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Performance of wheat (*Triticum Aestivum* L.) under different fertilizers and irrigation levels

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ABSTRACT

A field experiment entitled “Performance of Wheat (*Triticum aestivum* L.) under Different Fertilizers and Irrigation Levels” was conducted during the Rabi season of 2025–26 at the Agricultural Research Farm, Department of Agronomy, School of Agriculture, Suresh Gyan Vihar University, Jaipur, Rajasthan. The experiment was undertaken to evaluate the effects of different irrigation schedules and fertilizer levels on growth, yield, yield attributes and economics of wheat. The experiment comprised four irrigation levels and four fertilizer levels arranged in a factorial experimental design. Irrigation was scheduled at critical crop growth stages, while fertilizer treatments consisted of control, 50%, 100% and 125% of the recommended dose of fertilizer (RDF). Results revealed that irrigation at CRI + tillering + jointing + milk + dough stages (I_4) significantly improved plant height, dry matter accumulation, tillering, spike length, grains per spike, test weight, grain yield, straw yield and biological yield compared with restricted irrigation. The maximum grain yield under irrigation levels was 42.13 q ha⁻¹ with I_4 . Among fertilizer treatments, 100% RDF (F_3) recorded the highest grain yield of 37.45 q ha⁻¹ and was comparable with 125% RDF for several growth and yield attributes. Significant irrigation × fertilizer interactions were observed for spike length, grains per spike, grain yield, straw yield and biological yield. The highest grain yield (43.85 q ha⁻¹), straw yield (77.45 q ha⁻¹) and biological yield (121.03 q ha⁻¹) were obtained with $F_3 \times I_4$. This treatment also recorded the maximum net return of ₹87,713 ha⁻¹ and B ratio of 2.40. Thus, application of 100% RDF with irrigation at CRI, tillering, jointing, milk and dough stages was found most productive and economically beneficial under the agro-climatic conditions of Jaipur, Rajasthan.

Keywords: Wheat, Irrigation scheduling, Fertilizer, RDF, Grain yield, Economics, Productivity

1. Introduction

Wheat (*Triticum aestivum* L.) is one of the most important cereal crops globally and plays a vital role in food and nutritional security. India is among the leading wheat-producing countries, where the crop occupies about 31.25 million hectares with production of approximately 115.60 million tonnes during 2024–25 (FAOSTAT, 2025; Anonymous, 2025) [2, 1]. With limited scope for horizontal expansion of cultivated land, increasing wheat productivity through efficient management of available resources has become essential.

Among the major production inputs, fertilizer and irrigation play crucial roles in realizing the yield potential of wheat. Balanced fertilization, particularly adequate nitrogen, phosphorus and potassium, promotes vegetative growth, tillering, photosynthetic activity and grain development (Jiang *et al.*, 2004; Bloom, 2015) [4, 3]. Similarly, timely irrigation at critical crop growth stages ensures adequate soil moisture, improves nutrient-use efficiency and enhances yield and water productivity (Hira, 2009) [5].

In the arid and semi-arid regions of Rajasthan, limited water availability and declining groundwater resources necessitate efficient irrigation scheduling. Wheat yield can be substantially affected when moisture stress occurs during critical stages such as crown root initiation, tillering, jointing, flowering and grain filling. Therefore, identification of suitable combinations of irrigation scheduling and fertilizer application is essential for achieving higher productivity and profitability.

Keeping these considerations in view, the present investigation entitled “Performance of Wheat (*Triticum aestivum* L.) under Different Fertilizers and Irrigation Levels” was conducted to evaluate the effects of different irrigation schedules and fertilizer levels on wheat growth, yield and economic returns under the agro-climatic conditions of Jaipur, Rajasthan. The study also aimed to identify an efficient combination of fertilizer and irrigation management for sustainable wheat production.

