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Effect of Irrigation Stress and Nitrogen Levels on Growth, Yield and Economics of Wheat

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ABSTRACT

The results of nitrogen dose of 140 kg/ha significantly show that plant height 20 DAS (13.41 cm), 40 DAS (29.85cm), 70 DAS (63.32cm), at harvest (96.63cm), test weight 41.76 gm. respectively. Spike length 11.67cm, grain yield 36.45 q/ha, Straw yield 69.89 q/ha harvest index (105.13%) was found significantly maximum with application nitrogen level N_3 (120 kg N /ha). Significantly maximum plant height 20 DAS (13.21cm), 40 DAS (31.27cm), 70 DAS (68.95 cm), at harvest (100.95cm), spike length 11.57cm, grains per spike 48.10, test weight 43.73 gm, total produce 39 q/ha, grain yield 41.19 q/ha, Straw yield 79.21 q/ha and harvest index 105.63% was shown by I_3 (Irrigation stress at booting stage). Interaction effect of N_4 (140 kg N /ha) and I_3 (irrigation stress at booting stage) treatments shows maximum plant height 20DAS (13.68 cm), 40DAS (34 cm), at harvest 102.33cm, total produce in 42.35 q/ha, cost of cultivation Rs. 27845/ha. Significantly higher value of plant height 70DAS, spike length 13.11cm, number of grain per spike 49.10, test weight 45.38 gm., number of grain per spike 49.10, grain yield 46.12q/ha, straw yield 85.27 q/ha, harvest index (110.61 %), gross return Rs. 97483.66/ ha, net return Rs.70235/ha and benefit cost ratio 3.55 was noticed in the interaction of nitrogen level N_3 (120 kg N /ha) and I_3 (irrigation stress at booting stage) treatments as compared with other treatments. The results of this study showed that 140kg N/ha treatment and irrigation stress at booting stage individually has a great potential to increase growth parameters and 120kg N/ha has maximum benefit in yield parameters in the crop. The combination of nitrogen (120 kg/ha) and irrigation stress at booting stage fetched the highest grain yield and benefit cost ratio from wheat in comparison to other treatments.

***Key words**: Nitrogen, Irrigation, CRI, Tillering and Booting.*

Introduction

Wheat (*Triticum aestivum* L.) is cereal crop which is the staple food of major part of country and is rich in fibers and instant carbohydrates. Approximately 93.50 million tonnes of wheat is produced in India per year. About 29.8 million-hectare land in India is under the cultivation of wheat. India stands at 2nd position in wheat production in world. Due to the increasing population the country has to enhance the production of wheat to 105 million tons per annum (Anonymous, 2020). Uttar Pradesh is the largest producer of wheat. The state produces up to 300 lakh tons of wheat and area is 96 lakh ha of land in the state. In Punjab state stands at 3rd position in wheat production and it produces up to 16.08 million-tones. Water and nitrogen (N) are the main limiting factors affecting agriculturally production in arid and semiarid regions. Nitrogen is a primary plant nutrient that plays a major role in achieving the maximum economic yields. During the vegetative stage of growth, rapid expansion of the leaves requires large amounts of N and both fruit production and retention are dependent on leaf development and photosynthetic integrity (Oosterhuis *et al*., 1983).

Nitrogen (N) availability in modern wheat production is almost as important as soil water availability. Without adequate N supply, all stages of growth will be severely hindered. (Cassman *et al*., 2002). Nitrogen uptake and utilization are dependent upon soil water availability. In semi-arid regions (like western Nebraska) nitrogen uptake increases with irrigation (Ercoli*et al*., 2008). Increased N level before spike development can increase kernels per spike (Guarda*et al*., 2004). Quality is directly affected by nitrogen applications; however, the timing of the application has a significant impact on the utility of the application (Mahler *et al*., 1994).Water and nitrogen are important role in plant growth and grain production of wheat. The basic objective is to optimize nitrogen level under different irrigation regimes. This research is significant because it helps to address the challenges of wheat production variable irrigation and nitrogen availability situations.

