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Effect of different irrigation levels on newly released wheat varieties

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Abstract
A field experiment entitled "Effect of different irrigation levels on newly released wheat varieties" was conducted during *Rabi 2024-25* at the Instructional-cum-Research Farm, Barrister Thakur Chhedilal College of Agriculture and Research Station, Bilaspur (C.G.). The experiment was laid out in a split-plot design with three replications, comprising three irrigation levels-I_1: no irrigation, I_2: one irrigation at CRI stage, and I_3: two irrigations at CRI and boot leaf stages-in main plots, and nine wheat genotypes-V_1: UAS(d), V_2: HI8827(d)(C), V_3: MACS(d), V_4: DBW432, V_5: CG1040(c), V_6: HI8851(d), V_7: HI8823(d)(c), V_8: MPO(d), and V_9: DBW110(c)-in subplots. Results revealed that growth parameters such as plant height, number of tillers m^{-2}, dry matter accumulation, crop growth rate, and relative growth rate, as well as yield-attributing traits including ear length, grains ear^{-1}, test weight, biological yield, grain yield, straw yield, and harvest index were significantly influenced by irrigation levels. The I_3 treatment (two irrigations at CRI and boot leaf stages) recorded the highest values for most traits, statistically at par with I_2, while the lowest values were observed under I_1. Among genotypes, CG1040(c) exhibited superior performance for most growth and yield parameters, followed by MPO(d) and DBW432, whereas HI8827(d)(C) recorded the lowest. Plant population remained non-significant across treatments. The lowest harvest index was observed in DBW110(c).

Keywords: Restricted irrigation, wheat, genotypes, yield, yield attributes

Introduction
In India, wheat (*Triticum aestivum* L.) is the second most important food crop after rice and the most widely consumed cereal. It is a self-pollinated member of the Poaceae family, cultivated globally on about 224.49 million hectares with a production of 792.40 million tonnes and productivity of 3.52 t ha^{-1}. Wheat's high nutritive value-containing 65-75% carbohydrates, 8-13% protein, and essential minerals-makes it vital for human consumption.

In India, wheat occupies 31.82 million ha, producing 113.29 million tonnes with an average productivity of 33.11 q ha^{-1} (2023-24). In Chhattisgarh, it is grown on about 2.67 lakh ha with a productivity of 1.6 t ha^{-1} (Anonymous, 2023-24) [5]. Water plays a crucial role throughout crop growth, and irrigation frequency has a positive correlation with yield. Moisture stress during critical stages reduces test weight and yield, while efficient water management enhances productivity and lowers pest and disease vulnerability.

Restricted irrigation optimizes water use by supplying the right amount at critical stages. Over-irrigation causes excessive vegetative growth, poor grain quality, and lodging, whereas restricted irrigation improves resource partitioning and grain filling. When limited to one or two irrigations, the Crown Root Initiation (CRI) stage (18-25 DAS) is most critical for root and tiller development, followed by booting or flowering stages for better spike and grain formation.

In Chhattisgarh, irrigation sources include canals, dams, tube wells, ponds, and wells, covering 21.52 lakh ha-about 38.84% of the total cropped area. Canals contribute 52% of irrigation, followed by tube wells (29%). The total available surface and groundwater are approximately 48,296 MCM and 11,630 MCM, respectively-indicating limited water availability and frequent scarcity during the rabi season.

Therefore, adopting restricted irrigation practices in wheat is essential for water conservation, improved efficiency, and sustainable production. Selecting suitable, thermo-tolerant genotypes further enhances yield stability under water-limited conditions (Zhuanyun Si & Anzhen Qin, 2023). Restricted irrigation not only conserves resources but also reduces costs, supporting long-term agricultural sustainability in Chhattisgarh.

Materials and Methods

A field experiment entitled "Effect of different irrigation levels on newly released wheat varieties" was conducted during *rabi* 2024-25 at the Instructional-cum-Research Farm, Barrister Thakur Chhedilal College of Agriculture and Research Station, Bilaspur (C.G.). The experimental soil was sandy clay loam with a pH of 7.2 and EC of 0.22 dS m^{-1} (0-30 cm depth), low in available nitrogen, medium in phosphorus, organic carbon, and potassium.

The recommended fertilizer dose was 90:60:40 kg $N:P_2O_5:K_2O$ ha^{-1}. Treatments consisted of three irrigation levels-I_1: no irrigation, I_2: one irrigation at CRI stage, and I_3: two irrigations at CRI and boot leaf stages-assigned to main plots, and nine wheat genotypes-(V_1) UAS(d), (V_2) HI8827(d)(C), (V_3) MACS(d), (V_4) DBW432, (V_5) CG1040(c), (V_6) HI8851(d), (V_7) HI8823(d)(c), (V_8) MPO(d), and (V_9) DBW110(c)-in subplots, arranged in a split-plot design with three replications.

