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Research Article

Effect of Silicon Application and Restricted Irrigation on Growth and Yield of Wheat (*Triticum aestivum* L.)

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Abstract

A field experiment carried out at Research farm, Vivekananda Global University, Jaipur during *rabi* session 2025-26. The treatments comprising four irrigation levels (I1: no irrigation, I2: one irrigation at CRI, I3: two irrigation at CRI and booting stage and I4: three irrigation at CRI, booting and milking stage) and four silicon levels (S1: control, S2: 100 kg ha-1, S3: 150 kg ha-1 and S4: 200 kg ha-1), assigned respectively to main and sub plots and those were replicated three times in split plot design. Results revealed that under three irrigations crop obtained highest value of growth parameters (plant height, dry matter accumulation, total tillers, flag leaf area, days to 50 per cent heading and days to 50 per cent maturity) and yield attributes viz., effective tillers, grains ear^{-1}, weight of grains ear^{-1}, ear length and test weight as compared to other irrigation levels. However, the maximum crop growth rate between 50 to 75 DAS under one irrigation and between 75 DAS to at harvest under two irrigations however, highest relative growth rate was recorded under no irrigation. Superior performance of growth and yield attributes with three irrigations resulted in significant increased in grain, straw, biological yield and harvest index.

Application of silicon 200 kg ha^{-1} significantly increased growth parameters viz., plant height, dry matter accumulation, total tillers, crop growth rate, flag leaf area, days to 50 per cent heading and days to 50 per cent maturity and yield attributes i.e., effective tillers, grains ear-1, weight of grains ear^{-1}, ear length and test weight as compared to remaining silicon levels. The maximum grain, straw, biological yield and harvest index were obtained under silicon application 200 kg ha^{-1} resulted in highest.

Keywords: Silica, Irrigation growth, yield

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Introduction

Wheat (*Triticum aestivum* L.) is one of the most important cereal crops in the world and serves as a staple food for a large proportion of the global population. It is commonly referred to as the "King of Cereals" due to its wide adaptability, high productivity, and nutritional value. Wheat grains contain carbohydrates, proteins, vitamins, essential amino acids, and minerals, making them an important component of human nutrition. India is the second-largest producer of wheat after China, with wheat occupying about 30.55 million hectares and producing 107.18 million tonnes annually. Silicon (Si), the second most abundant element in the earth's crust, has gained attention as a beneficial element in crop production. Silicon application enhances plant growth, yield, resistance to diseases and insect pests, and tolerance to abiotic stresses such as drought, salinity, and metal toxicity. In wheat, silicon improves water-use efficiency by reducing transpiration through silica deposition in leaf tissues and supports physiological and metabolic activities under stress conditions.

Water is a critical input for wheat production, and proper irrigation management is essential for achieving higher productivity. Wheat generally requires 300–400 mm of irrigation water during its growth period, with critical stages including crown root initiation, tillering, jointing, flowering, milking, and dough stages. Among these, irrigation at the crown root initiation stage is particularly important for optimum growth and grain yield. Water scarcity and inefficient irrigation management are major constraints to wheat production, especially in arid and semi-arid regions. Considering the beneficial role of silicon in enhancing stress tolerance and the importance of efficient irrigation management, the present study was undertaken to evaluate the effect of silicon application and irrigation scheduling on the growth, yield, and productivity of wheat.

Materials and Methods

The field experiment carried out at Research farm, Vivekananda Global University, Jaipur during *rabi* session 2025-26. The soil of the experimental field was loamy sand in texture, slightly alkaline (pH 8.1), low in organic carbon (0.19%) and available nitrogen (274.46 kg ha^{-1}), medium in available phosphorus (21.68 kg ha^{-1}), and high in available potassium (329.76 kg ha^{-1}). The treatments comprising four irrigation levels (I_1: no irrigation, I_2: one irrigation at CRI, I_3: two irrigation at CRI and booting stage and I_4: three irrigation at CRI, booting and milking stage) and four silicon levels (S_1: control, S_2: 100 kg ha-1, S_3: 150 kg ha-1 and S_4: 200 kg ha-1), assigned respectively to main and sub plots and those were replicated three times in split plot design. Silicon was applied in the form of calcium silicate ($CaSiO_3$) containing approximately 24–28% Si (commercial grade). The required quantity of silicon was applied as a soil application and incorporated uniformly into the soil before sowing according to the treatment schedule (0, 100, 150 and 200 kg Si ha^{-1}). Irrigation water was applied through the check basin/flood irrigation method. Each irrigation supplied approximately 60 mm water depth. Accordingly, total irrigation water applied was: I_1 = 0 mm, I_2 = 60 mm , I_3 = 120 mm and I_4 = 180 mm

