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Effect of irrigation regimes & levels of nitrogen on growth & yield of wheat crop (*Triticum aestivum* L.)

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Abstract
A field experiment was conducted during rabi season of 2022-23 on loamy sand of in the rural area of Kanpur district of Mandhana, located 10 km from Kanpur in Uttar Pradesh to Effect of irrigation regimes & levels of nitrogen on growth & yield of wheat crop (*Triticum aestivum* L.).The soil was normal in pH of 7.65, electrical conductivity (EC) of 0.27 dSm^{-1}, organic carbon content of 0.41%, and available nutrients including nitrogen (N), phosphorus (P), and potassium (K) at levels of 217.0, 19.5, and 149.50 kg ha^{-1}, respectively. The experiment was laid out during Rabi season of 2023-24. The experiment consisted of 16 treatment combinations, was laid out in Split plot Design (SPD) with three replications.

Keywords: Irrigation, nitrogen, wheat

Introduction

A staple food consumed worldwide, wheat (*Triticum aestivum* L.) is a member of the Poaceae (Gramineae) family. The most significant cereal crop that is regarded as a crucial part of many countries' food security systems is wheat. Because of its large acreage and high productivity, it has been referred to as the "King of cereals" and holds a significant position in the global food grain trade.

Ninety-five percent of wheat is produced from bread wheat, four percent is produced from durum wheat, and only one percent is produced from dicoccum wheat.

Different products such as pasta, bread, biscuits, and chapatti require different qualities of wheat. To make good bread, hard wheat (*T. aestivum*) with strong and extensible gluten and high protein content is necessary. Hard wheat (*T. durum*) with strong gluten, high protein, low incidence of yellow berries, and high content of yellow pigment (β-carotene) is needed for pasta products. Twenty percent of calories and almost half of all carbohydrates come from wheat, which is a staple food consumed by two billion people (36% of the world's population). It is claimed that wheat has more nutrients than the other cereals when consumed as food. With 12.1 percent protein, 1.8 percent lipids, 1.8 percent ash, 2.0 percent reducing sugars, 6.7% pentose, and 314 calories per 100 grams of food, it has a good nutritional profile. In addition, wheat contains significant amounts of the following vitamins and minerals: riboflavin (0.13 mg/100 g), calcium (37 mg/100 g), iron (4.1 mg/100 g), thiamine (0.45 mg/100 g), and nicotinic acid (5.4 mg/100mg). In contrast to other cereals, wheat has a high gluten content, which is the protein that gives bread the elasticity needed to bake it to perfection. Hard wheat is especially good for yeast breads because it produces flour with a high gluten content and has a high protein content (10–17%) Dubey (2018) [1].

According to USDA report 2022-23, wheat is the most produced cereal in the world, accounting for 219.51 million hectares of area and 758.02 million tons of production. It is grown on 30.70 million hectares of land in India, where it produces 98.51 million tonnes of goods annually at an average productivity of 3200 kg ha^{-1}. Agricultural Statistics at a Glance 2022-23) states that Uttar Pradesh ranks first in terms of area (9.67 million hectares) and production (33.66 million tons). However, the productivity of Uttar Pradesh is significantly lower than that of Punjab and Haryana (4.50 tons ha^{-1}).

Although water is a crucial input, it is a limited resource for irrigation, so making effective use of irrigation water is crucial. The most efficient use of irrigation water results in higher yields per unit area and time, as well as better utilization of all other production factors. According to Kumar *et al*. (2019) [2], comprehensive research on plant-water relationships, climate, agronomic techniques, and economic analysis are necessary for effective water management. Because the weather is relatively dry during the growing season, irrigation is more important when growing high-yielding wheat varieties. Wheat yield and crop growth are significantly impacted by timely irrigation at the appropriate time.

For wheat to grow and develop properly, the root zone needs to have a suitable level of soil moisture. Wheat yield is significantly impacted by the soil's extractable water capacity, according to Verma *et al*. (2017) [5]. Maintaining the maize-wheat cropping sequence and combining limited irrigation water with N fertilizer is the best management option for N and irrigation levels in conditions of scarce rainfall and minimal irrigation, as it maximizes wheat M productivity. Montazar along with M. Mohseni (2016) [3]. Irrigation is a crucial strategy for increasing grain yield in wheat production, particularly in arid and semi-arid regions, according to reports from Rajala *et al*. (2018) [4] and Qui *et al*. (2016) [6]. Increased irrigation levels result in significantly higher wheat grain yields. It has been observed that early tillering, jointing, heading, and flowering—critical stages of wheat growth—increase spike number, fertile florets, and heavier single grain weight.

