage (Table 2).

Leaf area ratio (LAR)

Leaf area ratio values under different varieties were found higher at crown root to tillering stage and then declined with increasing growth period. This is due to abscission of mature and older leaves resulted in lower values of leaf area ratio at the later stages of growth. Leaf area ratio varied significantly due to varieties in all the growth stages.The maximum leaf area ratio was recorded from Prodip at crown root initiation to tillering stages. All the varieties produced the minimum leaf area at heading to grain filling stages. Nitrogen level showed significant effect on leaf area ratio in all the harvest. At crown root initiation to tillering stages the highest leaf area ratio was noted at 160 kg N ha^{-1} followed by 110 and 60 kg N ha^{-1} compared to control treatment (Table 1). Leaf area ratio increased more or less with the increase of nitrogen application. This result was observed as nitrogen induces better plant growth and sustains physiological functions. Similar result was reported by [9]. Lear area ratio varied significantly due to planting method. The highest leaf area ratio was found in bed planting system at crown root initiation to tillering stages followed by conventional planting. Leaf area ratio value decreased with increasing growth period. The lowest leaf area ratio was recorded at heading to grain filling stages (Fig. 1). Leaf area ratio was significantly influenced by the interaction of planting method and variety at all the successive growth stages. The highest leaf area ratio was found in Prodip in bed planting system at crown root initiation to tillering followed by conventional planting system. Leaf area ratio value declined in the successive growth stage and it reached the lowest at heading to grain filling stages. Sowing method × N-level interaction showed significant effect in leaf area ratio at all the successive growth stages. The highest leaf area ratio was recorded in bed planting system at 160 kg N ha^{-1} and the lowest one was recorded in conventional planting system at control treatment in all the harvest (Table 2).

Table 1. Effect of variety on NAR (mg cm^{-2} day^{-1}) and LAR (cm^2 g^{-1}) at different growth stages of wheat

Variety	NAR (mg cm^{-2} day^{-1})				LAR (cm^2 g^{-1})			
	CRI-T	T-B	B-H	H-GF	CRI-T	T-B	B-H	H-GF
V_1	2.510 a	0.993 a	1.634 c	0.370 a	54.123 c	43.291 b	30.031 b	15.585 c
V_2	2.312 b	0.804 b	1.721 b	0.347ab	57.601 b	42.489 b	30.120 b	17.343 b
V_3	2.491 a	0.886 a	1.994 a	0.385 a	52.834 d	41.667 b	30.367 b	15.564 c
V_4	2.224 b	0.896 a	1.590 c	0.295 b	63.413 a	49.645 a	34.230 a	19.091 a
N Level	NAR (mg cm^{-2} day^{-1})				LAR (cm^2 g^{-1})			
	CRI-T	T-B	B-H	H-GF	CRI-T	T-B	B-H	H-GF
N_0	2.345	0.897 a	1.324 c	0.281 c	49.815d	40.765 b	27.394 c	14.161 c
N_1	2.358	0.878 a	1.457 b	0.356 b	55.446ac	45.392 a	32.015 b	16.524 b
N_2	2.420	0.835 b	1.505ab	0.356 b	59.234ab	45.880 a	32.241 b	18.134 a
N_3	2.491	0.890 a	1.537a	0.421 a	63.385a	45.082 a	32.391 a	18.657 a
LS	NS	0.05	0.01	0.01	0.01	0.05	0.01	0.01
CV %	3.15	5.32	4.45	6.34	3.50	4.92	3.51	2.08

In a column, figures having similar letter(s) or without letter(s) do not differ significantly as per DMRT

Table 2. Interaction effect of sowing method and variety and sowing method and nitrogen level on NAR (mg cm^{-2} day^{-1}) and LAR (cm^2 g^{-1}) at different growth stages of wheat

