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IMPROVING YIELD AND QUALITY OF BARLEY FODDER WITH AGROCHEMICALS UNDER VARIOUS IRRIGATION REGIMES

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SUMMARY

A field experiment was conducted at Regional Research Station, Bawal (CCS HAU, Hisar) in *Rabi*, 2019-20 on barley crop grown in split plot design with three main plot and six sub plot treatments and replicated thrice owing to a total of fifty four plots. The experiment was carried out on dual purpose six rowed barley variety BH 393 to study the efficacy of agrochemicals under different irrigation levels in improving growth, yield and quality. Results of the experiment revealed that among different irrigation levels, treatment with two irrigation levels performed significantly better than other irrigation levels. Spray of salicylic acid (T_4), potassium nitrate (T_6) and combination of *Tragacanth katira* and salicylic acid (T_5) significantly improved growth, quality parameters and yield of barley crop. I_2 (two irrigation) among irrigation levels and T_5 (combination of *Tragacanth katira* @ 2.5 kg ha^{-1} + foliar spray of SA @ 200 ppm at booting and grain formation) treatment among agrochemicals were found most productive (17.2 and 21.8 % higher grain yield over control, respectively). Protein content was improved by 20.7 and 16.4 per cent with two irrigation and combination of *Tragacanth katira* with salicylic acid, respectively, among irrigation levels and agrochemicals.

Keywords : Irrigation, potassium nitrate, salicylic acid, *Tragacanth katira*

Barley shares about seven per cent of cereal production and 15 per cent of the coarse grains consumption all over the world and is the fourth most important crop after wheat, rice and maize (Neelam *et al*., 2018). It is highly valuable crop grown for food, feed and fodder for livestock (Kharub *et al.*, 2013). It has many industrial uses other the conventional uses. After green revolution, India with than become self-sufficient in food production but still fodder security is not achieved. In milk production also, India holds first rank by producing 22 per cent of worldwide milk production (Singh, 2020). The area under fodder crops in India is still only two per cent of the world's geographical area under fodder crops (Shah *et al*., 2011), which is quite very low looking fodder demands. In current scenario, a net deficit of about 35.6 per cent fodder, 10.9 per cent dry crop residues and 44 per cent feed is faced by India (Vision, 2013) which creates tremendous pressure for timely availability of feed and fodder for livestock (Singh *et al*., 2016). The higher demand and lesser production of fodder due to various constraints make them costly (Kumar *et al*., 2022). Also, the crude protein and TDN (total digestible nutrient) deficit stand at 24.6 and 19.9 per cent (Anonymous, 2020).

Barley has high biomass production capability and is highly salt tolerant which makes its cultivation in south-western Haryana highly preferable where soil is sandy, saline with less good quality water availability along with lesser rainfall. Due to its dual-purpose feature, the interest is increasing among researchers to exploit the potential of barley to achieve fodder security along with consistent supply of grain with limited irrigation in arid and semi-arid areas of northern plains region (Kumar *et al*., 2017). Agrochemicals which help in reducing the severity of water stress and helps in achieving sustainable yield even under the stress condition are expected to have a wider scope in the present climate change scenario. Salicylic acid (SA) is a phenolic phytohormone having substantial role in stomatal conductance and photosynthetic process (Arfan *et al*., 2007) and in activation of plant defense system with its signaling properties (Karlidag *et al*., 2009).

Foliar spray of potassium under stress gave endurance to plants along with enhancement in yield and water use efficiency (Mesbah, 2009). Hydrogels are water loving cross-linked polymers which have quite high capacity for holding and absorbing water and release slowly upto 95 per cent of the water

absorbed in stress conditions (Han *et al*., 2013). Natural hydrogels such as *Tragcanth katira* (also known as gond-katira) are very cheap and technically feasible. *Tragacanth katira* application by seed hydropriming cum pelleting technique increased wheat and barley production (Lather *et al*., 2015). SA and KNO_3 are well known for their role in increased nitrogen metabolism even under stress condition (Nazar *et al*., 2011; Raddatz *et al*., 2020). With the above facts cited, agrochemicals are expected to improve the growth, yield as well as quality of fodder of barley crop. Therefore, the present investigation was carried out to study the effect of agrochemicals under various irrigation regimes in improving yield and quality of fodder.

