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Effect of agrochemicals and irrigation regimes on productivity and profitability of barley (*Hordeum vulgare* L.)

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Abstract

The present study was conducted during *Rabi*, 2019-20 to evaluate the performance of various agrochemicals applied in barley under different irrigation levels. The investigation was carried out on six rowed dual-purpose BH-393 variety of barley at RRS, Bawal, CCSHAU, Hisar. The experiment was laid out in split plot design with three main plot and six sub plot treatments and replicated thrice. Main plot includes three water regimes *viz.* S_0-non stress (normal irrigation- irrigation at tillering and heading stage), S_1-moderate stress (irrigation withheld from tillering stage to season end) and S_2- severe stress (no irrigation); and sub-plot consists of six agrochemicals *viz.* control (T_1), seed treatment with *Tragacanth katira* @ 100 g/kg seed (T_2), soil application of *Tragacanth katira* @ 5 kg/ha(T_3), foliar spray of salicylic acid @ 200 ppm at booting and grain formation stage (T_4), combination of *Tragacanth katira* @ 2.5 kg/ha + foliar spray of salicylic acid @ 200 ppm at booting and grain formation stage (T_5) and; foliar spray of KNO_3 @ 1% at booting and grain formation stage (T_6). Data revealed that highest grain yield and B: C ratio (5.0 t/ha, 2.06) was achieved under non stress and combination of *Tragacanth katira* with salicylic acid. Net returns were 31.3% and 35.8% higher in non stress and combination of *Tragacanth katira* with salicylic acid treatments as compared to their respective controls among water regimes and agrochemicals, respectively. The best treatment was a combination of *Tragacanth katira* with salicylic acid among agrochemicals and non stress in water regimes.

Key words: Agrochemicals, barley, productivity, profitability, water stress

Barley (*Hordeum vulgare* L.) is the fourth most important staple cereal grain food crop in the world after wheat, rice and maize. It is highly preferred due to its nutritional and medicinal properties in its grains comprising 11.5 percent albuminoids, 74 percent carbohydrates, 1.3 percent fat, 3.9 percent crude fibre, β glucans and tocotrienols (effective in lowering cholesterol level in blood). It is grown for the purpose of food, feed, fodder, processing malt and as well as raw material for the brewing industry. In India, it occupied about 0.66 million hectare area with a productivity of 2.69 t/ha(Anonymous, 2022). The major barley growing states are Rajasthan, Uttar Pradesh, Haryana, Punjab, Madhya Pradesh and Uttarakhand. In Haryana, the area, production and productivity of barley are 9,260 ha, 30,960 tonne and 3.3 t/ha respectively (Anonymous, 2022). It is mainly grown in South-west zone of Haryana under limited irrigation or rainfed conditions. The wrath of climate change is increasing year by year severely altering the rainfall pattern over an area. The rise in dry spells between the two rains greatly affects the productivity and profitability of barley in these regions. Although barley is more tolerant to stress than other cereal

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crops, its' production is hampered under moderate to severe stress conditions. Severe water stress (moisture- 30% of field capacity) reduced the barley grain yield by 40-50 percent (Alghabari and Lhsan, 2018). However, the use of agrochemicals in addition to the traditional package adopted by the farmers can increase the yield and hence improve the profitability of the crop without putting undue burden on the farmers for their application.

Selection of agrochemicals to improve the net returns lies on the underlying facts that these will not cause unnecessary harm to the farm as well as the ecosystem while improving productivity and are economically as well as technically feasible. Agrochemicals such as humic acid, fulvic acid, thiourea, potassium nitrate, abscissic acid, salicylic acid, NPK, pusa hydrogel, herbal hydrogel are supposed to increase the yield as well as income under stressed environments (Dulaimy *et al*., 2020; Ul-Allah *et al*., 2020). However, the results are more clearly visible in drought and heat stressed environment due to higher percent increase in yield of the crops (Fahmi *et al*., 2020; Shemi *et al*., 2021). Potassium nitrate contains about 13 percent nitrogen and 45 percent K_2O which makes it a suitable source of nutrients and its properties makes its application quite easier even at the terminal growth stages. Being rich in potassium and nitrogen, it improves the metabolic mechanism of the plant against stress and also high-quality produce is obtained with increased yield (Singh *et al*., 2022).