Water Use Efficiency (WUE) was calculated as: WUE (kg ha^{-1} mm^{-1}) = Grain yield (kg ha^{-1}) / Total water used (mm)

Wheat variety MP 3336 was sown with a seed rate of 100 kg ha^{-1}. Recommended doses of fertilizers (90:60:40 kg $N_2O_{52}O$ ha^{-1}) were applied through urea, DAP and MOP. Observations on growth, yield attributes, physiological parameters, quality, nutrient uptake and soil properties were recorded using standard procedures. The experimental data were subjected to analysis of variance (ANOVA), and treatment means were compared at the 5% level of significance following the method described by Panse and Sukhatme (1989).

Result and Discussion

Growth Parameters

The growth parameters of wheat were significantly influenced by irrigation and silicon application. Among the irrigation treatments, three irrigations applied at CRI, booting and milking stages recorded maximum plant height (80.99 cm), dry matter accumulation (83.54 g per 0.5 m row length), total tillers (49.60), and crop growth rate, whereas the control treatment (no irrigation) produced the lowest values. Likewise, silicon application at 200 kg ha^{-1} recorded the highest plant height (77.43 cm), dry matter accumulation (81.56 g), total tillers (44.95) and flag leaf area (64.91 cm^2), which remained statistically at par with 150 kg ha^{-1}. The improvement in growth parameters under higher irrigation levels may be attributed to adequate soil moisture availability, which enhanced cell division, cell elongation and photosynthetic activity, resulting in greater dry matter production and crop growth. Similar findings were reported by Jalota et al. (2006), Kharrou et al. (2011), Sarwar et al. (2010) and Mer et al. (2014). Silicon application improved plant growth by enhancing leaf erectness, reducing self-shading and promoting photosynthetic efficiency under restricted moisture conditions. Silicon deposition in plant tissues also strengthened cell walls and increased assimilate production, thereby improving crop growth. Similar observations have been reported by Yoshida et al. (1980), Gong et al. (2003), Ma (2004) and Jaleel et al. (2009).

Yield Attributes and Yield

Yield attributes and yield of wheat were significantly affected by irrigation and silicon levels. Application of three irrigations produced the highest number of effective tillers (47.36 per 0.5 m row length), grains ear^{-1} (44.82), grain weight ear^{-1} (1.78 g), ear length (7.59 cm), test weight (41.79 g) and grain yield (4287 kg ha^{-1}). Maximum biological yield (11026 kg ha^{-1}) was also obtained under three irrigations, while straw yield (6860 kg ha^{-1}) was highest under two irrigations. Application of silicon at 200 kg ha^{-1} resulted in maximum effective tillers (43.18), grains ear^{-1} (42.65), grain weight ear^{-1} (1.66 g), test weight (40.69 g), grain yield (3814 kg ha^{-1}), straw yield (6425 kg ha^{-1}) and biological yield (10239 kg ha^{-1}), which remained statistically at par with silicon @ 150 kg ha^{-1}. The superior performance under three irrigations may be attributed to optimum moisture availability throughout crop growth, which improved photosynthetic activity and source-sink relationships, resulting in enhanced translocation of assimilates towards developing grains. Moisture stress under limited irrigation reduced metabolic activities and restricted grain development, leading to lower productivity. These findings are in agreement with those of Mubeen et al. (2013), Ali et al. (2012), Yadav et al. (2010) and Rahim et al. (2010). Similarly, silicon application enhanced yield attributes and yield through improvement in physiological processes, nutrient uptake and stress tolerance. Silicon-mediated enhancement in leaf erectness and photosynthetic efficiency increased carbohydrate synthesis and partitioning towards economic yield. Moreover, silicon reduced the adverse effects of moisture stress and improved overall plant metabolism, thereby resulting in higher grain, straw and biological yields. Comparable results have been reported by Buck et al. (2008), Gholami and Falah (2013), Wattanapayapkul et al. (2011), Ma and Takahashi (1993) and Sorrato et al. (2012).