MATERIALS AND METHODS

The investigation was carried out at CCS HAU, Regional Research Station, Bawal (Rewari) located in the zone 2 of Haryana, India at 28° 6' N latitude and 76° 30' E longitude and 266 meter above mean sea level (Arabian Sea). The mean weekly weather data during crop season *Rabi,* 2019-20 as given in Table 1 was recorded from meteorological observatory of RRS, Bawal. During the harvest season, a total of 105.3 mm of rainfall was received and nine rainy days were observed. The investigation was conducted on six rowed dual purpose BH-393 variety of Barley. The experiment was laid out in split plot design with three irrigation treatments in main plot and six agrochemical treatments in sub-plot replicated thrice. Irrigation treatments include no irrigation (control, I_0), one irrigation at tillering stage (I_1) and two irrigations at tillering and heading stage (I_2). Agrochemical treatments include control (T_1), seed treatment with *Tragacanth katira* at 100 g kg^{-1} seed (T_2), soil application of *Tragacanth katira* at 5 kg ha^{-1} (T_3), foliar spray of SA at 200 ppm at booting and grain formation stage (T_4), soil application of *Tragacanth katira* at 2.5 kg ha^{-1} + foliar spray of SA at 200 ppm at booting and grain formation stage (T_5) and, foliar spray of KNO_3 at 1 per cent at booting and grain formation stage (T_6). The crop was in accordance of package of practice recommended by CCS HAU, Hisar. Chlorophyll content at anthesis stage was determined using DMSO (dimethyl sulfoxide) method given by Hiscox and Israelstam (1979). Available nitrogen in straw was analyzed using method given by Lindner (1944). Nitrogen uptake and protein yield were calculated by multiplying straw yield with per cent nutrient content and protein content in straw, respectively. Attraction index was computed by dividing the grain yield by straw yield. Statistical analysis of the data was done using STAR software and "F" variance test was used to compare the significance of means.

RESULTS AND DISCUSSIONS

Effect of irrigation levels : No significant effect of irrigation levels was observed on plant population at 25 DAS. Highest number of effective tillers per metre row length were recorded with one irrigation (72.87) followed by two irrigation (72.47), which were at par and significantly higher over control (70.77). Similar results were also reported by Hingonia *et al*. (2018) and Shirazi *et al*. (2014). Effect of treatments with one and two irrigation was found statistically at par and significantly higher over control for dry matter accumulation (DMA) at 60 and 90 DAS (Table 2). At 90 DAS, the improvement with one and two irrigation was 19.96 and 28.28 per cent compared over control. Wairagade *et al*. (2020) also reported similar results for higher dry matter accumulation with irrigation. At 120 DAS, all the treatments showed significant difference with maximum in two irrigation (18.46 g) followed by one irrigation (16.91 g) and no irrigation (14.08 g). Results observed are in close proximity with the findings of Kumar *et al*. (2019) on barley. It might be due to increased moisture availability and improved cell division and cell elongation rates. Chlorophyll content was increased significantly with one and two irrigation treatments over control due to increased activity of chlorophillase and peroxidase enzymes (Sepehri and Golparvar, 2011). The results were supported by the findings of Seyed Sharifi (2020). Grain yield was observed 3.83 and 17.1 per cent significantly higher with two irrigation treatment compared to treatment with one and no irrigation, respectively (Table 3). It might be due to enhanced growth of plants with availability of ample moisture. Similar results were observed by Hingonia *et al*. (2018). Effect of irrigation levels on attraction index was observed non-significant. N uptake (38.4 %), protein content (20.7 %) and protein yield (66.7 %) in barley straw was higher under treatment involving two irrigation followed by treatment having one irrigation, compared to control. Similar results of increased protein content and protein yield with increase in number of irrigation were also reported by Jai *et al*. (2015).