Salicylic acid (SA) is considered an important signaling molecule and phyto-hormone protecting the plant from abiotic as well as biotic stress and mediating the plant physiological response to yield higher and make the crop cultivation profitable even under stressed environment (Sohag *et al*., 2020; Koo *et al*., 2020; Torun *et al*., 2022; Mabudi Bilasvar *et al*., 2022). Herbal hydrogel technically known as *Tragacanth katira* is a natural hydrogel and proved more economical over synthetic hydrogels such as Pusa hydrogel (Lather *et al*., 2015; Kumar *et al*., 2019). The application of hydrogels significantly reduces the required irrigation frequency in loamy and clay soils for a crop as available water content (AWC) is almost doubled (1.8-2.2 times) in the treatment where hydrogel is applied in comparison to the control (Abedi-Koupai *et al*., 2008). With all the points in view, the investigation was planned to study the effect of agrochemicals for improving yield and profitability under various irrigation regimes.

Materials and Methods

The field experiment was conducted on BH-393 variety of barley in split plot design during the *Rabi* season 2019-20 at Regional Research Station, Bawal, CCS Haryana Agricultural University, Hisar, Haryana. The location experiences subtropical semi-arid climatic conditions situated at 28° 6′ N latitude and 76° 30′ E longitude at an altitude of 266 meter AMSL. Experimental field soil had low organic carbon (0.20%), available N (119 kg/ha); and moderate (11.2 and 176 kg/ha) P and K, respectively. The experimental site observed weekly average maximum and minimum temperature varied from 12.8 °C to 36.8 °C and 3.2 °C to 14.2 °C, respectively during the crop growing season. Relative humidity ranged from 76 to 100 and 22 to 87 percent in morning and evening hours, respectively. The mean weekly evaporation varied from 4.3 to 10.7 mm and total rainfall of 105.3 mm (9 rainy days) was received during the crop season. Daily sunshine hours received during the crop growth varied from 2.0 to 8.7 and total pan evaporation was 44 mm. Total eighteen treatment combinations were observed in three replications comprising of three main plot treatments and six subplot treatments. The main plot treatments include three water regimes: S_0-non stress (normal irrigation- irrigation at tillering and heading stage), S_1-moderate stress (irrigation withheld from tillering stage to season end) and S_2- severe stress (no irrigation). The sub plot have various agrochemicals as treatments *viz*. control (T_1), seed treatment with *Tragacanth katira* @ 100 g/kg seed (T_2), soil application of *Tragacanth katira* @ 5 kg/ha (T_3), foliar spray of SA @ 200 ppm at booting and grain formation stage (T_4), combination of *Tragacanth katira* @ 2.5 kg/ha + foliar spray of SA @ 200 ppm at booting and grain formation stage (T_5) and; foliar spray of KNO_3 @ 1% at booting and grain formation stage (T_6). Seed treatment was done by treating the hydro primed seeds with jaggery solution and *Tragacanth katira* powder after they have attained a moisture content of 4 percent. Soil application of *Tragacanth katira* was done by line sowing the dry hydrogel powder followed by planking and all other cultural practices were followed as per the recommendation of CCSHAU, Hisar.

Half dose of nitrogen (60 kg/ha), full dose of phosphorus (30 kg/ha) and potash (15 kg/ha) were incorporated into soil through urea, DAP and muriate of potash. The biological yield (t/ha) was recorded by weighing the sun-dried harvested crop just before threshing. Grain yield (t/ha) was recorded after the grains attained moisture level to 14 percent. Cost of cultivation was worked out on the basis of prevailing market prices of inputs; and labour during the crop season. Gross returns (₹/ha) for each plot were calculated by considering the minimum support price (MSP) for economic product and market prices for by products. Net returns (₹/ha) for each treatment were calculated by deducting the cost of cultivation from gross returns for the particular treatment.