Review of literature

Nitrogen is an essential plant nutrient that positively impacts on growth and yield when used thoughtfully. However, it must be used in balance with other potential limitations to production, particularly water. Nitrogen will have little impact on crop yield if other factors present a greater limitation. The most important one of these factors is water and/or irrigation. Water/irrigation or precipitation limitation limited nitrogen used by crops. The yield is, thus, decreased significantly. Other factors affecting nitrogen use are: sowing locally adapted cultivars at the optimum time, ensuring there is a low risk of disease, adjusting soil pH if possible to levels where it presents little or no limitation to growth, ensuring nutrients such as phosphorus, zinc and trace elements are not limiting growth, ensuring there are no subsoil constraints to root growth such as sodicity or trace element toxicity (FAO, 2019).

Thus, management of nitrogen is part of a balanced fertility program. This can lead to increased efficiency and profitability for the growers. If a drought during especially sowing season occurs, irrigation must be applied absolutely after sowing and supplemental irrigations should be at the beginning of heading and milk stages. In the drought years, the wheat grain yield was determined or limited by amount of irrigation water applied. The negative effect of early drought (before milk stage) on grain yield was more significant than that of late drought (after milk stage) (Ozturtk, 1999). Khaliq *et al*. (1999) Different NPK levels significantly affected plant height, number of fertile tillers, 1000-grain weight, grain yield and grain protein content of wheat. In cereals like wheat the stress induced due to drought at the stage of grain-filling usually shortens the grain-filling period and reduces the grain-filling rate, eventually reducing grain yield. During seed development, appropriate soil water status is of critical importance for accumulation of starch in grains and thereby formation of grain yield (Mohammadi and Moradi, 2013).

The increase in number of spike/ ear might be due to ample supply of soil moisture may lead to profuse root development. Thereby absorption of nutrients may be more at critical stages and beneficial role of water in maintaining cell turgidity, cell elongation and cell division for a longer period of growth which ultimately increased the number of spike/ ear and yield. Similar results were found by Jain (2001). Islam*et al*., 2002) concluded that nitrogen application frequencies, plots applied with nitrogen in 2 split doses i.e., 50 % at seeding time and 50 % at 2nd irrigation significantly increased number of productive tillers m^{-2}, spikelets $spike^{-1}$, grains $spike^{-1}$, grain yield, harvest index, germination % age and seed size by weight. However, nitrogen applied in full at 2nd irrigation recorded maximum biological yield.

Aliasghar *et al*. (2011) suggested that under deficit irrigation, maximum water productivity (W ET) would be achieved when 98 kg N ha^{-1} is combined with a 156 mm of supplemental irrigation. Ali *et al*. (2011) results showed that number of tillers per $unit^{-1}$, plant height, spike's length, number of grain $spike^{-1}$, 1000-grain weight and grain yield were significantly increased by increasing the nitrogen levels over control. Among nitrogen levels, highest grain yield (3.848 tons' ha^{-1}) was obtained by an application of 180kg N ha^{-1}). Compared with the irrigated condition, wheat N accumulation was significantly decreased at each growth stage under dry land cultivation. Dryland condition decreased the N absorption ratio at anthesis-maturity stage, post anthesis N accumulation and its contribution to grain N Content (Sun *et al*., 2012). Nitrogen efficiency of drought-tolerant sib-lines under drought stress was studied in pot experiments to provide knowledge on how to apply efficiently water and nitrogen in arid and semi-arid regions in China. Nitrogen efficiency ratio, nitrogen uptake efficiency, nitrogen use efficiency and nitrogen fertilizer utilization efficiency of a given variety decreased significantly with increasing drought stress. Significant reduction in grain yield as a result of the drought after flowering stage was found. However, this reduction was more distinct with lower nitrogen application in the earlier stages (Gevrek and Atasoy, 2012).

Yousaf*et al*. (2014) suggest that the irrigation timing of 25 days after germination and 120 kg N ha^{-1} is suitable for maximum growth and wheat yield. Moreover, the higher performance of yield components was associated with higher nitrogen fertilization levels. Shia *et al*. (2014) reported that each drought and irrigation cycle, the severities of drought and N deficiency were immediately alleviated under all treatments following irrigation events.