Sowing was done on 5th November 2024, and harvesting on 1st March 2025. Full doses of P_2O_5 and K_2O, along with 50% N, were applied at sowing; the remaining N was top-dressed at the first irrigation (18-20 DAS) in I_2 and I_3. In I_1 (no irrigation), the entire NPK dose was applied at sowing. Observations on growth, morphology, and yield were recorded at 30, 60, and 90 DAS, and at harvest. Crops were harvested at full maturity, dried, threshed manually, and grain and straw yields were recorded separately.

Results and Discussion

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads:

Plant Height (cm)

The maximum plant height was observed under I_3 (two irrigations at CRI and boot leaf stages), which was statistically at par with I_2 (one irrigation at CRI stage), while the minimum height was recorded under the I_1 (no irrigation) treatment at 30 DAS. Similar trends were observed at 60, 90 DAS, and at harvest (Table 1). Among the genotypes, V_5 (CG1040(c)) recorded the highest plant height, which was at par with V_8 (MPO(d)) and V_4 (DBW432) at 30 DAS, whereas the lowest height was recorded in V_2 (HI8827(d)(C)). At 60 DAS, V_5 (CG1040(c)) again exhibited the maximum plant height, while V_2 (HI8827(d)(C)) remained the shortest. Similar trends continued at 90 DAS and harvest stages. The interaction effect between irrigation levels and genotypes on plant height was found to be non-significant. Overall, all genotypes showed increased plant height with irrigation at critical growth stages, which may be attributed to genotypic differences and improved growth conditions resulting from better nutrient availability and reduced moisture stress. These findings are consistent with the results reported by Wang *et al*. (2009), who observed that irrigation significantly influenced plant height.

Number of tillers (m^{-2})

The highest number of tillers was observed under I_3 (two irrigations at CRI and boot leaf stages), which was at par with I_2 (one irrigation at CRI), while the lowest tiller count occurred under I_1 (no irrigation). Similar trends were recorded at 60, 90 DAS, and at harvest (Table 2). Among genotypes, V_5 (CG1040(c)) produced the maximum number of tillers, statistically at par with V_8 (MPO(d)) and V_4 (DBW432), whereas the minimum was observed in V_2 (HI8827(d)(C)) across all stages of crop growth. The interaction between irrigation levels and genotypes was found to be non-significant. The higher number of tillers under I_3 may be attributed to timely irrigation at critical stages (CRI and boot leaf), ensuring optimum soil moisture for better vegetative growth and tiller development. These results agree with Ali *et al*. (2010) [4], who reported that adequate irrigation significantly enhances tiller production in wheat.

Dry Matter Accumulation (g $plant^{-1}$)

Maximum dry matter accumulation was observed under I_3 (two irrigations at CRI and boot leaf stages), which was statistically at par with I_2 (one irrigation at CRI), while the lowest was recorded under I_1 (no irrigation) at 30 DAS. Similar trends continued at 60, 90 DAS, and at harvest (Table 4). Among genotypes, V_5 (CG1040(c)) produced the highest dry matter, comparable with V_8 (MPO(d)) and V_4 (DBW432), whereas the minimum was recorded in V_2 (HI8827(d)(C)) across all stages. The interaction effect between irrigation levels and genotypes was non-significant. Higher dry matter under I_3 may be attributed to enhanced photosynthesis and nutrient uptake due to adequate moisture during critical growth stages. These results corroborate the findings of Boughdiri *et al*. (2014) [11], who reported that irrigation significantly improves dry matter accumulation in wheat.

Ear length (cm)

Maximum ear length was recorded under I_3 (two irrigations at CRI and boot leaf stages), which was at par with I_2 (one irrigation at CRI), while the minimum was observed under I_1 (no irrigation). Among genotypes, V_5 (CG1040(c)) produced the longest ears, followed by V_8 (MPO(d)) and V_4 (DBW432), whereas V_2 (HI8827(d)(C)) recorded the shortest ears at harvest (Table 3). The interaction between irrigation and genotype was non-significant. The increase in ear length with higher irrigation levels may be attributed to a steady water supply, which supports metabolic processes and enhances photosynthetic activity. Similar findings were reported by Atikullah *et al*. (2014) [7] and Ahmad and Kumar (2015) [2].