According to Mohammad *et al*. (2017) [7], irrigation is just as important as fertilizers in maximizing the yield potential of high-yielding wheat varieties. Only in guaranteed irrigated conditions can the best benefits of fertilizer application at its optimal dose be realized. It has been well established that dwarf wheat produces their potential yield when it is irrigated at all critical stages of plant growth *viz*. The initiation of crown roots, tardy tillering, delayed jointing, blossoming, milking, and dough stage. According to Naseri *et al*. (2015) [10], irrigation at the CRI stage is crucial. Nevertheless, forced maturity brought on by high temperatures, inadequate water, nutrient and pest management, and yearly droughts in some areas of the nation have severely impacted the crop's growth and field. According to Tunio *et al*. (2020) [8], the growing season's increased moisture scarcity may have had a negative impact on plant growth and development, which could account for the low yield.

Proteins, phytochromes, compounds, coenzymes, chlorophyll, and nucleic acids are all dependent on nitrogen Yadav *et al*. (2018) [9]. Higher doses of nitrogen, however, can occasionally be toxic and impair plant growth by increasing lodging susceptibility, which pollutes the environment through nitrate leaching and volatilization in the form of ammonia. Additionally, Malik *et al*. (2021) [11] suggested that only one-third of applied nitrogenous fertilizer is absorbed by cereal crops and assimilates into their grains. Because nitrogen plays a crucial role in promoting both vegetative and reproductive growth, wheat requires the addition of nitrogen fertilizer to ensure that nitrogen is available throughout the growing season. However, wheat is highly susceptible to water stress. It therefore requires regular irrigation to ensure healthy growth and yield. Researchers looked at how nitrogen fertilizer and irrigation affected spring wheat's grain yield and protein content in combination. They discovered that while grain yield responded strongly to nitrogen applied at the seedling stage, grain protein content only increased with nitrogen application after the start of stem elongation. According to reports, water stress causes a noticeable change in the metabolism of nitrogenous compounds (Kumar., A.E. (2019) [2] added that protein synthesis is one of the biochemical processes that is impacted by water stress and is closely linked to proline accumulation. Water stress also caused some disruptions in nitrogen metabolism.

The best combination for maximizing wheat grain yield was 150 kg N ha^{-1} and the soil water deficit, as reported by Karamet *et al*. (2016) [12]. To maximize fertilizer efficiency and minimize water loss, irrigation and fertilization levels are crucial.

Materials and Methods

A field experiment was conducted during rabi season of 2022-23 on loamy sand of in the rural area of Kanpur district of Mandhana, located 10 km from Kanpur in Uttar Pradesh to Effect of irrigation regimes & levels of nitrogen on growth & yield of wheat crop (*Triticum aestivum* L.). The soil was normal in pH of 7.65, electrical conductivity (EC) of 0.27 dSm^{-1}, organic carbon content of 0.41%, and available nutrients including nitrogen (N), phosphorus (P), and potassium (K) at levels of 217.0, 19.5, and 149.50 kg ha^{-1}, respectively. The experiment was laid out during Rabi season of 2023-24. The experiment consisted of 16 treatment combinations, was laid out in Split plot Design (SPD) with three replications. IRRIGATION REGIMES (I0No Irrigation, I1One Irrigation at CRI Stage, I2Two Irrigation at CRI, and Late Jointing, I3Three irrigations at CRI, Jointing and Booting Stage) Level of Nitrogen (kg/ha) (N0-0, N1 60, N2 120, N3 180) data were gathered on five plants chosen from each plot. END

Results and Discussion

Yield attributes parameter

Length of Spike (cm)

The length of the spike was statistically affected by the irrigation regimes; from one to three irrigation levels, the length of the spike increased. In comparison to the second irrigation at CRI, late jointing, and first irrigation at CRI stage, the maximum length of spike (9.68) was observed under three irrigation conditions: CRI, booting, and Late Jointing. With no irrigation, the shortest spike length (5.16) was recorded. Application of nitrogen had a significant impact on spike length (9.99 cm), with 180 kg N/ha applied, compared to the lowest values of spike length (4.80 cm) recorded by the remaining treatment crops without nitrogen.