Water is essential at every developmental phase starting from seed germination to plant maturation for harvesting the maximum potential yield of wheat. There is a positive correlation between grain yield and irrigation frequencies (Kumar *et al*., 2014). Sissons, *et al.* (2014) studied that irrigation is a key measure in improving grain yield in wheat production, especially in arid and semi-arid areas. With an increase in irrigation level, wheat grain yield is significantly improved. According to Nayak *et al*. (2015), total number of tiller/plant, grain weight/ ear (cm), ear length (cm), harvest index (%) and test weight (g) were found higher under I_1 (CRI, TL, BT, FL, ML, DS) and I_4 (0.8 IW: CPE ratio) treatment. The highest grain yield and straw yield (4380 & 4538 kg /ha) was recorded under I_1 treatment followed by I_4 and I_5 treatment. However, the lowest grain and straw yield (3600 kg/ha) (4025 kg/ha) was recorded under I_2 (0.4 IW: CPE ratio) treatment. It is concluded that application of water at CRI, TL, BT, FL, ML and DS is more economic for wheat than other tested water management treatment.

Gangwar *et al*. (2018) summarized above the main conclusions are drawn: - the 120:60:60 kg NPK/ha application was found most suitable for wheat crop. The fourth irrigation was found most suitable for wheat crop. 120:60:60 kg NPK/ha application and fourth irrigation have found most suitable and economic combination for wheat crop. Singh *et al*. (2020) concluded that growth parameters, yield and yield attributes were significantly higher with I_3 (CRI, Late jointing and Milking stage) and with the application of N_3 (175 kg ha-1), on the other hand, with the application of N_2 (125 kg ha^{-1}) the yield and yield attributes were at par with N_3 (175 kg ha^{-1}).According to Jahromi, *et al*. (2023) Application of 25% deficit irrigation with 140 kg ha$^{˝1}$ nitrogen fertilizer is suggested to obtain the maximum barley production and water use efficiency under semi-arid conditions.

Material and Methods

The field experiment was conducted at the Students' Research Farm at Guru Kashi University Talwandi Sabo, during *Rabi* season of 2022-23. The experimental site is located at 29°-59'N latitude and 75°- 4'E longitude and altitude of 213 meters above sea level. This tract is characterized by semi-arid zone, where both winters and summers are extreme. Experimental soil is having pH 7.8, EC 0.21dS m-1, available N 114.25 Kg ha^{-1}, available P 8.17 Kg ha^{-1} and available K 102.56 Kg ha^{-1}. The experiment was laid out in split plot design with four replicationsand12 treatment combinations, i.e. three main treatments vis: CRI, Tillering, Booting and four sub treatments vis: Nitrogen levels 0, 60, 120 & 140 kg N/ha. The following observation were recorded: plant height, spike length, number of grains per spike, test weight, grain yield, harvest index (%) and economics. Data was analysis with the help of eda software. The data were analyzed and are presented at the 5% level of significance.

Results and Discussion

Results of the field experiments entitled "**Effect of irrigation stress and nitrogen levels on growth, yield and economics of wheat.**" areoutlined as below

Plant height (20DAS)

Data on plant height as affected irrigation stress and nitrogen level are presented in Table 4.1. The maximum plant height 20DAS (13.68 cm) was recorded from N_4 (140 kg N /ha) and I3 (irrigation stress at booting stage) treatments as compared with other treatments. While, minimum plant height 20DAS (11.40 cm) was observed in N_1 (control dose) and I_1 (irrigation stress at CRI treatments).

The mean plant height was significantly higher (13.41cm) in 140kgN/ha and minimum plant height

11.87 cm was recorded nitrogen 0kg/ha treatment. The maximum mean plant height 20 DAS 13.21 was recorded in I_3 (Irrigation stress at booting stage) and minimum plant height 20 DAS was 11.96 cm by treatment I_1 (irrigation stress at CRI stage). Our results were supported by Islam (2002) that nitrogen levels of 140 kg ha^{-1} significantly augmented plant height. The interaction effect between irrigation and nitrogen was not significant.

