Original Research Article

Response of barley (*Hordeum vulgare* L.) to irrigation scheduling and nutrient management

Abstract

A study was carried out during *Rabi*-2020-21 at Crop Research Centre (CRC), School of Agriculture, ITM University, Gwalior (MP) to investigate the response of barley crop (*Hordeum vulgare* L.) to irrigation scheduling and nutrient management. The study was carried out in split plot design with irrigation scheduling at different crop growth stages and fertilizer applications. The treatments were $I_{0:}$ No irrigation; I_1: Irrigation at CRI stage; I_3: Irrigation at CRI and tillering stages. The results of the study revealed that irrigation scheduling has significant effect on morpho-physiological attributes and yield of the barley crop. Comparatively two irrigations at CRI and late tillering stages recorded maximum grain yield (4309.50 kg ha^{-1}) which was 28.90% and 20.90% significantly higher than barley plants received no irrigation and one irrigation at CRI stage, respectively. Comparatively foliar application of 100% NPK in combination with foliar application of 19:19:19 at 30 and 60 days (F4) was recorded significant improvement in morpho-physiological attributes of barley. Moreover, with F_4 treatment, the grain yield was recorded maximum (4064.4 kg ha^{-1}) as compared to other treatment. The treatment combination, I_2F_3 (Two irrigations and 100% NPK I combination with foliar application of 19:19:19 fertilizer at 30 and 60 days after sowing had maximum gross (₹ 89256.00/ha) and net income (₹ 60836.00/ha) with B:C ratio of 3.15.

Key words: Barley, irrigation scheduling, 19:19:19 fertilizer, gross and net income

Introduction

After the rice, wheat and maize, barley (*Hordeum vulgare* L.) is the fourth important cereal crop in the world contributing about 7% in total cereal production (Giraldo et al. 2019). Its cultivation has been reported from a wide range of agro-climatic conditions. Globally barley covers 50.90 Mha during 2020-21 (ICAR-IIWBR 2021). According to USDA (2021), barley contributes covers 153.47 MT production. Barley is an important rabi season crop of Northern India. In India, barley is considered as a poor man's cereal and small-holders crop and covers 0.61 Mha (2020-21) (ICAR-IIWBR 2021). During the year 2020-21, barley production was reached 1.82 MT with a productivity of 2988 kg/ha (ICAR-IIWBR 2021). The crop is suited to the areas having less irrigation facilities are less and alkaline soil. However, barley has high sensitivity to various stresses at different growth stages such as during jointing, booting and heading. Moreover, barley is also unable to withstand drought conditions (Jai et al. 2015). Drought stress during early growth stage results in the production of tillers that never produce heads, thus significantly reduces the total production. The presence of optimum moisture in soil is essential for having good production from barley crop.

Soil moisture levels should be more than 50% in rhizosphere from seedling to milking growth stage (Jai et al. 2015). Therefore, proper scheduling of irrigation timing is imperative for obtaining good production from barley crop. Provision of balanced nutrition to the plants and their efficient utilization plays a critical role in boosting the production and productivity of any crops. Insufficient N, P and K the reduced grain production and quality well below to the acceptable level, while nutrients application in higher amount results into low nutrient use efficiency and high cost of cultivation (Nirere et al. 2019). Recently, foliar application of nutrients to supplement the soil application of fertilizers is gaining more attention for efficient translocation and utilization of nutrients in plant thus for improving production as well as productivity (Ahmed et al. 1994). Recently, new generation water soluble fertilizers have been popularized especially for foliar application. NPK 19:19:19 fertilizer is available as hundred % water soluble complete fertilizer containing N(19%), P (19%) and K (19%) with low salt index. It application at critical stages can be beneficial where the nutrient requirement of plant exceeds the normal uptake for certain nutrients (Fageria et al. 2019). With soil application, the availability of macro and micro-nutrients is affected by soil as well as many environmental factors. Among the different soil factors affecting the fertilizer and nutrient use efficiency, the availability of optimum moisture in soil is essential. Considering this investigation involving the application of foliar application of fertilizer and maintenance of soil moisture status is essential for obtaining higher yield from barley crop.