2. Materials and Methods

A field experiment was conducted during the Rabi season of 2025–26 at the Agricultural Research Farm, Department of Agronomy, School of Agriculture, Suresh Gyan Vihar University, Jaipur, Rajasthan. The experiment was undertaken to evaluate the performance of wheat (*Triticum aestivum* L.) under different irriga

tion schedules and fertilizer levels. The experiment consisted of four irrigation levels: I_1 - irrigation at CRI + tillering, I_2 - CRI + tillering + jointing, I_3 - CRI + tillering + jointing + milk stage, and I_4 - CRI + tillering + jointing + milk + dough stages. Four fertilizer levels were evaluated: F_1 - control, F_2 - 50% RDF, F_3 - 100% RDF and F_4 - 125% RDF. The treatments were evaluated in a factorial experimental design with appropriate replication. Observations on plant height and dry matter accumulation were recorded at 30, 60, 90 DAS and harvest. Yield attributes, including total and effective tillers, spike length, grains per spike and test weight, were recorded at maturity. Grain, straw and biological yields were expressed in q ha^{-1} , and harvest index was calculated. Economic analysis was performed by calculating gross return, net return and benefit (B) ratio. The recorded data were subjected to statistical analysis of variance (ANOVA) to determine the significance of irrigation, fertilizer and their interaction. Treatment means were compared using the critical difference (CD) at the 5% level of significance.

3. Results and Discussion

3.1 Growth attributes

Plant height was significantly influenced by irrigation and fertilizer levels at 30, 60, 90 DAS and harvest, whereas their interaction was non-significant (Table 4.1). Among irrigation treatments, I_4 (irrigation at CRI + tillering + jointing + milk + dough stages) recorded the maximum plant height of 20.48, 46.27, 78.72 and 93.33 cm at 30, 60, 90 DAS and harvest, respectively, while I_1 recorded the minimum values of 16.25, 36.72, 62.47 and 74.08 cm. The superior growth under I_4 may be attributed to adequate soil moisture availability during critical growth stages, which enhanced nutrient uptake, photosynthetic activity and cell expansion. Similar improvement in wheat growth and yield with appropriate irrigation scheduling has been reported by Singh *et al.* (2011) [6].

Among fertilizer treatments, F_4 (125% RDF) recorded the maximum plant height at all stages, although it was statistically at par with F_3 (100% RDF). The lowest values were recorded under the control. Increased nutrient availability, particularly nitrogen, promotes vegetative growth and chlorophyll formation. However, the comparable performance of F_3 and F_4 indicates that application beyond the recommended fertilizer dose did not provide a proportionate improvement in plant height. Similar findings regarding the limited yield advantage from excessive nitrogen application have been reported by Singh *et al.* (2011) [6].

3.1.2 Dry matter accumulation

Dry matter accumulation was significantly affected by irrigation and fertilizer levels at all stages, whereas their interaction was non-significant (Table 4.2). I_4 recorded the highest dry matter accumulation of 11.39, 37.50, 160.86 and 243.46 g m^{-2} at 30, 60, 90 DAS and harvest, respectively, compared with 7.21, 23.74, 101.88 and 154.20 g m^{-2} under I_1 . The higher biomass under adequate irrigation may be attributed to improved leaf development, photosynthetic activity and assimilate production. Irrigation during critical reproductive stages helps maintain crop growth and grain-filling capacity (Singh *et al.*, 2011) [6]. F_4 recorded the maximum dry matter accumulation at all stages, while F_3 was statistically close to F_4 . The control recorded the minimum values. The increase in biomass with fertilizer application may be associated with improved nutrient availability and enhanced photosynthetic capacity. Thus, adequate irrigation and balanced fertilizer application promoted greater crop biomass.

3.2 Yield and yield-attributing traits

Irrigation significantly influenced total and effective tillers, spike length, grains per spike, test weight and yield. I_4 recorded the maximum total tillers (105.43 m^{-1}), effective tillers (98.47 m^{-1}), spike length (10.74 cm), grains per spike (48.94) and test weight (40.68 g), whereas I_1 recorded the minimum values. Adequate water availability during tillering and reproductive stages favoured tiller survival, spike

development and grain formation. Similar positive effects of timely irrigation on wheat yield components have been reported under North Indian conditions (Singh *et al.*, 2011; Singh *et al.*, 2013) [6, 7].