Net returns = Gross returns – Cost of cultivation

B: C ratio for each treatment was worked out by dividing the gross returns by the total cost of cultivation for the particular treatment.

$$\text{B:C ratio} = \frac{\text{Gross returns}}{\text{Cost of cultivation}}$$

The statistical analysis was carried out using STAR (Statistical Tool for Agricultural Research) software at 5 percent level of significance and "F" (variance test) was used to evaluate the significance of different treatment effects. Interaction was studied wherever observed.

Results and Discussion

Effect of water regimes on yield and economics

Grain yield as well as biological yield was decreased significantly with increased stress levels (Table 1). Maximum grain and biological yield were recorded under no stress (4.7,11.5 t/ha) followed by moderate stress (4.5, 11.1 t/ha) and severe stress (4.0, 9.9 t/ha), respectively. Safdari *et al.* (2018) reported that yield of barley in Iran showed a significant decrease when irrigation was given at maximum allowable depletion (MAD) of 90 percent of available soil moisture. Highest values of yield and yield traits were observed when MAD equals to 30 percent of available soil moisture in all cultivars. High relative leaf water content with increased moisture supply improves turgor in cell and elongation as well as division rates which in turn are responsible for the better growth and yield of plants (Abd El- Mageed *et al*., 2016; Nassef, 2017).

Significantly higher gross returns, net returns and B: C ratio was also achieved under non-stress followed by moderate and severe stress (Table 1). Proportionately higher increase in returns com-

Table 1. Effect of water regimes and agrochemicals on yield and economics of barley

Treatment	Grain yield (t/ha)	Biological yield (t/ha)	Cost of cultivation (₹/ha)	Gross returns (₹/ha)	Net returns (₹/ha)	B: C ratio (₹/ha)
Water regimes						
S_0	4.7a	11.5a	48233	95712a	47379a	1.98a
S_1	4.5b	11.1b	47283	92321b	45038b	1.95b
S_2	4.0c	9.9c	46233	82313c	36080c	1.77c
Agrochemicals						
T_1	3.9d	10.0d	45389	80935c	35546d	1.78c
T_2	4.3c	10.6c	47250	87177b	39656c	1.83c
T_3	4.3c	10.8bc	46281	88689b	42408bc	1.91b
T_4	4.6b	11.1abc	47552	93451a	45899ab	1.96ab
T_5	4.8a	11.5a	47998	96294a	48295a	2.01a
T_6	4.7ab	11.2ab	48959	94146a	45188ab	1.92b

S_0- non stress, S_1- moderate stress, S_2- severe stress, T_1- control, T_2- ST with *Tragacanth katira* @ 100 g/kg seed, T_3- soil application of *Tragacanth katira* @ 5 kg/ha, T_4- foliar spray of SA @ 200 ppm, T_5- $T_3/2 + T_4$, T_6- foliar spray of KNO_3 @ 1%. Means with same letters are not significantly different.

pared to increased cost of irrigation resulted in higher B: C ratio under non stress (1.98) compared over moderate (1.95) and severe stress (1.77). Barick *et al*. (2020) conducted a study on rapeseed and reported that the highest cost of cultivation (20192/ha), net return (18823.98 (₹/ha)/ha) and B: C ratio (1.94) were observed with irrigation at IW/CPE of 1.0. Net return was observed negative (-102.49/ha) for fully rainfed crop with 1.0 B: C ratio. Irrigation at 0.6 and 0.8 IW/CPE showed similar cost of cultivation, but gross return, net return and B: C ratio were higher with irrigation at 0.8 IW/CPE.

