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Effect of silicon application and irrigation scheduling on productivity and profitability of barley (*Hordeum vulgare* L.)

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Abstract

*Investigation entitled "Effect of silicon application and irrigation scheduling on productivity and profitability of barley (*Hordeum vulgare *L.)." using Silicon' was carried out in* Rabi *season of 2020-21 at Agricultural Research Farm, Deptt. of Agronomy, R.B.S. College Bichpuri, Agra. The variables involved in this study were four levels of irrigation viz. no irrigation(I_1), one irrigation at 30-35 DAS (I_2), two irrigations at 30-35 and 80-85 DAS (I_3) and three irrigations at 30-35, 60-65 and 90-95 DAS (I_4) along with four treatments of silicon application viz. 200 kg ha^{-1}(S_4), 150 kg ha^{-1}(S_3), 100 kg ha^{-1} (S_2) and control (S_1). Thus, in all 16 treatment combinations were compared in a 'split plot design' having levels of irrigation in main plots and silicon in sub-plots with three replications. The results reveled that silicon had significant positive effect on all morphological characters of Barley plant. Among all the treatments, silicon application @ 200 kg ha^{-1} showed significantly better plant growth and yield as compared to other lower levels and control. On the basis of maximum net return and B:C ratio barley crop grown with three irrigations along with application of silicon @ 200 kg ha^{-1} may be recommended for the farmers of Agra region.*

Key words: Barley, Drought-resistant, Irrigation, Productivity, Profitability and Silicon,

Introduction

The limited availability of water resources in arid and semi-arid regions poses a significant challenge to sustainable agriculture, with drought stress projected to cause up to a 30% reduction in global crop production by 2025. Barley, a drought-resistant crop rich in nutrients, is extensively cultivated in arid areas due to its stress tolerance and nutritional value. Barley serves as both human food and animal feed, with a substantial portion of India's barley production used for cattle feed and industrial purposes like beer and whisky production. (Sánchez-Díaz *et al.* 2002). Drought stress impacts barley growth and yield by affecting various physiological and biochemical processes, particularly during critical growth stages like spike emergence and grain development. Utilizing nano-fertilizers, particularly those containing silicon, can enhance nutrient efficiency, reduce environmental pollution, and mitigate the negative effects of over-fertilization, offering a sustainable solution for agriculture in water-stressed regions and contributing to global

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food security through improved crop productivity. (Temel *et al*., 2017).

Silicon, as an essential element for higher plants, plays a crucial role in enhancing plant tolerance to various abiotic stresses. Silicon fertilizer offers a dual benefit to the soil-plant system by improving plant-silicon nutrition, thereby reinforcing plant defenses against diseases, pests, and adverse climatic conditions, and by optimizing soil fertility through enhanced water retention, improved soil structure, and nutrient availability. Epstein and Bloom (2005), Despite the ubiquitous presence of silicon in soil, its essentiality in higher plants has been established, with silicon-deprived plants exhibiting abnormal growth compared to silicon-supplemented plants. Additionally, excess silicon does not harm plants and has been found to mitigate both biotic and abiotic stresses such as salinity, drought, heavy metal toxicity, and high temperatures. Studies have demonstrated that silicon application can enhance plant tolerance to salinity and drought, offering a practical approach to increasing crop yield in challenging environments. Furthermore, the use of silicon can reduce the need for irrigation, thereby helping to prevent soil salinization. Silicon fertilizer is considered a high-quality, environmentally friendly option for promoting sustainable and ecologically sound agricultural practices.(Bauer *et al.* 2011).

Materials and Methods

The field experiment was carried out during *Rabi* season of 2020-21 at Agricultural Research Farm, Deptt. of Agronomy, R.B.S. College, Bichpuri, Agra (U.P.). The variables involved in this study were four levels of irrigation viz. no irrigation (I_1), one irrigation at 30-35 DAS (I_2), two irrigations at 30-35 and 80-85 DAS (I_3) and three irrigations at 30-35, 60-65 and 90-95 DAS (I_4) along with four treatments of silicon application viz. 200 kg ha^{-1}(S_4), 150 kg ha^{-1}(S_3), 100 kg ha^{-1} (S_2) and control (S_1). Thus, in all 16 treatment combinations were compared in a 'split pilot design' having levels of irrigation in main plots and silicon in sub-plots with three replications.. Full dose of Nitrogen (60 kg ha^{-1}), P_2O_5 (30kg ha^{-1}) and K_2O (20 kg ha^{-1}) in only control plots i.e. I_1 (without irrigation) as basal dressing at the time of sowing. In rest of the plots half amount of recommended nitrogen (30 kg N ha^{-1}) , 30 kg P_2O_5 ha^{-1} and 20 kg K_2O ha^{-1} through DAP (46% P_20_5+18% N), Urea (46% N) and MOP (60% K_2O) were applied at the time of sowing as basal dressing. The remaining half amount (30 kg ha^{-1}) of Nitrogen was applied as top dressing through urea after first irrigation.

