



International Journal of Research in Agronomy

E-ISSN: 2618-0618
P-ISSN: 2618-060X
© Agronomy
NAAS Rating (2026): 5.20
www.agronomyjournals.com
2026; 9(6): 975-980
Received: 02-03-2026
Accepted: 06-04-2026

Bahnu Pratap Ghasil
Department of Agronomy,
Rajasthan Agricultural Research
Institute, Durgapura, Jaipur,
Rajasthan, India

OP Meena
Department of Agronomy,
Rajasthan Agricultural Research
Institute, Durgapura, Jaipur,
Rajasthan, India

MR Yadav
Department of Agronomy,
Rajasthan Agricultural Research
Institute, Durgapura, Jaipur,
Rajasthan, India

DK Jajoria
Department of Agronomy,
SKNCOA, Jobner, Rajasthan,
India

Basant Kumar Dadarwal
Department of Plant Physiology,
SKNCOA, Jobner, Rajasthan,
India

Santosh Choudhary
Department of Agronomy,
Rajasthan Agricultural Research
Institute, Durgapura, Jaipur,
Rajasthan, India

Corresponding Author:
Bahnu Pratap Ghasil
Department of Agronomy,
Rajasthan Agricultural Research
Institute, Durgapura, Jaipur,
Rajasthan, India

Response of Barley (*Hordeum vulgare* L.) to hydrogel and bioregulator applications under varying irrigation regimes

Bahnu Pratap Ghasil, OP Meena, MR Yadav, DK Jajoria, Basant Kumar Dadarwal and Santosh Choudhary

DOI: <https://www.doi.org/10.33545/2618060X.2026.v9.i6m.5812>

Abstract

A two-year field study evaluated the effects of hydrogel, irrigation levels, and bioregulators on barley (*Hordeum vulgare* L.) growth and yield. Individual treatments significantly increased plant height and dry matter accumulation at 60 DAS, 90 DAS, and harvest, though early growth at 30 DAS remained unaffected. Soil incorporation of hydrogel at 2.5 kg/ha maintained root-zone moisture, significantly increasing grain (4530 kg/ha), straw (6261 kg/ha), and biological yields (10,790 kg/ha) over the control. Similarly, scheduling three irrigations optimized moisture availability, producing significantly higher grain (4439 kg/ha), straw (6015 kg/ha), and biological yields (10,455 kg/ha) than two irrigations, while remaining statistically at par with four irrigations. Seed priming with a combination of salicylic acid at 500 ppm + thiourea at 100 ppm maximized physiological efficiency, delaying leaf senescence and securing the highest grain, straw, and biological yields (4660, 6390, and 11,049 kg/ha, respectively). However, the harvest index remained uniform across all factors, demonstrating that these management strategies scaled vegetative biomass and reproductive storage capacity to an equal degree. Conclusively, integrating hydrogel amendments, structured irrigation, and biochemical priming provides an efficient agronomic framework to enhance barley productivity.

Keywords: Barley, hydrogel, bioregulators, irrigation, yield etc.

Introduction

Barley (*Hordeum vulgare* L.) serves as a critical crop within both temperate and subtropical agricultural systems, displaying a remarkable capacity to adapt to diverse climatic conditions and marginal environments. Frequently categorized as a highly resilient species, it exhibits superior tolerance to soil salinity and challenging terrain compared to other coarse grains, accounting for approximately 15% of the global coarse grain supply. Beyond its ecological hardiness, the whole grain possesses a commendable nutritional profile, offering essential minerals and vitamins such as calcium, magnesium, phosphorus, potassium, niacin, and vitamins A and E. Globally, the utilization of barley is highly diversified, with roughly 70% directed toward livestock feed, 20% allocated for malting and brewing processes in the beverage industry, and 5% utilized for direct human consumption. In regions like India, it also holds substantial traditional value through dietary staples such as Missi Roti and 'sattu,' which is favored during summer months for its inherent cooling properties (Verma *et al.*, 2011) [25]. Furthermore, the crop provides a versatile biomass resource, serving as green fodder, straw, hay, or silage, which offers smallholder farmers a dependable avenue for supplemental income generation.

Despite its potential, barley productivity across domestic fields often remains suboptimal due to a combination of cultivation on resource-poor marginal lands, minimal input management, inadequate rainfall, and poor soil moisture conservation. These issues are frequently aggravated by poor crop establishment resulting from inadequate weed control, a slow rate of varietal replacement, and the continued use of genotypes with low yield potential. Addressing these limitations requires a dual strategy that combines the introduction of high-yielding, abiotic stress-resistant varieties with advanced crop management techniques (Ramage, 2011; Friedt *et al.*, 2011).

