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EFFECT OF IRRIGATION AND FERTILITY BALANCE ON PERFORMANCE AND PRODUCTION ECONOMICS OF BARLEY (*Hordeum vulgare* L.)

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Abstract-The experiment was carried out during *Rabi* season 2011-12 on sandy loam soil to evaluate "Effect of irrigation and fertility balance on performance and production economics of barley crop" by using split plot design with three replication. Result revealed that significantly maximum growth attributes *viz.,* plant height, fresh weight and dry weight/plant at 30 DAS and at maturity while number of tillers only at 30 DAS, yield and its contributes traits *viz.,* length of ear and number of grains per ear were recorded in treatment where irrigation was applied thrice (tillering, flag leaf and milking stage), besides obtained highest grain and biological yield (40.48 and 97.24 q/ha), respectively as against two and one irrigation. Besides, shown its superiority to removed nitrogen and build protein yield in plant. Besides, fetches more B:C ratio (2.66) and economic efficiency (309.44 Rs/day/ha). Likewise Balancing the recommended dose of inorganic fertilizers (NPK-60:30:30) along with biofertilizers (Azotobacter and PSB) and FYM helpful in yield maximization over other fertility levels ie. RDF + Biofertilizer + Vermicompost, RDF + Biofertilizer and RDF applied alone, besides achieved maximum performance, uptake and production economics.

Keywords- Barley Crop, Fertility Balance, Irrigation and Production Economics.

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Introduction

The incidence of cancer has been rising alarmingly for the last few decades. India is agrculture-based economy, after service sector agriculture has second place in contribution to the total GDP (14.2%) 2011-12. Among the cereals, it ranks fourth with respect to area and production after wheat, rice and maize. Barley occupies 0.46% of total cropped area, 0.62% of the food grains and 0.76% of the cereals in the world. World barley production forecast down 130.8 mt in 2010 from 134.3 mt [1]. Global malt production is estimated to around 22 mt more than 90% malt is produced from barley only. Owing to its very hardy nature, barley is successfully cultivated in adverse agro-environment like drought, salinity, alkalinity etc. U.P. and Rajasthan are two major barley-producing states in the country. These two states provide 64% of the total area and 72% of the total production of barley in India [1].

Barley is most sensitive to stress during jointing, booting and heading. Stress during grain filling substantially degrades malt quality of barley. Moreover, this crop does not tolerate prolonged or excessive drought, while drought stress during early vegetative state has impact on yield, such stress tend to cause excess tillering, often resulting in tillers that never produce heads. For crop production, soil moisture levels should remain above 50% MAD (deficit available soil moisture) in the active root zone from seedling to milking stage to optimize yield [2]. For that condition, sustainable use of water has to consider maximizing yield per unit of water rather than maximum yield per unit of area.

The efficacy of fertilizer, FYM and vermicompost to increase the yield will depend upon many factors among these, soil moisture is most important. Adequate moisture without fertilizer may result into low water and fertilizer use efficiency. Fertilizer levels and time of its application also affected the grain yield and quality. Insufficient N reduced grain yield and quality below acceptable level, while application of higher quantity of N resulted into undesirable high protein content [3] there is a linear increase in grain protein and yield depending upon initial soil N level.

Materials and Methods

A trial on barley crop was carried out in the Experiment Farm of Chandra Shekhar Azad University of Agriculture and Technology, Kanpur during *Rabi* season of 2011-12. Twelve treatment combinations of different irrigation levels, organic and inorganic source of fertilizer along with biofertilizer (Azatobacter + PSB) and farm yard manure were tested in split plot design with three replication in which scheduling of irrigation was kept in main plot and fertility level were kept in sub plot are also depict in different Table. The farm is situated in the main campus of university which lies between latitude of 25° 26 to 26° 58 north and longitude 79°31 to 80° 34 east. The climate of Kanpur district is sub tropical, semi –arid with hot dry summer and severe cold during winter. Maximum temperature during summer reaches up to 47°C, while during winter it fall up to 4.13°C the mean annual precipitation of the district is about 815 mm. The experimental field was well drained, sandy loam in texture (54.50 % sand, 22.7 % silt and 22.8 % clay, Bouyoucos hydrometer method) and slightly alkaline in reaction (pH 8.05, Glass electrode pH meter). It was medium in organic carbon (0.40 %), available nitrogen (220.6 kg/ha) but high in available phosphorus (34.2 kg/ha) and available potassium (239.0 kg/ha) with an electrical conductivity of 1.6 dS/m (1:2, soil: water suspension) and a bulk density and 1.42 Mg/m3. All the physic-chemical properties were analyzed as per the standard procedures given by Jackson [4]. Moreover, irrigation was applied on the physiological stage of crop growth. The irrigation depth was kept as 6 cm for all the irrigation treatment. The irrigation was applied at following stage. Furthermore, A full dose of phosphorus, potassium and half dose of nitrogen were applied uniformly as a basal dose in all the plots

