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Influence of irrigation levels and stress regulators on growth and productivity of wheat genotypes

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ABSTRACT

Wheat is major food crop of the rainfed areas. However, drought stress poses serious decline in the productivity of the crop. This research was therefore, conducted to evaluate the effect of irrigation levels and foliar application of stress regulators on the growth and productivity of wheat. The experiment was conducted in *rabi* season of 2021-2022 at AICRP on Wheat, College of Agriculture, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur. Thirty treatment combinations comprising of main plot treatments of three irrigation levels, sub-plot of two wheat varieties and sub-sub plot of five stress regulators were laid out in split-split plot design and replicated thrice. It was found that three irrigations at CRI, flowering and milking stage resulted in higher growth and yield (4288.26 kg ha^{-1}). Wheat genotype JW3288 outperformed JW3382 with 5.45% enhanced growth and 11.24% higher yield. Among the stress regulators, foliar application of 2% KCl produced highest growth and yield (4136.72 kg ha^{-1}) among other treatments. These results indicate that three irrigations with foliar application of 2% KCl can produce optimal yields in wheat crop under moisture scarcity. Also, wheat genotype JW3288 can be considered best to grow under limited water conditions.

Key words: *Foliar application, Moisture scarcity, Optimal yields, Stress regulators, Wheat*

Introduction

India has a total area of 31.86 million hectares and produces 109.52 million tonnes of wheat year (ICAR-IIWBR, 2022). This makes India the second-largest producer of wheat (*Triticum aestivum* (L.)) in the world. Wheat productivity in India is 3.46 tha^{-1} which is far less than the developed nations and the climatic potential of the country. In Madhya Pradesh, wheat covers an area of 6.69 m ha with a production of 17.57 mt (Sahu *et al*., 2023). Though more than 90% of the wheat acreage in India is irrigated (MoA and FW 2016–17), only around 1/3 of that area receives the necessary irrigation, and the remaining portion barely receives a few irrigations (Shinde, 2011). Sub-optimal irrigation supply results in soil moisture-stress at critical growth stages and consequently leads to poor yields (Bana *et al*., 2018). Further, fresh water demand in the country is anticipated to increase 2.3 times by 2050 (Islam and Karim, 2019). Thus, it is anticipated that the situation of water shortage, particularly the requirement for irrigation, would worsen soon. To decrease moisture stress and boost crop yield, particularly in water-limited ecologies, efficient management of irrigation water and soil moisture is crucial (Kumar *et al*., 2015).

There are a number of strategies for in-situ soil moisture management or conservation that, in addition to creating a good crop microclimate, may help wheat cope with stress. Wheat cultivation has proven to be resilient and productive even in regions grappling with limited water resources for irrigation (Shao *et al.*, 2011). Reduced irrigation techniques offer a pathway to enhance water use efficiency, which is crucial for achieving food security in a resource-constrained world (Yu *et al*., 2020). Ultimately, integrating reduced irrigation methods into wheat cultivation offers a multifaceted approach to address the challenges of water scarcity, enhance crop quality, and increase water use efficiency (Sidhu *et al*., 2021). Developing, exploration and adopting drought-tolerant wheat varieties that can withstand dry spells and less moisture without compromising productivity can also address moisture stress (Akter and Rafiqul, 2017).

The foliar application of stress regulators such as potassium chloride and ascorbic acid offers potential solution for mitigating the moisture stress in crops. The foliar application of nutrients allows nutrients to penetrate the leaf cuticle or stomata, entering the plant cells and facilitating their efficient utilization easily and rapidly. Potassium plays a vital role in maintaining plant vigor and resilience in the face of stress conditions. KCl plays a crucial role in crops under deficit irrigation by facilitating osmotic adjustment, stomatal regulation, enzyme activation, nutrient uptake, and stress resistance (Brestic *et al*., 2018). Its presence ensures optimal growth and productivity even in water-limited conditions. Ascorbic acid is well known to regulate stress tolerance in plants as reported in several studies (Dolatabadian *et al*., 2010). Furthermore, it acts as a co-factor for enzymes that work in various metabolic pathways (Rigano *et al*., 2017). Moreover, exogenously applied ascorbic acid is believed to be very effective in protecting proteins and lipids in plants exposed to water deficit and higher saline regimes (Farooq *et al*., 2020). There is a lack of research on the combination of these approaches towards optimising wheat yield under limited water access. Thus, this experiment was designed to identify optimum irrigation level, drought-tolerant cultivar and most effective stress regulator for this potential crop for successfully utilizing the drought-hit areas.