[19, 8]. Central to this management is the precise scheduling of irrigation water. Utilizing the critical growth stages approach has proven to be an accessible and economical strategy for farmers operating under limited water supplies to maximize output per unit volume. Conversely, when water supplies are relatively adequate, a climatological approach based on the ratio between irrigation water (IW) and cumulative pan evaporation (CPE) provides a highly systematic and judicious framework for water distribution.

To complement irrigation practices and mitigate the recurring threat of environmental drought, the integration of targeted soil moisture conservation and physiological interventions has gained considerable attention. Agronomic practices utilizing moisture-retaining agents like hydrogels, along with stover mulches, effectively regulate soil temperature, suppress weed proliferation, and minimize evaporation losses, thereby prolonging moisture availability during critical dry spells (Babu Lal, 2017) [3]. Simultaneously, the application of chemical bioregulators offers a promising pathway to enhance the plant's internal stress tolerance mechanisms. Among these, thiourea acts as a vital sulfhydryl and amino compound that improves canopy photosynthesis and overall photosynthetic efficiency due to the functional presence of its S-H group. This bio-regulatory action mimics cytokinin activity, which delays the senescence of both vegetative and reproductive organs (Halmann, 1980) [11] and preserves the photosynthetically active leaf surface during the crucial grain-filling period (Sahu *et al.*, 1993) [20]. Empirical evidence further indicates that these thiol-bioregulators actively assist in the translocation of sucrose from source to sink tissues under multi-stress environments (Srivastava *et al.*, 2008) [24]. Consequently, the strategic foliar application of substances like thiourea and salicylic acid not only supports basic vegetative growth but also optimizes dry matter partitioning, ultimately leading to enhanced grain yields in water-stressed environments (Arora, 2004) [2].

Material Methods

The experiment was conducted during *Rabi* seasons of 2022 -23 and 2023-24 at Research Farm, Rajasthan Agricultural Research Institute, Durgapura, Jaipur. Geographically this place is situated at 75°47' East longitude, 26°51' North latitude and at an altitude of 390 m above mean sea level in Jaipur district of Rajasthan. The region falls under Semi-Arid Eastern Plains Zone (IIIa) of Rajasthan.

Experimental details: RD 2907 is a recently developed, improved six-row barley variety (*Hordeum vulgare* L.) bred at the Rajasthan Agricultural Research Institute, Durgapura, Jaipur. This genotype has been specifically developed to perform well under saline and sodic soil environments, which are commonly found in reclaimed and degraded agricultural lands. The combinations of hydrogel and irrigation levels were taken in main plots and bioregulators in sub plots in split plot design. The treatments were randomly allocated to different plots, using random number table of Fisher and Yates (1963) [7].

Treatment application: Hydrogel was applied as per the treatment specifications at the time of sowing. The required quantity of hydrogel (2.5 kg/ha) was thoroughly mixed with soil and incorporated uniformly in the root zone to enhance soil moisture retention capacity. Seeds were treated with bioregulators prior to sowing. The required concentrations of Salicylic acid (500 ppm) and Thiourea (100 ppm) were prepared using distilled water. Seeds were soaked or coated uniformly with the respective

solutions and then shade-dried before sowing to ensure proper absorption of the chemicals. Irrigations were applied as per the treatment schedules assigned to each plot. The number and timing of irrigations were strictly maintained according to days after sowing (DAS) to evaluate their effect on crop growth and yield.

Plant height (cm): Five plants were selected randomly from net each plot and tagged permanently. Height of these five plants was measured at 30, 60 and 90 DAS and at harvest from the base of the plant to the top of the main shoot by meter scale and their mean was expressed as plant height (cm).

Dry matter accumulation (g/m²): For recording periodical changes in dry matter accumulation at 30, 60, 90 DAS and at harvest, the whole plants from randomly selected five plant from each experimental plot were cut from the ground level from sample rows. Samples were first sun dried and then dried in an oven 600°C for 72 hours to a constant weight. Thereafter, the dried samples were weighed and dry matter accumulation m² was recorded at each stage.

Grain yield (kg/ha): The total biomass harvested from each net plot was threshed and cleaned. The grains so obtained were weighed in kg/plot and then converted into kg/ha.