Plant height (40DAS)

Plant height (40 DAS) was significantly affected by nitrogen levels, irrigation stress and interaction of nitrogen levels and irrigation stress stages. Maximum plant height (40DAS) was recorded in N4 (140 kg N /ha) and I_3 (irrigation stress at booting stage) treatments as compared with other treatments. While, minimum plant height 40DAS (17.40 cm) was observed in N_1 (control dose) and I_1 (irrigation stress at CRI treatments).

The maximum average plant height (29.85) was recorded in 140 kg/ha and minimum plant average height 21.93 cm was recorded in nitrogen 0kg/ha treatment. The maximum average plant height 40 DAS 31.27cm was recorded in I_3(Irrigation stress at booting stage) and minimum plant height 40 DAS was 20.10 cm in treatment I_1 (irrigation stress at CRI stage). Similarly results have reported by Malik *et al.* (2012), Verma *et al.* (2017).

Plant height (70DAS)

The data on plant height at 70Das as affected by nitrogen levels and irrigation stress are presented in Table 4.3. The plant height was significantly of nitrogen and irrigation stress. The maximum plant height was observed 120 kgN/ha with stress at booting stage While, minimum plant height 70 DAS (45.30 cm) was observed in N_1 (control dose) and I_1 (irrigation stress at CRI) treatments, where no nitrogen was applied.

The mean plant height was significantly higher in nitrogen dose of 140 kg/ha 63.32 cm and minimum mean plant height 55.28 cm was recorded in nitrogen 0kg/ha treatment. Significantly higher plant height (70 DAS) 68.95cm was observed in I_3 (Irrigation stress at booting stage) and minimum plant height (70 DAS) was 47.76 cm in treatment I_1 (irrigation stress at CRI stage). These results were supported by Maliwal *et al.* (2000).

Plant height at harvest

Significantly maximum plant height at harvest 102.33cm was recorded in the interaction of nitrogen level N_4 (140 kg N /ha) and I_3 (irrigation stress at booting stage) treatments as compared with other treatments. While, minimum plant height at harvest (81.09 cm) was observed in N_1 (control dose) and I_1 (irrigation stress at CRI) treatments.

Table 1. Effect of irrigation stress and nitrogen levels on plant height 20 DAS of wheat.

Treatments	Nitrogen (0 kg/ha)	Nitrogen (60 kg/ha)	Nitrogen (120 kg/ha)	Nitrogen (140 kg/ha)	Mean
CRI (I_1)	11.1	11.5	12.1	13.1	11.9
Tillering (I_2)	12.8	12.5	12.8	13.4	12.7
Booting (I_3)	12.4	13.2	13.5	13.6	13.2
Mean	11.8	12.4	12.8	13.4	
Factors	I	N	I*N		
LSD (p=0.05)	0.30	0.34	NS		

Table 2. Effect of irrigation stress and nitrogen levels on plant height 40 DAS of wheat.

Treatments	Nitrogen (0 kg/ha)	Nitrogen (60 kg/ha)	Nitrogen (120 kg/ha)	Nitrogen (140 kg/ha)	Mean
CRI (I_1)	17.4	18.3	20.5	24.2	20.1
Tillering (I_2)	20.1	23.2	27.3	31.2	25.4
Booting (I_3)	28.2	30.3	32.4	34.1	31.2
Mean	21.9	23.9	26.7	29.8	
Factors	I	N	I*N		
LSD (p=0.05)	0.09	0.10	0.18		

The data on plant height as affect by nitrogen level and irrigation stress treatments is presented in Table 4. The plant height at harvest was significantly influenced by nitrogen levels, irrigation stress and interaction of nitrogen and stress treatments. The average plant height at harvest of nitrogen dose of 140 kg/ha was significantly higher 96.63 cm then other nitrogen levels. Significantly higher plant height at harvest (100.95cm) was observed in I_3 (Irrigation stress at booting stage) and lowest plant height at harvest was 84.75 cm in treatment I_1 (irrigation stress at CRI stage). Significant higher growth parameters may be due to the optimum moisture supplies under more regular irrigation treatments promoted the division and expansion of cell components and thereby stem elongation, which effectively increased the plant growth in terms of plant height The increase in plant height at level of nitrogen could be attributed to the fact that nitrogen being an essential constituent of plant tissue induced rapid cell division and cell elongation. Favorable effect of N applied up to 120 kg N ha^{-1} has been also been reported by Ali *et al*. (2011).