Number of grains ear $head^{-1}$

The highest number of grains per ear was recorded under I_3 (two irrigations at CRI and boot leaf stages), followed by I_2 (one irrigation at CRI), while the lowest was observed in I_1 (no irrigation). Significant differences were also observed among genotypes, with V_5 (CG1040(c)) producing the maximum grains per ear, at par with V_8 (MPO(d)) and V_4 (DBW432), whereas V_2 (HI8827(d)(C)) recorded the minimum (Table 3). The interaction between irrigation and genotype was non-significant. Higher moisture availability likely enhanced plant height, LAI, and dry matter accumulation, contributing to increased yield components through improved photosynthesis, translocation of photosynthates, and better potassium uptake. Consequently, I_3 produced the maximum grains per ear. Similar results were reported by Khokhar *et al*. (2010).

Test weight (g)

The highest test weight was recorded under I_3 (two irrigations at

CRI and boot leaf stages), which was at par with I_2 (one irrigation at CRI), while the lowest was observed in I_1 (no irrigation) plots. Among genotypes, V_5 (CG1040(c)) exhibited the highest test weight, at par with V_8 (MPO(d)) and V_4 (DBW432), whereas V_2 (HI8827(d)(C)) recorded the lowest (Table 3). The interaction between irrigation and genotype was non-significant. Regular irrigation throughout the growing season enhances dry matter accumulation in grains, improving their plumpness and, consequently, test weight. These findings are consistent with Karam *et al*. (2009) and Ahmad and Kumar (2015) [2].

Grain yield (q ha^{-1})

Both irrigation levels and genotypes significantly influenced grain yield at harvest. The highest grain yield was recorded under I_3 (two irrigations at CRI and boot leaf stages), which was at par with I_2 (one irrigation at CRI), while the lowest yield was observed in I_1 (no irrigation) plots. Among genotypes, V_5 (CG1040(c)) produced the highest grain yield, comparable with V_8 (MPO(d)) and V_4 (DBW432), whereas V_2 (HI8827(d)(C)) recorded the lowest (Table 3). The interaction between irrigation and genotype was non-significant. Higher grain yield under adequate irrigation is attributed to improved growth parameters and yield components resulting from optimal moisture availability. Similar increases in grain yield with irrigation were reported by Kumar and Pannu (2012) [17], Aslam *et al*. (2014) [6], and Bedarkar *et al*. (2017) [10].

Straw yield (q ha^{-1})

Both irrigation levels and genotypes significantly influenced straw yield. The highest straw yield was recorded under I_3 (two irrigations at CRI and boot leaf stages), which was at par with I_2 (one irrigation at CRI), while the lowest yield occurred in I_1 (no irrigation) plots. Among genotypes, V_5 (CG1040(c)) produced the highest straw yield, comparable with V_8 (MPO(d)) and V_4 (DBW432), whereas V_2 (HI8827(d)(C)) recorded the lowest (Table 3). The interaction between irrigation and genotype was non-significant. Lower straw yield under limited moisture is likely due to reduced growth and yield attributes during critical stages. These findings are consistent with and Idnani and Kumar (2012) [14].

Table 1: Plant height (cm) of wheat influenced by different irrigation and genotypes.

Treatments	Plant height (cm)			
	30 DAS	60 DAS	90 DAS	At harvest
A. Irrigation levels (Main-plot): 03				
I_1 - No irrigation	28.13	73.04	85.85	82.11
I_2 - One irrigation at CRI (18-20 DAS)	30.67	77.81	89.01	85.12
I_3 - Two irrigations at CRI and Boot leaf stage (65-70 DAS)	31.93	80.60	93.71	88.53
S.Em (±)	0.05	0.10	0.13	0.11
CD (5%)	1.26	2.75	3.33	3.02
B. Genotypes (Sub-plot): 09				
V_1 - UAS 484 (d)	31.23	78.48	90.28	86.54
V_2 - HI 8827 (d) (c)	25.19	67.27	86.06	78.45
V_3 - MACS 4131 (d)	30.49	78.02	89.98	85.88
V_4 - DBW 432	32.93	81.47	91.07	86.92
V_5 - CG 1040 (c)	34.19	83.34	92.76	88.35
V_6 - HI 8851 (d)	27.85	73.42	87.96	84.48
V_7 - HI 8823 (d) (c)	26.34	72.42	87.05	83.48
V_8 - MPO 1308 (d)	33.61	82.21	91.75	87.87
V_9 - DBW 110 (c)	30.34	77.7	88.79	85.31
S.Em (±)	0.91	0.74	0.75	0.53
CD (5%)	2.59	2.13	2.14	1.51
Interaction				
S.Em (±)	0.91	0.74	0.75	0.53
C.D. (5%)	NS	NS	NS	NS

Table 2: Number of tillers of wheat influenced by different irrigation and genotypes.