through DAP, muriate of potash and urea, respectively. Remaining half dose of nitrogen was top dressing at first irrigation (tillering stage). Although, the sowing of barley seed (*Var*. K-551 @100 kg seed/ha) is done behind desi plough on 06 December, 2011 with a row to row spacing 22.5 cm and a plot size of 12 m2. The desired plant population per plot was established by thinning after 10 days of sowing. The crop was grown as per recommended package of practices and harvested on 6 April, 2012.

Observations on initial plant population and various growth parameters *viz.,* plant height, fresh weight/plant, dry matter accumulation/plant and number of tillers/plant were recorded at 30 DAS and at maturity stage. Whereas, yield and its contributing attributes was recorded at harvest stage. The N content in grains and straw was determined by Kjeldahl method [5] and then multiply with 5.73 for protein content [6]. The uptake of the N was calculated by multiplying the nutrient content (%) by respective yield (kg ha1) and was divided by 100 to get the uptake values in kg ha1. The economic analysis *viz*., gross income, net income and B:C ratio was worked out at the prevailing market prices of the inputs and outputs at the time of harvest. The data obtained were subjected to statistical analysis as outlined by Gomez and Gomez [7]. The treatment differences were tested by using "*F*" test and critical differences (at 5 per cent probability). Economic efficiency was calculated by formula given by Kumawat *et al.* [8].

Results and Discussion

Initial plant population

Effect of various scheduling of irrigation on initial plant population shows non-significance result [Table-1]. Although, the maximum plant population was observed with three (tillering, flag leaf and milking stage) irrigation followed by two (tillering and milking stage) irrigation and one (tillering stage) irrigation, respectively.

Application of RDF along with bio-fertilizer (Azotobactor + PSB) and FYM recorded maximum initial plant population i.e. (99.51/m^2). However, impact of inorganic and organic fertilizer does not show any significant result on initial plant population. The minimum plant population (98.74/m^2) was obtained with the recommended dose of NPK.It might be due to favorable weather conditions. Similar findings were also reported by Amini*et al.* [9] and Dwivedi *et al*. [10].

Table-1 *Effect of irrigation and fertility balance on initial plant population per and growth attributes of barley*

S.No.	Treatments	Initial plant population per m^2	Plant height (cm)		Fresh weight per plant (g)		Dry weight per plant (g)		No. of tillers per plant at 30 DAS
			30 DAS	Maturity	30 DAS	Maturity	30 DAS	Maturity	
	Scheduling of Irrigation								
I_1	Irrigation at tillering stage	99.11	12.26	71.71	11.83	24.96	0.29	18.02	2.97
I_2	Irrigation at tillering and flag leaf stage	99.19	12.33	77.89	12.72	28.40	0.36	19.70	3.07
I_3	Irrigation at I_2 + milking stage	99.20	12.42	82.98	13.51	30.91	0.39	22.15	3.13
	SE(d)	1.02	0.25	1.03	0.27	0.43	0.017	0.30	0.31
	C.D. at 5%	NS	NS	2.85	0.75	1.20	0.048	0.85	0.85
	Fertility levels(kg/ha)								
F_1	RDF (60 kg N : 30 kg P_2O_5 : 30 kg K_2O/ha)	98.74	11.47	72.39	11.61	25.45	0.29	17.66	2.89
F_2	RDF + biofertilizer (Azatobacter +PSB)	99.16	12.29	77.66	13.28	27.30	0.35	19.39	3.00
F_3	RDF+biofertilizer+Vermicompost (2.5 t/ha)	99.24	12.66	78.82	14.46	28.65	0.36	20.77	3.06
F_4	RDF + biofertilizer + FYM (5t/ha)	99.51	12.93	81.25	16.21	30.96	0.39	22.01	3.28
	SE(d)	1.69	0.38	1.80	0.44	0.69	0.030	0.53	0.10
	C.D. at 5%	NS	0.81	3.80	0.92	1.46	0.063	1.12	0.29