Straw yield (kg/ha): The straw yield kg per plot was obtained by subtracting the seed yield/plot from biological yield/plot recorded earlier and then converted into kg/ha.

Biological yield (kg/ha): The harvested material from net area of each plot was thoroughly sun dried. After drying, the produce of individual plot was weighed to record the biological yield and was expressed in kg/ha.

Harvest index (%): The ratio of economic yield (grain) to the biological yield (grain + straw) was calculated to estimate the harvest index and was expressed as percentage (Singh and Stoskopf, 1971).

Results and Discussion

Plant height (cm)

An integrated analysis of the experimental data reveals that the individual applications of hydrogels, irrigation schedules, and bioregulators exerted a substantial influence on the structural development of barley (*Hordeum vulgare* L.) at 60 DAS, 90 DAS and at harvest, while early vegetative growth at 30 DAS remained statistically unaltered across all treatments. Regarding moisture-retaining polymers, the application of hydrogel at 2.5 kg/ha consistently achieved the maximum plant height, demonstrating pooled increases of 11.92%, 12.87%, and 11.36% over the untreated control plots at 60 DAS, 90 DAS and harvest, respectively. Simultaneously, varying moisture levels introduced significant variation in vertical crop architecture; scheduling three irrigations yielded significantly taller plants compared to the two-irrigation regimen reflecting a pooled expansion of 7.25%, 8.04% and 6.38% across the respective growth intervals while remaining statistically at par with the four-irrigation treatment. Furthermore, chemical bio-regulation via seed priming remarkably accelerated plant height metrics. The combined application of salicylic acid at 500 ppm and thiourea at 100 ppm produced the tallest plants throughout the study, securing pooled increases of 12.96%, 18.63% and 18.49% over the absolute control at 60 DAS, 90 DAS and harvest, respectively, while also significantly outperforming the individual applications of either substance.

The pronounced elongation in barley stature under these treatments is primarily driven by the stabilization of plant-water relationships and the subsequent acceleration of internal physiological processes. The moisture-retentive properties of hydrogels preserve consistent root-zone moisture over extended periods, which enhances nutrient solubility and root uptake to drive fundamental cell division and elongation (Sahu *et al.*, 1993; Anupama *et al.*, 2012) ^[20, 1]. This interacts synergistically with optimal water scheduling; providing three irrigations ensures continuous soil moisture availability, which maintains high turgor pressure within the meristematic cells to stimulate rapid cell enlargement and uniform vegetative expansion (Gupta *et al.*, 2017) ^[9]. This structural framework is further augmented by the biochemical inputs; salicylic acid functions as a critical plant hormone regulating vegetative growth and hormonal signaling (Kakhki *et al.*, 2016) ^[12], while thiourea exerts a strong cytokinin-like influence that prevents premature organ senescence and expands the photosynthetically active leaf surface (Sharma *et al.*, 2017) ^[21]. Together, the improved root environment and hormonal stimulation enhance chlorophyll longevity and overall photosynthetic efficiency, culminating in a taller, more robust crop architecture as corroborated by parallel growth responses observed in related field crops (Singh *et al.*, 2017a; Meena *et al.*, 2020a; Singh and Meena, 2019) ^[23, 17, 22].

Dry matter accumulation

An evaluation of the experimental data (Table 2) indicates that dry matter accumulation in barley (*Hordeum vulgare* L.) was significantly influenced by the individual applications of hydrogels, irrigation levels, and bioregulators at 60 DAS, 90 DAS and harvest, whereas early growth at 30 DAS showed no statistically significant differences. Soil incorporation of hydrogel at 2.5 kg/ha secured the highest dry matter accumulation, showing pooled increases of 13.29%, 12.43% and 10.74% over the control at 60 DAS, 90 DAS and harvest, respectively. Similarly, scheduling three irrigations recorded significantly greater dry

matter compared to two irrigations reflecting pooled gains of 7.99%, 7.88% and 7.11% across the respective stages while remaining statistically at par with four irrigations. Furthermore, bio-regulatory seed priming remarkably accelerated biomass metrics. Seed treatment with salicylic acid at 500 ppm + thiourea at 100 ppm produced the maximum dry matter accumulation throughout the study, achieving pooled increases of 36.43%, 61.24% and 55.05% over the control at 60 DAS, 90 DAS and harvest, respectively, while significantly outperforming individual applications of either chemical.

