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Research Article

Enhancing productivity through effective irrigation and nitrogen scheduling in wheat (*Triticum aestivum* L.)

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Abstract

This study investigates the impact of irrigation and nitrogen scheduling on wheat yield and quality. Conducted over one growing season, the research explores how different irrigation regimes and nitrogen application timings influence key agronomic parameters such as growth and yield of wheat crop. The present research "Enhancing productivity through effective irrigation and nitrogen scheduling in wheat (*Triticum aestivum* L.)" was carried out at Experimental Farm, Department of Agriculture, Mata Gujri College, Fatehgarh sahib, Punjab, India, during *Rabi* season of 2019-20. The experiment was laid out in split plot design with twelve treatment combinations and the treatments were replicated thrice. The growth parameters viz., number of plants in running meter, plant height (cm), dry matter accumulation (g/25 cm row length), leaf area index and yield attributes viz., number of grains/spike, spike length (cm), weight of spike (g), as well as crop yield were maximum under irrigation schedule I_4- First irrigation at CRI, second at tillering, third at flowering and fourth at milking stage, which was at par with I_3- First irrigation at CRI, second at tillering, third at late jointing and forth at milking stage. In nitrogen scheduling, highest growth and yield parameters were observed in N_3- 25 % as basal dose + 25 % at CRI + 25 % at late jointing stage + 25 % at flowering stage which was at par with N_2- 50% as basal dose + 25% after first irrigation + 25% at flowering stage and significantly superior over N_1. Optimal nitrogen timing, in conjunction with precise irrigation, improves nitrogen use efficiency and reduces environmental impacts. This study provides valuable insights into best practices for resource management in wheat cultivation, aiming to maximize productivity while minimizing ecological footprint.

Keywords: Wheat, Irrigation, Nitrogen, Scheduling

1. Introduction

Wheat (*Triticum aestivum* L.) belongs to family *Poaceae* (*Gramineae*) grown for the grain purpose worldwide. It assumes worldwide significance owing to its utilization as a human food and livestock feed and is the most important crop of the northern India (Singh *et al.*, 2017). Wheat is an excellent source of nutrition in terms of carbohydrates, minerals, protein and is unique among all the cereal grains as its flour makes a cohesive mass of dough when mixed with water which can be moulded to make innumerable products (Pal *et al.,* 2010). Wheat flour is used to prepare bread, produce biscuits, noodles, confectionary products and vital wheat gluten . Wheat is also used as animal feed, for ethanol production, brewing of wheat beer, wheat based raw material for cosmetics, wheat protein in meat substitutes and to make wheat straw composites. It contains carbohydrate 70.10%, protein 11-12%, fat 2.10%, minerals 2.10%, α and β carotene (Katyayan, 2021).

Irrigating the crop only at drought sensitive stages and declined application of water at other stages can help to manage water resources to meet crop requirement (Du *et al.*, 2010). The moisture content in the soil gradually decreases with time in dry season and simultaneously soil moisture tension increases. Excessive irrigation increases evapo-transpiration and decreases water use efficiency and may also reduce grain yield. Limited irrigation is an important constraint for wheat production in rainfed, tropical, arid and semi-arid regions (Shirazi *et al.*, 2014). Irrigation schedules at crown root initiation +tillering + jointing + flowering + milky + dough stages recorded maximum effective tillers at harvest, total dry matter production, leaf area index, the mean ear length, number of grains per ear, 1000 grain weight (Ahmad and Kumar, 2015). Singh *et al.*, (2020) reported that growth parameters, yield and yield attributes were recorded significantly higher with I_3 (CRI, Late jointing and Milking stage).

