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Effect of Agrochemicals and Irrigation Levels on Growth and Yield of Barley (*Hordeum vulgare* L.)

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***Abstract*:** A field experiment was conducted at RRS, Bawal, CCSHAU, Hisar during *Rabi*, 2019-2020 to study the growth and development of barley under various irrigation levels as affected by agrochemicals. The experiment was conducted in split plot design with three irrigation levels in main plot and six agrochemical levels in subplot. The main plot treatments included- no irrigation, one irrigation and two irrigation. The subplot treatments were- control, seed treatment with *Tragacanth katira* @ 100 g kg^{-1} seed, soil application with *Tragacanth katira* @ 5 kg ha^{-1}, foliar application of salicylic acid @ 200 ppm, soil application with *Tragacanth katira* @ 2.5 kg ha^{-1} + foliar spray with salicylic acid @ 200 ppm and foliar application with potassium nitrate @ 1%. Number of days taken to physiological maturity, plant height, shoot dry matter accumulation at harvest and grain yield was significantly higher with two irrigation and soil application of *Tragacanth katira* + foliar spray of salicylic acid among irrigation levels and agrochemicals, respectively. Days to 50% flowering were significantly lower with no irrigation compared to one and two irrigation with no significant difference among various agrochemicals.

Keywords: Barley, *Tragacanth katira,* Irrigation levels, Potassium nitrate, Salicylic acid

Barley (*Hordeum vulgare* L.), the fourth major cereal grain crop of the world is the hardiest crop when it comes to stress (drought, heat or salinity) tolerance. Water shortage combined with higher temperature is considered as the crucial yield declining factors in arid and semi-arid areas. The major barley producing states are Rajasthan (40-50%), U.P. (25-30%), Haryana, Punjab, Madhya Pradesh and Uttarakhand. In Haryana conditions, barley generally needs two irrigations for higher productivity but due to limiting irrigation facilities in south west zone of Haryana, it is grown as either rainfed or with one irrigation at critical stage. Rainfall behaviour in these areas is highly unpredictable and the factor which affect crop growth most is the long dry spells in between rains. Barley plants cope with minor stress conditions by reducing transpiration rates without affecting photosynthesis. But, as the stress level increases, the photosynthetic pathway is adversely affected and the vegetative growth and development of the plant stops. Stress at heading and grain formation is considered as more detrimental than stress at vegetative stages (Mahalingam and Bregitzer 2019). However, stress at earlier stages also cause significant yield loss.

The availability of proper moisture during the growth period of the crop leads to healthy and succulent plants. Water is better known to improve cell division and cell enlargement by increasing the turgor pressure inside cell. The other important role it plays in lush growth of plants is the nutrient absorption capacity by behaving like an ideal solvent for dissolving nutrients. To make the crop plants cope up with the water stress, one should either increase the availability of water by using hydrogels which have the property to absorb moisture by 350-400 times its weight and 80-180 times by its volume (Kalhapure et al 2016). Since hydrogel polymers are quite expensive and cultivators in India are mostly marginal farmers, its applicability is greatly reduced. An alternative to hydrogel polymers are natural hydrogels such as *Tragacanth katira* which are cost effective as well as easy to apply. *Tragacanth katira* commonly also known as *Gond-Katira*. The other way to protect crop plants from stress is to modify the physiology of crop plants with agrochemicals such as KNO_3, salicylic acid, ascorbic acid and humic acid etc. Salicylic acid (SA) alleviates the effect of stress condition by increasing the plant height and dry matter (El- Nasharty et al 2019). SA protects plant from stress by shortening the crop cycle evidenced by reduction in no. of days taken to 50% flowering in black gram (Narayanan et al 2015). KNO_3 helped plants in overcoming stress by maintaining turgor balance and improving plant height as well as dry matter accumulation. Considering the above points, the present study was planned to study the effect of agrochemicals on growth, development and yield of barley crop under different irrigation levels.