The pronounced increase in dry matter accumulation under these strategies is directly linked to enhanced photosynthetic capacity and optimal nutrient utilization. The moisture-retaining property of hydrogels maintains adequate root-zone moisture over extended periods, which facilitates better root growth and enhances nutrient uptake to support continuous vegetative development (Sahu *et al.*, 1993; Anupama *et al.*, 2012) ^[20, 1]. This interacts synergistically with proper water scheduling; providing three irrigations ensures sufficient soil moisture throughout the crop cycle, preventing moisture stress that could otherwise impair tillering and canopy development (Bhadur, 2012). This stable moisture supply increases the leaf area index, ensuring leaf turgidity and maximizing light interception, which significantly boosts photosynthetic activity per unit area and leads to higher dry matter production (Lockhart and Wiseman, 1988; Gupta *et al.*, 2017) ^[16, 9]. This physiological framework is further augmented by the biochemical inputs; thiourea stimulates carbon dioxide fixation and exhibits cytokinin-like activity that delays leaf senescence, while salicylic acid regulates vital hormonal and metabolic processes (Kakhki *et al.*, 2016) ^[12]. Together, these treatments sustain a larger active leaf surface area for a longer duration, translating into efficient source-to-sink translocation and superior dry matter partitioning as corroborated by similar findings in field crops (Singh *et al.*, 2017a; Meena *et al.*, 2020a; Singh and Meena, 2019) ^[23, 17, 22].

Table 1: Effect of hydrogel, bioregulators and irrigation levels on plant height at different stages of barley

Treatments	Plant height (cm)											
	30 DAS			60 DAS			90 DAS			At harvest		
	2022-23	2023-24	Pooled	2022-23	2023-24	Pooled	2022-23	2023-24	Pooled	2022-23	2023-24	Pooled
A. Hydrogel												
H ₀ -control	19.07	19.16	19.11	38.56	38.82	38.69	70.36	71.24	70.80	72.54	72.99	72.77
H ₁ -Hydrogel @ 2.5 kg/ha	19.67	19.76	19.71	43.08	43.52	43.30	79.31	80.50	79.91	80.46	81.63	81.04
SEm ±	0.32	0.33	0.23	0.56	0.64	0.43	1.36	1.23	0.91	1.08	1.18	0.80
CD (P = 0.05)	NS	NS	NS	1.77	2.02	1.26	4.27	3.86	2.70	3.42	3.72	2.37
B. Irrigation levels												
I ₁ - Two irrigations	18.69	18.87	18.78	38.79	39.01	38.90	70.25	71.68	70.97	73.16	73.13	73.14
I ₂ - Three irrigations	19.69	19.70	19.70	41.71	41.72	41.72	76.19	77.16	76.68	77.36	78.26	77.81
I ₃ - Four irrigations	19.72	19.80	19.76	41.95	42.78	42.37	78.06	78.76	78.41	78.99	80.54	79.76
SEm ±	0.40	0.41	0.28	0.69	0.78	0.52	1.66	1.50	1.12	1.33	1.45	0.98
CD (P = 0.05)	NS	NS	NS	2.17	2.47	1.54	5.23	4.73	3.30	4.18	4.56	2.90
C. Bioregulators												
S ₁ - Control	19.10	19.23	19.17	38.11	38.49	38.30	68.46	69.58	69.02	70.45	71.15	70.80
S ₂ - Salicylic acid @ 500 ppm	19.36	19.44	19.40	40.42	40.86	40.64	73.65	74.62	74.14	75.95	76.32	76.14
S ₃ - Thiourea @ 100 ppm	19.42	19.52	19.47	41.65	41.95	41.80	75.78	76.99	76.39	76.49	77.10	76.80
S ₄ - Salicylic acid @ 500 ppm + thiourea @ 100 ppm	19.59	19.64	19.62	43.10	43.38	43.24	81.46	82.29	81.88	83.12	84.66	83.89
SEm ±	0.40	0.39	0.28	0.61	0.66	0.45	1.25	1.16	0.85	1.03	1.11	0.76
CD (P = 0.05)	NS	NS	NS	1.76	1.90	1.27	3.57	3.32	2.40	2.95	3.20	2.14

Table 2: Effect of hydrogel, bioregulators and irrigation levels on dry matter accumulation at different stages of barley

