Original Research Article

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

Abstract

A research 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 nutrient management. The main plots consisted of 3 irrigation treatments *viz*., $I_{0:}$ No irrigation; I_1: Irrigation at CRI stage; I_3: Irrigation at CRI and tillering stages and sub plots consisted of four nutrient management treatments *viz*., N_1, N_2, N_3 and N_4. The results of the study revealed that irrigations scheduled 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. Among nutrient management, application of 100% NPK with foliar application of 19:19:19 at 30 and 60 days after sowing (DAS) registered significantly higher yield attributes and seed yield of barley (4064.40 kg ha^{-1}) while the treatment combination, two irrigations and 100% NPK with foliar application of 19:19:19 fertilizer at 30 and 60 days after sowing fetched maximum gross (₹ 89256.00/ha) and net returns (₹ 60836.00/ha) and B:C ratio of 3.15.

Key words: Barley, Irrigation scheduling, 19:19:19 fertilizer, Nutrient management, Monetary returns

Introduction

Barley (*Hordeum vulgare* L.) is the fourth important cereal crop after the rice, wheat and maize in the world contributing to about 7% in total cereal production [1]. It is cultivated over a wide range of agro-climatic conditions. Globally barley covers 50.90 Mha (Million hectare) during 2020-21[2]. According to USDA (2021), barley contributes to 153.47 MT (Metric Tonnes) 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 (Million hectare) (2020-21)[2]. During the year 2020-21, barley production was reached 1.82 MT with a productivity of 2988 kg/ha [2]. The crop is suited to areas having less irrigation facilities and alkaline soil. However, barley has high sensitivity to various stresses at different growth stages during jointing, booting and heading. Moreover, barley is also unable to withstand drought conditions [3]. 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 [3]. Therefore, proper scheduling of irrigation timing is imperative for obtaining good production in 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 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 [4]. 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 [5]. 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. Its application at critical stages is beneficial where the nutrient requirement of plant exceeds the normal uptake for certain nutrients [6]. In 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, availability of optimum moisture in soil is pivotal. Keeping these points in view the present investigation in barley was carried out to identify the effect of irrigation scheduling and nutrient management on growth and yield of barley.

Materials and Methods

The present experiment was conducted during *Rabi* (Dec, 2020- April, 2021) at Crop Research Centre (CRC), School of Agriculture, ITM University, Gwalior to evaluate the effect of Irrigation scheduling and nutrient management on growth, and yield parameters of barley. The field experiment consisted of three main treatments involving irrigation scheduling $I_{0:}$ No irrigation; I_1: Irrigation at CRI stage; I_3: Irrigation at CRI and tillering stages and four Sub plot

treatments namely; fertilizer application F_1: 50% NPK+ Foliar application of 19:19:19 at 30 and 60 days after sowing (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 split plot design was laid out and replicated thrice. Sowing of barley (variety: Prakhar) was done adopting the seed rate of 100 kg ha^{-1}. The soil of the experimental field was alluvial, sandy clay loam in texture. The nitrogen, phosphorus and potassium were applied through urea, (Diammonium phosphate) and MOP (Murate of Pottash). 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 treatments. All other agronomic practices except those under study were kept normal and uniform in all the treatments. All data related to growth and yield was collected and subjected to statistical analysis using the One Way Anova at OPSTAT software portal [7].

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 *viz;* plant height, number of tillers $plant^{-1}$ and number of ear-heads m^{-1}) and yield attributes characters (*i.e.*, length and weight of ear-heads, grains ear-head $^{-1}$ and test weight) of barley significantly were affected by irrigation scheduling at different growth stages (Table-1). and I_2 treatment (Irrigation at CRI and tillering stages) recorded significantly higher number of ear heads as compared to other treatments. The improvement in morpho-physiological attributes under I_2 treatment may be attributed to the increased moisture content in loamy sand that might have resulted in better nutrient use efficiency thereby leading to the profuse growth. Similar results have been reported by Kibe and Singh [8] and Singh *et al.* [9].

Maximum ear head length (7.23 cm), number of grains/ear head (38.09) ear head weight (4.56 g) and test weight (35.90 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 and resulted in higher growth and yield attributes. The results corroborates with the findings of Sharma and Verma [10] who observed significant improvement in yield attributes of wheat crop received with soil moisture at critical growth stages.

It is evident from results (Table-2), that irrigation at CRI stage (I_1) and irrigation at CRI and tillering stages (I_2) recorded significantly higher grain yield as compared to no irrigation treatment. The grain yield with I_1 and I_2 were 3565.40 and 4309.50 kg ha^{-1}. The results on grain and straw yield of barley are in confirmation with observations made by Sharma and Verma [10]. Harvest index of barley was observed in the range of 37.93 to 42.63 % under different irrigation scheduling treatments. Maximum value of harvest index

(42.63%) was observed with I_2 treatment (Irrigation at CRI and tillering stages). Similar results have also been reported by Jana *et al.* [11] and Yadav *et al*. [12].

It has been well established that by agronomic practices, production and productivity of crops could be considerably enhanced. Proper combination and application of macro as well as micronutrients is essential to bring significant improvement in the crop production. Adequate nitrogen to plants not only promotes food synthesis but also its subsequent partitioning from 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 were recorded with 100% NPK+ Foliar application of 19:19:19 at 30 and 60 DAS (F_3 treatment) which was significantly higher to 50% NPK+ Foliar application of 19:19:19 at 30 and 60 DAS (F_1 treatment) and 100% NPK (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.* [13] and Mamathashree *et al.* [14]. Grain yield was significantly highest (4064.4 kg ha^{-1}) with F_3 treatment and significantly lower grain yield (3199.3 kg ha^{-1}) was registered for F_1 treatment. Similar findings were also reported by Sharma and Verma [10] in wheat crop. Increased accumulation and translocation photosynthates from source to the sink under adequate availability of soil moisture may be attributed to the improvement in all growth and yield attributes. Increase dose of NPK fertilizers rate resulted in higher grain weight and grain yield as compared to the corresponding low level of fertilizer application (50% NPK). The findings of the study corroborates with the results of Cossani *et al.* [15] and Sharma *et al.*[16].

Economics analysis

Irrigation at CRI and tillering stages (I_2) treatment registered maximum gross and net returns (₹. 81913.00 and ₹ 57563.00/ha), respectively followed by irrigation at CRI stage (I_1) treatment. Moreover, B: C ratio and economic efficiency was also observed under I_2 treatment (Table-3). The increase in gross returns, net returns and B: C ratio in I_2 treatment might be due to increase in grain and straw yield over rest of the treatments. Similar results were also reported by Jai *et al.* [3]. Under different nutrient management treatments, highest gross and net income of ₹ 77513.00, ₹ 51093.00/ha and B:C ratio of 2.93 were accrued under F_3 treatment (100% NPK+ Foliar application of 19:19:19 at 30 and 60 DAS). Minimum gross and net income as well as B:C ratio were recorded with F_1 (50% NPK+ Foliar application of 19:19:19 at 30 and 60 DAS) treatment. Similar findings on higher monetary returns were recorded by Mamathashree *et al.[14]* and Rundla and Bairwa [17].

CONCLUSION

The study concluded that two irrigations at CRI and late tillering stages and application of 100% NPK + foliar spray of 19:19:19 at 30 & 60 DAS recorded higher yield attributes, grain yield and monetary returns in barley crop on sandy soils 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 × F)	**S***	**NS**	**NS**	**S***

Table 3: Economics of barley crop as influenced by irrigation schedule and nutrient management

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 × 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 (Minimum Support Price) of barley @ 1600/ quintal & straw 225/ quintal