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Research Article

Effect of irrigation regimes and nitrogen levels on phenology and grain yield of late sown wheat

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Abstract

A field experiment was conducted to study the response of irrigation regimes and nitrogen levels on phenology and grain yield of late sown wheat. The experiment consisting of three irrigation regimes *viz.* one irrigation (at CRI), two irrigations at (CRI and heading) and four irrigations at (CRI, late tillering, heading and milking) in main plots and five nitrogen levels *viz.* control *i.e.* 0, 50, 100, 150 and 200 kg N/ha in sub-plots was laid out in strip plot design. Days taken to heading, anthesis and physiological maturity delayed significantly with increased irrigation regimes and nitrogen levels. Similarly, plant height, dry matter accumulation, crop growth rate (CGR) and leaf area index (LAI) increased significantly with increased irrigation regimes from one to two and two to four irrigations and dose of nitrogen. The grain yield increased by 50.6 and 47.5% over one irrigation and 20.4 and 21.9% over two irrigations in four irrigations (3832 and 3989 kg/ha) during 2010-11 and 2011-12, respectively. The growth parameters namely plant height, LAI, dry matter accumulation and CGR showed significant positive relationship with grain yield. Increase in dose of nitrogen increased the grain yield significantly up to 150 kg N/ha during both the year. However, the grain yield of wheat was statistically at par with 150 and 200 kg N/ha.

Keywords: Grain yield, Irrigation regimes, late sown wheat, nitrogen

1. Introduction

Wheat (*Triticum aestivum* L.) is the second most important cereal crop after rice, grown under diverse agro-climatic conditions. During past few years, sowing of wheat often gets delayed till December or early January causing substantial loss in grain yield. This is primarily attributed to non availability of pre-sowing irrigation or owing to late harvest of preceding crop as a compulsion and not a choice of the farmers under, American cotton-wheat, basmati rice-wheat, rice-potato-wheat and sugarcane-wheat rotations.

Water and nitrogen are the two most important inputs in high-yield wheat cultivation. Wheat is highly responsive to irrigation application. Water is vital to every stage of wheat plant development from seed germination to plant maturation. Irrigation applied at sensitive stages would be a valuable management practice for improving yield. Decreased growth rate is caused primarily by reduction in radiation use efficiency, when drought was imposed at various growth stages such as tillering, booting, ear head emergence, anthesis and grain development stages. The best performance of crop depends upon availability of water during these stages. Efficient water supply during the early growing season increases the leaf area of the crop; enable it to intercept most of the incoming radiation (Asif *et al.*, 2012). Nitrogen a key element for plant nutrition an essential constituent of protein, which is associated with all the vital processes in plants. It increases LAI by increasing leaf production and expansion rate that effect interception of photosynthetically active radiation (PAR) and consequently the final dry matter production (Asif *et al*., 2012). Nitrogen is one of the major essential nutrients applied to the crop for higher vegetative growth, productivity and quality (Ali *et al*., 2012 and Iqbal *et al*., 2012). Kibe *et al.* (2006) studied nitrogen-water relationships in late cultivation of wheat crop with adequate and limited irrigation regimes. The results revealed that an increase in irrigation water and nitrogen led to increases in LAI, CGR, RGR, NAR and yield.

There was significant positive interaction between irrigation and nitrogen levels with respect to grain yield, water productivity and nitrogen use efficiency of wheat (Pradhan *et al*., 2013).

2. Material and methods

Field experiment was conducted during 2010-11 and 2011-12 at Agronomy Research Farm of CCS Haryana Agricultural University, Hisar (India) with latitude of $29^0 10'$ North and longitude of $75^0 46'$ East at 215.2 meters above mean sea level. The soil of the field was sandy loam, having 0.39% organic carbon and pH 7.95. It was low in available N (156.1 kg/ha), medium in available P (10.5 kg/ha) and rich in available K (306.4 kg/ha). The experiment consisting of three irrigation regimes *viz.* one irrigation at CRI, two irrigations at CRI and heading and four irrigations at CRI, late tillering, heading and milking in main plots and five nitrogen levels *viz.* control i.e. 0, 50, 100, 150 (recommended dose of nitrogen) and 200 kg N/ha in sub-plots was laid out in strip plot design with four replications.