Materials and Methods

The present experiment was conducted during the Rabi - 2020-21 at Crop Research Centre (CRC), School of Agriculture, ITM University, Gwalior to evaluate the combined effect of Irrigation scheduling and nutrient management on growth, and yield parameters of barley. The field experiment was consisted of three irrigation scheduling as main treatment namely; $I_{0:}$ No irrigation; I_1: Irrigation at CRI stage; I_3: Irrigation at CRI and tillering stages and four fertilizer

application as sub treatment; F_1: 50% NPK+ Foliar application of 19:19:19 at 30 and 60 DAS), F_2: 75% NPK+ Foliar application of 19:19:19 at 30 and 60 DAS, F_3: 100% NPK+ Foliar application of 19:19:19 at 30 and 60 DAS; F_4: 100% NPK in all possible combinations in split plot design. Each treatment was replicated thrice. Sowing of barley (variety: Prakhar) was done @ 100 kg ha^{-1}. The soil of the experimental field was alluvial, sandy clay loam in texture with pH of 7.76, and 188.80 kg/ha available N, 13.40 kg/ha P and 216.00 kg/ha K. The nitrogen, phosphorus and potassium were applied through urea, (Diammonium phosphate) and MOP (Murate of Pottash). The full dose of phosphorus, potassium and half dose of nitrogen were given below the seed at the time of sowing as basal dose, whereas, the remaining half dose of nitrogen was top-dressed after first irrigation. Foliar application of 19:19:19 was done @ 1% as per treatment .All other agronomic practices except those under study were kept normal and uniform for all the treatments. All data related to growth and yield was collected and subjected to statistical analysis using the One Way Anova (Fisher 1958).

Result and discussion

Morpho-physiological attributes are directly related to economic yield from a crop and change with the prevailing environmental conditions. From the study, it was evident that all the growth attributes including plant height, number of tillers $plant^{-1}$, and number of ear-head m^{-1}) and yield attributes characters (i.e. length and weight of ear-head, grains ear-head $^{-1}$, and test weight) of barley significantly affected by scheduling of irrigations at different growth stages (Table-1). In the study, I_2 treatment recorded significant higher number of ear heads as compared to the other treatment. The improvement in morpho-physiological attributes under I_2 treatment may be attributed to the increased moisture content in loamy sand soil which usually has limited water holding capacity. The increased moisture content in the soil might have resulted in better nutrient use efficiency thereby leading to the profuse growth. Similar results have been reported by Kibe and Singh (2003) and Singh *et al.* (2012).

The maximum ear head length (7.23 cm) and weight (4.56 g) was observed with I_2 treatment and was statistically similar to I_1 treatment (Table-1). I_2 treatment also recorded significantly higher number of grains per ear head and test weight of barley which was at par with I_1 treatment whereas minimum was recorded for I_0 treatment. The increased availability of moisture at critical growth stages might have increased the proliferation of leaf buds. The results corroborates with the findings of Sharma and Verma (2010) who observed significant improvement in yield attributes of wheat crop received proper soil moisture at critical growth stages.

It is evident from results (Table-2), that the irrigated treatments (I_1 and I_2) recorded significantly higher grain yield as compared to no irrigation treatment. With I2 treatment, significant improvement in yield was recorded (4309.50 kg ha^{-1}). The increment in yield was 28.90% and 20.90% higher as compared to I_0 and I_1 treatments, respectively. The results on grain and straw yield of barley are in confirmation with observations made by Sharma and Verma (2010). Harvest index of barley was observed in the range of 37.93

to 42.63 % under different irrigation scheduling treatments. The maximum value of HI (42.63%) was observed with I_2 treatment. Similar results have also been reported by Jana *et al.* (2001) and Yadav *et al.* (2005).

It has been well established that by giving better agronomic manipulations, production and productivity of any crop could be considerably increased. Proper combination and application of macro as well as microelements is essential to bring significant improvement in the crop production. Adequate nitrogen to plants not only promotes food synthesis but also its subsequent partitioning to the sink from the source. Nitrogen also promotes the better utilization of other nutrients. Deficiency of phosphorus affects carbon absorption and distribution in different plant parts. Potassium facilitates translocation of photosynthates towards various organs of plant body and increases plumpness and boldness of seeds.