Materials and Methods

A field experiment was conducted during R*abi* season of 2021-2022 at AICRP on Wheat, College of Agriculture, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (23°90' N latitude, 79°58' E longitude, and 411.78 m above MSL).

The climate of the experimental site was subtropical. The mean weekly maximum temperature ranged from 20.80 to 40.60 ºC while the mean weekly minimum temperature ranged between 3.90 to 20.40 ºC. The total rainfall received during the cropping season was 53.5 mm with 7 rainy days. The soil in the research field was sandy clay loam in texture, neutral in reaction (pH 7.25), medium levels of organic carbon (0.67%), available nitrogen (268.20 kg/ha), available phosphorus (19.50 kg/ha), and high levels of available potassium (298.40 kg/ha) with electrical conductivity (0.32 dS/m).

With three replications, the experiment was set up using a split-split plot design. There were 30 different treatment combinations, including main plot treatments with three different irrigation levels (I_1- one irrigation at CRI, I_2- two irrigation at CRI and flowering and I_3- three irrigations at CRI, flowering and milking stage), subplot treatments of 2 wheat cultivars (JW3288 and JW3382) and sub-sub plot treatments of 5 stress regulators (S_1: Control (Water spray) at tillering (40-45) and flowering (75-80 DAS), S_2: 1 % KCl application at tillering (40-45) and flowering (75-80 DAS) S_3: 2 % KCl application at tillering (40-45) and flowering (75-80 DAS), S_4: 0.1 % Ascorbic acid application at tillering (40-45) and flowering (75-80 DAS) and S_5: 0.2 % Ascorbic acid application at tillering (40-45) and flowering (75-80 DAS). The crop was drilled at a seed rate of 100 kg/ha with a row spacing of 20 cm on November 8, 2021. The crop management practices were followed according to the recommended package of practices. Crop growth rate (CGR) was measured 30–60 DAS using formula given by Watson (1952). Net assimilation gain per unit of leaf area and time was determined during 30–60 DAS using the Nichiporovich (1967) formula. After harvest, the grain yield for each net plot was recorded. The wheat grains obtained from the net plot area of each plot after threshing and winnowing were weighed on an electronic balance. The grain yield was then converted from kilograms per plot to kilograms per hectare.

The data recorded was analyzed statistically by using the techniques of Analysis of Variance (ANOVA) as suggested by Gomez and Gomez (1984). Critical difference at 0.05 probability level was worked out to compare the treatments when the "F" test was found not to be significant.

Results and Discussion

Growth parameters

The findings showed that all the treatments had a significant impact on Crop growth rate (CGR) and Net assimilation rate (NAR) at 30-60 DAS (Table 1). Among the irrigation levels, maximum crop growth rate was recorded when applying I_3-three irrigation (10.36 gm^{-2}day^{-1}) followed by I_2-two irrigations (8.91 gm^{-2}day^{-1}) and lowest in I_1-one irrigation level (7.46 gm^{-2}day^{-1}). Similar trend was observed in net assimilation rate with maximum NAR under I_3 irrigations (0.0587 gm^{-2} day^{-1}). Adequate soil moisture under three irrigations foster vigorous vegetative growth and leads to increased biomass. Similar findings have been reported by Zhao *et al*., 2020. As regards with varieties, at 30-60 DAS, variety V_1-JW3288 recorded significantly higher crop growth rate and net assimilation rate as compare to V_2-JW3382 (Fig.1) which may be due to genetic traits related to growth efficiency and photosynthetic capacity (Silva *et al*., 2020). Among the stress regulators, Foliar application of 2% KCl produced maximum CGR (9.29 gm^{-2}day^{-1}) and NAR (0.0562 gm^{-2}day^{-1}) as compared to other treatments. Potassium is an essential nutrient that plays a central role in various plant processes which are crucial for efficient photosynthesis. These findings are in confirmation with Ishfaq *et al*., 2023.