Spike length (cm)

The data on spike length as affected by nitrogen levels and irrigation stress is presented in table 4.5. Irrigation stress at different stages and nitrogen levels had significant effect on spike length (cm). The highest spike length 13.11cm was recorded in the interaction of nitrogen level N_4 (120 kg N /ha) and I_3 (irrigation stress at booting stage) treatments as compared with other treatments. Minimum spike length 9.08 cm was observed in N_1 (control dose) and I_1 (irrigation stress at CRI) treatments.

Significant higher value of spike length 11.67cm was found with application nitrogen level N_3 (120 kg N /ha) and at par with N_4 (140kg/ ha) 11.59 cm spike length. Maximum spike length 11.57 was recorded in irrigation stress at booting stage and it

Table 4.3. Effect of irrigation stress and nitrogen levels on plant height 70DAS of wheat.

Treatments	Nitrogen (0 kg/ha)	Nitrogen (60 kg/ha)	Nitrogen (120 kg/ha)	Nitrogen (140 kg/ha)	Mean
CRI (I_1)	45.3	47.1	48.0	50.4	47.7
Tillering (I_2)	55.2	57.4	65.3	67.4	61.3
Booting (I_3)	65.2	67.3	72.0	71.0	68.9
Mean	55.2	57.3	61.5	63.3	
Factors	I	N	I*N		
LSD (p=0.05)	0.12	0.137	0.24		

Table 4.4. Effect of irrigation stress and nitrogen levels on plant height at harvest of wheat.

Treatments	Nitrogen (0 kg/ha)	Nitrogen (60 kg/ha)	Nitrogen (120 kg/ha)	Nitrogen (140 kg/ha)	Mean
CRI (I_1)	81.0	82.2	87.4	88.3	84.7
Tillering (I_2)	90.5	93.2	97.2	99.2	95.0
Booting (I_3)	100.1	100.3	101.1	102.3	100.9
Mean	90.5	91.9	95.2	96.6	
Factors	I	N	I*N		
LSD (p=0.05)	0.16	0.18	0.32		

Table 4.5. Effect of irrigation stress and nitrogen levels on spike length (cm) of wheat.

Nitrogen Level Irrigation stress	Nitrogen (0 kg/ha)	Nitrogen (60 kg/ha)	Nitrogen (120 kg/ha)	Nitrogen (140 kg/ha)	Mean
CRI	9.0	9.4	10.2	11.5	10.0
Tillering	10.6	10.7	11.6	11.8	11.2
Booting	10.8	10.9	13.1	11.3	11.5
Mean	10.1	10.3	11.6	11.5	
Factors	I	N	I*N		
LSD (p=0.05)	0.78	0.90	0.15		

was at par with I_2 (irrigation stress at tillering stage) with spike length 11.21cm. However lowest value of spike length (10.09cm) was noticed in irrigation stress at CRI stage. These results are in line with the work of Ali *et al*. (2011) and Ram *et al.* (2013).

Number of grains per spike

The data on effect of nitrogen levels and irrigation stress on number grains per spike is given in Table 4.6. Nitrogen levels and irrigation stress affected the number of grains per spike significantly. The nitrogen levels increased the number of grains significantly upto 140kg N/ha. Maximum number of grains per spike 48.10 was recorded in irrigation stress at booting stage. However lowest number of grains per spike 40.49 was noticed in irrigation stress at CRI stage. This may be due to cause that sufficient moisture in the soil profile under three scheduling of irrigation levels, plant nutrients particularly nitrogen, phosphorus and potassium were more available and might have translocated to produce more dry matter. Similar results were reported by Pardhan*et al*. (2013).

Test weight (gm)

The data on test weight as influenced by nitrogen levels and irrigation stress is depicted in Table 4.7. Nitrogen levels and irrigation stress affected the number of grains per spike significantly. Significant higher test weight 45.38 gm was observed with application of N_3 (120 Kg /ha-) and irrigation stress at booting stage but the lowest value of test weight 37.50 gm was found with application of N_1 (0 Kg ha^{-1}) and irrigation stress at CRI stage.