Fertilizer P and K applied as basal dose @60 kg each P_2O_5 and K_2O/ha. The nitrogen doses were applied in the form of urea. Half dose of nitrogen was applied as basal dose and remaining half as top dressed after 1st irrigation as per treatments. Wheat cv. WH 1021 was sown with the help of seed drill in rows 18 cm apart at the seed rate of 125 kg/ha. Crop was sown on 18th December during both the years. The weeds were removed by hand hoeing and hand pulling. The growth parameters were recorded at 30 days interval till crop maturity. Data on plant height, dry weight, LAI, CGR and grain yield were recorded by using standard procedure. Data were analysed statistically with OPSTAT software.

3. Results and discussion

The time taken for phenological development in wheat under different irrigations was recorded at emergence, heading, anthesis and physiological maturity (Table 1). Application of four irrigations resulted in significant delay in heading, anthesis and physiological maturity by 3, 3 and 3.4 days and 4.4, 4.6 and 6 Days in 2010-11 and 2.5, 3, 3 days and 4, 5, 5.6 days in 2011-12, respectively over crop irrigated twice and crop given one irrigation. The significant delay in development of different phenophases in four irrigations may be due to more availability of irrigation water and continuous availability of moisture to the crop because of frequent irrigation. This high availability of moisture increased the plant growth. The longer crop duration and longer reproductive phase of crop growth under higher level of irrigation has been also reported by Dhaka *et al.* (2006) and Ngwako and Mashiqa (2013).

Increase in crop duration by three to four days in well fertilized crop was significant over control. Increase in days to heading, anthesis and maturity may be attributed to the increased vegetative growth and increased light use efficiency with the increase of N doses. Higher level of nitrogen enhances cell division and enlargement leading to the new tissue development in the younger leaves, which slowed down the development of phenophases and finally slowed down the process of senescence, hence delayed the maturity (Rehman *et al*., 2010).

LAI increased up to 90 DAS and declined thereafter, during both the years (Table 2). The maximum LAI was recorded with maximum number of irrigations *i.e.* four, which was significantly higher than two and one irrigation at 90 DAS. Efficient water supply during the growing season increased the leaf area of the crop; enabling it to intercept most of the incoming radiation. These results were in confirmation with Asif *et al.* (2012) and Kumar *et al.* (2012). Similarly, application of nitrogen doses also influenced the LAI significantly at all the stages of crop growth during two years of study. The maximum LAI was observed with 200 kg N/ha followed by 150, 100, 50 kg N/ha and minimum LAI was found in control *i.e.* 0 kg N/ha, which was significantly lower than other doses of nitrogen at all the stages of crop growth during both the years. However, in 2010-11, LAI found in 200 kg N/ha was significantly higher than 100 kg N/ha, but in 2011-12 it was statistically at par with 100 kg N/ha. Whereas, LAI at 150 kg N/ha statistically at par with 100 and 200 kg N/ha at all the stages of crop growth during 2010-11 and 2011-12. The increase in leaf area index with higher N levels might be due to more leaf area on account of more accumulation of assimilates. Asif *et al.* (2012) reported enhanced LAI by application of higher levels of N fertilizer.

The plant height and dry matter accumulation increased significantly with increase in number of irrigations during both the years (Table 4), because of more water availability to the crop plants. The higher amount of available water kept the higher turgor potential, which lead to higher rate of photosynthesis due to more opening of stomata for longer period of time. Similar findings were also recorded by Pannu and Sharma (2004), Kumar *et al.* (2012) and Shirazi *et al.* (2014). The increase in nitrogen dose increased the plant height and dry matter accumulation up to 100 kg N/ha. At highest dose of 200 kg N/ha, the increase in plant height and dry weight was significantly higher than 100 kg N/ha. However, the differences at 150 kg N/ha was statistically at par with 100 and 200 kg N/ ha. Significantly lower plant height and dry weight were observed in control than other doses of nitrogen might be because of under nourishment of the plant, because of low availability of nutrients. Similar results were confirmed by Rehman *et al.* (2010), Ali *et al.* (2011), Shahzad *et al.* (2013) and Shirazi *et al.* (2014).