MATERIAL AND METHODS

The field experiment was conducted in *Rabi,* 2019-2020 at Regional Research Station, Bawal, Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana (India) located at 28° 6' N latitude and 76° 30' E longitude at an elevation of 266 metres above mean sea level. The mean weekly meteorological data recorded during the crop season is given in Figure 1. A total of nine rainy days with 105.3 mm of total rainfall were recorded during crop growth period. The investigation was carried out on BH-393 variety of barley grown in split plot design with three replications and 18 treatment combinations. Three irrigation levels *viz*. no irrigation- control (I_0), one irrigation at 40-45 DAS (I_1) and two irrigation at 40-45 and 80-85 DAS (I_2) were taken as main plot factors and six agrochemicals in subplots *viz.* control (T_1), seed treatment with *Tragacanth katira* @ 100 g kg^{-1} seed (T_2), soil application of *Tragacanth katira* @ 5 kg ha^{-1} (T_3), foliar spray of SA @ 200 ppm at booting and grain formation stage (T_4), combination of *Tragacanth katira* @ 2.5 kg ha^{-1} + 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 hydro-priming the seeds followed by air drying for 12 hrs to attain moisture near to initial level and then treating them with jaggery solution and *Tragacanth katira* powder. Soil application of *Tragacanth katira* was done by line sowing the dry hydrogel powder followed by planking. Cultural practices were followed as per the recommendation of CCSHAU, Hisar. Half dose of nitrogen (30 kg ha^{-1}), full dose of phosphorus (30 kg ha^{-1}) and potash (15 kg ha^{-1}) were incorporated into soil through urea, DAP and muriate of potash, respectively. Remaining half dose of nitrogen (30 kg ha^{-1}) was broadcasted after first irrigation. Plant height and dry matter accumulation (shoot) was recorded at 30, 60, 90, 120 DAS and at harvest. Plant height was recorded in centimetres from base of the main shoot to the highest tip of the plant. Days to 50 per cent flowering were recorded when flowering was observed in 50 per cent of the plants in a plot and days to maturity when plants attained physiological maturity. Absolute growth rate (AGR) and Relative growth rate (RGR) were calculated with methods by Radford (1967) and Blackman (1919) for the shoot dry matter accumulation during the interval 30-60, 60-90 and 90-120 DAS, respectively:

$$AGR = \frac{W_2 - W_1}{t_2 - t_1}$$

$$RGR = \frac{\ln W_2 - \ln W_1}{t_2 - t_1}$$

where, w_1 and w_2 are dry weights of plant at time t_1 and t_2, respectively.

AGR was expressed as mg day^{-1} and RGR was expressed as mg g^{-1} day^{-1}. Grain yield was recorded at harvest after sun-drying the grains to reduce the moisture content to 14 per cent. Recorded data was subjected to statistical analysis using STAR software at 5 per cent level of significance and F variance test was used to evaluate the significance of different treatment effects.

RESULTS AND DISCUSSION

Growth parameters: The plant height indicated no significant difference at 30 DAS among irrigation levels (Table 1). At 60 and 90 DAS, I_1 and I_2 were observed at par and significantly increased plant height compared over I_0. At 120 DAS and at harvest, all three treatments differed significantly with maximum height recorded with I_2 followed by I_1 and I_0. The improved plant height with irrigation might be due to the higher nutrient uptake and increased rate of cell elongation and cell division with increase in turgor pressure by virtue of high moisture uptake (Jai et al 2015). Among

