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Effect of micro irrigation scheduling on growth, yield attributes and grain yield of barley (*Hordeum vulgare* L.)

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Abstract
A field experiment was conducted at Agronomy farm, S.K.N. College of Agriculture, Jobner, Jaipur (Rajasthan) during *rabi* season of 2018-19 to study the effect of micro irrigation scheduling on growth, yield attributes and grain yield of barley. The experiment comprising of eight treatments of irrigation *viz.*, flood, sprinkler and drip irrigation at 0.4, 0.6 and 0.8 IW/CPE ratios with 2 and 4 days interval was laid out in randomized block design and replicated thrice. The results showed that drip irrigation at different IW/CPE ratios, except drip irrigation at 0.4 IW/CPE ratio with 2 and 4 days interval, significantly increased growth parameters, yield attributes and grain yield of barley. The results further revealed that the drip irrigation at 0.8 IW/CPE ratio with 4 days interval, being at par with 2 days interval at same IW/CPE ratio, recorded significantly higher plant height at 80 DAS and harvest and dry matter accumulation per metre row length at 40, 80 DAS and at harvest, number of total tillers at 80 DAS and harvest and number of effective tillers/m row length (75.19), number of grain/spike (51.47), spike length (13.66), test weight and grain yield (55.51 q/ha) over lower IW/CPE ratio of drip irrigation as well as flood irrigation.

Keywords: Barley, grain yield, growth parameters, micro irrigation, yield attributes

Introduction
Barley (*Hordeum vulgare* L.) is an ancient cereal grain, which upon domestication has evolved from a food grain to a feed and malting grain. It belongs to grass family Poaceae, tribe Triticeae and genus *Hordeum*. Barley is a diploid with 2n= 14 chromosomes. The cultivated barley (*Hordeum vulgare* sp. *vulgare*) is one of the oldest of the cultivated plants. Barley grain contains 12.5 per cent moisture, 11.5 per cent albuminoids, 74 per cent carbohydrates, 1.3 per cent fat, 3.9 per cent crude fibre and 1.5 per cent ash (Choudhary, 2017) [5]. Barley is considered fourth largest grown cereal crop in the world with a share of 7 per cent of the global cereal production (Pal *et al.*, 2012) [7]. Globally barley was cultivated on nearly 49-million-hectare area with a production of 132 million tonnes. India ranks first in world in barley production with 693 thousand hectares with average grain productivity of 2580 kg per hectare and a total production of 1788 thousand tonnes (Anonymous, 2016-17a) [1]. It is mainly grown in northern plains and concentrated in the states of U.P, Rajasthan, M.P, Bihar, Haryana and Punjab. In Rajasthan, it is grown over an area of 276 thousand hectares with average grain productivity of 3297 kg per hectare and a total production of 910 thousand tonnes (Anonymous, 2016-17b) [2]. Rajasthan stands second with regard to its acreage and production. Important traditional systems of irrigation employing different method like flooding basin, furrow irrigation revolved around the concept of replenishing the moisture level of field capacity only after depletion of 50-60 percent of available water. The overall efficiency has not been more than 40% with traditional method of irrigation. Sprinkler system also called overhead irrigation system because the water is piped to one or more central locations with the field and distributed by overhead high-pressure sprinklers or gun. The sprinkler system irrigates the field and used in sandy areas. It checks the wastage of water through evaporation and seepage. Due to spraying method refreshing effect occurs on plant & it apply less water than intake of soil so no run-off occurs. Drip/micro irrigation refers to a variety of irrigation methods in which water is delivered directly to small areas through emitters or applicators placed along a water delivery line (typically a polyethylene hose). Because drip/micro irrigation systems are "solid set," they have the potential for automation. Improper scheduling of irrigation often leads to reduction in crop yields.

In areas having ample and cheap water resources with assured supplies throughout the crop season, it may be possible to schedule irrigation as and when required to meet the full water needs of crops and realize maximum yields. In IW/CPE approach, known amount of irrigation water is applied when cumulative pan evaporation reaches predetermine level. For practical purpose irrigation should be started when allowable depletion of available moisture in the root zone reaches. Thus, irrigation scheduling provides information to the managers to develop irrigation strategies for each plot of field on the farm. The proper irrigation interval can play a major role in increasing the water use efficiency and the productivity by applying the required amount of water as & when it is needed. Hence, in the present study, different effects of micro irrigation scheduling are evaluated under semi-arid conditions of Rajasthan for growth, yield attributes and grain yield of barley crop.