SM × V	NAR (mg cm^{-2} day^{-1})				LAR (cm^2 g^{-1})			
	CRI-T	T-B	B-H	H-GF	CRI-T	T-B	B-H	H-GF
$S_1 \times V_1$	2.515 a	0.941 b	1.764cd	0.317 b	51.791 e	43.741 b	30.267cd	15.141 e
$S_1 \times V_2$	2.321 b	0.815 c	1.942 b	0.357ab	57.465 b	41.975bc	29.545 e	16.612 c
$S_1 \times V_3$	2.461 a	0.937 b	1.931 b	0.410 a	53.277 c	42.356bc	29.412 e	14.623 e
$S_1 \times V_4$	2.235 c	0.759 d	1.732 d	0.257 c	63.281 a	49.865 a	34.210 a	18.857ab
$S_2 \times V_1$	2.475 a	0.106 a	1.488 c	0.397 a	56.432 b	42.841 b	29.778 de	16.061cd
$S_2 \times V_2$	2.266bc	0.804 c	1.487e	0.336 b	57.732b	43.012 b	30.645 c	18.080 b
$S_2 \times V_3$	2.505 a	0.925b	2.143 a	0.371ab	52.375 c	40.976 c	31.331 b	16.456 c
$S_2 \times V_4$	2.209 c	0.817 c	1.445 c	0.332 b	63.476 a	49.881 a	34.064 a	19.310 a
SM × N Level	NAR (mg cm^{-2} day^{-1})				LAR (cm^2 g^{-1})			
	CRI-T	T-B	B-H	H-GF	CRI-T	T-B	B-H	H-GF
$S_1 \times N_0$	2.301 d	0.885cd	2.631 a	0.280 e	48.989 f	42.495ab	27.043 e	13.021 e
$S_1 \times N_1$	2.315 d	0.864 d	1.803 c	0.349 b	56.395 d	46.167 a	31.505 c	16.095 c
$S_1 \times N_2$	2.461 b	0.812 e	1.620 d	0.356bc	58.410 c	45.109 a	32.645 b	17.646ab
$S_1 \times N_3$	2.263 d	0.881cd	1.509 e	0.359 c	61.374 b	44.210 a	32.234 b	18.445 a
$S_2 \times N_0$	2.415 b	0.920 a	2.010 b	0.287 e	49.658 f	39.125 b	27.774 d	15.289 d
$S_2 \times N_1$	2.398 c	0.911ab	1.526 e	0.352bc	54.534 e	44.601 a	32.489 b	16.932 c
$S_2 \times N_2$	2.383 c	0.875cd	1.402 f	0.319cd	60.223 b	46.678 a	33.201 a	18.643 b
$S_2 \times N_3$	2.517 a	0.898bc	1.345 g	0.483 a	65.420 a	45.976 a	32.387 b	19.641 a
LS	0.01	0.05	0.01	0.01	0.01	0.05	0.01	0.01
CV %	3.15	5.32	4.45	6.34	3.50	4.92	3.51	2.08

In a column, figures having similar letter(s) or without letter(s) do not differ significantly as per DMRT

V_1= Protiva V_2= Saurav V_3=Shatabdi V_4= Prodip N_0= 0 kg N ha-^{1} N_1= 60 kg N ha-^{1} N_2= 110 kg N ha-^{1} N_3=160 kg N ha-^{1}

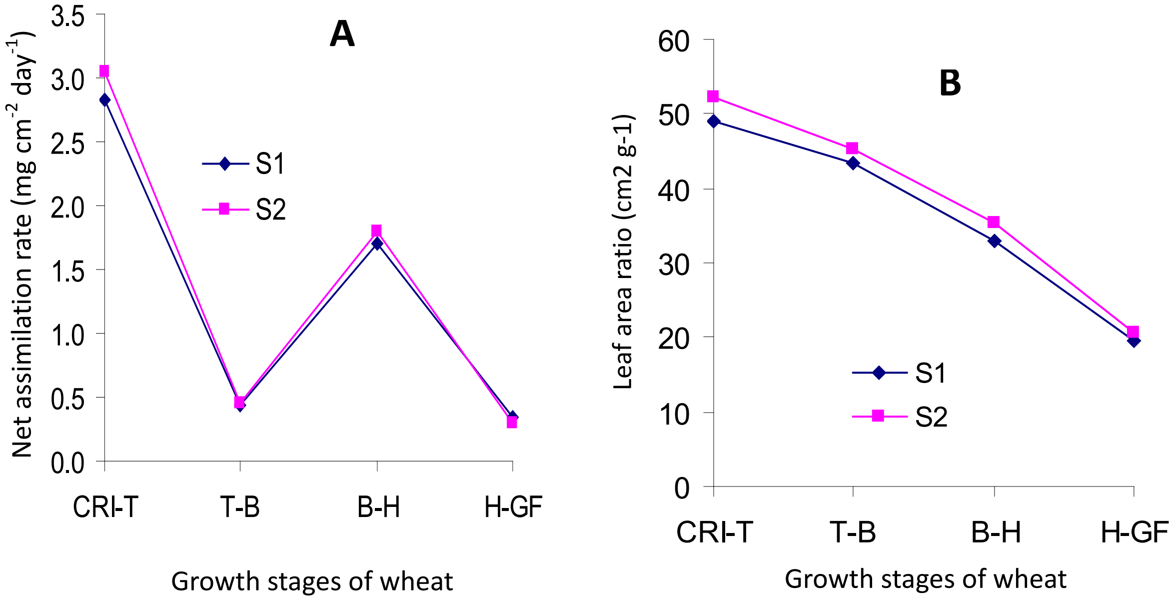

Figure 1. Effect of sowing method on net assimilation rate (A) and leaf area ratio (B) at different growth stages of wheat