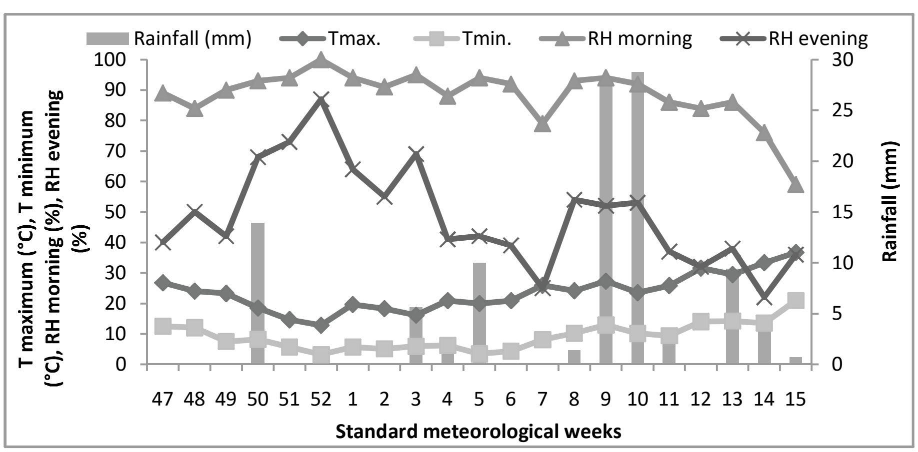

Fig. 1. Weekly meteorological data of crop season

agrochemicals, no significant difference in plant height was recorded upto 60 DAS. T_4, T_5 and T_6 were observed significant over control at 90 DAS and over control, T_1 and T_2 at 120 DAS and at harvest. The effect of *Tragacanth katira* on plant height at 30, 60, 90 and 120 DAS is consistent with the findings of Kumar et al (2019) and at harvest, with Lather (2019) and Kumar and Singh (2020). The increased plant height with SA might be accrued to their role as a phenolic phytohormone and signaling molecule in plant system, which induces specific changes in leaf anatomy and enhances ion uptake improving plant growth (Pandey et al 2020). In case of T_6, the increased plant height might be due to additional supply and faster absorbance of nutrients with application of KNO_3 supported by the findings of Hellal et al (2020).

I_2 was significantly more productive and increased shoot weight (at harvest) by 31.1 per cent over I_0 (Table 2). This may be attributed to the high photosynthesis rates and increased cell division and elongation with high moisture availability and similar findings were also reported by Shirazi et al (2014). Among agrochemicals, higher shoot dry matter accumulation in barley varied significantly with maximum under treatments with *Tragacanth katira* (T_2 and T_3) at 30 and 60 DAS. It might be due to water holding capacity of *Tragacanth katira* and more availability of water in the root zone when plant needs it. At 90 and 120 DAS as well as at harvest, combination of *Tragacanth katira* and SA (T_5) resulted in 54.6, 64.0 and 58.5 per cent higher shoot dry weight as compared to control. Foliar spray of SA (T_4) and KNO_3 (T_6) recorded statistically at par results as were observed with combination of *Tragacanth katira* and SA (T_5). The findings were supported by the

Table 1. Effect of irrigation levels and agrochemicals on plant height (cm)

Treatment	Plant height (cm)				
	30 DAS	60 DAS	90 DAS	120 DAS	At harvest
Irrigation levels					
I_0	26.75a	53.44b	83.44b	87.33c	87.72c
I_1	26.65a	57.92a	87.90a	94.66b	95.04b
I_2	26.01a	58.48a	91.50a	98.48a	98.81a
Agrochemicals					
T_1	50.22a	25.67a	56.18a	84.78c	90.74b
T_2	57.00a	27.35a	57.50a	85.67bc	91.08b
T_3	53.11a	26.98a	56.89a	85.44bc	90.86b
T_4	48.22a	26.04a	56.22a	89.44ab	95.40a
T_5	53.44a	26.93a	56.61a	90.47a	97.48a
T_6	52.11a	25.83a	56.27a	89.89a	95.38a

Means with same letters are not significantly different

Table 2. Effect of irrigation levels and agrochemicals on shoot dry matter accumulation (g plant^{-1})