Crop growth rate (CGR) was lowest between 0-30 days increased till 90 days and attained maximum value between 60-90 days and then declined consistently till crop maturity (Table 3). The CGR increased with increase in number of irrigations significantly during both the years at later stages of crop growth *i.e.* 90-120 DAS and 120 DAS-maturity. The difference in CGR at 0-30 DAS were non significant and between 60-90 DAS CGR having one irrigation is significantly lower than higher levels of irrigation. However, between 60-90 days interval CGR of two irrigations and four irrigations were statistically at par.

Nitrogen application increases the CGR of late sown wheat. With advancement of crop growth between 30-60 DAS CGR increases significantly up to 100 kg N/ha. CGR at 0 Kg N/ha was significantly lower than all other doses of nitrogen at all the growth stages. The CGR at 60-90 DAS increased with each level of increase in nitrogen dose. Although, the crop responded significantly up to 50 kg N/ha during 2010-11, but during 2011-12 the CGR recorded at 200 kg N/ha was significantly higher than 50 kg N/ha. However, it was at par in 100, 150 and 200 kg N/ha. Asif *et al.* (2012) also found that CGR increases with increasing levels of irrigation and nitrogen. The increase in irrigation number from one to two, two to four and one to four irrigations increased the grain yield of wheat by about 25.1, 20.4 and 50.6 % during 2010-11 and 21.0, 21.9 and 47.5 % during 2011-12, respectively (Table 4). The maximum grain yield of 3832 and 3989 kg/ha was obtained with four irrigations which was significantly higher as compared to two irrigations and minimum in one irrigation, which was significantly lower than two and four irrigations during first and second year, respectively. The higher irrigation regimes fulfilled the timely crop water requirement and continuous availability of moisture to the crop because of frequent irrigation, which resulted into better growth ultimately grain yield. Similar results were also observed by Wang *et al.* (2012), Pradhan *et al.* (2013) and Shirazi *et al.* (2014).

The wheat grain yield increased significantly with increased dose of nitrogen. The minimum grain yield was found in control (1932 and 2026 kg/ha) and the increase in yield was significant up to 150 kg N/ha during both the years of study.

Table 1. Effect of irrigation regimes and nitrogen levels on phenophases (days) of late sown wheat

Treatments	Emergence		Heading		Anthesis		Maturity	
	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12
Irrigation levels								
One	11.4	11.2	82.8	83.9	88.1	89.2	121.2	122.7
Two	11.4	11.5	84.1	85.4	89.5	91.3	123.8	125.2
Four	11.1	11.4	87.2	87.9	92.7	94.3	127.2	128.3
CD at 5%	NS	NS	0.8	1.7	1.3	1.7	1.8	1.6
Nitrogen (kg/ha)								
0	11.7	11.8	83.5	84.5	88.4	89.9	122.3	123.5
50	11.6	11.6	84.1	85.2	89.5	91.0	123.6	124.8
100	11.3	11.4	84.7	85.8	90.2	91.6	124.1	125.3
150	11.0	11.0	85.3	86.5	90.9	92.6	125.0	126.6
200	10.8	10.9	85.8	86.8	91.5	93.0	125.4	126.9
CD at 5%	NS	NS	1.2	1.3	1.2	1.4	1.5	1.4

Table 2. Effect of irrigation regimes and nitrogen levels on leaf area index (LAI) of late sown wheat

