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Assessment of nitrogen content and uptake in wheat (*Triticum aestivum* L.) under different irrigation and zinc fertilization regimes using Zadoks scale

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Abstract

A field experiment was conducted in winter seasons (*Rabi*) of 2023-2024 at the research farm of Teerthankar Mahaveer college of Agricultural Sciences, Teerthankar Mahaveer University, Moradabad, Uttar Pradesh (India). Nutrient content and nutrient uptake of wheat was significantly influenced by irrigation scheduling and zinc fertilization. There was a significant increase in uptake and content of nitrogen of wheat with combined application of zinc fertilization along with irrigation scheduling. Uptake of nutrients were significantly higher with treatment irrigation at CRI+Late tillering+Late flowering and application of 5 kg Zn ha⁻¹ + 0.20% foliar spray at Z 71(early dough), also in case of protein content and protein yield were significantly improved due to this treatment recorded highest protein content in grain (12.90%), straw (12.82%) and protein yield grain (629.47 kg ha⁻¹) straw (372.29 kg ha⁻¹) in wheat than the rest of the treatment.

Keywords: Nutrient uptake, nutrient content

Introduction

Wheat (*Triticum aestivum* L.) is one of the most important staple food crops globally, contributing significantly to food security and agricultural sustainability. In India, wheat occupies a pivotal role in the rabi season, where optimizing yield and nutrient use efficiency is essential for sustainable production. Among the critical factors influencing wheat productivity, nitrogen (N) plays a central role in enhancing growth, grain formation, and overall yield. However, nitrogen uptake and utilization by the wheat crop are significantly influenced by irrigation management and the availability of micronutrients, particularly zinc (Zn). Irrigation scheduling and zinc management, when aligned with the crop's phenological stages as described by the Zadoks decimal growth scale can greatly enhance water use efficiency and nutrient assimilation. Proper timing of irrigation ensures optimal moisture availability during critical stages such as tillering, stem elongation, and grain filling, thereby improving nitrogen uptake and translocation. Conversely, inappropriate irrigation timing can lead to leaching losses and reduced nutrient availability. The present study aims to evaluate the combined effect of irrigation scheduling and zinc fertilization on the nitrogen nutrient content and uptake in wheat across different growth stages based on the Zadoks scale. This research will provide insights into developing nutrient and water management strategies that enhance wheat yield and resource use efficiency under varying agro-ecological conditions.

Material and method

A field experiment was conducted during the *Rabi* (winter) seasons of 2023-24 to evaluate the outcome of "Enhancing Productivity and Quality of Wheat (*Triticum aestivum* L.) through Optimized Irrigation Scheduling and Zinc Fertilization Under the Zadoks Scale" on sandy loam soils at college of Agriculture science Teerthankar Mahaveer University Moradabad, Uttar Pradesh, India. Situated at 125.9 meter altitude, 26.49122° North latitude, and 80.3070120 East longitude. The experiment consisted three irrigation scheduling, first irrigation at CRI + Late

Tillering +Late Flowering, second irrigation at CRI + Late Tillering+Late jointing + Late flowring, third irrigation at CRI + Late tillering + Late jointing + Late flowring + Late milking. Three zinc fertilization treatment are 0 kg Zn ha⁻¹ (Control), 5 kg Zn ha⁻¹ at basal + 0.20% ZnSO₄ foliar spray at early dough stage, 10 kg Zn ha⁻¹ at basal +0.40% ZnSO₄ foliar spray at dough stage. The field experiment was framed in Factorial Randomized block design with three replications. The variety, DBW-303 was used for sowing in experiment. The soil of experimental field was moist, well drained with uniform plane topography. The soil of the experimental field was sandy loam in origin, sandy loam in texture and slightly acidic in reaction having pH 6.4,(1:2.5 soil: water suspension method given by (Jackson ML 1973), medium organic carbon (0.6% and 0.8% Walkley and Black's rapid titration method given by (Walkley A 1934), with medium available nitrogen 181.40 and 179.25 kg ha⁻¹ (Alkaline permanganate method given by (Subbiah BV, Asija CL 1956), low in available phosphorus as sodium bicarbonate-extractable P was 12.50 and 11.28 kg ha⁻¹ (Olsen's calorimetrically method, Olsen SR *et.al* 1954) and medium in available potassium was 170.0 and 168.25 kg ha⁻¹ (Flame photometer method given by (Hanway JJ, Heidel H 1952)respectively, in 2023-2024 ^[1, 10, 11, 12].