With different fertilizer treatments, maximum value of growth and yield attributes was recorded with F_3 treatment which was significantly higher to F_1 and F_4 treatments. Significant improvement in yield attributes may be due to increased availability of minerals to the plants, which resulted in increased synthesis and accumulation of nutrients in leaves and their translocation to the productive organs,. Similar findings have also been reported by Asghar et al. (2011) and Mamathashree et al. (2017). With F_3 treatment, the yield was significantly the yield was recorded highest (4064.4 kg ha^{-1}) and minimum grain yield (3199.3 kg ha^{-1}) was noted for F_1 treatment. Similar findings were also reported by Sharma and Verma (2010) for wheat crop. The increased accumulation and translocation photosynthetic from source to the sink under easy availability of soil moisture may be attributed to the improvement in increased all the growth and yield attributes. Increase dose of NPK fertilizers rate resulted in higher grain weight and grain yield compared with the lower level of fertilizer application i.e 50 % NPK. which could be associated with the increase in number of grains per ear head. The findings of the study corroborates with the results reported by Cossani *et al.* (2009) and Sharma *et al.(*2020).

Economics analysis

The I_2 treatment registered maximum gross and net return (₹. 81913.00 and ₹ 57563.00/ha), respectively followed by I_1 treatment. Moreover, B:C ratio and economic efficiency was also observed under I_2 treatment (Table-3). The increase in gross and net returns and B:C ratio in I_2 treatment might be due to increase in grain and straw yield increase in under the same treatments. A similar result has also been reported by Jai et al. (2015). Under different fertilizer application, highest gross and net income of ₹ 77513.00 and ₹ 51093.00/ha and B:C ratio of 2.93 was recorded under F_3 treatment which was higher over rest of other treatments. However, minimum gross and net income as well as B:C ratio was recorded for F_1 treatment. Similar findings with different fertilizer treatments were recorded by Mamathashree *et al.* (2017) and Rundla and Bairwa (2018).

CONCLUSION

The study concluded that 100% NPK + foliar spray of 19:19:19 at 30 & 60 DAS with two irrigations at CRI and late tillering stages produced the higher economic yield form barley crop. The above combination of irrigation and fertilizer treatment also gave the highest net returns and benefit cost ratio in barley in Sandy Clay Loam soil of Gwalior district of Madhya Pradesh.

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Table 1: Effect of irrigation scheduling and fertilizer application on growth and yield attributes of barley

Treatments	Growth and yield attributed characters						
	Plant height (cm)	Number of tillers/plant	Number of ear-head	Ear head length (cm)	Number of grains/ear head	Ear head Weight (g)	Test weight (g)
Irrigation scheduling (I)							
I_0 : No irrigation	83.96	12.76	176.45	6.21	32.93	4.03	31.95
I_1 : One irrigation - only at CRI stage	92.77	14.20	184.71	7.02	36.48	4.36	34.39
I_2 : Two irrigations - at CRI and late tillering stages	97.95	16.07	194.39	7.23	38.09	4.56	35.90
SE(m) ±	**0.74**	**0.15**	**2.45**	**0.07**	**0.41**	**0.03**	**0.52**
CD (5%)	**2.90**	**0.57**	**9.60**	**0.29**	**1.63**	**0.12**	**2.05**
Fertilizer application (F)							
F_1: 50% NPK+19:19:19 at 30 & 60 DAS	83.37	12.67	172.42	5.73	31.18	3.79	29.87
F_2: 75% NPK+ 19:19:19 at 30 & 60 DAS	90.58	14.02	182.92	6.84	35.22	4.34	34.30
F_3: 100% NPK+19:19:19 at 30 & 60 DAS	98.57	15.47	193.66	7.52	38.65	4.64	36.21
F_4: 100% NPK	93.71	15.22	191.75	7.18	38.26	4.49	35.94
SE(m) ±	**1.18**	**0.23**	**4.26**	**0.07**	**0.67**	**0.05**	**0.37**
CD (5%)	**3.52**	**0.68**	**13.16**	**0.22**	**1.98**	**0.15**	**1.08**
Interaction (I x F)	**NS**	**S***	**NS**	**S***	**NS**	**NS**	**NS**