Treatment	Shoot dry matter accumulation (g plant^{-1})				
	30 DAS	60 DAS	90 DAS	120 DAS	At harvest
Irrigation levels					
I_0	0.14a	2.38b	9.35b	12.06c	13.07c
I_1	0.14a	2.82a	11.23a	14.69b	15.70b
I_2	0.14a	2.80a	12.01a	16.12a	17.13a
Agrochemicals					
T_1	0.13b	2.37b	8.21c	10.34d	11.34c
T_2	0.15a	3.01a	10.60b	13.76c	14.77b
T_3	0.16a	3.09a	10.79b	14.04bc	15.05b
T_4	0.13b	2.54b	11.38ab	15.16bc	16.18ab
T_5	0.13b	2.66ab	12.68a	16.96a	17.98a
T_6	0.13b	2.49b	11.61a	15.49ab	16.51a

Means with same letters are not significantly different observations of Azmat et al (2020) by virtue of the improved osmotic balance, enhanced nutrient uptake and enhanced metabolism of plants.

Higher growth rate indicate plant is healthy, photosynthesizes properly and efficiently deposits the photosynthates in sink organs. Among irrigation levels, I_1 and I_2 treatments produced similar effects on AGR and RGR during all developmental phases, except during 60-90 DAS, where AGR was significantly higher with I_2 compared to both I_1 and I_0 (Fig. 2). Among agrochemicals, during 30-60 DAS, AGR was maximum with *Tragacanth katira*, while, RGR was not significantly affected (Fig. 3). During 60-90 and 90-120 DAS, T_5 improved AGR and RGR and was at par with T_4 and T_6. It is obviously due to increased metabolic activities of the plant with two foliar sprays of SA at 65 and 85 DAS and higher moisture availability due to good amount of rainfall (59.4 mm) during 90-120 DAS. Similar findings were also reported by Nagaraju (2014). Likewise, two sprays of KNO_3 enhanced supply of nitrogen and potassium which might have resulted in higher growth rate.

Developmental parameters: I_1 and I_2 delayed days to 50 per cent flowering by 2 to 3 days compared to I_0 and; delayed days also to physiological maturity by 3 to 7 days, respectively (Table 3). This may be attributed to the fact that vegetative as well as reproductive phase of plant is enhanced with adequate moisture availability. Stress at any stage of crop growth shortened the life cycle of plant by few days as they tend to complete it at earliest to avoid or escape unfavorable conditions of stress. Similar results were also reported by Hussen et al (2019) in mung bean and Muleke et al (2022) in wheat. No significant effect of agrochemicals was observed on days to 50 per cent flowering while, days to physiological maturity was delayed by 4 to 5 days under T_5. It showed the role of SA on stomatal conductance and water uptake. T_4 and T_6 also delayed days to physiological maturity and were found at par with T_5. Rehman and Khalil (2018) also reported similar results.

Grain yield: Significantly higher grain yield was observed in I_2 followed by I_1 and I_0 (Table 3) obviously due to higher dry matter accumulation and partitioning as supported by the findings of Kumar et al (2019), Singh and Meena (2020). Among agrochemicals, all treatments yielded significantly higher over control with T_4, T_5 and T_6 significant over T_2 and T_3 also. Higher grain yield with SA and KNO_3 was observed in line with findings of Suryavanshi and Buttar (2016), Abdelaal

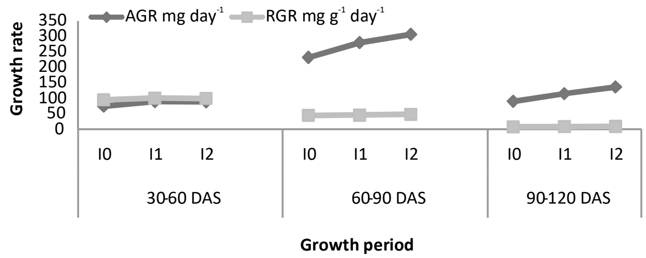

Fig. 2. Effect of irrigation levels on AGR and RGR at various crop growth stages

Table 3. Effect of irrigation levels and agrochemicals on grain yield and developmental parameters

