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Effect of Irrigation, Variety and Nitrogen on Growth and Productivity of Wheat (*Triticum aestivum* L.) in the Lateritic Belt of West Bengal

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Abstract

A field experiment was conducted at Sriniketan to study the performance of wheat (*Triticum aestivum* L.) varieties under limited nitrogen and water supply in red and lateritic belt of West Bengal. The experiment was laid out in a split plot design with irrigation levels (no irrigation and three irrigations at Crown root initiation stage (CRI), heading and soft dough stages) as the main plots and crop varieties (S*onalika* and UP 262) and nitrogen levels (50 and 100 kg ha^{-1}) combinations in the sub plots. Results indicated that irrigation had significant influence on dry matter accumulation, leaf area index, no of earheads m^{-2}, number of grains per earhead and test weight of grain that ultimately led to high grain and straw yield and harvest index. Significant response of nitrogen was also obtained on all the growth and yield parameters along with grain and straw yield and harvest index. UP 262 showed higher LAI at heading and greater number of grains per earhead and finally produced higher grain yield and harvest index. Nitrogen level (100 kg ha^{-1}) with three irrigations at CRI, heading and soft dough stages may be followed for obtaining high grain yield of wheat variety UP 262 in lateritic belt of West Bengal.

1. Introduction

India became the second largest wheat producing country in the world and achieved a record production during 2009-10. The total production increased by more than six folds from nearly 12.3 million tonnes in 1964-65 to an estimated 78.4 million tons in 2007-08 (Gautam et al., 2008). India is expected to produce 109 million tonnes of wheat by 2020 with annual rate of increase in production by about 2.2%, while present rate of increase is only about 1%. The most important aspects directly related to improve the productivity of wheat are water management, nutrient management, and crop variety. Wheat requires water at its critical stages so that the crop may not suffer from water stress. Many farmers of this region have the problem to irrigate the crop in late milking stage to avoid lodging due to wind which leads to shrivel grain and finally lower yield. Nutrient management plays a very important role to increase productivity of wheat. Wheat is an exhaustive crop and requires substantial amount of nutrients for higher productivity. In many parts of West Bengal, it has been reported that yield of wheat is declining due to deterioration of soil health in terms of depletion of organic matter. Nitrogen is an essential element for optimal functioning of crops. Nitrogen use efficiency of wheat ranges from 45-60%. Very little works have been made to study the growth and yield performance of wheat varieties at different levels of nitrogen and irrigation particularly in red and lateritic belt of West Bengal. Keeping this in view and realizing the importance of the problem, the present research was undertaken to study the effect of irrigation and nitrogen level on growth and productivity of wheat varieties.

2. Materials and Methods

A field experiment was conducted at the Agricultural College Farm of Palli Siksha Bhavana (Institute of Agriculture), Visva-Bharati, Sriniketan, West Bengal during *rabi* season of 2004-05, 2005-06 and 2006-07. The farm is situated at $23^0 39'$ N and $87^0 42'$ E with an average altitude of 58.9 m above the mean sea level. The soil of the experimental plot was sandy loam in texture with 5.25 pH, 0.41% organic carbon, 425.8 kg ha^{-1} available N, 19.24 kg ha^{-1} available P_2O_5 and 212.8 kg ha^{-1} available K_2O. The experiment was carried out in a split plot design with two levels of irrigation (no irrigation and three irrigation) as the main plots, two cultivars (Sonalika and UP-262) and two levels of nitrogen (50 and 100 kg ha^{-1}) combinations in the subplots of 5m x 3m in size replicated thrice. Half dose of nitrogen in the from of urea and full quantity of phosphate (50 kg P_2O_5 ha^{-1}) as single super phosphate and potash (50 kg K_2O ha^{-1})