Among fertilizer treatments, F_4 produced the maximum total and effective tillers, while F_3 recorded the highest grains per spike (44.18) and test weight (39.96 g). Spike length was highest under F_3 (9.64 cm), which was statistically at par with F_4 . The improvement in yield attributes with fertilizer application can be attributed to improved nitrogen availability and crop vigour. Nitrogen management synchronized with crop demand has been shown to improve wheat yield and nitrogen-use efficiency (Singh *et al.*, 2011) [6].

3.3 Yield

Grain, straw and biological yields were significantly influenced by irrigation, fertilizer and their interaction (Table 4.8). I_4 produced the maximum grain yield (42.13 q ha^{-1}), straw yield (74.63 q ha^{-1}) and biological yield (116.76 q ha^{-1}), while I_1 recorded the minimum values. The greater yield under I_4 was associated with improved plant growth, tillering, spike development, grain number and grain filling. Studies conducted in North-West India have similarly shown that appropriate irrigation at critical growth stages improves wheat grain yield and yield components (Singh *et al.*, 2013) [7].

Among fertilizer treatments, F_3 recorded the highest grain yield (37.45 q ha^{-1}), whereas F_4 recorded the highest straw yield (66.99 q ha^{-1}) and biological yield (104.05 q ha^{-1}). The similarity between F_3 and F_4 for grain yield indicates that increasing fertilizer application from 100 to 125% RDF did not provide a corresponding increase in grain production. This agrees with findings that excessive nitrogen application may increase input use without proportionate yield benefits (Singh *et al.*, 2011) [6].

The irrigation $\times$ fertilizer interaction was significant for yield. The maximum grain yield of 43.85 q ha^{-1} , straw yield of 77.45 q ha^{-1} and biological yield of 121.03 q ha^{-1} were obtained with $F_3 \times I_4$ (100% RDF + irrigation at CRI, tillering, jointing, milk and dough stages). The minimum grain yield (29.52 q ha^{-1}) and biological yield (79.97 q ha^{-1}) were recorded under the control combination. These results demonstrate the importance of synchronizing nutrient and water availability to maximize wheat productivity. Previous research has also reported significant responses of wheat yield and resource-use efficiency to combined irrigation and nitrogen management (Singh *et al.*, 2011; Singh *et al.*, 2017) [6].

Harvest index was not significantly influenced by irrigation, fertilizer or their interaction, indicating that the treatments increased grain and total biomass production broadly in proportion.

3.4 Economics

Economic analysis revealed significant differences among treatment combinations. The maximum net return ($\text{₹}87,713 \text{ ha}^{-1}$) and B:C ratio (2.40) were obtained with $F_3 \times I_4$, whereas the control combination recorded the minimum net return ($\text{₹}47,663 \text{ ha}^{-1}$) and B:C ratio (1.89). The economic superiority of $F_3 \times I_4$ was mainly due to its higher grain and biological yields without the additional fertilizer cost associated with 125% RDF. Similar research has demonstrated that optimized combinations of irrigation and nitrogen can improve both wheat productivity and economic efficiency (Singh *et al.*, 2011) [6].

Conclusion

The experiment demonstrated that improved irrigation scheduling significantly enhanced wheat growth, yield attributes and productivity. I_4 was superior for most growth and yield parameters, while F_3 (100% RDF) was sufficient for obtaining maximum grain yield. The interaction of $F_3 \times I_4$ produced the highest grain yield (43.85 q ha^{-1}), straw yield (77.45 q ha^{-1}), biological yield (121.03 q ha^{-1}), net return ($\text{₹}87,713 \text{ ha}^{-1}$) and B:C ratio (2.40). Therefore, under the conditions of Jaipur, Rajasthan, 100% RDF combined with irrigation at CRI + tillering + jointing + milk + dough stages may be considered the most productive and economically suitable treatment combination.