Specific leaf area (SLA)

Results revealed that there was a significant variation among the genotypes in case of specic leaf area. Prodip showed the highest specific leaf area at crown root initiation stage followed by Sourav. The lowest specific leaf area was observed at tillering stage. There was a significant effect of nitrogen level on specific leaf area at all the harvest. At crown root initiation stage highest specific leaf area value was obtained at 160 N ha^{-1} followed by 110 and 60 kg N ha^{-1} compared to control treatment. (Table 3). Specific leaf area varied significantly due to planting method. The lowest specific leaf area was observed at tillering stage. The highest specific leaf area was obtained at crown root initiation stage in bed planting system followed by conventional planting system (Fig. 2). Planting method × variety had significant effect on specific leaf area. Prodip produced the highest specific leaf area in bed planting system followed by conventional planting system at crown root initiation stage. The value of specific leaf area was minimum at tillering stage. At grain filling stage the highest specific leaf area was noticed in bed planting system with the variety Prodip followed by conventional planting system. Interaction effect of sowing method and nitrogen level had significant effect on specific leaf area. Maximum specific leaf area was found in crown root initiation stage and minimum was found at tillering stage and thereafter it increased upto grain filling stage. The highest value for specific leaf area was noted at crown root initiation stage in bed planting system at 160 kg N ha^{-1} followed by conventional planting system. At crown root initiation stages, the minimum specific leaf area was found in conventional planting system at control treatment. (Table 4).

Leaf weight ratio (LWR)

Variety had significant effect on leaf weight ratio at all the successive growth stages. At tillering stages, Prodip gave the highest leaf weight ratio followed by Shatabdi. At crown root initiation stage, the second highest leaf weight ratio was found in Protiva. Leaf weight ratio significantly affected by nitrogen level. The highest leaf weight ratio was found at tillering stage. At tillering stages the highest specific leaf area was observed at 160 Kg N ha^{-1} followed by 110 kg N ha^{-1} and 60 kg N ha^{-1}. The second highest weight ratio was noted at crown root initiation stage and thereafter it declined at the successive growth stages upto grain filling stage (Table 3). Sowing method had significant effect on leaf weight ratio. The highest leaf weight ratio was found in bed planting system followed by conventional planting system at all the successive growth stages (Fig. 2). Sowing method ×variety was significant on leaf weight ratio at all the harvest in both the experimental years. The maximum leaf weight ratio was noticed in bed planting system with the variety Prodip at tillering stage followed by conventional planting system. The second highest leaf weight ratio was observed at crown root initiation stage in bed planting system with the variety Protiva followed by conventional planting system. Interaction effect of planting method and nitrogen level on leaf weight ratio was statistically significant. The highest value for leaf weight ratio at tillering stages was obtained from bed planting system at 160 Kg N ha^{-1} followed by 110 kg N ha^{-1}. The second highest leaf weight ratio was noticed at crown initiation stages in bed planting system with the application of 160 Kg N ha^{-1} followed by conventional planting system (Table 4).

Table 3. Effect of variety on SLA (cm^2 g^{-1}) and LWR (g g^{-1}) at different growth stages of wheat

Variety	SLA (cm^2 g^{-1})					LWR (g g^{-1})				
	CRI	T	B	H	GF	CRI	T	B	H	GF
V_1	203.270 c	57.695a	128.900b	150.312b	149.201b	0.634a	0.574c	0.421a	0.124b	0.098b
V_2	221.245 b	58.145a	126.621b	149.143b	160.812b	0.597b	0.631b	0.381c	0.141a	0.099a
V_3	209.858 c	52.478b	127.291b	160.678a	154.820b	0.573c	0.638b	0.402b	0.125b	0.097c
V_4	237.645 a	59.745a	139.941a	157.305a	187.341a	0.591b	0.685a	0.419a	0.138a	0.098a
LS	0.01	0.01	0.05	0.01	0.05	0.01	0.01	0.01	0.05	0.05
CV %	3.47	5.18	3.71	4.63	4.25	2.67	2.12	4.65	3.97	5.45
N Level	SLA (cm^2 g^{-1})				LWR (g g^{-1})					
	CRI	T	B	H	GF	CRI	T	B	H	GF
N_0	204.845c	45.689d	119.950c	131.201b	141.025c	0.591bc	0.604b	0.414b	0.125b	0.099a
N_1	214.356 b	53.401c	129.301b	160.565a	160.072b	0.588 c	0.611b	0.424b	0127 b	0.092b
N_2	223.523ab	60.767b	135.634a	161.615a	174.251a	0.597ab	0.613b	0.394c	0.139a	0.093b
N_3	229.310 a	68.224a	138.454a	163.967a	176.845a	0.599 a	0.661a	0.468a	0.137a	0.094a
LS	0.01	0.01	0.05	0.01	0.05	0.01	0.01	0.01	0.05	0.05
CV %	3.47	5.18	3.71	4.63	4.25	2.67	2.12	4.65	3.97	5.45