as muriate of potash were applied as basal in each plot as per treatment before sowing and remaining half dose of nitrogen was top dressed at first irrigation. Wheat seeds at 100 kg ha^{-1-} were soaked overnight for better germination and treated with Agrosan GN (2.5 g kg^{-1} seed) to check disease infestation. The treated seeds were sown in lines of 25 cm apart in a depth of 4–5 cm below the soil by making shallow furrows with the help of tynes and covered with soil immediately after sowing in the first week of December. Hand weeding and hoeing operations were done twice, one at 15 days after sowing (DAS) and the other at 30 DAS. In irrigated crop, three irrigations were given at CRI (21 DAS), heading (70 DAS) and soft dough (90 DAS) stages following border strip method of irrigation. The crop was harvested at 110-115 DAS during all the three years. Observations on plant height, number of tillers m^{-2} dry matter accumulation and leaf area index at different stages, number of ear-heads m^{-2} number of grains/ear-head and test weight along with grain and straw yields were recorded at maturity. N uptake by the crop, water use efficiency, soil water status, organic carbon and available N in soil were also estimated. The analysis of variance method (Cochran and Cox, 1977; Panse and Sukhatme, 1978) was followed to statistically analyse the data. The significance of different source of variations was tested by "Error Mean Square Method" of Fisher Snedecor's 'F' test at probability level 0.05. In the tables of result and discussion chapter, the standard error of Mean (SEm ±) and the value of critical difference (C.D.) to compare the differences between means have been provided.

3. Results and Discussion

3.1. Growth attributes

The results clearly indicated that plant height at 50 and 70 days after sowing (DAS) of wheat and number of tillers per unit area increased significantly due to application of irrigation water over without irrigation in all the three years of the experiment (Table 1). The irrigated crop did not experience to water stress that resulted in vigorous growth by increasing tillering and plant height. The results are in conformity with the findings of Pal et al. (2001). Among the varieties, '*Sonalika*' produced taller plants than that of UP 262 at both the stages, but UP 262 recorded significantly greater number of tillers per unit area than that of '*Sonalika*' during all the three years under study. It was also revealed that increasing level of nitrogen from 50 kg N ha^{-1} to 100 kg N ha^{-1} significantly enhanced the plant height at both 50 and 70 DAS and tiller production during all the three years. This might be due to positive effect of nitrogen on cell division and cell enlargement that ultimately led to increase tillering and plant height. The results corroborate the findings of Singh et al. (2002).

The leaf area index (Table 2) and dry matter accumulation (Table 3) increased significantly due to the application of irrigation water over those of no irrigated plots at all growth stages during all the three years. Higher availability of water in irrigated plots where three irrigations at different critical growth stages were applied led to enhance physiological activities and ultimately increased the leaf area index and dry matter accumulation over those of the rainfed crop. The results are

Table 1: Effect of irrigation, variety and nitrogen on plant height (cm) and number of tillers m-2 of wheat

Treatments	Plant height (cm)						Number of tillers m^{-2}		
	50 DAS			70 DAS			70 DAS		
Irrigation	2005	2006	2007	2005	2006	2007	2005	2006	2007
No irrigation	28.6	30.4	30.2	64.5	66.8	63.2	220	223	228
Three irrigation	50.6	51.0	52.0	90.0	92.2	95.6	321	323	325
SEm±	1.2	1.43	1.4	2.23	2.06	2.20	12.2	10.9	11.6
CD (*p*=0.05)	3.7	4.4	4.3	6.8	6.3	6.7	37.2	33.2	35.4
Variety									
Sonalika	42.5	43.3	44.7	83.2	85.5	86	258	262	266
UP 262	36.7	38.1	37.5	71.3	73.5	72.8	283	284	287
SEm±	0.85	0.92	0.89	1.24	1.05	1.12	6.5	6.2	5.8
CD (*p*=0.05)	2.5	2.7	2.6	3.7	3.1	3.3	19.2	18.4	17.2
Nitrogen									
50 kg N ha^{-1}	37.7	38.4	39.1	74.1	76.3	75.5	263	266	272
100 kg N ha^{-1}	41.5	43	43.1	80.4	82.7	83.3	278	280	281
SEm±	0.9	0.9	0.9	1.2	1.1	1.1	6.5	6.2	5.8
CD (*p*=0.05)	2.5	2.7	2.6	3.7	3.1	3.3	19.2	18.4	17.2

Table 2: Effect of irrigation, variety and nitrogen on leaf area index (LAI) of Wheat