Treatments	Dry matter (g/plant)											
	30 DAS			60 DAS			90 DAS			At harvest		
	2022-23	2023-24	Pooled	2022-23	2023-24	Pooled	2022-23	2023-24	Pooled	2022-23	2023-24	Pooled
A. Hydrogel												
H ₀ -control	0.397	0.412	0.404	2.81	2.91	2.86	10.28	10.48	10.38	11.42	11.68	11.55
H ₁ -Hydrogel @ 2.5 kg/ha	0.411	0.415	0.413	3.20	3.29	3.24	11.59	11.75	11.67	12.75	12.83	12.79
SEm ±	0.006	0.006	0.004	0.05	0.05	0.03	0.17	0.20	0.13	0.18	0.19	0.13
CD (P = 0.05)	NS	NS	NS	0.16	0.15	0.10	0.55	0.64	0.39	0.58	0.59	0.39
B. Irrigation levels												
I ₁ - Two irrigations	0.398	0.407	0.403	2.83	2.93	2.88	10.24	10.59	10.41	11.41	11.65	11.53
I ₂ - Three irrigations	0.406	0.415	0.411	3.05	3.16	3.11	11.14	11.32	11.23	12.27	12.43	12.35
I ₃ - Four irrigations	0.408	0.418	0.413	3.12	3.20	3.16	11.43	11.43	11.43	12.58	12.69	12.64
SEm ±	0.008	0.008	0.005	0.06	0.06	0.04	0.21	0.25	0.16	0.22	0.23	0.16
CD (P = 0.05)	NS	NS	NS	0.19	0.18	0.12	0.67	0.78	0.48	0.70	0.72	0.47
C. Bioregulators												
S ₁ - Control	0.395	0.405	0.400	2.52	2.64	2.58	8.32	8.49	8.41	9.44	9.56	9.50
S ₂ - Salicylic acid @ 500 ppm	0.401	0.412	0.407	2.96	3.06	3.01	10.81	11.01	10.91	12.00	12.19	12.10
S ₃ - Thiourea @ 100 ppm	0.408	0.416	0.412	3.05	3.15	3.10	11.15	11.29	11.22	12.25	12.49	12.37
S ₄ - Salicylic acid @ 500 ppm + thiourea @ 100 ppm	0.412	0.421	0.417	3.48	3.55	3.52	13.46	13.66	13.56	14.66	14.79	14.73
SEm ±	0.007	0.006	0.005	0.06	0.06	0.04	0.21	0.22	0.15	0.21	0.20	0.15
CD (P = 0.05)	NS	NS	NS	0.17	0.17	0.12	0.61	0.63	0.43	0.61	0.58	0.41

Grain Yield

An evaluation of the experimental data (Table 3) indicates that the grain yield of barley (*Hordeum vulgare* L.) was significantly increased by the individual applications of hydrogels, irrigation levels, and bioregulators. Soil incorporation of hydrogel at 2.5 kg/ha achieved the maximum pooled grain yield of 4530 kg/ha, representing an 8.87% increase over the untreated control. Similarly, scheduling three irrigations recorded a significantly higher pooled grain yield of 4439 kg/ha compared to two irrigations (4114 kg/ha) reflecting a 7.90% increase while remaining statistically at par with four irrigations. Furthermore, seed treatment with salicylic acid at 500 ppm + thiourea at 100 ppm recorded the maximum pooled grain yield of 4660 kg/ha, securing a substantial increase of 18.42% over the control and outperforming individual applications of either chemical. This improvement in grain yield is driven by enhanced root-zone moisture availability, prolonged photosynthetic capacity, and optimized source-to-sink translocation. Hydrogels absorb and gradually release water to maintain favorable soil moisture, which improves root development and nutrient uptake under water-limited conditions (Yadav *et al.*, 2025) ^[26]. This acts synergistically with proper water scheduling; providing three irrigations maintains leaf chlorophyll content and extends the reproductive period, allowing for a larger allocation of net photosynthates to the developing grain (Kumar *et al.*, 2021; Kumawat *et al.*, 2022) ^[13, 15]. Additionally, the combined bioregulators enhance floral primordial differentiation, delay leaf senescence to preserve active photosynthetic sites (Gurjar *et al.*, 2022a) ^[10], and strengthen the metabolic sink capacity of the seeds, ensuring efficient translocation of food materials during the critical grain-filling phase (Parmar *et al.*, 2021) ^[18].