Table 1 Effect of irrigation and silicon levels on growth parameters of wheat

Treatment	Plant population	Plant Height (cm)				Dry matter accumulation (g) (0.5 m row length)				Total tillers	CGR		RGR	
		25DAS	50DAS	75DAS	At harvest	25 DAS	50DAS	75DAS	At harvest		75DAS	At harvest	75DAS	At harvest
Irrigation levels														
I1	8.48	25.16	32.92	61.28	63.06	7.23	18.46	55.62	63.74	31.47	12.09	1.57	0.0523	0.0027
I2	8.96	34.2	43.24	75.92	78.05	8.08	24.98	73.53	83.09	45.01	15.89	1.9	0.0517	0.0022
I3	8.59	34.26	44.72	77.52	79.91	8.37	26.16	74.53	84.17	46.97	15.83	1.92	0.0499	0.0022
I4	8.66	35.05	45.12	80.41	80.99	8.91	27.19	73.95	83.54	49.6	15.29	1.9	0.0478	0.0022
SEm±	0.15	0.21	0.61	1.26	0.73	0.12	0.43	1.47	1.61	0.45	0.41	0.2	0.0005	0.0001
CD	NS	1.47	2.85	5.09	3.27	0.33	2.22	5.82	6.31	2.29	2.17	0.03	NS	0.0001
Silicon levels														
S1	8.93	29.78	39.2	71.47	73.77	7.76	22.79	65.03	73.91	41.05	13.78	1.74	0.0499	0.0025
S2	8.6	32.45	41.48	73.2	74.97	8.14	24.15	69.53	78.77	42.78	14.83	1.82	0.051	0.0023
S3	8.55	33.23	41.87	74.59	75.84	8.27	24.77	70.95	80.3	44.26	15.09	1.85	0.0503	0.0023
S4	8.6	33.2	43.45	75.88	77.43	8.42	25.08	72.12	81.56	44.95	15.38	1.87	0.0504	0.0023
SEm±	0.1	0.19	0.3	0.75	0.4	0.02	0.26	1.44	1.58	0.36	0.26	0.03	0.001	0.00001
CD	NS	1.12	1.44	2.76	1.72	0.07	1.33	4.78	5.18	1.63	NS	0.02	NS	0.0001

Table 1 Effect of irrigation and silicon levels on Yield of wheat

Treatment	Flag leaf area at 70 DAS	Days to 50 per cent heading	Days to 50 per cent Maturity	Effective Tillers (0.5 m row length)	Grains Ear-1	Weight Grains Ear-1 (g)	Ear Length (cm)	Test Weight (g)	Grain Yield (Kg ha-1)	Straw Yield (Kg ha-1)	Biological Yield (Kg ha-1)	Harvest Index (%)
Irrigation levels												
I1	63.26	61.3	90.97	31.04	33.15	1.18	6.55	37.23	2185	4516	6701	32.61
I2	63.7	70.88	99.38	43.23	42.15	1.57	7.05	39.44	3388	6317	9705	34.91
I3	64.53	72.38	103.8	44.99	43.23	1.68	7.28	40.94	3850	6860	10710	35.95
I4	64.8	73.05	107.13	47.36	44.82	1.78	7.59	41.79	4287	6739	11026	38.88
SEm±	0.17	0.28	1.02	0.57	0.68	0.07	0.1	0.39	84.74	123.02	207.76	40.79
CD	NS	1.45	4.03	2.23	2.59	0.01	0.57	1.6	317.84	450.32	768.16	41.38
Silicon levels												
S1	63.38	67.55	99.38	39.67	39.73	1.44	7.08	38.02	2994	5725	8719	34.34
S2	63.82	68.97	98.97	41.23	40.23	1.54	7.1	40.25	3252	5991	9243	35.18
S3	64.18	70.22	101.3	42.56	40.73	1.57	7.05	40.45	3649	6292	9941	36.71
S4	64.91	70.88	101.63	43.18	42.65	1.66	7.24	40.69	3814	6425	10239	37.25
SEm±	0.1	0.13	0.58	0.49	0.47	0.02	0.02	0.29	78.43	82.21	160.64	48.82
CD	0.02	0.26	1.44	1.63	1.56	0.05	NS	1.05	248.1	259.14	507.24	48.91

Conclusion

The study revealed that application of three irrigations at CRI, booting and milking stages significantly enhanced growth and yield of wheat. Silicon application at 200 kg ha^{-1} produced the highest grain yield; however, yields obtained with 150 and 200 kg ha^{-1} were statistically at par. Therefore, application of 150 kg Si ha^{-1} along with three irrigations may be recommended as an economically viable practice for enhancing wheat productivity under restricted irrigation conditions.

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