Significant higher test weight 41.76 gm was observed with application nitrogen level N_4 (140 kg N /ha) at par with treatment N_3 (120kg/ha) test weight 41.62gm and the minimum test weight 39.19gm was found with nitrogen control treatment. Maximum test weight 43.73 gm was recorded in irrigation stress at booting stage. However lowest test weight 38.08 gm was noticed in irrigation stress at CRI stage. Similar results were reported by Naresh *et al.* (2014).

Grain yield (q/ha)

The data on grain yield as affected by nitrogen levels and irrigation stress are presented in Table 4.8 Nitrogen levels and irrigation stress effect was statistically significant. The interaction effect of nitrogen and irrigation stress was also significant. Interaction effect shows that significant higher grain yield 46.12q/ha was found with application of N_3 (120 Kg /ha^{-1}) and irrigation stress at booting stage but lower value grain yield 20q/ha was found with application of N_1 (0 Kg ha^{-1}) and irrigation stress at CRI stage.

Differential response of nitrogen levels was observed in respect to yield attributes; it is clear that seed yield 36.45 q/ha was found significantly higher

Table 4.6. Effect of irrigation stress and nitrogen levels on number of grains per spike of wheat.

Nitrogen Level Irrigation stress	Nitrogen (0 kg/ha)	Nitrogen (60 kg/ha)	Nitrogen (120 kg/ha)	Nitrogen (140 kg/ha)	Mean
CRI	36.2	37.3	43.2	45.1	40.4
Tillering	45.2	45.5	47.1	48.3	46.5
Booting	47.4	47.6	49.1	48.1	48.1
Mean	42.9	43.5	46.5	47.2	
Factors	I	N	I*N		
LSD (p=0.05)	0.12	0.14	0.24		

Table 4.7. Effect of irrigation stress and nitrogen levels on test weight (gm)of wheat.

Nitrogen Level Irrigation stress	Nitrogen (0 kg/ha)	Nitrogen (60 kg/ha)	Nitrogen (120 kg/ha)	Nitrogen (140 kg/ha)	Mean
CRI	37.5	37.2	38.3	39.2	38.0
Tillering	38.6	39.5	41.1	41.9	40.3
Booting	41.3	44.0	45.3	44.1	43.7
Mean	39.1	40.2	41.6	41.7	
Factors	I	N	I*N		
LSD (p=0.05)	0.40	0.47	0.81		

in 120 kg/ha nitrogen dose over 0 kg N/ha with grain yield 29.49 q/ha in control treatment. Maximum grain yield 41.19 q/ha was recorded in irrigation stress at booting stage. However lowest grain yield 21.12q/ha was noticed in irrigation stress at CRI stage. It is mainly due to sufficient supply of nitrogen nutrient for the development of plant growth which promotes for increasing per plant grain weight and their characters. The results were conformity with the finding of Chamani and Mahmoodi (2010).

Straw yield (q/ha)

The data on straw yield of wheat as affected by nitrogen levels and irrigation stress are presented in Table 4.8 Nitrogen levels and irrigation stress effect was statistically significant. The interaction effect of nitrogen and irrigation stress was also significant. Interaction effect shows that significant higher straw yield 85.27 q/ha was recorded with application of N_3 (120 Kg /ha) and irrigation stress at booting stage but lower straw yield 41.12 q/ha was found with application of N_1 (0 Kg ha^{-1}) and irrigation stress at CRI stage.

Response of nitrogen level were observed in respect to straw yield, it is clear that straw yield 69.89 q/ha was found significantly higher in 120 kg/ha nitrogen dose over 0 kg N/ha with straw yield 57.800 q/ha in control treatment. The highest maximum straw yield 79.21 q/ha was recorded with irrigation stress at booting stage. However lowest straw yield 45.73 q/ha was observed in irrigation stress at CRI stage.