Materials and Methods

The experiment was conducted during *rabi* season of 2018-19 at Agronomy farm, S.K.N. College of Agriculture, Jobner, Jaipur (Rajasthan). The soil of the experimental field was loamy-sand in texture, alkaline in reaction (pH 8.1), poor in organic carbon (0.18%), low in available nitrogen (129.5 kg/ha) and medium in phosphorus (17.1 kg/ha) and potassium (181.2 kg/ha). The experiment consisting of eight treatments of irrigation *viz.*, flood, sprinkler and drip irrigation at 0.4, 0.6 and 0.8 IW/CPE ratios with 2 and 4 days interval that were laid out in randomized block design and replicated three times. The plot size was 4.5 m x 4.5 m. Barley crop was sown on 9th November 2018. Before sowing, the seeds were treated with bavistin @ 3 g/kg seed to protect the crop from seed borne diseases. Sowing was done by kera method at row spacing of 22.5 cm using a seed rate of 100 kg/ha at a depth of 4-5 cm. A uniform basal dose of 20 kg N + 30 kg P_2O_5/ha through urea and DAP was drilled prior to sowing. Remaining half of the dose of nitrogen of 20 kg/ha was top dressed after first irrigation. In order to minimize weed competition, one hoeing-cum-weeding was done manually at 20 days after sowing. To maintain uniform plant stand at an intra-row spacing of 15 cm for barley, extra plants were thinned out. Five plants were selected randomly from each plot and tagged permanently. The height of each plant was measured from base of the plant to the tip of main shoot at 40, 80 DAS and at harvest. Dry matter production was recorded at 40, 80 DAS and at harvest stage. For this, plants from one metre row length were uprooted randomly from sample rows of each plot. After removal of root portion, the samples were first air dried for some days and finally dried in an electric oven at 70^{0}C till constant weight. The number of spike bearing tillers were counted following the same procedure as for total number of tillers and their average was taken as the number of effective tillers per metre row length. Five spikes were taken randomly from each plot. Length of these spikes was measured and average length (cm) per spike was worked out. Five spikes taken from each plot for recording spike length were threshed. The grains were counted and average number of grains per spike was worked out. One thousand grains were counted from the produce of each plot and their weight was expressed in grams. Barley crop was harvested on 15th March, 2019 after leaving two border rows on each side of plot along the length on both sides, a net area of 1.8m × 3.5m. Plots were harvested separately and tied in bundles and tagged. These bundles were left on the threshing floor for sun drying. After complete drying, bundles were weighed to record biological yield. Thereafter, threshing was done by beating the plants with sticks. The clean grain obtained from individual plot was weighed separately and weight recorded as grain yield.

Table 1: Effect of micro irrigation scheduling on plant height, dry matter accumulation per metre row length and total number of tillers/metre row length in barley

Treatments	Plant height (cm)			Dry matter accumulation (g/m row length)			Total number of tillers/m row length		
	40 DAS	80 DAS	At harvest	40 DAS	80 DAS	At harvest	40 DAS	80 DAS	At harvest
Flood irrigation	32.75	57.71	71.75	33.01	59.04	147.62	72.05	73.11	68.07
Sprinkler irrigation	33.43	65.39	82.12	36.63	66.89	168.95	74.01	77.17	76.53
Drip irrigation at 0.4 IW/CPE ratio with 2 days interval	32.41	55.49	70.71	32.77	58.03	145.13	71.54	72.73	68.15
Drip irrigation at 0.4 IW/CPE ratio with 4 days interval	31.96	55.37	69.13	30.86	55.37	142.96	70.07	71.12	67.09
Drip irrigation at 0.6 IW/CPE ratio with 2 days interval	33.07	63.93	80.09	34.93	63.16	166.04	73.19	76.01	74.48
Drip irrigation at 0.6 IW/CPE ratio with 4 days interval	33.48	65.63	81.98	36.59	65.09	170.08	74.02	77.96	77.35
Drip irrigation at 0.8 IW/CPE ratio with 2 days interval	34.04	73.57	94.52	38.17	75.01	188.01	75.78	79.89	78.51
Drip irrigation at 0.8 IW/CPE ratio with 4 days interval	34.51	76.68	97.85	39.75	77.07	193.87	77.93	83.48	83.14
S.Em +	1.35	1.99	2.85	1.37	2.41	5.55	2.60	2.67	2.55
CD (P=0.05)	NS	6.03	8.63	4.16	7.32	16.82	NS	8.09	7.75

NS - Non-significant

Table 2: Effect of micro irrigation scheduling on number of effective tillers/meter row length, number of grains/spike, spike length, test weight and grain yield in barley

Treatments	Number of effective tillers/metre row length	Number of grains/spike	Spike length (cm)	Test weight (g)	Grain yield (q/ha)
Flood irrigation	58.77	44.11	10.03	42.65	39.02
Sprinkler irrigation	65.89	48.59	11.57	47.44	45.66
Drip irrigation at 0.4 IW/CPE ratio with 2 days interval	57.13	43.63	9.72	41.11	38.53
Drip irrigation at 0.4 IW/CPE ratio with 4 days interval	56.02	41.72	9.49	40.13	36.50
Drip irrigation at 0.6 IW/CPE ratio with 2 days interval	63.15	47.31	10.33	46.07	44.48
Drip irrigation at 0.6 IW/CPE ratio with 4 days interval	65.41	48.08	11.81	48.99	45.08
Drip irrigation at 0.8 IW/CPE ratio with 2 days interval	72.13	50.55	12.79	50.22	54.37