Treatments	Number of tillers (m^{-2})			
	30 DAS	60 DAS	90 DAS	At harvest
A. Irrigation levels (Main-plot): 03				
I_1 - No irrigation	185.10	289.54	311.50	305.53
I_2 - One irrigation at CRI	189.90	299.31	330.70	326.55
I_3 - Two irrigations at CRI and Boot leaf stage	193.80	320.01	346.50	340.24
S.Em (±)	0.27	0.51	0.65	0.49
CD (5%)	6.85	12.96	16.4	12.32
B. Genotypes (Sub-plot): 09				
V_1 - UAS 484 (d)	189.62	309.63	332.42	325.15
V_2 - HI 8827 (d) (c)	180.91	270.70	290.31	281.94
V_3 - MACS 4131 (d)	188.44	301.91	322.83	316.44
V_4 - DBW 432	195.66	329.40	351.90	347.59
V_5 - CG 1040 (c)	197.32	331.42	353.82	350.23
V_6 - HI 8851 (d)	187.21	283.93	324.01	318.75
V_7 - HI 8823 (d) (c)	183.10	277.11	311.42	297.93
V_8 - MPO 1308 (d)	196.53	330.50	352.60	348.80
V_9 - DBW 110 (c)	187.84	291.72	327.01	316.09
S.Em (±)	2.38	1.24	1.16	1.26

CD (5%)	6.78	3.54	3.31	3.58
Interaction				
S.Em (±)	2.38	1.24	1.16	1.26
C.D. (5%)	NS	NS	NS	NS

Table 3: Length of ear (cm), number of grains ear head$^{-1,}$ test weight (g), Grain yield (q ha^{-1}) and straw yield (q ha^{-1}) of wheat influenced by different irrigation and genotypes.

Treatments	Length of ear (cm)	Number of grains ear head^{-1}	Test weight (g)	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})
Irrigation levels (Main-plot): 03					
I_1 - No irrigation	7.16	26.85	27.68	24.53	26.72
I_2 - One irrigation at CRI	8.59	29.99	31.01	30.59	35.55
I_3 -Two irrigations at CRI and Boot leaf	9.08	35.16	34.90	33.82	40.34
S.Em (±)	0.11	0.06	0.20	0.20	0.13
CD (5%)	0.31	3.19	0.60	0.59	3.51
B. Genotypes (Sub-plot): 09					
V_1 - UAS 484 (d)	8.56	30.99	31.90	30.86	35.41
V_2 - HI 8827 (d) (c)	6.33	31.45	27.96	24.10	29.10
V_3 - MACS 4131 (d)	8.33	31.37	30.91	29.54	34.30
V_4 - DBW 432	9.28	30.16	32.89	32.26	36.55
V_5 - CG 1040 (c)	10.02	30.02	34.45	35.32	38.39
V_6 - HI 8851 (d)	7.34	29.76	29.77	26.76	32.21
V_7 - HI 8823 (d) (c)	7.02	30.70	29.24	25.85	30.67
V_8 - MPO 1308 (d)	9.67	30.12	33.57	33.42	37.71
V_9 - DBW 110 (c)	7.92	31.42	30.07	28.69	33.51
S.Em (±)	0.26	0.80	0.49	0.43	0.77
CD (5%)	0.76	1.89	1.16	1.03	2.19
Interaction					
S.Em (±)	0.26	1.38	0.85	0.75	0.95
C.D. (5%)	NS	NS	NS	NS	NS

Table 4: Dry matter accumulation (g plant^{-1}) of wheat influenced by different irrigation and genotypes.

Treatments	Dry matter accumulation			
	30 DAS	60 DAS	90 DAS	At harvest
A. Irrigation levels (Main-plot): 03				
I_1 - No irrigation	0.51	3.89	8.13	13.1
I_2 - One irrigation at CRI (18-20 DAS)	0.52	4.61	10.1	16.5
I_3 - Two irrigations at CRI and Boot leaf stage(65-70 DAS)	0.57	5.53	11.5	18.2
S.Em (±)	0.01	0.02	0.05	0.05
CD (5%)	0.03	0.72	1.24	1.3
B. Genotypes (Sub-plot): 09				
V_1 - UAS 484 (d)	0.56	4.86	10.20	16.70
V_2 - HI 8827 (d) (c)	0.44	3.83	7.77	12.60
V_3 - MACS 4131 (d)	0.53	4.72	9.95	16.10
V_4 - DBW 432	0.58	5.11	11.10	17.80
V_5 - CG 1040 (c)	0.63	5.60	12.00	19.20
V_6 - HI 8851 (d)	0.48	4.25	8.84	14.00
V_7 - HI 8823 (d) (c)	0.45	4.01	8.50	13.60
V_8 - MPO 1308 (d)	0.60	5.18	11.20	18.00
V_9 - DBW 110 (c)	0.51	4.51	9.55	15.40
S.Em (±)	0.02	0.24	0.50	0.64
CD (5%)	0.06	0.67	1.43	1.82
Interaction				
S.Em (±)	0.01	0.18	0.49	0.60
CD (5%)	NS	NS	NS	NS