The interaction effect between irrigation levels and wheat varieties on grain yield was found to be significant ($p>0.05$) (Table 2) with the maximum growth rate under I_3V_1 (three irrigations + JW-3288) combination. The interaction between wheat varieties and stress regulators exhibited a significant difference ($p<0.05$) with maximum CGR and NAR in variety JW-3288 with the foliar application of 2% KCl (V_1S_3). Similarly, the interaction effect between

Table 1. Effect of irrigation levels and stress regulators on the growth parameters and grain yield of wheat

Treatments	CGR (g m^{-2} day^{-1}) 30-60 DAS	NAR (g m^{-2} day^{-1}) 30-60 DAS	Grain yield (kg ha^{-1})
Irrigation levels			
I_1- One irrigation	7.46	0.0503	2821.30
I_2- Two irrigation	8.91	0.0547	3701.11
I_3-Three irrigation	10.36	0.0587	4288.26
SEm±	0.251	0.0010	64.985
C.D. (5%)	0.986	0.0038	255.16
Varieties			
V_1- JW 3288	9.16	0.0560	3818.18
V_2- JW 3382	8.66	0.0531	3388.94
S.Em±	0.105	0.0003	37.319
C.D. (5%)	0.362	0.0011	129.13
Stress regulators			
S_1- Water spray	8.46	0.0523	3102.39
S_2- 1% KCl	9.09	0.0554	3714.70
S_3- 2% KCl	9.29	0.0562	4136.72
S_4- 0.1% AA	8.84	0.0540	3369.91
S_5- 0.2% AA	8.88	0.0549	3694.07
S.Em±	0.192	0.0007	54.646
C.D. (5%)	0.546	0.0020	155.38
Interaction effect (Irrigation levels x varieties)			
SEm±	0.182	0.0006	64.638
C.D. (5%)	0.628	0.0019	223.67
Interaction effect (Varieties x Stress regulators)			
S.Em±	0.272	0.0010	77.282
C.D. (5%)	0.773	0.0028	223.36
Interaction effect (Irrigation levels x Stress regulators)			
S.Em±	0.333	0.0012	94.650
C.D. (5%)	0.946	0.0034	303.46

irrigation levels and stress regulators on grain yield was found to be significant (p>0.05). The I_3S_3 (three irrigations + 2% KCl) combination recorded the maximum growth.

Grain yield

Statistically significant outcomes (p>0.05) were attained for grain yield concerning irrigation levels, wheat varieties and stress regulators (Table 1). The highest grain yield was recorded when applying I_3-three irrigations (4288.2 kg ha^{-1}) while the lowest was observed for I_1-one irrigation (2821.3 kg ha^{-1}). The higher yield in three irrigations might be due to better growth and development of the crop owing to better moisture availability (Narolia *et al*., 2016; Verma *et al*., 2023). Variety JW-3288 recorded the highest grain yield (3818.1 kg ha^{-1}) compared to variety JW-3382 (3388.9 kg ha^{-1}). Maximum yield was obtained under the application of S_3-2% KCl (4136.7 kg ha^{-1}), which was significantly superior over other treatments (Fig. 2). The foliar application of potassium results in higher water uptake, nutrient uptake and efficient transport of the photosynthates which could have resulted in higher yield (Abid *et al*., 2016).

The interaction effect between irrigation levels and wheat varieties on grain yield was found to be significant (p>0.05) with maximum grain yield under I_3V_1 (three irrigations + JW-3288) combination (Table 2). The interaction between wheat varieties and stress regulators exhibited a significant difference (p<0.05). The maximum grain yield was consis-