Nitrogen plays a vital role in all living tissues of the plant. All vital processes in the plant are associated with protein of which nitrogen is essential constituent. Nitrogen is constituent of proteins, enzymes, coenzymes, nucleic acids, phytochromes and chlorophyll (Yousaf *et al.*, 2014). Split application of N is one of the methods to improve N use by the crop while reducing the nutrient loss through leaching, denitrification, runoff and volatilization. So to maintain crop growth and yield, it is important to reduce nitrogen losses, Therefore, split application of nitrogen in proper propositions as per crop demands is an effective tool (Amani *et al.*, 2020). Irrigation and nitrogen management are crucial factors affecting wheat growth and productivity. Proper scheduling of these inputs can enhance nutrient use efficiency, reduce waste, and optimize crop performance. Effective irrigation and nitrogen scheduling are critical for optimizing wheat production. This paper explores the interplay between irrigation management and nitrogen application, examining how various scheduling practices affect wheat yield, quality, and resource use efficiency. Through a review of recent studies and field experiments, we highlight best practices for integrating these two components to enhance sustainable wheat cultivation. The findings indicate that synchronized irrigation and nitrogen scheduling can significantly improve crop performance and reduce environmental impacts.

2. Material and methods

A field experiment was conducted at research farm of Mata Gujri College, Shri Fatehgarh Sahib, Punjab, India, during the *Rabi* season of 2019-20. The experiment was laid out in split plot design with four irrigation schedules and three spits of nitrogen i.e. total twelve treatment combinations replicated thrice.

The treatment details are as:

Main plot- Irrigation scheduling, I_1- First irrigation at CRI, I_2- First irrigation at CRI, second at tillering stage, I_3- First irrigation at CRI, second at tillering and third at late jointing stage, I_4- First irrigation at CRI, second at tillering, third at flowering and fourth at milking stage and

Sub plot- Nitrogen scheduling, N_1- 50 % nitrogen as basal dose + 50% after first irrigation, N_2- 50% as basal dose + 25% after first irrigation + 25% at flowering stage, N_3- 25% as basal dose + 25% at CRI + 25% at late jointing stage + 25% at flowering stage. The soil of experimental field was clay loam texture with pH 7.32. It was moderately fertile with available nitrogen (297.92 kg ha^{-1}), available phosphorus (10.304 kg ha^{-1}), available potassium (370.496 kg ha^{-1}), Organic carbon (0.95 %) and Electrical conductivity (0.32 dS m^{-1}). The sowing of wheat variety 'PBW725' was done in the field on November 20^{th} 2019.

The wheat crop was sown using seed 100 kg ha^{-1} at row to row spacing of 22.5 cm with the help of hand seed drill. The recommended dose of fertilizers for wheat crop is 120, 60 and 40 k ha^{-1} of N, P_2O_5 and K_2O respectively. Full dose of P and K fertilizers were applied at sowing time and nitrogen was applied as per the treatments in different sub plots. First dose of nitrogen was applied as basal dose; second dose was applied at CRI, third dose of nitrogen applied at late jointing and fourth at flowering stage in different plots in combination with irrigation. Pre-sowing irrigation was applied before sowing. After that irrigations were applied as per the treatments. First irrigation was applied at 21 days after sowing i.e. at CRI stage, second irrigation was applied at tillering stage, third at late jointing and flowering stage and fourth irrigation was applied at milking stage in different main plots. For effective weed control Pendimethalin @ 1 kg ha^{-1} was sprayed in the evening after one day of sowing, while

Hand weedings were done at 15 days interval from sowing to harvest of crop. All the package of practices and plant protection measures were followed timely to ensure good crop stand. All the experimental plots were sprayed with confidor @300 ml ha^{-1} to protect the crop from aphids. The crop was harvested manually with the help of sickle on 18th April, 2020 when the spikes and straw colour changed into green to yellow and grains were fully ripened and then tied into labeled bundles. The sun dried weight of bundles was recorded. The threshing of crop was done with the help of tractor drawn thresher. Thus, grain yield of each plot was recorded as kg $plot^{-1}$ and then converted into q ha^{-1}. Regular biometric observations were recorded at periodic intervals of 30, 60, 90 DAS and at harvest stage. Yield parameters were recorded just before the harvesting of crop. The grain yield of each plot was recorded and converted in hectare. Statistical analysis was done as per the procedures given by Gomez and Gomez (1984).

3. Result and discussion

3.1 Effect of irrigation and nitrogen scheduling on growth of crop

The result of the present study indicated that the growth parameters of plants such as number of plants in running meter, plant height, dry matter accumulation and leaf area index were significantly affected by irrigation and nitrogen scheduling.