Straw yield

An evaluation of the experimental data (Table 3) indicates that the straw yield of barley was significantly increased by individual applications of hydrogels, irrigation levels, and bioregulators. Soil incorporation of hydrogel at 2.5 kg/ha achieved the maximum pooled straw yield of 6261 kg/ha, representing a 12.97% increase over the control. Similarly, scheduling three irrigations recorded a significantly higher pooled straw yield (6015 kg/ha) than two irrigations (5550 kg/ha) an 8.38% increase

while remaining statistically at par with four irrigations. Furthermore, seed priming with salicylic acid at 500 ppm + thiourea at 100 ppm recorded the maximum pooled straw yield of 6390 kg/ha, securing a 20.77% increase over the control and significantly outperforming individual applications of either chemical.

This improvement in straw yield is driven by enhanced root-zone moisture, vigorous vegetative growth, and increased dry matter accumulation. Hydrogels maintain favorable soil moisture by gradually releasing stored water, which improves early leaf area expansion and nutrient uptake (Yadav *et al.*, 2025) ^[26]. This acts synergistically with adequate moisture scheduling; providing three irrigations prevents moisture stress during critical vegetative phases, allowing the crop to flourish vigorously (Kumawat *et al.*, 2022) ^[15]. Additionally, the combined bioregulators improve photosynthetic efficiency and delay leaf senescence to prolong active vegetative growth (Gurjar *et al.*, 2022a) ^[10]. Together, these management practices optimize plant water status and assimilation, directly translating into superior biomass and straw production (Parmar *et al.*, 2021) ^[18].

Biological yield

The biological yield of barley (Table 3) significantly increased with individual applications of hydrogels, irrigation levels, and bioregulators. Soil incorporation of hydrogel at 2.5 kg/ha achieved the maximum pooled biological yield of 10,790 kg/ha, an 11.20% increase over the control. Scheduling three irrigations recorded a significantly higher pooled yield (10,455 kg/ha) than two irrigations (9,664 kg/ha) representing an 8.19% increase while remaining statistically at par with four irrigations. Furthermore, seed priming with salicylic acid at 500 ppm + thiourea at 100 ppm achieved the maximum pooled biological yield of 11,049 kg/ha, securing a 19.76% increase over the control and significantly outperforming individual applications of either chemical. This enhanced biomass accumulation is driven by improved root-zone moisture availability, prolonged photosynthetic capacity, and optimized source-to-sink translocation. Hydrogels maintain favorable soil moisture through gradual water release, improving early leaf area expansion and nutrient uptake (Yadav *et al.*, 2025) ^[26]. Concurrently, three irrigations eliminate moisture stress, lower soil mechanical

resistance to root development, and sustain green canopy coverage for longer periods (Kumawat *et al.*, 2022) ^[15]. Additionally, the combined bioregulators improve photosynthetic efficiency and delay leaf senescence to extend carbon assimilation (Gurjar *et al.*, 2022a) ^[10]. Because biological yield integrates both vegetative and reproductive development, these treatments interact favorably to optimize dry matter production and overall crop productivity (El Hardy *et al.*, 2009; Parmar *et al.*, 2021) ^[18].

Harvest index

An evaluation of the data (Table 3) indicates that the harvest index of barley was not significantly influenced by hydrogel applications, irrigation levels, or bioregulators, maintaining

almost uniform values across all treatments during both years and in the pooled analysis. This non-significant response occurs because these management strategies enhanced grain yield and straw yield to a statistically similar degree. While optimum resource availability and physiological regulations improved overall yield-attributing characters like effective tillers and test weight, they scaled vegetative growth and reproductive efficiency equally (Kumar *et al.*, 2017; Kumawat *et al.*, 2022) ^[14, 15]. Consequently, the simultaneous and proportional expansion of both biomass accumulation and reproductive storage capacity kept the allocation ratio of net photosynthates stable, resulting in uniform harvest index values across all treatments (Chouhan *et al.*, 2017; Singh *et al.*, 2022) ^[5, 23].