Results and Discussion

Growth and Development

According to Table 1 in, the results for the yield attributes of the barley crop as influenced by

Table 1: Yield attributes of barley crop as influenced by irrigation levels and silicon application

Treatments	Stand count/m^2	Ear head/m^2	Length of spike(cm)	No. of spikelets spike^{-1}	No. of fertile spikelets spike^{-1}	No. of grains spike^{-1}	1000 grain weight(g)
Irrigation levels							
I_1	273.66	256.16	4.02	40.28	36.76	31.28	27.52
I_2	298.19	283.94	5.10	48.22	45.50	37.50	38.02
I_3	329.46	313.02	6.50	50.87	49.12	46.38	39.40
I_4	344.68	332.04	8.03	53.55	52.19	48.10	40.39
SEm±	1.50	0.60	0.17	0.65	1.03	0.38	0.25
CD(p=0.05)	4.12	1.65	0.48	1.78	2.83	1.04	0.70
Silicon application							
S_1	301.56	288.31	5.44	46.09	43.49	33.21	33.20
S_2	310.92	294.03	5.78	47.66	45.56	39.50	38.38
S_3	313.11	299.16	6.10	48.77	46.85	43.10	39.40
S_4	320.41	303.66	6.33	50.40	48.82	46.22	40.23
SEm±	1.42	0.76	0.07	0.41	0.58	0.44	0.22
CD(p=0.05)	3.44	1.83	0.17	1.00	1.41	1.06	0.53

irrigation levels and silicon application are as follows, Effect of irrigation levels three irrigations (I_4) at 30-35, 60-65 and 90-95 DAS resulted in significantly higher values for stand count/m^2, earheads/m^2, length of spike, number of spikelets/spike, number of fertile spikelets/spike, number of grains/spike, and 1000 grain weight compared to other irrigation levels.

The values for these parameters decreased with decreasing number of irrigations, with the lowest values observed in the no irrigation (I_1) treatment. Grain yield is the combined effect of length of spike, number of grains spike, weight of grains spike^{-1} and 1000-grain weight. These characters were maximum with three irrigations and they were significantly higher over all other levels of irrigation under test. One or more characters among number of spikes per metre^2, length of spike, number of grains spike^{-1}, grain weight spike^{-1} were significantly increased with three irrigations have also been reported by Galav and Bharos (2017), Tomar, *et al.* (2016) and Singh *et. al* (2018).

Application of silicon at 200 kg/ha (S_4) resulted in significantly higher values for stand count/m^2, earheads/m^2, length of spike, number of spikelets/spike, number of fertile spikelets/spike, number of grains/spike, and 1000 grain weight compared to lower levels of silicon and the control (S_1). The values for these parameters decreased with decreasing levels of silicon application, with the lowest values observed in the control treatment without silicon application. In summary, the best yield attributes were observed with three irrigations and silicon application at 200 kg/ha, indicating the positive effects of both irrigation and silicon supplementation on the growth and development of the barley crop. The results are in close proximity with the results obtained by Maghsoudi *et al*., (2016) and Behboudi *et al*., (2018).

Yield Studies

Three irrigations (I_4) at 30-35, 60-65, and 90-95 DAS recorded significantly higher biological yield, grain yield, and straw yield compared to two irrigations (I_3), one irrigation (I_2), and no irrigation (I_1).The respective increase in biological yield with three irrigations was 16.03%, 35.25%, and 83.62% over two irrigations, one irrigation, and no irrigation, respectively.Grain yield with three irrigations was 54.17 q/ha, which was an increase of 16.95%, 38.15%, and 89.54% over two irrigations, one irrigation, and no irrigation, respectively.The maximum straw yield was recorded with three irrigations, and it was appreciably higher compared to no irrigation, one irrigation, and two irrigations. Every increase in the number of irrigations increased the harvest index appreciably, with three irrigations having a significantly higher harvest index than two,