Among the irrigation scheduling highest number of plants in running meter, plant height, dry matter accumulation and leaf area index was observed in treatment I_4 -First irrigation at CRI, second at tillering, third at flowering and fourth at milking stage followed by I_3 -First irrigation at CRI, second at tillering, third at late jointing stage.

Due to availability of well distributed soil moisture at different growth stages due to irrigation probably enhanced the growth of plant. It is evident from several studies that increase in plant height at higher moisture regimes might be due to maintenance of adequate and continuous moisture to plant which maintained good establishment of roots and various metabolic processes. Significantly 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. These results are in understanding with those reported by Verma *et al., (*2017), Maliwal *et al.*, (2000).

Table 1: Effect of irrigation and nitrogen scheduling on growth attributes at harvest stage

Treatments	Number of plants in running meter	Plant height (cm)	Dry matter accumulation (g/25 cm row length)	Leaf area index
	20 DAS	At Harvest	At harvest	90 DAS
Main plot (Irrigation scheduling)				
I1	20.67	90.94	111.05	3.10
I2	21.33	94.68	113.61	3.31
I3	23.00	97.35	126.47	3.42
I4	26.33	102.17	132.37	4.03
SEm±	0.92	1.54	1.91	0.14
CD (P= 0.05)	NS	6.04	7.52	0.54
Sub plot (Nitrogen scheduling)				
N1	24.92	93.46	108.49	3.24
N2	22.00	94.47	125.77	3.41
N3	21.58	100.92	128.37	3.75
SEm±	0.83	1.95	5.13	0.12
CD (P= 0.05)	2.43	5.69	14.96	0.35

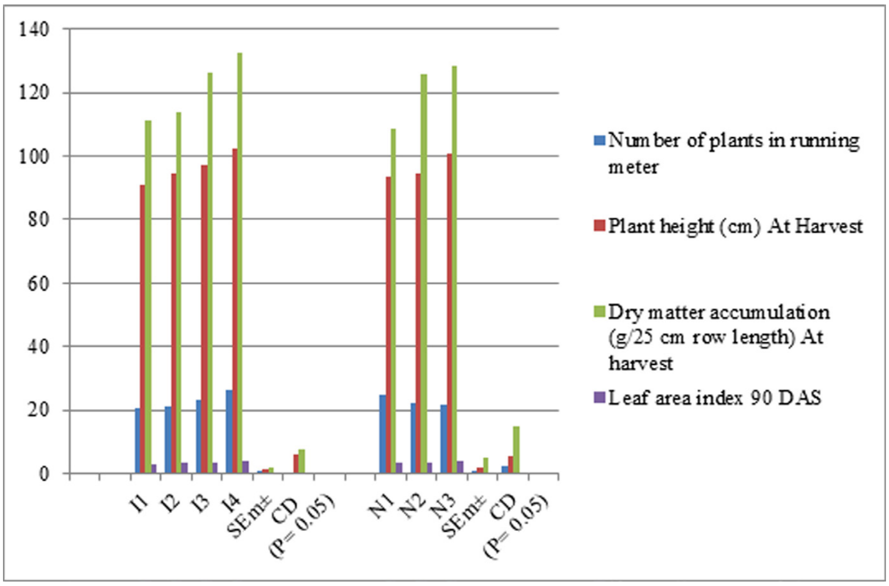

Fig 1: Effect of irrigation and nitrogen scheduling on growth attributes at harvest stage

Among the nitrogen scheduling the highest number of plants in running meter, plant height, dry matter accumulation, leaf area index was observed in treatment N_1 - 50 % nitrogen as basal dose + 50% after first irrigation followed by N_2- 50% as basal dose + 25% after first irrigation + 25% at flowering stage at 30 DAS. Nitrogen fertilizers are essential for growth of plants. Higher value of growth attributes can be attributed to the availability of higher dose of nitrogen at initial growth stages that result in increased growth of plants and biomass production as well as dry matter accumulation at 30 DAS. Similar results were obtained by Kadam *et al.*, (2019) and Akhter *et al.*, (2017).