No of spike lets spike^{-1}

Three irrigations at CRI, Booting, and Late Jointing produced the maximum spikelet's spike-1 (45.19), which was better than two irrigations at CRI, late jointing, and first irrigation at CRI stage. With no irrigation, the lowest spikelet's spike-1 (32.14) was recorded.

Notably, the application of 180 kg/ha resulted in significantly higher values of all yield attributes, including the number of spikelets spike-1 (46.19), when compared to the remaining treatments, with the exception of 120 kg N/ha. The crop with the lowest number of spikelets per spike-1 (35.60) was the one without nitrogen.

No of Spike/m^2

In comparison to the second irrigation at CRI, the late jointing and first irrigation at CRI stage, the maximum No of Spike /m2 (311.75) was observed under three irrigation at CRI, Booting, and Late Jointing. With no irrigation at first, the lowest number of spikes per square meter (273.61) was recorded. In comparison to all other treatments, with the exception of 120 kg N/ha

(305.17), the maximum number of spikes per square meter was recorded when 180 kg/ha (308.70) was applied. The crop with the lowest values of (220.16) was the one without nitrogen.

No. of grain/Spike

In comparison to the second irrigation at CRI, the late jointing and first irrigation at CRI stage, the maximum number of grain/spike (45.19) was observed under three irrigations at CRI, booting, and late jointing. With no irrigation, the lowest amount of grain/spike (32.14) was recorded. Interestingly, when 180 kg/ha was applied, the number of grains per spike (46.69) was significantly higher than when all other treatments combined (120 kg N/ha). The crop with the lowest number of grains per spike (24.80) was the one without nitrogen.

Grain weight (g)/Spike

In comparison to the second irrigation at CRI, the late jointing and first irrigation at CRI stage, the maximum grain weight (g)/spike (1.47) was observed under three irrigation conditions at CRI, Booting, and Late Jointing. Without irrigation, the lowest grain weight (g)/spike (1.35) was measured. Nitrogen application had a significant impact on grain weight (g)/spike (1.46), which was recorded when 180 kg/ha was applied as opposed to the other treatments (120 kg N/ha and below). The crop with the lowest Grain Weight (g)/Spike (1.32) was the one that did not receive nitrogen.

Test weight (g)

The highest test weight (g) (41.26) was noted during the three irrigation stages at CRI: Booting, Late Jointing, and CRI. This was better than the second irrigation stage at CRI, as well as the late jointing and first irrigation stages at CRI. With no irrigation, the lowest test weight (g) of 33.10 was recorded. In comparison to all other treatments, with the exception of 120 kg N/ha (38.43), the application of 180 kg N/ha (40.98) resulted in the Maximum Test Weight being recorded. The crop with the lowest values, 35.06, was the one without nitrogen.

Grain yield (qha^{-1})

In comparison to the second irrigation at CRI, the late jointing and the first irrigation at CRI stage, the maximum grain yield (qha^{-1}) (45.47) was noted under three irrigations at CRI, booting, and late jointing. Without irrigation, the lowest grain yield (qha^{-1}) (32.60) was observed.

Increased effective tillers and test weight were also responsible for the maximum grain yield that was observed under three irrigation conditions at CRI, Booting, and Late Jointing. Additionally, higher plant water status, stomatal conductance, and leaf area index under increased irrigation frequency may have led to a higher rate of photosynthesis and a higher translocation of photosynthate from various plant organs to the developing grains. Different nitrogen levels had a statistically significant impact on the yields. The application of nitrogen significantly increased the grain yield, straw yield, and biological yield over control, according to the results. However, the application of 180 kg N/ha produced the highest grain yield (42.96 qha^{-1}), straw yield (63.58 qha^{1}), and biological yield (106.54 q/ha), surpassing all other levels of nitrogen except 120 kg N/ha at crop harvest.