Table - 2: Effect of irrigation scheduling and fertilizer application on yield parameters of barley

Treatments	Yield (kg/ ha)			HI (%)
	Grain	Straw	Biological	
Irrigation scheduling				
I_0 : No irrigation	3343.70	5464.10	8807.80	37.93
I_1 : One irrigation - only at CRI stage	3565.40	5492.60	9058.00	39.33
I_2 : Two irrigations - at CRI and late tillering stages	4309.50	5760.40	10069.90	42.63
SE(m) ±	**23.00**	**49.70**	**59.70**	**0.24**
CD (5%)	**90.10**	**195.20**	**234.50**	**0.93**
Fertilizer application				
F_1: 50% NPK +19:19:19 at 30 & 60 DAS	3199.3	5551.6	8750.9	36.53
F_2: 75% NPK+ 19:19:19 at 30 & 60 DAS	3881.0	5686.5	9567.5	40.45
F_3: 100% NPK+ F. A. of 19:19:19 at 30 & 60 DAS	4064.4	5547.6	9612.0	42.11
F_4: 100% NPK	3813.5	5503.8	9317.3	40.77
SE(m) ±	**58.40**	**74.20**	**104.20**	**0.42**
CD (5%)	**173.60**	**NS**	**309.70**	**1.25**
Interaction (I x F)	**S***	**NS**	**NS**	**S***

Table 3: Economics of different treatments under barley crop

Treatments	Cost of cultivation (Rs./ha)			Gross return (Rs./ha) *	Net return (Rs./ha)	B : C ratio
	Exclusive treatment	Treatment cost	Total cost			
Irrigation scheduling						
I_0 : No irrigation	22350.00	0.00	22350.00	65793.00	43443.00	2.94
I_1 : One irrigation	22350.00	1000.00	23350.00	69405.00	46055.00	2.97
I_2 : Two irrigations	22350.00	2000.00	24350.00	81913.00	57563.00	3.36
Fertilizer application						
F_1: 50% NPK+ 19:19:19 at 30 & 60 DAS	22350.00	2610.00	24960.00	63679.00	38719.00	2.55
F_2: 75% NPK+ 19:19:19 at 30 & 60 DAS	22350.00	3340.00	25690.00	74890.00	49200.00	2.92
F_3:100% NPK+ 19:19:19 at 30& 60 DAS	22350.00	4070.00	26420.00	77513.00	51093.00	2.93
F_4: 100% NPK	22350.00	2920.00	25270.00	73399.00	48129.00	2.90
Irrigation scheduling x fertilizer application						
$I_0 \times F_1$	22350.00	2610.00	24960.00	59073.00	34113.00	2.37
$I_0 \times F_2$	22350.00	3340.00	25690.00	68305.00	42615.00	2.66
$I_0 \times F_3$	22350.00	4070.00	26420.00	68977.00	42557.00	2.61
$I_0 \times F_4$	22350.00	2920.00	25270.00	66817.00	41547.00	2.64
$I_1 \times F_1$	22350.00	3610.00	25960.00	64158.00	38198.00	2.47
$I_1 \times F_2$	22350.00	4340.00	26690.00	71811.00	45121.00	2.69
$I_1 \times F_3$	22350.00	5070.00	27420.00	74307.00	46887.00	2.71
$I_1 \times F_4$	22350.00	3920.00	26270.00	67344.00	41074.00	2.56
$I_2 \times F_1$	22350.00	4610	26960.00	67807.00	40847.00	2.52
$I_2 \times F_2$	22350.00	5340.00	27690.00	84554.00	56864.00	3.05
$I_2 \times F_3$	22350.00	6070.00	28420.00	89256.00	60836.00	3.15
$I_2 \times F_4$	22350.00	4920.00	27270.00	86036.00	58766.00	3.14

* Calculation based on MSP of barley @ 1600/ q & straw 225/ q