Table 2: Yield of barley crop as influenced by irrigation levels and silicon application

Treatments	Biological yield (q ha^{-1})	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Harvest index (%)
Irrigation levels				
I_1	71.02	28.58	42.44	40.23
I_2	96.42	39.21	57.21	40.65
I_3	112.39	46.32	66.07	41.21
I_4	130.41	54.17	76.24	41.54
SEm±	1.48	0.60	0.89	0.06
CD (p=0.05)	4.08	1.64	2.45	0.16
Silicon application				
S_1	94.02	38.43	55.59	40.74
S_2	100.41	41.09	59.33	40.79
S_3	105.80	43.52	62.28	41.02
S_4	110.00	45.24	64.77	41.06
SEm±	2.17	0.90	1.27	0.06
CD (p=0.05)	5.26	2.18	3.08	0.15

Table 3: Economics of barley crop (Rs. ha^{-1}) as influenced by irrigation levels and silicon application

Treatments	Gross income (Rs. ha^{-1})	Cost of cultivation (Rs. ha^{-1})	Net income (Rs. ha^{-1})	B:Cratio
I_1S_1	70701	35575	35126	1.99
I_1S_2	73477	37075	36402	1.98
I_1S_3	75920	37825	38095	2.01
I_1S_4	77730	38575	39155	2.02
I_2S_1	81761	37475	44286	2.18
I_2S_2	84537	38975	45562	2.17
I_2S_3	86980	39725	47255	2.19
I_2S_4	88789	40475	48314	2.19
I_3S_1	88954	39375	49579	2.26
I_3S_2	91730	40875	50855	2.24
I_3S_3	94173	41625	52548	2.26
I_3S_4	95983	42375	53608	2.27
I_4S_1	96974	41275	55699	2.35
I_4S_2	99750	42775	56975	2.33
I_4S_3	102193	43525	58668	2.35
I_4S_4	104002	44275	59727	2.35

one, and no irrigation.The results are in close proximity with the results obtained by Bahadur *et al.* (2013)*,* Tomar *et al*., (2016) and Galav *et al*., (2017).

Application of silicon at 200 kg/ha (S_4) produced a significantly higher biological yield by 9.55% and 17.00% compared to 100 kg/ha and the control, respectively, while it was at par with 150 kg/ha. The application of silicon at 200 kg/ha (S_4) and 150 kg/ha (S_3) produced grain yields of 45.24 and 43.52 q/ha, respectively, which were significantly higher compared to 100 kg/ha and the control. The application of silicon at 200 kg/ha (S_4) and 150 kg/ha (S_3) produced significantly higher straw yields compared to 100 kg/ha and the control.The application of silicon increased the harvest index considerably over the control, with 200 kg/ha and 150 kg/ha being at par. The results are in close proximity with the results obtained by Martin *et al*., (2017), and Hellala *et al*. (2020).

Economic analysis of barley

The economic feasibility of different agronomic practices is usually a deciding factor for its adoption by the farmers for commercialization of any crop production program. It is, therefore, of common interest to calculate the effect of different treatments taken in this study on the yield of barley. Economic efficiency of various treatments taken in this study was worked out on the basis of net return.

The regional adaptability of any agronomic practice in the cultivation of any crop is completely based on maximum economic value of treatments. Based on the cost analysis, highest net profit of Rs. 59727 ha^{-1} (Table-3) was obtained from application of silicon @ 200 kg ha^{-1} with three irrigation followed by application of silicon @ 150 kg ha^{-1} with three irrigation gave net return of Rs. 58668 ha^{-1}. Maximum B:C ratio (2.35) was noted with application of silicon @ 200 kg ha-1 with three irrigations but it was same with 150 kg silicon ha-1 and no silicon with three irrigation. Additional benefit with each rupee invested in these cases is due to less investment. The similar results have also been reported by Rao *et al*., (2018), Kumar *et al*., (2019), Sharma *et al*. (2020) and Prajapat *et al*. (2022).

Conclusion

Based upon the results, barley crop grown with three irrigations at 30-35, 60-65 and 90-95 DAS along with the application of silicon at 200 kg/ha showed significantly better growth, yield attributes (stand count, earheads, spike length, spikelets, grains per spike, 1000-grain weight), biological yield, grain yield, and straw yield and economic analysis (net return Rs. 59,727 ha^{-1}, benefit-cost ratio 2.35) although the B:C ratio was the same as silicon at 150 kg/ha and no silicon application with three irrigations compared to other treatment combinations.

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