At 60, 90 and at harvest stage highest growth parameters were observed in treatment N_3- 25% as basal dose + 25% at CRI + 25% at late jointing stage + 25% at flowering stage followed by N_2- 50% as basal dose + 25% after first irrigation + 25% at flowering stage. It may be due to supply of proper amount of N at different growth stages. The N promotes plant growth, increase the number and length of internodes which resulted in taller plants and better growth attributes Amani *et al.*, (2020).

3.2 Effect of irrigation and nitrogen scheduling on yield attributes of crop

Among the irrigation schedules the maximum grains per spike, weight of spike and spike length were recorded in treatment I_4- First irrigation at CRI, second at tillering, third at flowering and fourth at milking stage followed by I_3- First irrigation at CRI, second at tillering, third at late jointing stage. This is because of optimum availability of water at all critical stages of crop growth that provides all available nutrients from the soil. Besides this, it maintained chlorophyll content of wheat or leaves and plant remain stay-green for longer period of time that helped higher photosynthesis of crop through better assimilation of carbon from atmosphere that favours the growth of wheat plant. Therefore, it helps in improving yield attributing characters. Chaplot and Sumeriyan., (2013) also reported similar results.

In nitrogen schedules the maximum grains per spike, weight of spike and spike length were recorded in treatment N_3- 25% as basal dose + 25% at CRI + 25% at late jointing stage + 25% at flowering stage followed by N_2- 50% as basal dose + 25% after first irrigation + 25% at flowering stage. It might be due to sufficient availability of nitrogen during tillering stage that leads to increased number of tillers/m^2 and hence increased the number of spikes/m^2. The positive role of nitrogen in increasing the protein and carbohydrate content of grain and in grain-filling process increased the 1,000-grain weight and the grains/spike. Similar results were obtained by Abedi *et al.*, (2011).

3.3 Effect of irrigation and nitrogen scheduling on yield of crop

Maximum crop yield was observed in treatment I_4- First irrigation at CRI, second at tillering, third at flowering and fourth at milking stage followed by I_3- First irrigation at CRI, second at tillering, third at late jointing stage and significantly superior to other treatments. This is because of higher growth as well as yield attributing characters under these treatments which ultimately favours yield. Biological yield of wheat is the total biomass weight of the crop including straw, grain etc. This might be attributed to maintenance of favorable soil moisture balance in the crop root zone resulting in higher biomass production. Similar results were found by Shivani *et al.*, (2003) and Maliwal *et al.*, (2000).

Table 2: Effect of irrigation and nitrogen scheduling on yield attributes and yield of crop

Treatments	Number of grains/ spike	Weight of spike (g)	Spike length (cm)	Grain yield (q/ha)	Straw yield (q/ha)	Biological yield (q/ha)
Main plot (Irrigation scheduling)						
I1	58.24	3.82	10.69	42.10	56.21	98.31
I2	63.21	3.76	10.80	45.75	57.92	103.67
I3	65.25	4.26	11.12	48.82	61.72	110.54
I4	68.32	4.61	12.59	51.99	63.38	115.37
SEm±	1.36	0.11	0.27	1.35	1.11	1.48
CD (P= 0.05)	5.35	0.45	1.05	5.29	4.35	5.80
Sub plot (Nitrogen scheduling)						
N1	59.71	3.81	10.64	43.29	56.79	100.08
N2	65.37	4.20	11.05	48.79	58.08	106.86
N3	66.18	4.33	12.21	49.42	64.56	113.98
SEm±	1.66	0.12	0.38	1.52	2.00	2.37
CD (P= 0.05)	4.85	0.36	1.12	4.42	5.84	6.92