Treatments	Days to 50% flowering	Days to physiological maturity	Grain yield (kg ha^{-1})
Irrigation levels			
I_0	71.11b	117.06c	4025c
I_1	73.72a	120.50b	4538b
I_2	73.61a	124.33a	4712a
Agrochemicals			
T_1	72.78a	117.06c	3912d
T_2	72.89a	120.39b	4261c
T_3	72.78a	120.28b	4334c
T_4	72.67a	121.61ab	4620b
T_5	72.89a	122.39a	4765a
T_6	72.89a	122.06a	4657ab

Means with same letters are not significantly different

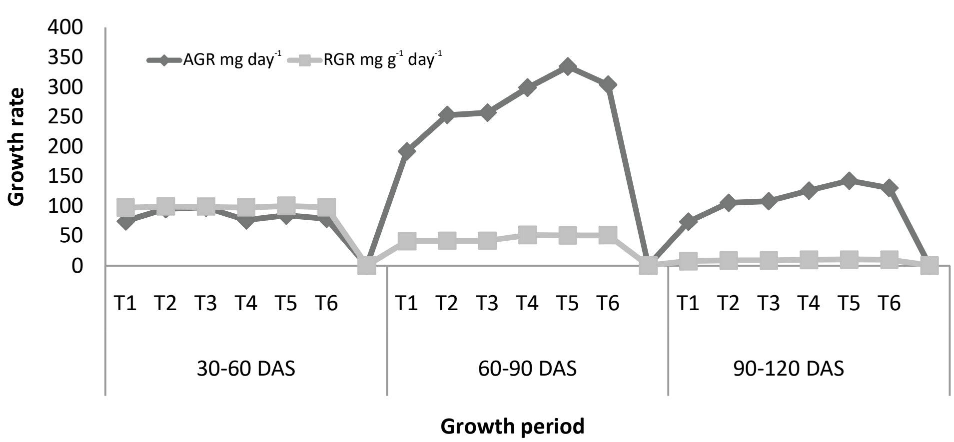

Fig. 3. Effect of agrochemicals on AGR and RGR at various growth stages

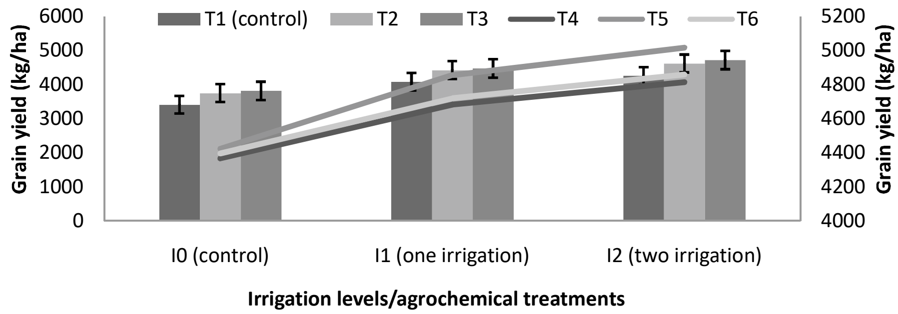

Fig. 4. Interaction effect of irrigation levels and agrochemicals on grain yield (kg ha^{-1})

et al (2020) and Meena et al (2020). Significant interaction was also observed among irrigation levels and agrochemicals for grain yield (Fig. 4).

CONCLUSIONS

The study concluded that with different irrigation levels, all agrochemical treatments were productive over control, however combination of soil application of *Tragacanth katira* @ 2.5 kg ha^{-1} with two foliar sprays of SA @ 200 ppm at booting and grain formation stage (T_5) was observed most beneficial. Farmers can adopt any of the agrochemical treatment depending on the availability of moisture and the economic resources available to them.

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