Treatments	Leaf area index								
	30 DAS			50 DAS			70 DAS		
Irrigation	2005	2006	2007	2005	2006	2007	2005	2006	2007
No irrigation	0.40	0.65	0.31	1.93	2.15	1.85	2.14	2.39	2.05
Three irrigation	0.66	0.89	0.66	2.57	2.61	2.57	2.86	2.90	2.85
SEm±	0.04	0.03	0.05	0.08	0.07	0.09	0.09	0.08	0.10
CD (p=0.05)	0.24	0.18	0.30	0.49	0.42	0.53	0.54	0.47	0.59
Variety									
Sonalika	0.59	0.84	0.55	2.12	2.27	2.09	2.36	2.52	2.32
UP 262	0.47	0.70	0.42	2.37	2.49	2.32	2.63	2.77	2.58
SEm±	0.03	0.04	0.03	0.06	0.05	0.06	0.07	0.07	0.08
CD (p=0.05)	0.09	0.12	0.10	0.18	0.16	0.17	0.21	0.20	0.23
Nitrogen									
50 kg N ha^{-1}	0.45	0.68	0.40	2.12	2.28	2.10	2.36	2.53	2.33
100 kg N ha^{-1}	0.61	0.85	0.57	2.37	2.48	2.31	2.63	2.75	2.57
SEm±	0.03	0.04	0.03	0.06	0.05	0.06	0.07	0.07	0.08
CD (p=0.05)	0.09	0.12	0.10	0.18	0.16	0.17	0.21	0.20	0.23

Table 3: Effect of irrigation, variety and nitrogen on dry matter accumulation (g m^{-2}) of Wheat

Treatments	Dry matter accumulation (g m^{-2})								
	30 DAS			50 DAS			70 DAS		
Irrigation	2005	2006	2007	2005	2006	2007	2005	2006	2007
No irrigation	52.3	46.0	44.0	215	188	233	296	259	310
Three irrigation	59.8	55.0	53.5	278	236	364	382	413	455
SEm±	1.8	1.9	1.7	5.3	5.1	4.6	7.3	7.0	6.4
CD (p=0.05)	5.6	5.8	5.2	31.8	30.1	28.8	43.7	41.4	39.6
Variety									
Sonalika	58.0	53.3	51.5	238	205	289	324	325	370
UP 262	54.0	47.8	46.3	255	223	307	355	347	395
SEm±	1.2	1.3	1.4	4.8	5.0	5.4	6.7	6.9	7.1
CD (p=0.05)	3.5	3.7	4.0	14.2	14.8	16.0	20.0	20.5	21.2
Nitrogen									
50 kg N ha^{-1}	54.5	48.5	46.8	236	201	281	310	315	352
100 kg N ha^{-1}	59.0	52.5	51.0	258	223	307	369	357	413
SEm±	1.2	1.3	1.4	4.8	5.0	5.4	6.7	6.9	7.1
CD (p=0.05)	3.5	3.7	4.0	14.2	14.8	16.0	20.0	20.5	21.2

in conformity with the findings of Pal et al., 2001.

The two varieties responded differently because of their differential growth behaviour. *Sonalika* having faster growth habit produced significantly higher leaf area index and dry matter yield than those of UP-262'at initial stage (30 DAS) during all the years. But UP 262 put forth its growth later on and recorded significantly higher leaf area index and greater dry matter accumulation as compare to that of *Sonalika* at jointing (50 DAS) and at heading (70 DAS) stages during all the three years (Table 2 and 3).

Both leaf area index and dry matter production increased steadily up to the heading stage (70 DAS) of wheat. Nitrogen had significant effect on both the growth parameters of wheat during all the years. Application of higher dose of nitrogen

(100 kg N ha^{-1}) markedly increased the leaf area index and dry matter production than those recorded at its lower dose (50 kg N ha^{-1}) at both the growth stages during the three years (Tables 2 and 3). Adequate nutrition of the crop at high nitrogen level was mainly responsible for producing higher LAI and greater dry matter accumulation in wheat (Pandey et al., 2003).

3.1.2. *Yield attributes and yield*

Irrigation exerted significant effect on all the yield components of wheat recorded in the study. Number of earheads m^{-2} number of grains/earhead and test weight (1000-grain weight) increased significantly in crop receiving three irrigations over those of the control plots during all the three years (Table 4). High LAI functioning over the growing period of irrigated crop was mainly responsible for increasing the earhead production, grain formation and grain development of the crop over those of the rain fed crop. The results indicated the need of adequate water supply through irrigation at critical growth stages of wheat for improving its yield components.

The crop variety (Sonalika and UP 262) varied widely in earhead production, grain formation and grain development during all the three years under study. UP 262 produced significantly higher number of earhead m^{-2} and grains/earhead than those of Sonalika; but Sonalika produced bolder grains which was significantly greater than that of UP 262 during all the three years (Table 4). This showed the differential behaviour of the two varieties in expressing yield attributing characters.