Table 3: Effect of hydrogel, bioregulators and irrigation levels on yield of barley

Treatments	Grain yield (kg/ha)			Straw yield (kg/ha)			Biological yield (kg/ha)			Harvest index (%)		
	2022-23	2023-24	Pooled	2022-23	2023-24	Pooled	2022-23	2023-24	Pooled	2022-23	2023-24	Pooled
A. Hydrogel												
H ₀ -control	4100	4222	4161	5500	5584	5542	9600	9806	9703	42.70	43.05	42.88
H ₁ -Hydrogel @ 2.5 kg/ha	4449	4610	4530	6200	6322	6261	10649	10932	10790	41.79	42.22	42.01
SEm ±	63	54	42	88	80	59	138	136	97	0.57	0.58	0.41
CD (P = 0.05)	198	171	123	276	251	175	435	429	286	NS	NS	NS
B. Irrigation levels												
I ₁ - Two irrigations	4041	4187	4114	5515	5586	5550	9556	9772	9664	42.30	42.87	42.59
I ₂ - Three irrigations	4360	4519	4439	5938	6092	6015	10298	10611	10455	42.36	42.63	42.49
I ₃ - Four irrigations	4422	4543	4483	6097	6181	6139	10519	10724	10621	42.09	42.41	42.25
SEm ±	77	66	51	107	98	73	169	167	119	0.70	0.71	0.50
CD (P = 0.05)	243	209	150	338	308	214	533	525	350	NS	NS	NS
C. Bioregulators												
S ₁ - Control	3846	4024	3935	5241	5341	5291	9087	9365	9226	42.30	42.96	42.63
S ₂ - Salicylic acid @ 500 ppm	4267	4405	4336	5791	5926	5859	10058	10331	10195	42.45	42.67	42.56
S ₃ - Thiourea @ 100 ppm	4386	4514	4450	6034	6100	6067	10420	10614	10517	42.13	42.57	42.35
S ₄ - Salicylic acid @ 500 ppm + thiourea @ 100 ppm	4599	4721	4660	6335	6445	6390	10933	11166	11049	42.12	42.34	42.23
SEm ±	64	59	43	112	97	74	166	164	117	0.57	0.58	0.41
CD (P = 0.05)	183	168	122	322	279	210	477	470	329	NS	NS	NS

Conclusion: Conclusively, integrating hydrogel at 2.5 kg/ha, scheduling three irrigations, and priming seeds with a combination of salicylic acid and thiourea provides an efficient agronomic framework for barley cultivation. These interventions successfully stabilized root-zone moisture and delayed leaf senescence, driving substantial and concurrent increases in grain, straw, and biological yields over the control. Furthermore, because vegetative growth and reproductive storage capacity expanded proportionally, the ultimate harvest index remained uniform across all management strategies.

References

- Anupama, Parmar BS. Pusa hydrogel—an indigenous semisynthetic superabsorbent technology for conserving water and enhancing crop productivity. Success Story No. 14. New Delhi: Indian Agricultural Research Institute; 2012.
- Arora D. Effect of thiourea and zinc on growth, yield and quality of barley (*Hordeum vulgare* L.). Bikaner: Rajasthan Agricultural University; 2004.
- Babu L. Response of sesame (*Sesamum indicum* L.) to vermicompost and moisture conservation practices [MSc thesis]. Jobner: S.K.N. College of Agriculture, Sri Karan Narendra Agriculture University; 2017.
- Bahadur MM, Paul NK, Chowdhury MF. Effect of irrigation levels on growth and yield of barley (*Hordeum vulgare* L.). Journal of the Bangladesh Agricultural University. 2012;10(2):163–168.
- Chouhan BS, Kaushik MK, Napelia V, Solanki NS, Singh B, Devra NS, *et al.* Effect of sowing methods, scheduling of irrigation based on IW/CPE ratio and chemical weed control on plant height, dry matter accumulation and yield of wheat. Journal of Pharmacognosy and Phytochemistry. 2017;6(3):169–172.
- El-Hardy OA, Abo-Sedera SA. Conditioning effect of composts and acrylamide hydrogels on a sandy calcareous soil. II. Physico-biochemical properties of the soil. International Journal of Agriculture and Biology. 2006;8(6):876–884.
- Fisher RA, Yates F. Statistical tables. Edinburgh: Oliver and Boyd; 1963.
- Friedt W, Horsley RD, Harvey BL, Poulsen DM, Lance R, Ceccarelli S, *et al.* Barley breeding history, progress, objectives, and technology. In: Ullrich SE, editor. Barley: production, improvement, and uses. Ames (IA): Wiley-Blackwell; 2011. p. 160–220.
- Gupta S, Kushwah SS, Sharma RK, Singh OP. Effect of irrigation regimes and nutrient levels on growth, yield and quality of drip irrigated broad bean (*Vicia faba*). Indian Journal of Agricultural Sciences. 2017;87(10):1314–1319.
- Gurjar BS, Yadav LR, Rathore BS, Yadav P, Singh K, Kumar R. Effect of foliar nutrition on growth and yield of hybrid pearl millet [*Pennisetum glaucum* (L.) R. Br.]. The Pharma Innovation Journal. 2022;11(2):252–255.
- Halmann M. Synthetic plant growth regulators. Advances in