Effect of agrochemicals on yield and economics

All agrochemical treatments resulted in significantly higher grain and biological yield as compared to control treatment. Among all, T_5 recorded maximum yields (4.8 and 11.5 t/ha grain and biological, respectively) which was observed at par with T_6. T_4 was also at par with T_6, however higher yield was with T_6; and T_1 and T_2 also recorded similar yields. Higher yield with various agrochemicals over control was observed as a result of their effect on increasing moisture availability at either early growth stages (*Tragacanth katira*) or at later stages (salicylic acid and potassium nitrate) responsible for better growth and physiology of a crop. Abdelaal *et al*. (2020) reported that drought stress in barley led to significant decrease (35.6%) in grain yield compared to control while SA spray under drought conditions significantly increased yield by 108.4 percent compared to yield under drought and by 34.2 per cent when compared to control. Hellal *et al*. (2020) observed that biological yield (ton fed^{-1}) and grain yield (ton fed^{-1}) were decreased to 3.3 and 1.1 under conditions of water stress from 3.7 and 1.8 of control (no stress). Potassium nitrate spray at 2 percent at 40 and 60 DAS in wheat in drought stressed conditions increased the same attributes to 3.8 and 1.2 respectively in Giza-125 variety of barley. Kumar *et al.* (2019) reported that herbal hydrogel statistically improved grain yield (3.2 t/ha), straw yield (4.0 t/ha) and biological yield (7.2 t/ha) compared to control. However, maximum yields were recorded with Pusa hydrogel.

All agrochemical treatments yielded significant higher gross returns (₹/ha- 87177, 88689, 93451, 96294, 94146), net returns (₹/ha- 39656, 42408, 45899, 48295, 45188) and B: C ratio (1.91, 1.96, 2.01, 1.92) as compared to control treatment (₹/ha) 80935, 35546) except T_2 (1.83), which was observed at par with control (1.78) for B: C ratio. Treatment T_5 was recorded at par with T_4 and T_6. Lower B: C ratio with T_6 (1.92) compared to T_4 (1.96) in spite of higher gross return was due to higher cost incurred in treatment application. Devi *et al*. (2017) observed that treatment having foliar application of KNO_3 at 2% showed maximum B: C ratio of 1.20 followed by KNO_3 at 1.5% (1.12), 2.5% (1.09), 1% (1.05), 3% (1.01), 0.5% (0.91) and control (0.38). Maximum benefit in grain yield (107.4%) was recorded when KNO_3 was sprayed at 2% at active tillering and panicle initiation stage in wheat crop compared to control (water spray). Three foliar spray of KNO_3 at 15 days interval starting from flowering resulted in higher mean net monetary returns of 55053(₹/ha with B: C ratio of 2.03 in comparison to control (no foliar spray) (Amarjeet *et al*., 2018). Higher cost of cultivation and net return were observed with soil application of Pusa hydrogel at 2.5 kg ha^{-1} followed by seed treatment with herbal hydrogel and control (no treatment). However, higher B: C ratio (1.67) was observed with herbal hydrogel which was equal to control and lowest with Pusa hydrogel (1.64) (Kumar and Singh, 2020).

Interaction effect of water regimes and agrochemicals on yield and economics

Significant interaction of water regimes and agrochemicals were observed on grain yield and B: C ratio (Table 2, 3). Treatment T_5 brought out 17.9, 19.0 and 29.8 percent significantly higher grain yield in comparison with control at S_0, S_1 and S_2, respectively. Under severe stress conditions (S_2), T_4, T_5 and T_6 were found at par and were significantly higher than T_1, T_2 and T_3. With S_1 (moderate stress), T_5 was observed statistically at par with T_4 and T_6 and were observed significantly superior compared to T_1. Treatment T_5 recorded significantly higher grain yield than T_2 and T_3, while, treatments T_4 and T_6 were statistically at par with T_2 and T_3. With S_0 (non-stress), T_3, T_4, T_5 and T_6 were significantly superior grain yielders than T_1.

Maximum B: C ratio of 2.06 was recorded with

Table 2. Interaction effect of water regimes and agrochemicals on grain yield (t/ha)

Treatment	T_1 (control)	T_2	T_3	T_4	T_5	T_6
S_0 (non stress)	4.2c	4.6b	4.7ab	4.8ab	5.0a	4.9ab
S_1 (moderate stress)	4.1c	4.4b	4.5b	4.7ab	4.9a	4.7ab
S_2 (severe stress)	3.4c	3.7b	3.8b	4.4a	4.4a	4.4a

S_0- non stress, S_1- moderate stress, S_2- severe stress, T_1- control, T_2- ST with *Tragacanth katira* @ 100 g/kg seed, T_3- soil application of *Tragacanth katira* @ 5 kg/ha, T_4- foliar spray of SA @ 200 ppm, T_5- $T_3/_2$ + T_4, T_6- foliar spray of KNO_3 @ 1%. Means with same letters are not significantly different.