Application of higher level of nitrogen (100 kg N ha^{-1}) favourably and positively influenced all the yield attributing characters under study. Crop receiving 100 kg N ha^{-1} produced significantly higher number of earheads m^{-2}, grains/earhead and test weight of grain than those obtained at its lower level (50 kg N ha^{-1}) during all the three years. However, the number of grains/earhead did not vary between the nitrogen levels during all the years (Table 4). The results showed that wheat required high dose of nitrogen application for its good growth high yield attributing characters essential for obtaining high yield in the lateritic acid belt of West Bengal. The positive effect of nitrogen on increasing yield attributing characters was also noticed by Sharma and Dhillon (2002).

3.1.3. *Crop productivity*

The perusal of the data on wheat productivity clearly showed that application of irrigation water had significant effect on grain yield, straw yield and harvest index of wheat in all the three years under study (Table 5). The crop receiving three irrigations produced significantly higher yield (3.61, 3.49 and 3.65 Mg ha^{-1} during 2005, 2006 and 2007 respectively) compared to that of the rainfed crop (2.05, 2.00 and 2.08 Mg ha^{-1} in 2005, 2006 and 2007 respectively). The irrigated crop also produced 75.5% higher straw yield, greater harvest index than that of the rainfed crop during all the three years. This indicated that the irrigated crop not only produced higher grain and straw yield but also exerted greater efficiency in partitioning photosynthate towards grain production in comparison to that of the rainfed crop. Three irrigations at crown root initiation (CRI), heading and soft dough stages considerably improved the water availability in soil throughout the growing period of wheat leading to improving the growth attributes and yield components that not only enhanced grain and straw yield but also improved its

Table 4: Effect of irrigation, variety and nitrogen on yield components of wheat

Treatments	No. of earheads m^{-2}			No. of grains earhead^{-1}			Test weight (g)		
Irrigation	2005	2006	2007	2005	2006	2007	2005	2006	2007
No irrigation	190	195	192	37	35	39	34.2	34.0	33.6
Three irrigation	227	224	232	45	43	47	36.3	35.8	35.2
SEm±	2.5	2.4	2.2	0.7	0.6	0.8	0.21	0.23	0.20
CD (p=0.05)	15.0	14.4	13.2	4.1	3.7	4.5	1.26	1.37	1.20
Variety									
Sonalika	200	204	205	39	37	40	36.5	36.0	35.6
UP 262	216	215	219	43	41	46	34.0	33.8	33.2
SEm±	1.6	1.7	1.5	0.5	0.7	0.6	0.29	0.26	0.25
CD (p=0.05)	4.7	5.0	4.3	1.4	2.0	1.7	0.86	0.77	0.74
Nitrogen									
50 kg N ha^{-1}	194	200	197	40	38	42	34.8	34.5	34.0
100 kg N ha^{-1}	222	219	227	42	40	44	35.7	35.3	34.8
SEm±	1.6	1.7	1.5	0.5	0.7	0.6	0.29	0.26	0.25
CD (p=0.05)	4.7	5.0	4.3	1.4	2.0	1.7	0.86	0.77	0.74

Table 5: Effect of irrigation, variety and nitrogen on wheat productivity

Treatments	Grain yield (Mg ha^{-1})				Straw yield (Mg ha^{-1})			Harvest index (%)		
Irrigation	2005	2006	2007	Pooled	2005	2006	2007	2005	2006	2007
No irrigation	2.05	2.00	2.08	2.04	3.71	3.41	3.73	35.6	37.0	35.8
Three irrigation	3.61	3.49	3.65	3.58	5.18	5.23	5.18	41.1	40.0	41.3
SEm±	0.12	0.11	0.10	0.09	0.18	0.20	0.21	0.69	0.50	0.76
CD (*p*=0.05)	0.73	0.67	0.61	0.55	1.10	1.21	1.23	4.03	3.00	4.54
Variety										
Sonalika	2.69	2.61	2.66	2.65	4.23	4.12	4.21	38.9	38.8	38.7
UP 262	2.97	2.88	3.06	2.97	4.66	4.52	4.58	38.9	38.9	40.1
SEm±	0.09	0.08	0.10	0.07	0.12	0.14	0.13	0.36	0.37	0.42
CD (*p*=0.05)	0.26	0.23	0.28	0.20	0.35	0.40	0.37	NS	NS	1.22
Nitrogen										
50 kg N ha^{-1}	2.42	2.49	2.45	2.45	4.00	3.99	4.13	37.7	38.4	37.2
100 kg N ha^{-1}	3.24	3.00	3.28	3.17	4.88	4.65	4.67	39.9	39.2	41.3
SEm±	0.09	0.08	0.10	0.07	0.12	0.14	0.13	0.36	0.37	0.42
CD (*p*=0.05)	0.26	0.23	0.28	0.20	0.35	0.40	0.37	1.07	1.10	1.22