Table 1. Effect of irrigation and fertilizers on plant height of wheat at 30, 60, 90 DAS and at harvest

Sr. no.	Treatments	Plant height (cm)			
		30 DAS	60 DAS	90 DAS	At harvest
A.	Irrigation levels				
1	I ₁ : At CRI + Tillering	16.25	36.72	62.47	74.08
2.	I ₂ : At CRI + Tillering + Jointing	17.94	40.54	68.96	81.77
3.	I ₃ : At CRI + Tillering + Jointing + Milk stage	18.50	41.81	71.13	84.34
4.	I ₄ : At CRI + Tillering + Jointing + Milk stage + Dough stage	20.48	46.27	78.72	93.33
	<i>S.E.m.</i> _±	0.30	0.65	1.09	1.30
	CD%	0.85	1.89	3.16	3.75
B.	Fertilizer levels				
1.	F ₁ : Control	17.03	38.44	65.45	77.92
2.	F ₂ : 50% of RDF	18.25	41.29	70.18	82.92
3.	F ₃ : 100% of RDF	18.68	42.18	71.80	85.45
4.	F ₄ : 125% of RDF	19.20	43.44	73.84	87.23
	<i>S.E.m.</i> _±	0.30	0.65	1.09	1.30
	CD%	0.85	1.89	3.16	3.75
A × B	Irrigation levels × Fertilizer levels				
	<i>S.E.m.</i> _±	0.59	1.31	2.19	2.60
	CD%	NS	NS	NS	NS
	CV%	5.60	5.48	5.39	5.35

Table 2. Effect of irrigation and fertilizers on dry matter accumulation of wheat

Sr. no.	Treatments	Dry matter accumulation (g/m ²)			
		30 DAS	60 DAS	90 DAS	At harvest
A.	Irrigation levels				
1	I ₁ : At CRI + Tillering	7.21	23.74	101.88	154.20
2.	I ₂ : At CRI + Tillering + Jointing	7.51	24.72	106.05	160.43
3.	I ₃ : At CRI + Tillering + Jointing + Milk stage	9.88	32.53	139.54	211.13
4.	I ₄ : At CRI + Tillering + Jointing + Milk stage + Dough stage	11.39	37.50	160.86	243.46
	<i>S.E.m.</i> _±	0.11	0.37	1.57	2.47
	CD%	0.32	1.07	4.53	7.14
B.	Fertilizer levels				
1.	F ₁ : Control	7.80	25.70	110.28	166.94
2.	F ₂ : 50% of RDF	8.95	29.48	126.40	191.19
3.	F ₃ : 100% of RDF	9.46	31.14	133.60	202.17
4.	F ₄ : 125% of RDF	9.77	32.19	138.05	208.91
	<i>S.E.m.</i> _±	0.11	0.37	1.57	2.47
	CD%	0.32	1.07	4.53	7.14
A × B	Irrigation levels × Fertilizer levels				
	<i>S.E.m.</i> _±	2.22	0.74	3.14	4.94
	CD%	NS	NS	NS	NS
	CV%	4.29	4.31	4.28	4.45

Table 3. Effect of irrigation and fertilizers on number of total tillers per m row length of wheat

Sr. no.	Treatments	Number of total tillers per m row length
A.	Irrigation levels	
1	I ₁ : At CRI + Tillering	91.25
2.	I ₂ : At CRI + Tillering + Jointing	92.78
3.	I ₃ : At CRI + Tillering + Jointing + Milk stage	98.51
4.	I ₄ : At CRI + Tillering + Jointing + Milk stage + Dough stage	105.43

(continued on next page)

Sr. no.	Treatments	Number of total tillers per m row length
	<i>S.E.m.</i> _±	1.49
	CD%	4.30
B.	Fertilizer levels	
1.	F ₁ : Control	93.41
2.	F ₂ : 50% of RDF	96.38
3.	F ₃ : 100% of RDF	98.16
4.	F ₄ : 125% of RDF	100.01
	<i>S.E.m.</i> _±	1.49
	CD%	4.30
A × B	Irrigation levels × Fertilizer levels	
	<i>S.E.m.</i> _±	2.98
	CD%	NS
	CV%	5.32

Table 4. Effect of irrigation and fertilizers on number of effective tillers per m row length and spike length of wheat