Harvest index (%)

Data pertaining to harvest index as affected by various nitrogen levels and irrigation timings is presented in Table 4.10. Maximum harvest index (110.61 %) was recorded in those treatments where nitrogen levels was 120 kg/ha with combination of irrigation stress at booting stage followed by N_4 and I_3 with value of 108.26 % and the minimum harvest index (95.25 %) was observed in those treatments where no nitrogen and irrigation stress at CRI stage was applied. The results of Rajput et al 1994 collaborate with the findings obtained regarding irrigation and nitrogen effect. These the findings are also in conformity with those of Khaliq et al. 1999.

Nitrogen level up to 120kg N/ha increased to harvest index. Significant higher harvest index 105.63%was recorded in irrigation stress at booting stage. However lowest harvest index 101.32%was recorded in irrigation stress at CRI stage.

Economics

To judge the best combination of input for getting maximum output in farming business have great importance. In this connection the economics was

Table 4.8. Effect of irrigation stress and nitrogen levels on grain yield (q/ha) of wheat.

Nitrogen Level Irrigation stress	Nitrogen (0 kg/ha)	Nitrogen (60 kg/ha)	Nitrogen (120 kg/ha)	Nitrogen (140 kg/ha)	Mean
CRI	20.1	22.8	26.0	23.7	23.2
Tillering	32.1	34.2	37.1	34.2	34.4
Booting	36.1	39.2	46.1	43.2	41.1
Mean	29.3	32.1	36.4	33.7	
Factors	I	N	I*N		
LSD (p=0.05)	0.06	0.07	0.13		

Table 4.9. Effect of irrigation stress and nitrogen levels on straw yield (q/ha) of wheat.

Nitrogen Level Irrigation stress at	Nitrogen (0 kg/ha)	Nitrogen (60 kg/ha)	Nitrogen (120 kg/ha)	Nitrogen (140 kg/ha)	Mean
CRI	41.1	45.1	51.2	45.4	45.7
Tillering	62.1	66.1	73.1	68.1	67.4
Booting	70.1	77.3	85.2	84.0	79.2
Mean	57.8	62.9	69.8	65.8	
Factors	I	N	I*N		
LSD (p=0.05)	0.09	0.10	0.18		

calculated and presented in Table 4.11. Results showed that maximum cost of cultivation Rs. 27845/ha was calculated in 140 kg nitrogen level and I_3 (Irrigation stress at tillering stage). The combined effect of respective 120kg/ha nitrogen level and irrigation stress at booting stage was also computed maximum gross return RS 97483.66/ ha over other nitrogen and irrigation stress stages. Maximum net return Rs. 70235/ha was found in nitrogen level 120kg/ha and irrigation stress at booting stage and minimum net return Rs. 22000/ha from nitrogen 0kg/ha and irrigation stress at CRI stage. Economic analysis showed that maximum benefit cost ratio 3.55 was noticed in nitrogen level 120kg/ha dose with combination of irrigation stress at booting stage and lowest benefit cost ration 2.07 was found in in control treatment. The improvement in grain yield with 120kg N/ha and irrigation stress at booting stage attributed to higher net returns.

Table 4.11. Effect of irrigation stress and nitrogen levels on cost of cultivation, gross return, net return per hectare and B: C ratioof wheat.

Treatments	Cost of cultivation Rs./ha	Gross return Rs./ha	Net return Rs./ha	B:C ratio
I1 N1	20,500	42,500	22000	2.073
I1N2	22,408	48,408	26000	2.160
I1N3	23,250	55,250	32000	2.376
I1N4	22,150	50,150	28000	2.264
I2N1	22,000	68,000	46000	3.090
I2N2	25,250	72,250	47000	2.860
I2N3	28,625	78,625	50000	2.746
I2N4	24,250	72,250	48000	2.979
I3N1	27,500	76,500	49000	2.789
I3N2	27,000	82,875	55000	3.069
I3N3	27,515	97,750	70235	3.552
I3N4	27,845	92,119	65000	3.308

Summary

Effect of nitrogen levels on growth, yield and economics of wheat.