efficiency in grain productivity over those of the rainfed crop. Pooled analysis of three years data also showed the superiority of irrigated crop in increasing wheat productivity over that of rainfed crop. The results are in conformity with the findings of Saren et al. (2004) and Singh and Chandra (2004). The results emphasized the need of three irrigations at CRI, heading and soft dough stages of wheat for obtaining high yield of wheat in the lateritic belt of West Bengal.

Among the two varieties, UP 262 produced significantly higher grain yield (2.97, 2.88 and 3.06 Mg ha^{-1}) and straw (4.66, 4.52 and 4.58 Mg ha^{-1}) yield than those of *Sonalika* during 2005, 2006, 2007 respectively. However, harvest index did not differ significantly between the two varieties in any of the three years (Table 5). The results showed the superiority of UP 262 in grain and straw productivity as compare to that of *Sonalika*. The pooled analysis also confirmed the superiority of UP 262 over *Sonalika* in grain productivity.

Nitrogen played a significant role in influencing the productivity of wheat crop. Application of 100 kg N ha^{-1} increased grain and straw yield significantly over that recorded at its lower level (50 kg N ha^{-1}) during all the three years. This was also confirmed in pooled analysis. The high grain yield was mainly responsible for higher number of earheads m^{-2} greater number of grains/earhead and higher test weight at high nitrogen level. The results are in conformity with the findings of Raigar and Pareek (2003). It was further noted that the crop receiving 100 kg N ha^{-1} recorded much higher harvest index than that of the crop at low nitrogen level (50 kg N ha^{-1}) during all the three years (Table 5). This clearly indicated that high nitrogen nutrition not only increased the grain and straw productivity of wheat but also made the crop more efficient in grain production as reflected by its higher harvest index. Pandey et al. (2003) also noticed increased harvest index with the increasing dose of nitrogen.

3.1.4. Nitrogen uptake

The data related to N uptake (Table 6) revealed that N uptake by wheat grain and straw was highest in the crop receiving three irrigations during all the three years under study. This ultimately led to high total N uptake by the crop and might be due to presence of higher amount of soil moisture that increased the availability of nitrogen which in turn improved the yield and nitrogen uptake by the crop. The variety UP 262 recorded significantly higher N uptake by grain, straw as well as total N uptake over that of Sonalika during all the three years. Increase of nitrogen dose from 50 N ha^{-1} to 100 N ha^{-1} was found to increase the N uptake by grain and straw as well as total N uptake in wheat during the three years. Better availability of N in soil at high nitrogen level favourably influenced N uptake through grain and straw that ultimately resulted in higher N uptake by the crop. The results are in conformity with the findings of Kaur et al., 2010.

3.1.5. Soil water availability and water use efficiency

The changes in soil water content of the 0-30cm, 30-60cm ad 60-90 cm soil depth as recorded in 2005 (Fig 1a, 1b and 1c) and 2006 (Figure 2a, 2b and 2c). The effective rainfall received by the wheat crop during 2005, 2006 and 2007 was 9.41 cm, 14.02 cm and 7.04 cm respectively (Table 7). The results clearly showed that soil water content in irrigated plots improved considerably with the application of irrigation water during

Table 6: Effect of irrigation, variety and nitrogen on N uptake (kg ha^{-1})