Drip irrigation at 0.8 IW/CPE ratio with 4 days interval	75.19	51.47	13.66	51.66	55.11
S.Em +	2.16	1.60	0.37	1.55	1.68
CD (P=0.05)	6.56	4.86	1.12	4.71	5.04

Results and Discussion

Effect on growth parameters

The results revealed that drip irrigation at 0.8 IW/CPE ratio with 2 and 4 days interval had favourable effect on growth and biomass production of barley over flood and sprinkler irrigation as well as drip at lower IW/CPE ratios. All the growth parameter *viz.* plant height, dry matter accumulation and total number of tillers/m row length significantly increase in drip at 0.8 IW/CPE ratio with 4 days interval (Table 1). This increment was statistically significant over drip irrigation at 0.4 and 0.6 IW/CPE ratios with 2 and 4 days interval, but remained at par with drip at 0.8 IW/CPE ratio with 2 days interval. It is well established fact that where sufficient soil moisture for continued growth is maintained by providing drip irrigation it leads to greater development of green tissue area and results in a higher photosynthetic assimilation. As a result, plant growth improves leading to higher accumulation of the total dry matter. The crop plants are able to maintain higher water potential with increasing IW/CPE ratio under drip irrigation which improves physiological and biochemical activities. These facts clearly suggest the importance of adequate supply of water for the optimum metabolism in the plants for better growth and development. Bhunia *et al*. (2015) [4] reported that there was an increase in plant height of wheat with the increase of drip irrigation level from 60% PE to 100% PE. The drip irrigation at 0.8 IW/CPE ratio with 4 days interval had significant improvement in dry matter accumulation and total number of tillers/m row length at different growth stages of barley seems to an account of better vegetative growth which is well reflected by increase in plant height and branches/plant. It is an established fact that the soil water deficiency inhibits leaf expansion and stem elongation in plants through its reduction of relative turgidity. Reduced water supply also causes closure of stomata which raises the plant temperatures consequently increases respiration leading to higher break down of assimilates and ultimately poor growth and reduced dry matter accumulation under lower IW/CPE ratio of 0.4 and 0.6 with 2 and 4 days interval, flood and sprinkler irrigation. Viswanath *et al*. (2000) reported in sweet corn that drip irrigation scheduled at 80 per cent Epan recorded significantly higher dry matter of leaf, stem and total dry matter (222.02 g per plant) as compared to drip irrigation scheduled at 40 and 60 percent Epan in sandy loam soils of Bengal during *rabi* season.

Effect on yield attributes and yield

The results presented in table 2 showed that the drip irrigation at 0.8 IW/CPE ratio with 4 days interval caused significant increase in yield attributes *viz*., effective tillers per metre row length (75.19), number of grains/spike (51.47), spike length (13.66), test weight (51.66 g) as well as grain yield (55.11 q/ha) of barley over flood and sprinkler irrigation as well as lower levels of drip irrigation but remained at par with drip at 0.8 IW/CPE ratio with 2 days interval. The marked improvement in yield attributes with increasing IW/CPE ratios under drip irrigation could be ascribed to overall improvement in crop growth by virtue of increased growth parameters of the crop. The increased dry matter production of successive stages with increased water availability might have led to greater availability of photosynthates towards formation of reproductive structure and their growth resulting in their better initiation and development. Singh *et al*. (2006) [9] also indicated that each increment level of irrigation from 0.5, 0.7 and 0.9 of IW/CPE ratio increased grain yield of wheat. These results are in close conformity with Chouhan *et al.* (2015) [6]. The accumulation and subsequent partitioning of assimilates towards sink are major factors in determining yield of a crop. In present investigation drip irrigation at 0.8 IW/CPE ratio with 4 days interval recorded significantly higher seed yield by 41.23 and 20.69 per cent over flood and sprinkler irrigation. This increase in seed yield might be due to maintenance of sufficient moisture in root zone during critical stages of the crop growth, resulting in higher yields. Also, higher seed yield with increasing IW/CPE ratio could be the resultant of cumulative beneficial effects of irrigation schedules first on vegetative growth and later on better partitioning of photosynthates towards the sink. The yield increase in drip irrigation with high IW/CPE ratio is due to frequent water application through drip irrigation results in favourable micro climate and keeps continuously soil moisture near to field capacity which helps in increasing the yield. Singh *et al.* (2012) [9] also reported increase in yield of malt barley with increasing levels of irrigation. Bhowmik *et al*. (2018) also reported that drip irrigation at 75 or 100% CPE on two days interval recorded significantly higher grain yield over conventionally irrigated wheat.

Conclusion

On the basis of the findings of the present investigation, it can be concluded that drip irrigation at 0.8 IW/CPE ratio with 4 days interval for barley proved to be the most superior treatment for obtaining higher growth parameters, yield attributes and grain yield in barley over other treatments but remained at par with drip irrigation at 0.8 IW/CPE ratio with 2 days interval.

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