Straw yield (qha^{-1}

In comparison to the second irrigation at CRI, the late jointing and first irrigation at CRI stage, the maximum straw yield (qha^{-1}) (63.66) was observed under three irrigations at CRI, booting, and late jointing. Without irrigation, the lowest straw yield (qha^{-1}) (36.41) was observed. ultimately connected to development and growth, and thus high yield of straw. When 180 kg of nitrogen were applied per hectare, a notable increase in straw yield (63.58 qha^{3}) was observed. The reported minimum straw yield was 0 N kg/ha (30.85).

Biological yield (qha^{-1})

Under three irrigation techniques at CRI, Booting, and Late Jointing, the maximum Biological yield (qha^{-1}) (109.65) was observed. This was superior to the second irrigation technique at CRI, late jointing, and first irrigation at CRI stage. Without irrigation, the lowest biological yield (qha^{-1}) of 63.99 was observed. The highest biological yield (qha^{-1}) (97.01) among the nitrogen practice levels was recorded at 180 kg/ha (106.54), while the lowest yield (qha^{-1}) (50.40) was recorded at 0 kg/ha.

Harvest index (%)

In comparison to one CRI stage, two irrigations at CRI and Late Jointing (I2), and three irrigations at CRI + Late Jointing + Booting stage (I3), the maximum Harvest index (%) (43.10) was recorded under one irrigation. The minimum Harvest index (%) of 40.65, as noted with late jointing and two irrigation CRI. Applying 180 kg N/ha resulted in the highest harvest index (42.15) being recorded. when 0 kg N/ha was applied, the minimum harvest index (38.79%) was noted. With a higher amount of nitrogen, the dry matter partitioning has proven effective, raising the harvest index.

Table 4.5: Yield attributing characters of wheat as affected by irrigation regimes and Level of Nitrogen at different growth stage

Treatment	No. of	Spike length	No of spikelets	No. of grains	Grain Weight	Test
Irrigation Regimes	**spike m^{-2}**	**(cm)**	**spike^{-1}**	**spike^{-1}**	**(g)/spike**	**weight (g)**
No irrigation	273.61	5.16	32.14	33.45	1.35	33.10
One irrigation at CRI Stage	292.14	7.15	38.45	40.15	1.42	35.23
Two irrigation at CRI + late jointing	304.58	8.62	42.12	42.59	1.45	38.12
Three irrigation at CRI + late jointing + Booting Stage	311.75	9.68	45.19	45.89	1.47	41.26
SEm±	2.35	0.25	1.02	1.09	0.008	0.21
CD at 5%	7.17	1.00	3.07	3.20	0.02	0.63
Level of Nitrogen (kg/ha)						
0	220.16	4.80	35.60	24.80	1.32	35.06
60	301.90	6.05	40.35	34.15	1.36	36.10
120	305.17	8.57	43.91	41.59	1.43	38.43
180	308.70	9.99	46.17	46.69	1.46	40.98
SEm±	0.29	0.47	0.75	1.70	0.01	0.85
CD at 5%	0.86	1.42	2.26	5.10	0.03	2.55

Table 4.6: Grain, straw and biological yield (q/ha) and harvest index (%) as affected by irrigation regimes and Level of Nitrogen

Treatment	Days after sowing			
Irrigation Regimes	**Grain yield**	**straw yield**	**biological yield**	**Harvest index**
No irrigation	27.58	36.41	63.99	43.10
One irrigation at CRI Stage	38.66	51.80	90.46	42.74
Two irrigation at CRI + late jointing	42.54	62.11	104.65	40.65
Three irrigation at CRI + late jointing + Booting Stage	45.47	63.66	109.13	41.67
SEm±	0.60	0.96	1.56	0.14
CD at 5%	1.79	2.88	4.67	1.02
Level of Nitrogen (kg/ha)				
0	19.55	30.85	50.40	38.79
60	26.48	37.07	63.55	41.67
120	35.80	50.84	86.64	41.32
180	42.96	58.96	101.92	42.15
SEm±	0.70	0.99	1.69	2.30
CD at 5%	2.10	2.99	5.09	N.S

Conclusion
The crop was irrigated three times at CRI; the late jointing and booting stage produced the highest growth, yield attributes, and yield, with two irrigations following. Compared to then, the highest growth, yield attributes, and yield were obtained with N applied at a rate of 180 kg/ha.

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