Treatments	N uptake by grain (kg ha^{-1})			N uptake by straw (kg ha^{-1})			Total N uptake (kg ha^{-1})		
Irrigation	2005	2006	2007	2005	2006	2007	2005	2006	2007
No irrigation	30.75	30.00	31.20	14.84	13.64	14.92	45.59	43.64	46.12
Three irrigation	54.15	52.35	54.75	20.72	20.92	20.72	74.87	73.27	75.47
SEm±	2.20	1.78	2.09	1.08	0.93	0.91	3.20	2.87	2.84
CD (*p*=0.05)	6.67	5.38	6.31	3.27	2.88	2.81	9.82	8.75	8.67
Variety									
Sonalika	40.35	39.15	40.05	17.22	16.68	17.22	57.57	55.83	57.27
UP 262	44.55	43.20	45.90	18.34	17.88	18.42	62.89	61.08	64.32
SEm±	1.14	1.08	1.10	0.33	0.31	0.29	1.25	1.13	1.11
CD (*p*=0.05)	3.33	3.15	3.26	0.95	0.88	0.83	3.70	3.34	3.28
Nitrogen									
50 kg ha^{-1}	36.30	37.35	36.75	16.04	15.96	16.73	52.34	53.31	53.48
100 kg ha^{-1}	48.60	45.00	49.20	19.52	18.60	18.91	68.12	63.60	68.11
SEm±	1.14	1.08	1.10	0.33	0.31	0.29	1.25	1.13	1.11
CD (*p*=0.05)	3.33	3.15	3.26	0.95	0.88	0.83	3.70	3.34	3.28

Table 7: Effect of irrigation, variety and nitrogen on total water use (cm) and water use efficiency (WUE) in wheat

Treatments	IW* (cm)	Effective rainfall (cm)			Total water use (cm)			WUE (kg $ha^{-1}cm^{-1}$)		
Irrigation		2005	2006	2007	2005	2006	2007	2005	2006	2007
No irrigation	0.00	9.41	14.02	7.04	9.41	14.02	7.04	157.8	121.3	205.1
Three irrigation	24.0	9.41	14.02	7.04	33.41	38.02	31.04	106.6	89.7	95.3
SEm±								8.89	7.64	9.97
CD (*p*=0.05)								27.1	23.3	30.4
Variety										
Sonalika	12.0	9.41	14.02	7.04	21.41	26.02	19.04	125.6	98.4	139.7
UP262	12.0	9.41	14.02	7.04	21.41	26.02	19.04	138.7	112.6	160.7
SEm±								4.23	3.67	4.78
CD (*p*=0.05)								12.5	10.9	14.1
Nitrogen										
50 kg N ha^{-1}	12.0	9.41	14.02	7.04	21.41	26.02	19.04	113.0	95.7	128.3
100 kg N ha^{-1}	12.0	9.41	14.02	7.04	21.41	26.02	19.04	151.3	115.3	172.1
SEm±								4.23	3.67	4.78
CD (*p*=0.05)								12.5	10.9	14.1

all the three years. Higher amount of water used in the crop was also noted in irrigated plots as compare to that of rainfed crop during all the three years. But, the water use efficiency was significantly higher in the rainfed crop than that of the irrigated crop. Singh and Chandra (2004) also found that the water use efficiency was highest with rainfed crop.

Among the varieties, UP 262 recorded significantly higher water use efficiency as compared to Sonalika. The superiority of UP 262 in water use efficiency might be responsible for higher productivity. Similarly, application of 100 kg N ha^{-1} significantly increased the water use efficiency of the crop over its lower dose during all the three years. The higher N dose increased the grain and straw productivity and thus made the crop more efficient in water use. Khan et al. (2000) also reported similar results.

3.1.6. Soil organic carbon and nitrogen status

The soil organic carbon and available nitrogen status of the soil after the harvest of the crop during all the three years of experimentation were estimated in the laboratory and presented in the Table 8. Since no organic input was added to the soils, the organic carbon content of the soil did not vary much under the study. It ranged from 0.60-0.63 % in 2005, 0.62-0.66 % in 2006 and 0.61-0.64 % in 2007 irrespective of different treatments evaluated in the study. The results indicated that irrigation, crop variety and nitrogen dose did not help in influencing the organic carbon content of the soil. The available nitrogen content was found to be slightly higher in rainfed plots as compare to the irrigated plots. The low available nitrogen in the irrigated plots might be due to more uptake of N by the irrigated crop. In addition, leaching loss of nitrogen was likely to be more in irrigated plots than that of rainfed plots. The plots occupied by UP 262 left relatively higher amount of available nitrogen in soil as compare to that of Sonalika because of more biomass productivity. Plots having higher dose of nitrogen left higher amount of available nitrogen in the soil than that of the plots with low nitrogen dose. Similar increase in soil available nitrogen due to use of higher nitrogen dose was also obtained by Pathak et al. (2005).