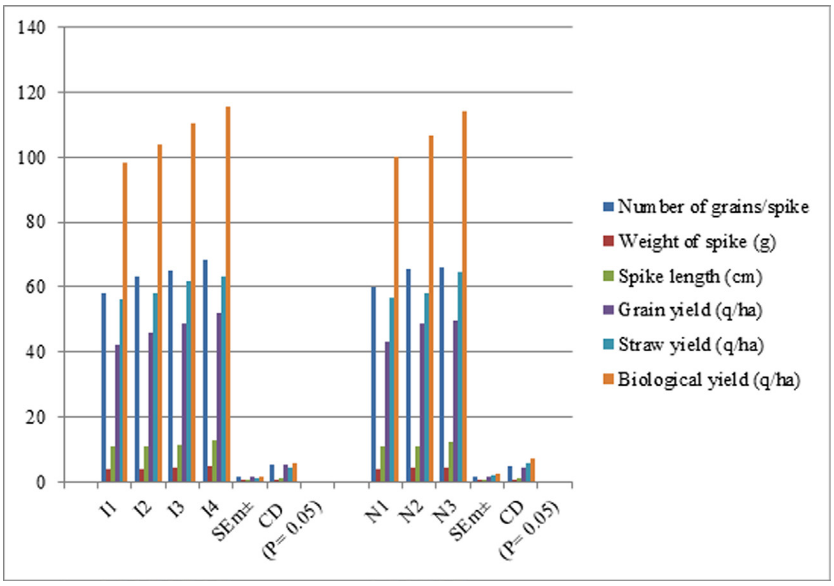

Fig 2: Effect of irrigation and nitrogen scheduling on yield attributes and yield of crop

Among nitrogen scheduling maximum crop yield was observed in treatment N_3- 25% as basal dose + 25% at CRI + 25% at late jointing stage + 25% at flowering stage followed by N_2- 50% as basal dose + 25% after first irrigation + 25% at flowering stage. The reason for higher value of grain yield can be discussed in the light of the fact that there was positive correlation between grain yield and yield components like number of effective tillers and grains/spike which were increased in nutrient availability. Crop yield of wheat was increased with the increasing nitrogen splitting as well as increased nutrient use efficiency and also less chance of nitrogen losses due to leaching, immobilization and denitrification that ultimately leads to higher crop yield. Split application of nitrogen maintained continuous supply of nutrients resulted better translocation of photosynthates from source to sink which was responsible for good growth and yield revealed by Mahajan *et al.*, (2010).

Conclusion

Irrigation and nitrogen scheduling are fundamental to optimizing wheat production, each influencing crop yield, quality, and overall resource efficiency. Effective management of these two factors is crucial for addressing the increasing demands for food security while mitigating environmental impacts.

On the basis of results summarized above, it can be concluded that among different Irrigation schedules, the higher growth and yield attributes were recorded in treatment where four irrigations were applied *viz.* I_4 - First irrigation at CRI, second at tillering, third at flowering and fourth at milking stage followed by I_3- First irrigation at CRI, second at tillering, third at late jointing was found to be second best treatment. Minimum growth and yield parameters were observed in I_1- First irrigation at CRI. Among the nitrogen scheduling, the higher growth and yield attributes were recorded under N_3- 25 % as basal dose + 25 % at CRI + 25 % at late jointing stage + 25 % at flowering stage and second best treatment was N_2- 50% as basal dose + 25% after first irrigation + 25% at flowering stage.

Amongst treatment combinations, I_4N_3 i.e. irrigation schedule I_4 - First irrigation at CRI, second at tillering, third at flowering and fourth at milking stage with nitrogen schedules N_3- 25% as basal dose + 25% at CRI + 25% at late jointing stage + 25% at flowering stage was found to be best treatment in growth and yield parameters followed by I_3N_2 i.e. irrigation schedule I_3- First irrigation at CRI, second at tillering, third at late jointing with nitrogen schedule N_2- 50% as basal dose + 25% after first irrigation + 25% at flowering stage. Effective irrigation and nitrogen scheduling are essential for optimizing wheat production. By aligning irrigation practices with nitrogen application, farmers can achieve better crop yields, quality, and resource efficiency. Ongoing research and technological advancements will continue to play a critical role in refining these practices and addressing challenges in wheat cultivation.

Author contributions

The conceptualization of research (K.K. and S.K.); Designing of the experiments (K.K. and S.K.); Execution of field experiments and data collection (K.K. and S.K.); Analysis of data and interpretation (K.K. and S.K.); writing–original draft preparation, K.K. and S.K.; writing–review and editing, K.K. and S.K.; Preparation of the manuscript (K.K. and S.K.).