Nitrogen dose of 140 kg/ha caused significant increase in plant height at 20 DAS, 40 DAS, 70 Das and at harvest. The lowest plant height was observed at 20 DAS, 40 DAS, 70 Das and at harvest respectively 11.87 cm, 21.93cm, 55.28cm and 81cm in 0kg N/ha treatment respectively. The spike length of wheat was significantly affected by nitrogen levels and irrigation stress. The highest spike length and grains per spike was observed in N_3 (120kg N/ha) and I_3 (irrigation stress at booting stage). The lowest spike length was recorded in N_1 (0kg N/ha) and I_1 (irrigation stress at CRI).Test weight of what grains was also significantly by nitrogen levels and irrigation stress treatments.Maximum grain yield 41.19 q/ha, Straw yield 79.21 q/ha and harvest index 105.63% was recorded in irrigation stress at booting stage. However lowest grain yield 21.12q/ha was noticed in irrigation stress at CRI stage.

Interaction effect of nitrogen levels and irrigation stress stages on growth, yield and economics of wheat.

Maximum plant height 20DAS (13.68 cm), 40DAS (34 cm) and at harvest (102.33 cm) was recorded from N_4 (140 kg N /ha) and I_3 (irrigation stress at booting stage) treatments. Minimum plant height 20DAS (11.40 cm) was observed in N_1 (control dose) and I_1 (irrigation stress at CRI treatments, where no nitrogen was applied. Significantly higher value of plant height 70DAS was noticed in the interaction of nitrogen level N_3 (120 kg N /ha) and I_3 (irrigation stress at booting stage) treatments as compared with other treatments. While, minimum plant height 70DAS (45.30 cm) was observed in N_1 (control dose) and I_1 (irrigation stress at CRI) treatments, where no nitrogen was applied.

Significantly maximum spike length 13.11cm, grains per spikeand test weight 45.38 gmwas recorded in the interaction of nitrogen level N_4 (120 kg N /ha) and I_3 (irrigation stress at booting stage) and

Table 4.10. Effect of irrigation stress and nitrogen levels on harvest index (%)of wheat.

Nitrogen Level Irrigation stress	Nitrogen (0kg/ha)	Nitrogen (60kg/ha)	Nitrogen (120kg/ha)	Nitrogen (140kg/ha)	Mean
CRI	95.2	98.6	103.2	107.2	101.0
Tillering	106.4	106.4	103.0	96.8	103.2
Booting	102.2	106.4	110.6	108.2	106.8
Mean	101.3	103.8	105.6	104.1	
Factors	I	N	I*N		
LSD (p=0.05)	0.29	0.33	0.58		

N_3 (120 Kg /ha-) with irrigation stress at booting stage respectively treatments as compared with other treatments. Minimum spike length 9.08 cm was observed in N_1 (control dose) and I_1 (irrigation stress at CRI) treatments.

Interaction effect shows that significant higher grain yield 46.12q/ha, straw yield 85.27 q/haand harvest index (110.61 %) was found with application of N_3 (120 Kg /ha-) with irrigation stress at booting stage but lower value grain yield 20q/ha was found with application of N1 (0 Kg ha^{-1}) and irrigation stress at CRI stage.

Economics

Result showed that maximum cost of cultivation Rs. 27845/ha was calculated in 140 kg nitrogen level and I_3 (Irrigation stress at booting stage). The combined effect of respective 120kg/ha nitrogen level and irrigation stress at booting stage was also computed maximum gross return Rs. 97483.66/ ha over other nitrogen and irrigation stress stages. Maximum net return Rs.70235/ha was found in nitrogen level 120kg/ha and irrigation stress at booting stage and minimum net return Rs. 22000/ha from nitrogen 0kg/ha and irrigation stress at CRI stage. It is mostly due to superior grain yield (q/ha) recorded under the respective nitrogen level and irrigation schedule. Economic analysis showed that maximum benefit cost ratio 3.55 was noticed in nitrogen level 120kg/ha dose with combination of irrigation stress at booting stage and lowest benefit cost ration 2.07 was found in in control treatment.

Conclusion

It concluded that the nitrogen level120kg N/ha resulted in maximum in yield and economics in wheat, which was significantly higher than theother nitrogen levels. Irrigation stress at booting stage recorded the best growth parameters and yield among the other irrigation stress stages. With the treatment: Irrigation stress at booting stage + Nitrogen 120 Kg/ hashows significant effect on growth, yield and economics of wheat.

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