Growth attributes

It is clearly shown in [Table-1] that scheduling of irrigation shows significant effect on growth attributes, except plant height at 30 DAS, where scheduling of irrigation does not shows any significant effect. Moreover, maximum growth attributes *viz.,* plant height (12.42 and 82.98 cm), fresh weight per plant (13.51 and 30.91 g) and dry weight per plant (0.39 and 22.15 g) at 30 DAS and at maturity, besides no. of tillers per plant (3.13) at 30DAS recorded with three levels of irrigations (tillering, flag leaf and milking stage). Although it remained statistically on par with irrigation at tillering and flag leaf stage for only dry weight per plant and no. of tillers per plant at 30 DAS. The minimum attributes were measured with irrigation scheduling at tillering stage of growth only. The possible reason could have been attributed that adequate and balance supply of soil moisture to plant at tillering, flag leaf as well as at milking stage might have increased the succulence in the meristematic cells and maintained turgor with favoured better proliferation of leaf buds Similar results have also been reported by Kumar[11] and Amini *et al.*[9].

The impact of different fertility level at various physiological stages also shows significant effect on growth attributes. The maximum plant height (12.93 and 81.25 cm), fresh weight per plant (16.21 and 30.96 g) and dry weight per plant (0.39 and 22.01 g) at 30 DAS and at maturity, and also no. of tillers per plant (3.28) at 30 DAS were recorded with fertility treatment, where recommended dose of fertilizer along with biofertilizer and FYM (5 t/ha) at all physiological stages of growth. Though, it remained on par with RDF+biofertilizer+Vermicompost (2.5 t/ha)for only dry weight per plant and no. of tillers per plant (3.13) at 30 DAS .It mainly due to higher amount of organic which result greater microbial activity. The minimum growth attributes were recorded with treatment where only recommended dose of fertilizer (60 kg N: 30 kg P_2O_5: 30 kg k_2O/ha) was applied. This may be due to

proper and steadily nutrient supply throughout the crop stages. These results are in close conformity with the findings of Paramjit and Singh[12] and Roy *et al.*[13].

Yield contributing traits

It is clearly shown that scheduling of irrigation had significant effect on yield contributing traits in barley crop [Table-2]. The maximum length of ear (9.19 cm) and number of grains per year (48.45) recorded with scheduling of irrigation where three irrigation were applied. It also showed its superiority over Irrigation at tillering and flag leaf stage and irrigation at tillering stage. Moreover, lower contributing traits were seen under irrigation at tillering stage.

It is evident from the data on fertility level that shows significant result in term of yield contributing traits in barley crop. The maximum length of ear (9.07 cm) and number of grains per year (47.45) as recorded where RDF along with biofertilizer and FYM were applied, followed by treatment where RDF along with biofertilizer and vermicompost were applied, both were statistically at par for only length of ear. The minimum length of ear and number of grains per year was recorded with treatment where RDF was applied.This might be due to scarcity of nutrients, which result poor photosynthesis was possible reason for reduction in yield attributes. Similar results were also reported by Paramjit and Singh [12], Kumar [11] and Roy and Singh [14].

Yields

It is clearly evident from the data that various scheduling of irrigation has significant influence on yields of barley crop [Table-2]. The maximum grain and biological yield (40.48 and 97.24 q/ha) was recorded when irrigation is scheduled at three stage of crop growth i.e., tillering, flag leaf and milking stage which was significantly superior over other two scheduling of irrigation levels. The increase in yields of barley with three irrigations given at tillering, flag leaf and milking stage to the tune of 13.48 and 5.94 percent for grain yield and 3.29 and 8.57 percent for biological yield as compared to one irrigation given at tillering stage and two irrigation given at tillering and milking stage, respectively. The yields increased significantly as the level of irrigation increased from one to three. The minimum yield was recorded where only one irrigation is schedule i.e. tillering stage. The adequate and frequent availability of irrigation water with, early and more number of irrigations applied under three irrigations given at tillering, flag leaf and milking stage might have been the cause for higher biological yields as compared to delayed and lesser number of irrigation applied under one or two irrigation given either at tillering or tillering and flag leaf stages. The results on grain and straw yield of barley are in confirmation with observations made by Kumar [11], Sharma and Verma [15] and Refay [16] observed that grain yield was significantly increased with three irrigations given at tillering, flag leaf and milking stages as compared to two irrigation tillering and flag leaf flag leaf and one irrigation given at tillering stage.