Table 3. Interaction effect of water regimes and agrochemicals on B: C ratio

Treatment	T_1 (control)	T_2	T_3	T_4	T_5	T_6
S_0 (non stress)	1.89b	1.94ab	2.04a	2.00ab	2.06a	1.96ab
S_1 (moderate stress)	1.86b	1.90ab	1.90ab	1.99ab	2.05a	1.95ab
S_2 (severe stress)	1.60c	1.66c	1.74bc	1.90a	1.91a	1.86ab

S_0- non stress, S_1- moderate stress, S_2- severe stress, T_1- control, T_2- ST with Tragacanth katira @ 100 g/kg seed, T_3- soil application of Tragacanth katira @ 5 kg/ha, T_4- foliar spray of SA @ 200 ppm, T_5- $T_3/_2$ + T_4, T_6- foliar spray of KNO_3 @ 1%. Means with same letters are not significantly different

S_0T_5 which was 29 percent higher than the lowest B: C ratio obtained with S_2T_1. T_5 brought out 3.7, 4.8 and 16.2 percent significantly increased B: C ratio as compared to control at S_0, S_1 and S_2, respectively.

The experiment results concluded that grain yield (t/ha), gross returns (₹/ha), net returns (₹/ha) and B: C ratio were reduced by 14.6, 13.9, 23.9 and 10.6 percent under severe stress (S_2) compared to non-stress water regimes (S_0- 4.7, 95712, 47379, 1.98). Economically, best treatment among agrochemicals was combination of *Tragacanth katira* @ 5 kg/ha and foliar spray of SA @ 200 ppm at booting and grain formation stage (T_5) which fetched 21.8, 18.9, 35.8 and 12.9 percent higher grain yield (t/ha), gross returns (₹/ha), net returns (₹/ha) and B: C ratio as compared to control treatment (3.9, 80935, 35546, 1.78).

References

Abd El-Mageed, T.A., Semida, W.M., Mohamed, G.F. and Rady, M.M. 2016. Combined effect of foliar-applied salicylic acid and deficit irrigation on physiological–anatomical responses, and yield of squash plants under saline soil. *South African Journal of Botany*, **106**: 8-16.

Abdelaal, K.A., Attia, K.A., Alamery, S.F., El-Afry, M.M., Ghazy, A.I., Tantawy, D.S., Al-Doss, A.A., El-Shawy, E.S.E., M Abu-Elsaoud, A. and Hafez, Y.M. 2020. Exogenous application of proline and salicylic acid can mitigate the injurious impacts of drought stress on barley plants associated with physiological and histological characters. *Sustainability*, **12**(5): 1736.

Abedi-Koupai, J., Sohrab, F. and Swarbrick, G. 2008. Evaluation of hydrogel application on soil water retention characteristics. *Journal of Plant Nutrition*, **31**(2): 317-331.

Alghabari, F. andIhsan, M.Z. 2018. Effects of drought stress on growth, grain filling duration, yield and quality attributes of barley (*Hordeum vulgare* L.). *Bangladesh Journal of Botany*, **47**(3): 421-428.

Amarjeet, Ahlawat, K.S, Singh, A., Mehta, S.K., and Singh, B. 2018. Evaluation of impact of foliar sprays of potassium nitrate (KNO_3) on yield and economics of Bt cotton (*Gossypium hirsutum*) through front line demonstrations. *Indian Journal of Agricultural Sciences*, **88**(2): 249–52.

Anonymous, 2022. Crop wise area, average yield and production of barley in Haryana and India. Available at: https://www.indiastat.com/table/haryana-state/barley/selected-state-wise-area-production-productivity-b/1423785.

Barick, B.B., Patra, B.C. and Bandyopadhyay, P. 2020. Performance of rapeseed (*Brassica compestris* L.) under varied irrigation and sowing methods. *Journal of Crop and Weed*, **16**(2): 269-273.