Effect of Agrochemicals: No significant effect on plant population was observed with

TABLE 1
Weekly meteorological data during crop season

SMW	$T_{max.}$	$T_{min.}$	R.H. morning	R.H. evening	Rainfall	Evaporation	Sunshine hours
47	26.8	12.5	89	40	-	2.0	4.4
48	24	12	84	50	0	2.0	3.1
49	23.2	7.5	90	42	0	1.8	5.0
50	18.5	8.2	93	68	13.9	1.0	2.0
51	14.6	5.7	94	73	0	0.6	2.7
52	12.8	3.2	100	87	0	0.6	2.7
1	19.6	5.7	94	64	0	1.1	40
2	18.2	5.1	91	55	0	1.3	4.8
3	16.1	5.9	95	69	5.6	0.9	2.6
4	20.9	6.2	88	41	1.4	2.0	6.2
5	20	3.4	94	42	10	1.9	7.6
6	20.9	4.3	92	39	0	2.0	7.5
7	25.9	8.1	79	25	0	4.2	8.7
8	24.1	10.2	93	54	1.4	2.0	4.8
9	27.3	12.9	94	52	27.8	2.6	5.9
10	23.5	10.1	92	53	28.8	2.3	5.7
11	25.8	9.4	86	37	2.8	3.2	6.9
12	31.6	14	84	32	0	4.4	5.9
13	29.4	14.2	86	38	9.4	4.0	6.1
14	33.3	13.5	76	22	4.2	6.1	8.5
15	36.7	20.9	59	36	0.7	7.3	7.7

application of agrochemicals (Table 1). Lather *et al.* (2015) also reported similar results in wheat. Maximum effective tillers were observed with combination of *Tragacanth katira* and SA (73.1) followed by KNO_3 spray (72.4), SA spray (72.3), soil application with *Tragacanth katira* (71.9), ST with *Tragacanth katira* (71.7) and minimum in control (70.9). Treatment having combination of *Tragacanth katira* with SA was significantly higher over control, seed treatment and soil application of *Tragacanth katira* and at par with foliar spray of KNO_3 and SA. Karimian *et al.* (2015) and Ahmad *et al.* (2019) also reported similar kind of results. Only treatment T_2 and T_3 were observed significant for DMA at 60 DAS. It was due to the reason that treatments having SA and KNO_3 foliar spray were applied at 65 DAS (Table 2). The results observed with *Tragacanth katira* were in line with the findings of Kumar *et al.* (2019). All treatments were significant

TABLE 2
Effect of irrigation levels and agrochemicals on growth parameters

Treatments	Plant population (No./m.r.l.) (25 DAS)	Effective tillers/ metre row length	Total dry matter accumulation/plant			Total chl
			60 DAS	90 DAS	120 DAS	
Irrigation levels						
I_0	51.97a	70.77b	2.89b	10.57b	14.08c	2.95b
I_1	53.81a	72.87a	3.38a	12.68a	16.91b	3.43a
I_2	51.28a	72.47a	3.35a	13.56a	18.46a	3.42a
Agrochemicals						
T_1	50.22a	70.90c	2.87c	9.23c	12.18e	3.06b
T_2	57.00a	71.70bc	3.59ab	11.86b	15.82d	3.09b
T_3	53.11a	71.90b	3.67a	12.07b	16.15cd	3.08b
T_4	48.22a	72.27ab	2.92c	13.02ab	17.52bc	3.44a
T_5	53.44a	73.06a	3.18bc	14.34a	19.39a	3.48a
T_6	52.11a	72.39ab	3.01c	13.11ab	17.84ab	3.45a

I_0–No irrigation, I_1–One irrigation, I_2–Two irrigation, 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
Effect of irrigation levels and agrochemicals on yield and quality parameters