Conflict of interest

No

Declaration

The authors declare no conflict of interest.

References

1. Abedi T, A Alemzadeh and SA Kazemeini. 2011. Wheat yield and grain protein response to nitrogen amount and timing. Australian Journal of Crop Sciences 5(3):330–336.
2. Ahmad A and R Kumar. 2015. Effect of irrigation scheduling on the growth and yield of wheat genotypes. Agricultural Science Digest 35(3):199-202.
3. Akhter S, R Kotru, B Lone A and R Jan. 2017. Effect of split application of potassium and nitrogen on wheat (*Triticum aestivum*) growth and yield under temperate Kashmir. Indian Journal of Agronomy 62(1):49 53.
4. Amani A and MA Behzad. 2020. Effect of split application of nitrogen on growth and yield of wheat (*Triticum aestivum* L.). Journal of Experimental Agriculture International 42 (6):44-48.
5. Chaplot PC and HK Sumeriyan. 2013. Effect of balanced fertilization, organic manures and bioregulator on growth, chlorophyll content and dry matter accumulation of late sown wheat (*Triticum aestivum* L.). Environment and Ecology 31(2):1057–1060.
6. Du TS, J Kang, X Sun, Zhang and J Zhang. 2010. An improved water use efficiency of cereals under temporal and spatial deficit irrigation in north China. Agriculture and Water Management 97:66-74.

7. Gomez KA and AA Gomez. 1984. Statistical procedure for agricultural research 2nd Edition. John Willy and sons, New York, 680.

8. Kadam SB, SB Pawar and SR Jakkawad. 2019. Response of pearl millet (*Pennisetum glaucum* L.) to levels and scheduling of nitrogen under Maharashtra condition. Journal of Pharmcognosy and Phytochemistry 8(3):2922-2925.

9. Katyayan A. 2021. Fundamentals of Agriculture (volume-1). Kushal publications and distributors Varanasi PP: 74-82.

10. Mahajan G, S Kumar, M Kumar, R Kumar and MK Yadav. 2010. Effect of cultivars and nitrogen scheduling on yield, nutrient uptake, and quality of late sown wheat (*Triticum aestivum* L.). Environment and ecology 28(3):1898-1900.

11. Maliwal GL, JK Patel, RR Kaswala, ML Patel, R Bhatnagar and JC Patel. 2000. Scheduling of irrigation for wheat (*Triticum aestivum* L.) under restricted supply in Narmada region. Indian Journal of Agricultural Sciences 70(2):90-92.

12. Pal S, P Chhuneja, A Sharma, RP Singh and NS Bains. 2010. Introgression of quality traits from *Triticum diciccoides* to bread wheat cultivar PBW 343. Crop Improvement 37:183-188.

13. Shirazi SM, Z Yusop, NH Zardari and Z Ismail. 2014. Effect of irrigation regimes and nitrogen levels on the growth and yield of wheat. Advances in Agriculture 1-6.

14. Singh H, S Singh, M Lal, S Kumar and L Singh. 2020. Response of irrigation schedule and nitrogen on growth and yield of wheat (*Triticum aestivum* L.) under irrigated conditions of Punjab. Journal of Pharmacognosy and Phytochemistry 9(3):1020-1023.

15. Singh NA, S Sorokhaibam, K Pramanik and L Nabachandra. 2017. Effect of planting time and nitrogen fertilization on yield, nutrient uptake and NUE of hybrid rice under rainfed shallow land condition of north east India. International Journal of Current Microbiology and Applied Sciences 6(11):2112-2120.

16. Verma SH. 2017. Effect of irrigation scheduling and organic manures on growth, yield and quality of wheat. Journal of Environmental Science 33(2):34-37.

17. Yousaf M, M Shaaban, SAI Ali, S Fahad, MJ Khan, Y Wang, AN Shah, SAI Sabiel and KA Osman. 2014. The effect of nitrogen application rates and timins of first irrigation on wheat growth and yield. International Journal of Agriculture Innovations and Research 2(4):645-653.