- Agronomy. 1980;43:47–105.
12. Kakhki F, Fazel S, Mohammad G, Morteza G. Effect of salicylic acid on drought stress through improving some morphological, physiological and yield component traits of mustard plant (*Brassica campestris*). Environmental Stresses in Crop Sciences. 2016;7(1):65–77.
 13. Kumar G, Nanad V, Kumar A, Singh AK, Himanshu. Influence of moisture regimes on growth parameters, yield attributes and yield with sowing methods of wheat (*Triticum aestivum* L.) cultivar. International Journal of Chemical Studies. 2021;9(1):2781–2785.
 14. Kumar S, Dhar S, Barthwal A, Upadhyay PK. Effect of irrigation scheduling and nitrogen management on growth, yield and water use efficiency of wheat (*Triticum aestivum*). Indian Journal of Agronomy. 2017;62(3):320–325.
 15. Kumawat SK, Shivran AC, Garg K, Bhukhar OS, Shekhawat RK, Verma L. Effect of micro-irrigation scheduling on growth, yield attributes and grain yield of barley (*Hordeum vulgare* L.). The Pharma Innovation Journal. 2022;11(4):2058–2061.
 16. Lockhart JAR, Wiseman AJL. Introduction to crop husbandry. 6th ed. Oxford: Pergamon Press; 1988.
 17. Meena BS, Narolia RS, Meena LK, Meena CK, Meena SN. Evaluation of hydrogel and salicylic acid application effect on yield, quality, economics and water-use efficiency of Indian mustard (*Brassica juncea*) under restricted irrigation conditions of south-eastern Rajasthan. International Journal of Current Microbiology and Applied Sciences. 2020;9(5):3274–3283.
 18. Parmar GM, Patel PR, Parmar SK, Mungra KD, Sharma MK. Effect of growth substances on morpho-physiological traits and yield in pearl millet under rainfed condition. Journal of Pharmacognosy and Phytochemistry. 2021;10(2):971–974.
 19. Ramage RT. A history of barley breeding methods. Plant Breeding Reviews. 2011;5:95–138.
 20. Sahu MP, Solanki NS, Dashora LN. Effect of thiourea and ascorbic acid on growth and yield of maize (*Zea mays* L.). Journal of Agronomy and Crop Science. 1993;171:65–90.
 21. Sharma N, Nehal N, Singh M, Singh P, Rajpoot P, Pandey AK, *et al.* Effect of plant growth regulators on growth, biochemical changes and yield of mustard [*Brassica juncea* (L.) Czern. & Coss.]. Plant Archives. 2017;17(1):33–38.
 22. Singh A, Meena RS. Effect of foliar spray of bioregulators and irrigation on dry matter accumulation of mustard (*Brassica juncea* L.). Bangladesh Journal of Agricultural Research. 2019;44(4):689–693.
 23. Singh SM, Shukle A, Choudhary S, Semwal MP, Bhushan, Negi MS, *et al.* Enhancing water-use efficiency of Indian mustard (*Brassica juncea*) under deficit and adequate irrigation scheduling with hydrogel. International Journal of Basic and Applied Agricultural Research. 2017;15(12):1–4.
 24. Srivastava AK, Nathawat NS, Ramaswamy NK, Sahu MP, Singh G, Nair JS, *et al.* Evidence for thiourea-induced enhanced in situ translocation of ¹⁴C-sucrose from source to sink in *Brassica juncea*. Environmental and Experimental Botany. 2008;64:250–255.
 25. Verma RPS, Kharub AS, Kumar D, Sarkar B, Kumar RS, Singh R, *et al.* Fifty years of coordinated barley research in India. Research Bulletin No. 27. Karnal: Directorate of Wheat Research; 2011. p. 46.
 26. Yadav R, Kumar S, Siddiqui MZ, Khan N, Kumar A, Kumar S, *et al.* Integrated effects of irrigation scheduling, Pusa hydrogel and foliar micronutrients on yield attributes of barley (*Hordeum vulgare* L.). Journal of Scientific Research

and Reports. 2025;31(11):278–289.