Table 5: Irrigation levels and genotypes on economics of wheat (*Triticum aestivum* L.) cultivation.

Treatments	Cost of cultivation (₹ ha^{-1})	Gross return (₹ ha^{-1})	Net return (₹ ha^{-1})	B:C Ratio
A. Irrigation levels (Main-plot): 03				
I_1 - No irrigation	27095.00	59325.75	32230.75	1.18
I_2 - One irrigation at CRI	28271.00	73003.50	44732.50	1.58
I_3-Two irrigations at CRI and Boot leaf stage	29069.00	79968.00	50899.00	1.75
B. Genotypes (Sub-plot): 09				
V_1 - UAS 484 (d)	28271.00	72649.50	44378.50	1.57
V_2 - HI 8827 (d) (c)	28271.00	57326.25	29055.25	1.02
V_3 - MACS 4131 (d)	28271.00	70134.00	41863.00	1.48
V_4 - DBW 432	28271.00	76866.00	48595.00	1.71
V_5 - CG 1040 (c)	28271.00	82340.25	54069.25	1.91

V_6 - HI 8851 (d)	28271.00	63186.75	34915.75	1.23
V_7 - HI 8823 (d) (c)	28271.00	60563.25	32292.25	1.14
V_8 - MPO 1308 (d)	28271.00	77844.75	49573.75	1.75
V_9 - DBW 110 (c)	28271.00	67623.00	39352.00	1.39

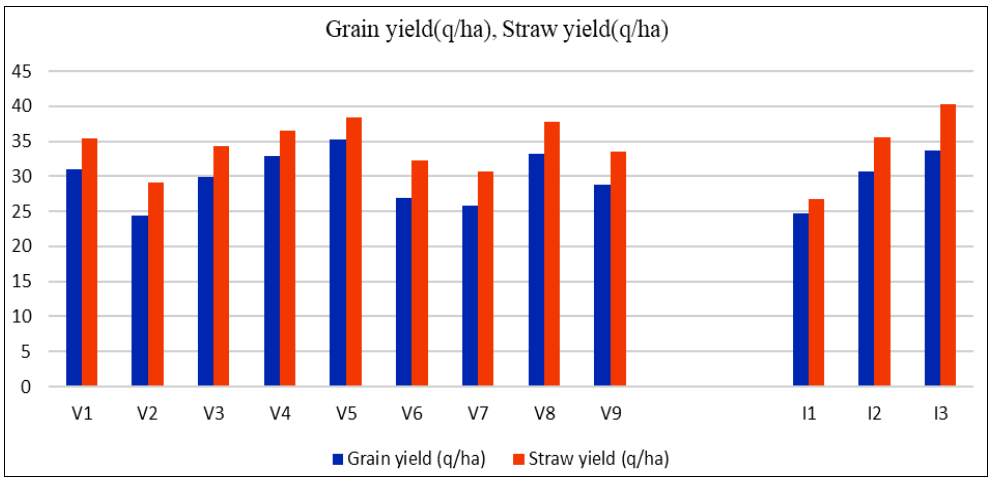

Fig 1: Effect of irrigation levels and genotypes on grain yield q ha^{-1}, straw yield q ha^{-1} of wheat (*Triticum aestivum* L.).

Conclusion

The highest grain yield was recorded under I_3 (two irrigations at CRI and boot leaf), producing 33.82 q ha^{-1}, which was significantly higher than I_2 (one irrigation, 30.59 q ha^{-1}) and I_1 (no irrigation, 24.53 q ha^{-1}). Among genotypes, CG1040(c) achieved the maximum grain yield (35.32 q ha^{-1}), at par with MPO 1308(d) (33.42 q ha^{-1}) and DBW 432 (32.26 q ha^{-1}) under restricted irrigation. These results indicate that CG1040(c) is a promising genotype for wheat cultivation in Chhattisgarh under restricted irrigation, offering superior productivity and favorable growth characteristics.

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