In a column, figures having similar letter(s) or without letter(s) do not differ significantly as per DMRT

Table 4. Interaction effect of sowing method and variety and sowing method and nitrogen level on SLA (cm^2 g^{-1}) and LWR (g g^{-1}) at different growth stages of wheat

SM×V	SLA (cm^2 g^{-1})					LWR (g g^{-1})				
	CRI	T	B	H	GF	CRI	T	B	H	GF
$S_1 \times V_1$	202.095e	54.556ab	135.072 b	146.945e	139.856 d	0.618 b	0.571 f	0.428a	0.123 c	0.101d
$S_1 \times V_2$	226.567bc	57.623ab	126.060 d	149.612c	158.571bcd	0.587cd	0.621 e	0.375e	0.137ab	0.094d
$S_1 \times V_3$	207.367de	53.668ab	123.670 c	154.445b	152.261cd	0.556e	0.643 c	0.401c	0.120 c	0.085f
$S_1 \times V_4$	232.132ab	59.957 a	137.421 b	157.668b	174.734 b	0.589c	0.657 b	0.426a	0.139 a	0.102b
$S_2 \times V_1$	204.467de	56.843 c	122.754 d	153.667b	158.534bcd	0.631a	0.579 f	0.415b	0.125 c	0.094d
$S_2 \times V_2$	215.901cd	58.678ab	127.201 c	148.634c	163.071bc	0.591 c	0.639cd	0.384d	0.147 a	0.105a
$S_2 \times V_3$	212.389de	62.301a	126.800cd	166.912a	157.365bcd	0.582 d	0.631de	0.401c	0.128bc	0.089e
$S_2 \times V_4$	243.187 a	62.543 a	142.489 a	156.982b	201.051 a	0.592 c	0.697 a	0.415b	0.137ab	0.095c
SM×N Level	SLA (cm^2 g^{-1})					LWR (g g^{-1})				
	CRI	T	B	H	GF	CRI	T	B	H	GF
$S_1 \times N_0$	200.381e	48.041de	122.810 d	128.135 c	132.567e	0.586cd	0.626c	0.443a	0.119 b	0.096b
$S_1 \times N_1$	216.235bcd	52.845cd	130.390 c	163.174ab	155.445cd	0.582 d	0.615d	0.423c	0.121 b	0.094d
$S_1 \times N_2$	225.945ab	60.210 b	136.401ab	158.100 b	164.156bc	0.591bc	0.617 d	0.394d	0.138 a	0.095c
$S_1 \times N_3$	225.610ab	64.745 b	136.710ab	160.201ab	173.220ab	0.598ab	0.663b	0.373e	0.141 a	0.097b
$S_2 \times N_0$	209.332de	43.345 e	115.901 e	134.214 c	149.461d	0.597ab	0.603 e	0.424c	0.132 a	0.101a
$S_2 \times N_1$	212.501cd	53.946 c	128.224 c	158.170 b	164.681bc	0.596ab	0.624 c	0.429b	0.133 a	0.092e
$S_2 \times N_2$	221.102bc	61.334 b	134.912 b	165.230ab	184.241a	0.602a	0.614 b	0.394d	0.137 a	0.091f
$S_2 \times N_3$	233.025a	71.708 a	140.165 a	168.561a	180.465a	0.603a	0.673 a	0.367f	0.133 a	0.099a
LS	0.05	0.05	0.01	0.01	0.01	0.05	0.01	0.01	0.05	0.01
CV %	3.47	5.18	3.71	4.63	4.25	2.67	2.12	4.65	3.97	5.45

In a column, figures having similar letter(s) or without letter(s) do not differ significantly as per DMRT
CRI= crown root initiation T = tillering B=Booting H= Heading
GF=Grain filling SM= Sowing method V= variety N= Nitrogen