The maximum grain and biological yield (40.70 and 98.37 q/ha) was observed where RDF along with biofertilizer and FYM were applied, which was significantly superior to all other treatments of fertility. The increase in grain yield of barley with RDF + biofertilizer + FYM to the tune of 5.35, 8.62 and 14.03 per cent for grain and 3.27, 6.09 and 8.76 percent for biological yield than RDF + biofertilizer +vermicompost, RDF + biofertilizers and only RDF, respectively. Although, minimum yields were recorded with under RDF alone was applied. The highest grain and straw yield in this treatment was mainly due to the fact that under favorable soil conditions, the plant accumulates and translocation photosynthetic from source to the sink more efficiently which in turn increased all the growth and yield attributes too. Similar report was also made by Roy and Singh [14], Katiyar and Uttam [17] and Sharma and Verma [15].

Table-2 *Effect of irrigation and fertility balance on yield and its contributing traits*

S.No.	Treatments	Length of ear (cm)	No. of grains per ear	Grain yield (q/ha)	Biological yield (q/ha)
	Scheduling of Irrigation				
I_1	Irrigation at tillering stage	7.38	40.15	35.67	89.56
I_2	Irrigation at tillering and flag leaf stage	8.95	44.43	38.21	94.14
I_3	Irrigation at I_2 + milking stage	9.19	48.45	40.48	97.24
	SE(d)	0.11	0.59	0.53	0.42
	C.D. at 5%	0.32	1.64	1.48	1.18
	Fertility levels(kg/ha)				
F_1	RDF (60 kg N : 30 kg P_2O_5 : 30 kg K_2O/ha)	7.94	41.34	35.69	90.45
F_2	RDF + biofertilizer (Azatobacter +PSB)	8.21	43.33	37.47	92.72
F_3	RDF+biofertilizer+Vermicompost(2.5 t/ha)	8.81	45.26	38.63	95.25
F_4	RDF + biofertilizer + FYM (5t/ha)	9.07	47.45	40.70	98.37
	SE(d)	0.20	0.92	0.87	0.81
	C.D. at 5%	0.43	1.95	1.83	1.70

Nitrogen uptake

It is evident from the data shows significant effect of scheduling of irrigation on nitrogen uptake [Table-3]. As the level of scheduling of irrigation increase from one to three the nitrogen uptake in grain increase in similar manner. The maximum nitrogen uptake in grain and straw (56.04 and 27.77 kg/ha) was observed in scheduling of irrigation where three irrigation (tillering, flag leaf and milking stage) followed by irrigation schedule where two irrigation (tillering and flag leaf stage) was given i.e. 50.47 and 22.69 kg/ha in grain and straw both shows significantly higher nitrogen uptake. The minimum nitrogen uptake in grain and straw of barley was recorded with one irrigation i.e. tillering stage. The higher uptake of nitrogen with irrigation schedules of three irrigations might have been attributed to increased in the grain and straw yields with water regimes as compared to drier regimes. Similar results were also observed by Paramjit and Singh [12] and Kumar [11].

The maximum nitrogen uptake in grain (56.27 q/ha) as well as in straw (27.46 q/ha)was observed with fertility treatment RDF along with biofertilizer and FYM was applied, which was superior to all other fertility treatments where RDF along with biofertilizer and vermicompost were applied rank second best in term of nitrogen uptake of barley. The fertility treatment where RDF along with biofertilizer was applied shows statistically significant higher uptake over RDF was applied. The minimum nitrogen uptake was recorded in barley grain where only RDF was applied. Possible reason for higher uptake may have been greater mineralization by the microbes which result higher availability of nutrients consequently greater uptake of nutrients

Quality parameters

It is clearly evident from the data that significant improvement of protein content in grain and their yield of barley with all three scheduling of irrigation [Table-3]. Maximum protein content (8.62%) and protein yield (348.94 kg/ha) was recorded where scheduling of irrigation was given at tillering, flag leaf and milking stages of crop growth which is significantly superior with all other scheduling of irrigations. Protein content (8.18%) and protein yield (312.48 kg ha) was recorded where two irrigation scheduled at tillering and flag leaf stages. The minimum protein content as well as protein yield was recorded where only one irrigation is schedule i.e. tillering stage of crop growth. The increase in protein content might be attributed to increase in nitrogen content in grain with increasing number of irrigation. Whereas, higher protein yield with three irrigations was attributed to the increased grain yield. These results are in confirmation with those reported by Kumar [11] and Pessarakli *et al.* [18].