Table 8: Effect of irrigation, variety and nitrogen on organic carbon (%) and available N (kg ha^{-1}) content in soil

Treatments	Organic Carbon (%)			Available N (kg ha^{-1})		
Irrigation	2005	2006	2007	2005	2006	2007
No irrigation	0.60	0.62	0.61	626.59	631.52	638.67
Three irrigation	0.63	0.66	0.64	619.89	626.5	629.79
Variety						
Sonalika	0.61	0.63	0.62	620.89	625.59	630.87
UP 262	0.62	0.65	0.63	625.59	632.43	636.59
Nitrogen						
50 kg ha^{-1}	0.6	0.63	0.61	620.25	624.28	629.26
100 kg ha^{-1}	0.63	0.65	0.64	626.23	633.75	638.23

4. Conclusion

The study indicated that irrigation had significant influence on dry matter accumulation, leaf area index, no of earhead m^{-2}, number of grains per earhead and test weight of grain that ultimately led to high grain yield, straw yield and harvest index. Significant response of nitrogen was also obtained on all the growth and yield parameters along with grain yield, straw yield and harvest index. UP 262 recorded higher LAI at heading and greater number of grains/earhead that finally gave higher grain yield and harvest index over that of Sonalika. UP 262 at high nitrogen level (100 kg N ha^{-1}) with three irrigation at CRI, heading and soft dough stages of wheat may be recommended for the lateritic belt of West Bengal.

5. References

Cochran, W.G., Cox, G.M., 1963. Experimental Designs. 1st India Ed. Asia publishing House

Gautam, P. L., Kochar, S., Mishra, B., 2008. Need to work on short and long-term strategies. The Hindu Survey of Indian Agriculture 2008, 26-29.

Khan, J.A., Tiwari, O.P., Shrivastava, G.K., Singh, A.P., 2000. Effect of irrigation schedules, nitrogen levels and split application on rooting pattern, light interception, water use and economics of late sown wheat (*Triticum aestivum*). Annals of Agricultural Research 21(4), 561-563.

Kaur, A., Pannu, R.K., Buttar, G.S., 2010. Impact of nitrogen application on the performance of wheat (*Triticum aestivum*) and nitrogen use efficiency under different dates of sowing. Indian Journal of Agronomy 55(1), 40-45.

Pal, S.K., Verma, U.N., Singh. M.K., Upasani, R.R., Thakur, R., 2001. Growth and yield of late sown wheat (*Triticum aestivum*) under different irrigation schedules. Indian Journal of Agricultural Sciences 71(10), 664- 667.

Pandey, I.B., Singh, H., Tiwari, S., 2003. Response of timely sown wheat to levels and time of nitrogen application. Journal of Research, Birsa Agricultural University 15(1), 35-38.

Panse, V.G., Sukhatme, R.V., 1978. Statistical method for agricultural workers. ICAR, New Delhi, 33-46

Pathak, S.K., Singh, S.B., Jha, R.N., Sharma, R.P., 2005. Effect of nutrient management on nutrient uptake and changes in soil fertility in Maize (*Zea mays*)-Wheat (*Triticum aestivum*) cropping system. Indian Journal of Agronomy 50(4), 269-273.

Raigar, R. S., Pareek, R.G., 2003. Yield and yield attributes of wheat as influenced by different levels of nitrogen and time of application. Current Agriculture 27 (1/2), 115-116.

Saren, B. K., Dey, S., Mandal, D., 2004. Effect of irrigation and sulphur on yield attributes, productivity, consumptive use and consumptive use efficiency of wheat (*Triticum aestivum*). Indian Journal of Agricultural Sciences 74 (5), 257-261.

Sharma, J.S., Dhillon, S.S., 2002. Response of durum wheat (*Triticum aestivum* L.) to rate and time of nitrogen application under irrigated conditions. Journal of Research, Punjab Agricultural University 39(1), 46- 49.

Singh, C.B., Kumar, J., Khan, A.A., Katiyar, R.A., Katiyar, A.K., (2002). Effect of nitrogen levels and dates of sowing on yield and quality of wheat (*Triticum aestivum* L.) seeds. Progressive Agriculture 2(1), 92-93.

Singh, R. D., Chandra, S. 2004. Yield and water use of wheat under minimum irrigation and nitrogen topdressing. Indian Journal of Soil Conservation 32(1), 78-79.