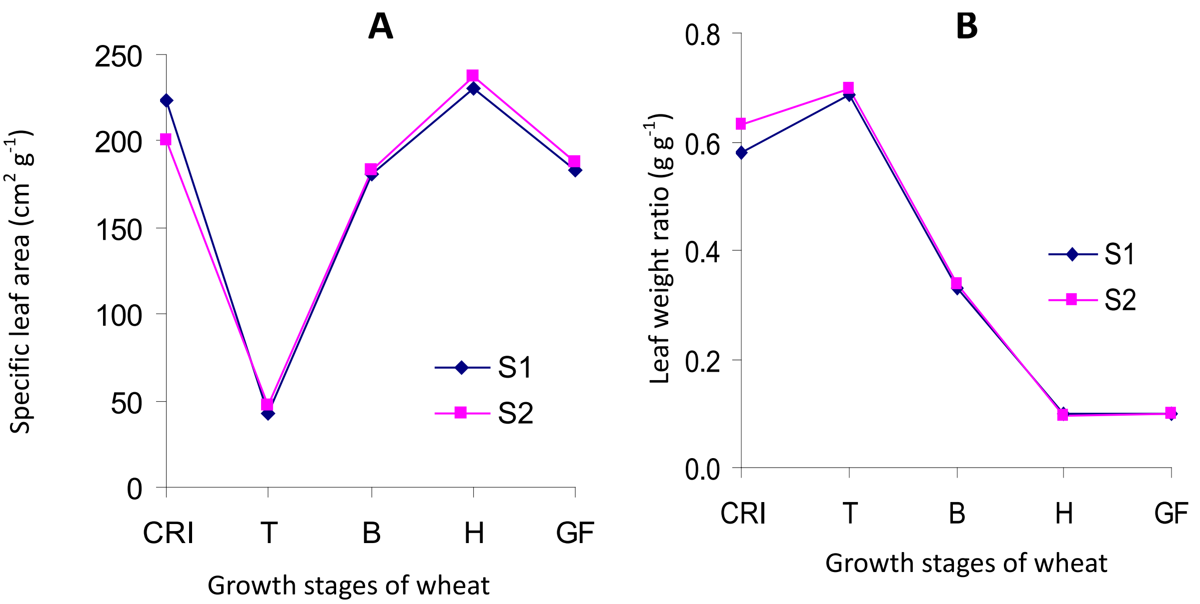

Figure 2. Effect of sowing method on specific leaf area (A) and leaf weight ratio (B) at different growth stages of wheat

4. Conclusions

The over all result indicate that bed planting is better than conventional one. The values of physiological characters were highest at 160 N ha^{-1}. Prodip performed better with 160 N ha^{-1} in bed planting system.

REFERENCES

[1] Ali, A., M.A., Choudhry, M.A., Malik. R., Ahmad and Saifullah, 2000, Effect of various doses of nitrogen on the growth and yield of two wheat cultivar, Pak. J. Biol. Sci., 3(6): 1004-1005.

[2] BBS (Bangladesh Bureau of Statistics), 2011-12, Estimates of yield of wheat, Bangladesh Bureau of Statistics, Government of the Peoples republic of Bangladesh, Agriculture Wing, Parishankhyan Bhaban E-27/A, Agargoan, Dhaka-1207.

[3] BFSR (Bangladesh Food Situation Report), 2011, Estimates of food grain Production, Food Division Ministry of Food and Disaster Management, 1-86.

[4] Fahong, W., Xuqing W., Sayre K.D., 2004, Comparison of conventional, flood irrigated, flat planted with furrow irrigated, raised bed planting for winter wheat in China, Field Crops Res.,87:35-42.

[5] Gomez, K.A. and Gomez, A.A., 1984, Statistical procedures for agricultural research, 2nd Edn. John Willey and Sons, New York, Pp. 97-411.

[6] Haloi, B. Baldev, B. 1980, Effect of irrigation on growth attributes in chickpea when grown under different dates of sowing population pressure, Indian J. Plant Physiol., 29: 14-27.

[7] Pandey, R.K., Saxena, Mc. and Singh, V. B., 1978, Growth analysis of blackgram genotypes. Indian J. Agric. Sci., 48: 466-473.

[8] Radford, P.J. 1967, Growth analysis formulae their use and abuse, Crop Sci.,7:171-175.

[9] Rahman, M.A., 2004, Effect of irrigation on nitrogen uptake, yield and yiled attributes of wheat varieties, Ph.D. Thesis, Crop Physiology Laboratory, Dept. Bot., Rajshahi Univ.

[10] Reddy, S.R., 2004, Agronomy of Field Crops, Kalyani Publishers Ludhiana, p.143.

[11] Sayre K.D., 2003, Raised-Bed Cultivation. Encyclopedia of Soil Science, p 1-4.