It is apparent from the data that the combine application of organic, inorganic and biofertilizer brought significant improvement in protein content in grain and protein yield of barley crop. As the level of fertility improved protein content in barley grain, improve in similar manner. Application of RDF along with biofertilizer and FYM shows 8.62% protein content in grain and 350.83 kg/ha protein yield which is statistically at par with fertility treatment where RDF along with biofertilizer and vermicompost was applied for protein content. Minimum protein content in grain and protein yield of barley recorded where only RDF was applied. These results are in close conformity with the findings of Kumawat [19].

Table-3 *Effect of irrigation and fertility balance on nitrogen uptake and quality parameters*

S.No.	Treatments	Nitrogen uptake (kg/ha)		Protein content (%)	Protein yield (kg/ha)
		Grain	Straw		
	Scheduling of Irrigation				
I_1	Irrigation at tillering stage	43.66	18.95	7.00	249.74
I_2	Irrigation at tillering and flag leaf stage	50.47	22.69	8.18	312.48
I_3	Irrigation at I_2 + milking stage	56.04	27.77	8.62	348.94
	SE(d)	0.77	0.34	0.14	3.61
	C.D. at 5%	2.14	0.93	0.40	9.99
	Fertility levels(kg/ha)				
F_1	RDF (60 kg N : 30 kg P_2O_5 : 30 kg K_2O/ha)	43.74	17.68	7.56	269.82
F_2	RDF + biofertilizer (Azatobacter +PSB)	48.96	22.19	8.12	304.26
F_3	RDF+biofertilizer+Vermicompost(2.5 t/ha)	51.74	25.22	8.37	323.36
F_4	RDF + biofertilizer + FYM (5t/ha)	56.27	27.46	8.62	350.83
	SE(d)	1.31	0.54	0.15	5.65
	C.D. at 5%	2.77	1.14	0.31	11.88

Production economics

Three irrigations applied at tillering, flag leaf and flag leaf stage registered maximum gross and net return (61959 and 37752 Rs/ha), respectively followed by irrigation given twice at tillering and flag leaf and once at tillering stage of crop growth [Table-4]. It mainly due to greater yield and less water intake due to precipitation. Moreover, B:C ratio and economic efficiency was also seen under this treatments. The increase in gross and net returns and B:C ratio in three irrigation given at tillering, flag leaf and milking stage might be due to increase in grain and straw yield increase in under the same treatments. A similar result has also been reported by Kumar [11].

Application of recommended dose of fertilizers + biofertilizers + FYM (5 t/ha) registered maximum gross and net returns of barley followed by RDF + biofertilizer

+ vermicompost (2.5 t/ha) and RDF + biofertilizers. Similar trend was also obtained with respect to net return, benefit: cost ratio and economic efficiency. Minimum production economic was recorded in recommended dose of inorganic fertilizers. The increase in gross and net returns along with benefit : cost ratio and economics with combined application of organic, inorganic and biofertilizer might be due to increase in grain and straw yield of barley. The similar results have also been corroborated by Katiyar and Uttam [17] and Kamawat [19].

Conclusion

From the present study it may be concluded that three irrigations at tillering stage, flag leaf stage and milking stage should be applied to the barley crop for obtaining higher yield and higher profit. The use of recommended dose of Fertilizer + Biofertilizer+ FYM may also be recommended to obtained higher yield and higher net profit under the dry climate condition in barley crop.

Table-4 *Effect of irrigation and fertility balance on production economics*

S.No.	Treatments	Gross return (Rs/ha)	Net return (Rs/ha)	B:C ratio	Economic efficiency (Rs/day/ha)
	Scheduling of Irrigation				
I_1	Irrigation at tillering stage	55375	32965	2.40	270.20
I_2	Irrigation at tillering and flag leaf stage	61742	36648	2.57	300.39
I_3	Irrigation at I_2 + milking stage	61959	37752	2.66	309.44
	SE(d)	11.51	24.21	0.008	0.20
	C.D. at 5%	32.83	69.00	0.024	0.57
	Fertility levels(kg/ha)				
F_1	RDF (60 kg N : 30 kg P_2O_5 : 30 kg K_2O/ha)	54674	33235	2.47	272.42
F_2	RDF + biofertilizer (Azatobacter +PSB)	57713	35358	2.55	289.82
F_3	RDF+biofertilizer+Vermicompost(2.5 t/ha)	59800	36382	2.57	298.21
F_4	RDF + biofertilizer + FYM (5t/ha)	66581	38180	2.58	312.95
	SE(d)	13.60	20.30	0.005	0.17
	C.D. at 5%	28.85	42.98	0.011	0.35

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