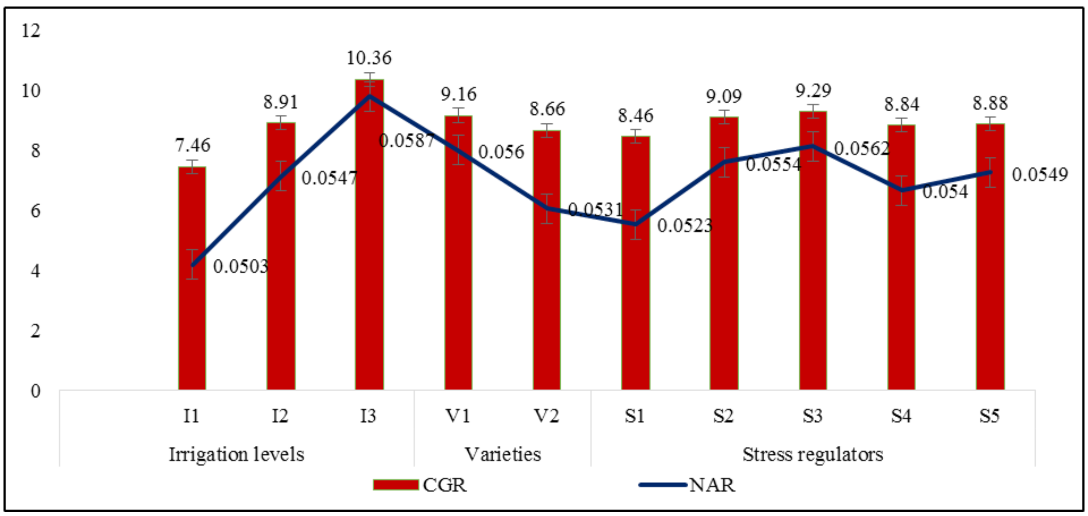

Fig. 1. Effect of irrigation levels, varieties and stress regulators on growth parameters of wheat

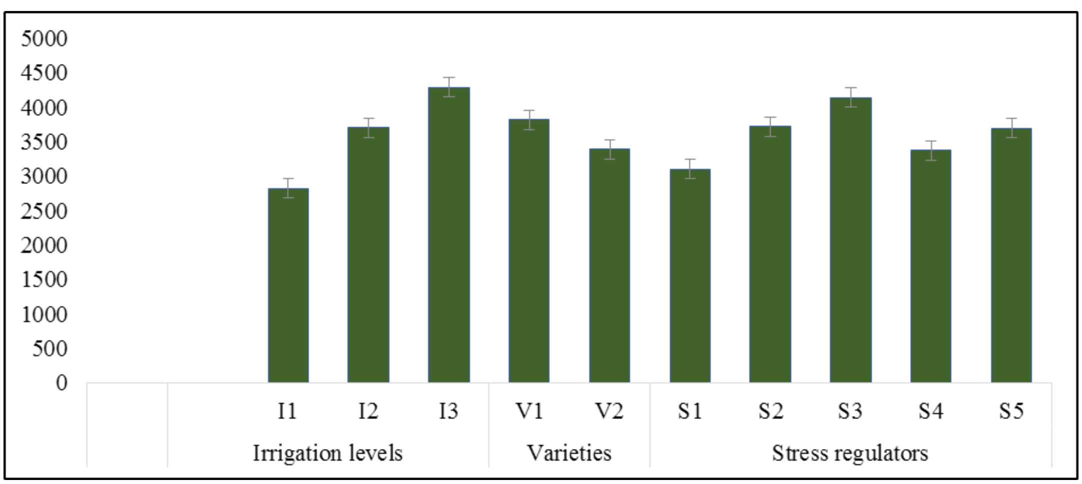

Fig. 2. Effect of deficit irrigation, varieties and stress regulators on grain yield (Kg ha^{-1}) of wheat

tently observed in variety JW-3288 with the foliar application of 2% KCl (V_1S_3). Similarly, the interaction effect between irrigation levels and stress regulators on grain yield was found to be significant (p>0.05). The I_3S_3 (three irrigations + 2% KCl) combination recorded the maximum grain yield. These findings corroborated with Ahmad *et al*., 2018.

Conclusion

This research aimed at evaluating the combination of most optimum irrigation level, stress regulator and wheat genotype under limited water access. From this experiment, it can be concluded that the three irrigations at CRI, flowering and milking is the optimum irrigation schedule with foliar application of 2% KCl and genotype JW3288 for achieving higher growth and yield in wheat.

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Conflict of Interest

The authors have no conflicts of interest to disclose.

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