Treatments	Leaf Area Index (LAI)							
	30 DAS		60 DAS		90 DAS		120 DAS	
	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12
Irrigation levels								
One	0.21	0.24	2.21	2.25	2.69	2.83	0.55	0.60
Two	0.24	0.25	2.17	2.32	3.39	3.45	0.69	0.70
Four	0.22	0.23	2.63	2.63	3.81	3.82	0.79	0.82
CD at 5%	NS	NS	0.23	0.15	0.23	0.16	0.15	0.16
Nitrogen (kg/ha)								
0	0.15	0.17	2.04	2.07	2.60	2.66	0.48	0.52
50	0.20	0.23	2.23	2.37	3.17	3.23	0.61	0.65
100	0.23	0.25	2.39	2.52	3.45	3.52	0.71	0.73
150	0.25	0.27	2.49	2.58	3.60	3.67	0.78	0.80
200	0.27	0.28	2.54	2.61	3.68	3.74	0.82	0.84
CD at 5%	0.05	0.03	0.28	0.20	0.20	0.23	0.12	0.09

Table 3. Effect of irrigation regimes and nitrogen levels on crop growth rate (CGR, g /m^2 /day) at different growth intervals of late sown wheat

Treatments	Days after sowing									
	0-30		30-60		60-90		120 DAS		120- Maturity	
	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12
Irrigation levels										
One	0.40	0.41	7.36	7.68	19.85	20.21	3.90	3.44	0.73	1.76
Two	0.42	0.40	7.38	7.62	21.83	21.89	4.62	4.69	2.97	3.88
Four	0.41	0.40	9.43	9.75	21.98	21.99	8.16	8.13	5.77	6.44
CD at 5%	NS	NS	0.39	0.32	0.96	1.01	1.22	0.89	1.74	1.81
Nitrogen (kg/ha)										
0	0.37	0.38	6.75	7.00	19.86	19.96	4.89	4.96	1.26	2.43
50	0.40	0.40	7.69	7.98	20.97	21.07	5.49	5.39	2.51	3.49
100	0.41	0.41	8.29	8.62	21.56	21.69	5.68	5.48	3.62	4.17
150	0.42	0.41	8.66	9.00	21.71	21.93	5.86	5.63	3.82	4.88
200	0.42	0.42	8.87	9.17	22.01	22.16	5.89	5.66	4.57	5.15
CD at 5%	0.02	0.03	0.65	0.69	1.60	0.54	1.08	1.38	1.48	1.30

Table 4. Effect of irrigation regimes and nitrogen levels on growth and grain yield of late sown wheat

Treatments	Plant height (cm)		Dry weight (g/mrl)		Grain yield (kg/ ha)		
	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12	Pooled
Irrigation levels							
One	80.8	82.5	171.4	174.1	2544	2704	2624
Two	90.9	89.6	189.3	192.6	3183	3272	3228
Four	98.8	100.5	224.4	226.9	3832	3989	3911
CD at 5%	1.8	3.4	3.1	7.5	190	183	136
Nitrogen (kg/ha)							
0	11.7	11.8	83.5	84.5	88.4	89.9	1979
50	11.6	11.6	84.1	85.2	89.5	91.0	3005
100	11.3	11.4	84.7	85.8	90.2	91.6	3549
150	11.0	11.0	85.3	86.5	90.9	92.6	3815
200	10.8	10.9	85.8	86.8	91.5	93.0	3922
CD at 5%	NS	NS	1.2	1.3	1.2	1.4	120

However, the yield of 150 kg N/ha was statistically at par with 200 kg N/ha during both years.The improvement in wheat yield and its components with increasing N rates were also obtained by Shirazi *et al.* 2014.

Conclusion

From the results of two year study during 2010-11 and 2011-12, it can be concluded that increasing irrigation regimes and N doses delay the days to heading, anthesis and physiological maturity. Grain yield improved significantly with increased irrigation regimes and nitrogen doses. Yield increased significantly up to 150 kg N/ha. Four irrigations at CRI, late tillering, heading and milking with 150 kg N/ha is the best option for getting higher wheat yield.

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