Treatments	Grain Yield (q/ha)	Straw Yield (q/ha)	Attraction index (%)	N uptake (kg/ha)	Protein content (%)	Protein yield (kg/ha)
Irrigation levels						
I_0	40.25c	59.32b	67.61a	22.92c	2.41c	55.37c
I_1	45.38b	66.04a	68.78a	28.94b	2.74b	79.24b
I_2	47.12a	68.15a	69.27a	31.72a	2.91a	92.25a
Agrochemicals						
T_1	39.12d	60.77c	64.55b	24.31b	2.50b	60.79b
T_2	42.61c	63.34bc	67.47ab	25.51b	2.52b	64.22b
T_3	43.34c	64.58ab	67.22ab	26.01b	2.52b	65.48b
T_4	46.20b	64.79ab	70.43a	29.45a	2.84a	83.65a
T_5	47.65a	67.49a	71.10a	30.67a	2.84a	87.13a
T_6	46.57ab	66.06ab	70.54a	30.74a	2.91a	89.42a

I_0–No irrigation, I_1–One irrigation, I_2–Two irrigation, 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.

at 90 and 120 DAS compared to control for DMA. At 90 and 120 DAS, 55.4 and 59.2 per cent increase in plant DMA was observed in T_5 treatment having combination of *Tragacanth katira* and SA. Effect of SA in improving DMA in barley plants were also reported by El- nasharty *et al*. (2019) and Pandey *et al*. (2020). Similar effects of KNO_3 were also reported by Devi *et al*. (2017). The possible reasons of increment in dry matter accumulation with SA could be due to its role as a phenolic phytohormone, enhanced ion uptake and photosynthetic efficiency. Improved dry matter with KNO_3 spray could be attributed to additional supply and faster absorbance of nutrients (N and K). Treatments with foliar spray of SA and KNO_3 significantly improved chlorophyll over control and treatments having *Tragacanth katira* only. Maximum chlorophyll was observed with combination of *Tragacanth katira* and SA, however it was at par with treatments containing only foliar spray of SA and KNO_3. Proficiency in grain and straw yield was 21.8 and 11.1 per cent, respectively, with T_5 treatment (combination of SA and *Tragacanth katira*), compared to control (Table 3). Similar findings of increased yield with SA were also reported by Abdelaal *et al*. (2020). Grain and straw yield recorded under T_6 (foliar spray of KNO_3) were observed statistically at par with T_4 (foliar spray of SA) and T_5 (combination of *Tragacanth katira* and SA). Chaurasiya *et al*. (2018) also reported similar results for KNO_3. Meena *et al*. (2020) also reported higher yield for combination of polymer-based hydrogel and SA. Attraction index was observed higher in combination of *Tragacanth katira* and SA (71.1 %), and the treatment was found statistically at par with foliar spray of KNO_3 (70.5 %); and SA (70.4 %). Maximum protein content (2.9 %) was observed under T_6 treatment (foliar spray of KNO_3) and protein yield (89.4 kg ha^{-1}) under T_5 treatment (combination of *Tragacanth katira* with SA). It was due to the reason that protein content and protein yield are reflection of N content and grain yield, respectively. Significant interaction was observed between irrigation levels and agrochemicals in respect of grain yield (Fig. 1).

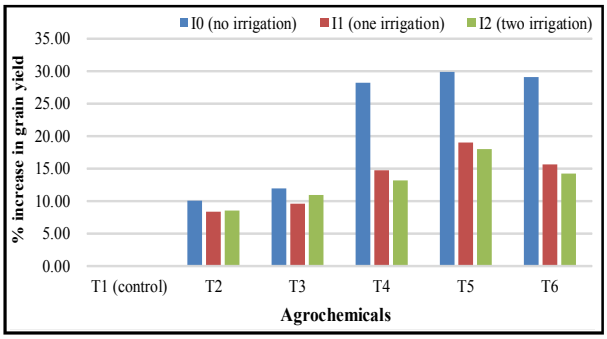

Fig. 1. Interaction effect of irrigation levels and agrochemicals on grain yield.

From the one year study, it can be concluded that combination of *Tragacanth katira* and salicylic acid was highly effective in improving growth, productivity (grain and straw) and; protein content in barley straw, fulfilling the need of both grain as well as quality fodder. Higher grain and straw yield by 21.8 and 11.1 per cent were obtained with combination of *Tragacanth katira* (soil application at 2.5 kg ha^{-1}) and salicylic acid (foliar spray at 200 ppm at booting and grain formation stage) compared to conventional practice (control).

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