Sr. no.	Treatments	Number of effective tillers per m row length	Spike length (cm)	Number of grains per spike
A.	Irrigation levels			
1	I ₁ : At CRI + Tillering	84.28	8.45	36.74
2.	I ₂ : At CRI + Tillering + Jointing	85.81	8.67	40.67
3.	I ₃ : At CRI + Tillering + Jointing + Milk stage	91.54	9.57	43.53
4.	I ₄ : At CRI + Tillering + Jointing + Milk stage + Dough stage	98.47	10.74	48.94
	<i>S.E.m.</i> _±	0.86	0.14	0.67
	CD%	2.48	0.41	1.95
B.	Fertilizer levels			
1.	F ₁ : Control	83.12	8.98	41.05
2.	F ₂ : 50% of RDF	92.74	9.30	41.58
3.	F ₃ : 100% of RDF	87.86	9.64	44.18
4.	F ₄ : 125% of RDF	96.37	9.51	43.07
	<i>S.E.m.</i> _±	0.86	0.14	0.67
	CD%	2.48	0.41	1.95
A × B	Irrigation levels × Fertilizer levels			
	<i>S.E.m.</i> _±	1.72	0.23	1.35
	CD%	NS	0.69	3.90
	CV%	5.88	5.28	5.50

Table 4.5. Effect of irrigation and fertilizers grain yield and straw yield of wheat

Sr. no.	Treatments	Test weight (g)	Grain yield (q/ha)	Straw yield (q/ha)
A.	Irrigation levels			
1	I ₁ : At CRI + Tillering	39.04	31.65	55.09
2.	I ₂ : At CRI + Tillering + Jointing	39.16	32.51	59.83
3.	I ₃ : At CRI + Tillering + Jointing + Milk stage	39.93	38.04	66.44
4.	I ₄ : At CRI + Tillering + Jointing + Milk stage + Dough stage	40.68	42.13	74.63
	<i>S.E.m.</i> _±	0.21	0.66	0.93
	CD%	0.63	1.92	2.69
B.	Fertilizer levels			
1.	F ₁ : Control	39.39	34.01	60.20
2.	F ₂ : 50% of RDF	39.66	35.81	63.75
3.	F ₃ : 100% of RDF	39.96	37.45	65.05

(continued on next page)

Sr. no.	Treatments	Test weight (g)	Grain yield (q/ha)	Straw yield (q/ha)
4.	F ₄ : 125% of RDF	39.79	37.07	66.99
	<i>S.Em.</i> _±	0.21	0.66	0.93
	CD%	0.63	1.92	2.69
A × B	Irrigation levels × Fertilizer levels			
	<i>S.Em.</i> _±	0.19	1.25	1.86
	CD%	NS	3.74	5.37
	CV%	4.58	6.38	5.04

Table 6. Effect of irrigation and fertilizers biological yield of wheat

Sr. no.	Treatments	Biological yield (q/ha)	Harvest index (%)
A.	Irrigation levels		
1	I ₁ : At CRI + Tillering	86.73	36.55
2.	I ₂ : At CRI + Tillering + Jointing	92.34	35.21
3.	I ₃ : At CRI + Tillering + Jointing + Milk stage	104.49	36.40
4.	I ₄ : At CRI + Tillering + Jointing + Milk stage + Dough stage	116.76	36.07
	<i>S.Em.</i> _±	1.26	0.58
	CD%	3.63	NS
B.	Fertilizer levels		
1.	F ₁ : Control	94.21	36.21
2.	F ₂ : 50% of RDF	99.56	35.98
3.	F ₃ : 100% of RDF	102.50	36.47
4.	F ₄ : 125% of RDF	104.05	35.57
	<i>S.Em.</i> _±	1.26	0.58
	CD%	3.63	NS
A × B	Irrigation levels × Fertilizer levels		
	<i>S.Em.</i> _±	2.45	1.16
	CD%	7.35	NS
	CV%	4.35	

Table 7. Effect of irrigation and fertilizers on economics

Treat. no.	Gross return (Rs/ha)	Net return (Rs/ha)	B:C ratio
1	101163	47663	1.89
2.	108305	53305	1.97
3.	114563	58063	2.03
4.	110845	53595	1.94
5.	122763	66263	2.17
6.	128213	70213	2.21
7.	134313	74813	2.26
8.	137665	77415	2.28
9.	109013	52513	1.93
10.	112478	54478	1.94
11.	115313	55813	1.94
12.	113163	52913	1.88
13.	135403	75903	2.28
14.	144445	83445	2.37
15.	150213	87713	2.40
16.	150103	86853	2.37

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