Devi, K.N., Devi, K.M., Lhungdim, J., Athokpam, H., Chanu, Y.B. and Lenin, K. 2017. Foliar application of potassium under water deficit conditions improved the growth and yield of wheat (*Triticum aestivum* L.). *The Bioscan*.

Dulaimy, J.A.M.A., and El-Fahdawi, W.A. 2020. Effect of humic acid on growth and yield of barley as humic acid as interacted with row spacing. *Indian Journal of Ecology,* **47**: 62-65.

Fahmi, A.H., Sallume, M.O., Aswad, A.H., Abdulrahman, A.L., Hamdi, G.J. and Abood, M.A. 2020. Interaction effect of potassium fertilizer, humic acid and irrigation intervals on growth and yield of wheat. *Research on Crops*, **21**(1): 31-35.

Hellal, F., El-Sayed, S., Gad, A.A., Karim, G.A. and Abdelly, C. 2020. Antitranspirants application for improving the biochemical changes of barley under water stress. *The Iraqi Journal of Agricultural Science,* **51**(1): 287-298.

Koo, Y.M., Heo, A.Y. and Choi, H.W. 2020. Salicylic acid as a safe plant protector and growth regulator. *The Plant Pathology Journal*, **36**(1): 1.

Kumar, S, Sharma P.K., Yadav M.R., Sexena R., Gupta K.C., Kumar R., Garg N.K. and Yadav H.L. 2019. Effect of irrigation levels and moisture conserving polymers on growth, productivity and profitability of wheat. *Indian Journal of Agricultural Sciences,* **89**(3): 509-14.

Lather, V.S., Ashwani, K., Chopra, N.K., Choudhary, D., Yadav, R.N. and Seth, R. 2015. Novel herbal hydrogel' Tragacanth-Katira gel' and farmer's friendly seed priming-hydrogel coating technology for water saving, making agriculture sustainable and resilient to climatic variability. *International Journal of Tropical Agriculture*, **33**(2): 1167-1171.

Mabudi Bilasvar, H., Ghassemi-Golezani, K., and Mohammadi Nassab, A.D. 2022. Seed development, oil accumulation and fatty acid composition of drought stressed rapeseed plants affected by salicylic acid and putrescine. *Gesunde Pflanzen*, 1-13.

Nassef, D.M. 2017. Impact of irrigation water deficit and foliar application with salicylic acid on the productivity of two cowpea cultivars. *Egyptian Journal of Horticulture*, **44**(1): 75-90.

Safdari, S.F., Farahani, S.M. and Eskandari, A. 2018. Effect of irrigation scheduling on some characteristics of Barley under water deficit conditions. *Journal of Bioscience and Biotechnology*, **7**(1).

Shemi, R., Wang, R., Gheith, E.S., Hussain, H.A., Hussain, S., Irfan, M. and Wang, L. 2021. Effects of salicylic acid, zinc and glycine betaine on morpho-physiological growth and yield of maize under drought stress. *Scientific Reports*, **11**(1): 1-14.

Singh, A., Bali, A., Kumar, A., Yadav, R.K., and Minhas, P.S. 2022. Foliar Spraying of potassium nitrate, salicylic acid, and thio-urea effects on growth, physiological processes, and yield of sodicity-stressed paddy (*Oryza sativa* L.) with alkali water irrigation. *Journal of Plant Growth Regulation*, 1-10.

Sohag, A.A.M., Tahjib-Ul-Arif, M., Brestic, M., Afrin, S., Sakil, M.A., Hossain, M.T. and Hossain, M.A. 2020. Exogenous salicylic acid and hydrogen peroxide attenuate drought stress in rice. *Plant, Soil and Environment*, **66**(1): 7-13.

Torun, H., Novák, O., Mikulík, J., Strnad, M., and Ayaz, F.A. 2022. The Effects of exogenous salicylic acid on endogenous phytohormone status in *Hordeum vulgare* L. under salt stress. *Plants*, **11**(5): 618.

Ul-Allah, S., Ijaz, M., Nawaz, A., Sattar, A., Sher, A., Naeem, M. and Mahmood, K. 2020. Potassium application improves grain yield and alleviates drought susceptibility in diverse maize hybrids. *Plants*, **9**(1): 75.