Result and discussion

The highest nitrogen concentration in grain (2.06%) was achieved under the I1 irrigation treatment (CRI + LT + LF). Although the I₃ treatment (CRI + LT + LJ + LF + LM) showed similar performance, it was statistically comparable to I₂ (CRI + LT + LJ + LF). However, the lowest nitrogen content was recorded in the I₂ irrigation schedule, signifying a comparatively reduced nutrient concentration. Similar results have also been reported by Madane *et al* (2017) Pirmoradian *et al.* (2004); Shekara *et al.* (2010) ^[8]; The analysis of zinc application on grain nitrogen content revealed that the lowest nitrogen concentration (1.97%) was observed in the control group (0 kg Zn ha⁻¹). This value was statistically similar to the treatment with 10 kg Zn ha⁻¹ + 0.40% foliar spray at Z83. In contrast, the highest nitrogen content (2.05%) was recorded with the application of 5 kg Zn ha⁻¹ +

0.20% foliar spray at Z71, highlighting the beneficial effect of moderate zinc application in improving nitrogen accumulation in grain. There were no statistically significant differences in nitrogen concentration in straw at harvest across different irrigation schedules. However, numerically the highest nitrogen content (0.87%) was noted with I₃ (CRI + LT + LJ + LF + LM), while the lowest concentration was recorded in I₁ (CRI + LT + LF), indicating minor variability under varying irrigation conditions. The application of 5 kg Zn ha⁻¹ + 0.20% foliar spray at Z71 resulted in the highest nitrogen content in straw (0.87%), reflecting a significant improvement compared to other treatments. In contrast, the control treatment (0 kg Zn ha⁻¹) registered the lowest nitrogen concentration (0.78%), highlighting the beneficial impact of zinc on straw nitrogen accumulation.

Grain nitrogen uptake showed significant variation across different irrigation schedules. The highest uptake (100.7 kg ha⁻¹) was achieved under the I1 treatment (CRI + LT + LF), indicating better nitrogen assimilation under this regime. In contrast, the lowest uptake (72.4 kg ha⁻¹) was recorded under the I2 schedule (CRI + LT + LJ + LF), suggesting lower nutrient efficiency with this irrigation pattern Madane *et al* (2021) ^[9]. Among the zinc treatments, the application of 5 kg Zn ha⁻¹ + 0.20% foliar spray at Z71 led to the highest grain nitrogen uptake (91.86 kg ha⁻¹). The control treatment (0 kg Zn ha⁻¹) had the lowest uptake, highlighting the crucial role of zinc in enhancing nitrogen absorption in grains. Nitrogen uptake in straw was also significantly affected by irrigation practices. The I₁ schedule (CRI + LT + LF) resulted in the highest nitrogen uptake (169.7 kg ha⁻¹) in straw, whereas the lowest uptake (120.8 kg ha⁻¹) was observed under the I2 schedule (CRI + LT + LJ + LF). These findings underscore the importance of well-timed irrigation in improving nutrient movement and utilization in plant biomass. Similar to grain uptake, the application of 5 kg Zn ha⁻¹ + 0.20% FS at Z71 resulted in the maximum nitrogen uptake in straw (162.3 kg ha⁻¹). Treatments with 10 kg Zn ha⁻¹ + 0.40% FS at Z83 and the control (0 kg Zn ha⁻¹) showed comparable performance, with the lowest uptake recorded under the control treatment.

Table 1: Effect of irrigation scheduling and Zinc fertilization on Nitrogen content (%), nitrogen uptake (kg ha⁻¹) and total nitrogen uptake (kg ha⁻¹) of wheat

Treatments	Nitrogen content (%)		Nitrogen uptake (kg ha ⁻¹)		Total nitrogen uptake (kg ha ⁻¹)
	Grain	Straw	Grain	Straw	
Irrigation Management					
I ₁ (CRI+LT+LF)	2.06	0.72	100.7	169.7	270.4
I ₂ (CRI+LT+LJ+LF)	1.97	0.84	72.4	120.8	193.2
I ₃ (CRI+LT+LJ+LF+LM)	1.99	0.87	67.3	135.1	202.5
SEm±	0.01	0.021	4.42	7.55	11.97
C D (P=0.05)	0.03	NS	13.2	22.6	35.9
Zinc Management					
Z ₁ (0 kg Zn ha ⁻¹ Control)	1.97	0.78	73.90	131.4	205.3
Z ₂ (5 kg Zn ha ⁻¹ + 0.20%FS Z71)	2.05	0.87	91.86	162.3	254.2
Z ₃ (10kg Zn ha ⁻¹ + 0.40%FS at Z 83)	1.98	0.79	74.79	131.9	206.7
SEm±	0.01	0.021	4.42	7.55	11.97
C D (P=0.05)	0.03	0.064	13.2	22.6	35.90

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Fig 1: Plot at time of Harvest

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