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Research Communication

Influence of irrigation schedules and fertilizer levels on barley (*Hordeum vulgare*) in western Uttar Pradesh

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ABSTRACT

A field experiment was carried out at the Janta Vedic (P.G.) College, Baraut, Baghpat, Uttar Pradesh, to study response of barley (*Hordeum vulgare* L.) to irrigation scheduling and fertilizer levels during the winter (*rabi*) season of 2014–15. The experiment was conducted in split-plot design with three irrigation levels *viz*. one irrigation at tillering stage, 2 irrigations at tillering and flag-leaf stage, 3 irrigations at tillering, flag leaf and milking stage and 4 fertility levels, viz. recommended dose of fertilizer (RDF) : 60 kg N : 30 kg P_2O_5 : 30 kg K_2O/ha, RDF + biofertilizer [*Azotobacter* + phosphate solubilizing bacteria), RDF + biofertilizer + vermicompost (2.5 t/ha) and RDF + biofertilizer + FYM (5 t/ha) in subplots. The growth attributes, yield and yield attributes were the maximum with 3 irrigations applied at tillering, flag leaf and milking stage as compared to 2 irrigations applied at tillering and flag-leaf stage and once at tillering stage. Three irrigations applied at tillering, flag leaf and milking stage also registered the maximum gross and net returns of barley. The combined application of RDF + biofertilizer + FYM (5 t/ha) resulted in significantly highest grain, straw and biological yields of barley as compared with the rest doses of fertilizer application. Maximum nitrogen uptake and higher net returns were also higher with recommended dose of fertilizer + biofertilizer + FYM (5 t/ha). Thus for getting higher yield and net returns in barley, 3 irrigations should be applied at tillering, flag leaf and milking stage and crop should be fertilized with RDF + biofertilizer + FYM (5 t/ha) in Indo-Gangetic plains.

Key words : Biofertilizer, Flag leaf, Irrigation, Net return; Protein content

Barley is one of the most important and oldest cereal crop of the world, having been used since biblical time for food and feed also. It contributes 0.86% of the total cereals production and 0.81% of the total foodgrains in India. Owing to its very hardy nature, barley is successfully cultivated in adverse agro-environment like drought, salinity, alkalinity etc. Uttar Pradesh and Rajasthan are two major producing states in the country. These two states contribute 64% of the total area and 72% of the total production of barley in India.

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Yield and yield attributes are complex traits, which exhibit polygenic or quantitative inheritance pattern. The expression of quantitative traits is largely governed by environment in which they are exposed; and, thus, it results in scale or rank shift of their performance (Dia *et al.*, 2016; 2016a). Barley is the most sensitive to moisture stress during jointing, booting and heading. Considering drought stress before, during and after heading, reduction in yield was the maximum by stress just before heading. Thus to overcome the problem of yield reduction due to moisture stress, irrigation is given before heading. The sustainable use of water has to consider for maximizing yield/unit of water rather than maximum yield/unit of area and thus irrigation scheduling is a very critical. By knowing the soil, water-holding capacity and the crop-water requirement at different growth stages to meet crop-water needs and replenish depleted moisture within the crop root zone, while minimizing loss to deep percolation and run off. Judicious use of water and fertilizer, vermicompost, FYM and biofertilizer are the important inputs in crop production. The efficacy of fertilizer, FYM and biofertilizer to enhance

the yield depends upon many factors and among these, soil moisture is the most important one. To maintain the protein content at required level both fertilizer and irrigation should be given at critical stage of the plant growth. Adequate moisture without fertilizer may result into low water and fertilizer-use efficiency.

A field experiment was conducted at the Research farm of Janta Vedic (P.G.) College, Baraut, Baghpat, Uttar Pradesh, during the winter (*rabi*) season of 2014–15. This location has a sub tropical, semi-arid with hot dry summer and severe cold during winter. The soil was sandy loam, alkaline (*p*H 8.2), low in organic carbon (0.52 %) and nitrogen (145 kg/ha), high in phosphorus (15.7 kg/ha) and medium in available potassium (210.26 kg/ha). The experiment was conducted in a split-plot design with 3 irrigation levels, viz. one irrigation at tillering stage, 2 irrigations at tillering and flag-leaf stage, 3 irrigations at tillering, flag leaf and milking stage in main plots and 4 fertility levels [RDF (60 kg N : 30 kg P_2O_5 : 30 kg K_2O/ha), RDF + biofertilizer (*Azotobacter* + phosphate-solbulizing bacteria), RDF + biofertilizer + vermicompost (2.5 t/ha) and RDF + biofertilizer + FYM (5t/ha)] in subplots. Barley cv. 'DWR78' @ 100 kg seed/ha was sown at a row- to- row distance of 22.5 cm at 4–5 cm depth on 5 December 2015. Data on various growth and yield attributes, grain and straw yields and economic return were calculated as per the standard procedures.

Significantly higher tillers/plants and plant dry matter (g/plant) of barley were recorded with three irrigations applied at tillering, flag leaf and milking stage (Table 1). The possible reason could have been attributed to adequate and balance supply of soil moisture to plant at critical growth stages which might have increased the succulence in the meristematic cells and maintained turgor and favoured better proliferation of leaf buds. Similar findings were also reported by Refay (2010). Application of RDF (60 kg N: 30 kg P_2O_5: 30 kg K_2O/ha) + biofertilizers recorded significantly higher plant height, tillers and dry-matter accumulation than rest of the fertility levels. Application of RDF + biofertilizer + vermicompost also ranked second best treatments in producing significantly higher number of tillers/plant 60 days after sowing than recommended dose of inorganic fertilizers. Roy and Singh (2006) also reported similar results.

Significantly more ear length grains/ear and effective ears of barley were noted with 3 irrigations given at tillering, flag leaf and milking stages than the other treatments (Table 2). The timely and adequate availability of irrigation water to barley plants might have helped the plants to produce higher value of yield attributes than those either with 2 irrigations applied at tillering and flag-leaf stages or one at tillering stage. The plants under adequate soil-moisture condition with 3 irrigations given a tillering, flag leaf and milking stage might have produced sound and bolder seeds thereby increased the 1,000-grain weight as compared to other irrigation levels. The maximum length of ear/plant, highest number of grains/ear, 1,000-grain weight and effective ears/m in barley were obtained with the application of RDF + biofertilizer + FYM (5 t/ha) as compared to rest of the fertility levels. These findings confirm the results of Sharma and Verma (2010).

Significantly higher grain, straw and biological yields of barley were produced with three irrigations applied at

Table 1. Effect of irrigation scheduling and fertilizer levels on growth parameters

Treatment	Plant height (cm) at harvest	Dry-matter (g/plant) at harvest	Number of tillers at 60 DAS	Ear length (cm)	Grains/ ear	Ears/m	1,000-grain weight (g)
Irrigation schedule							
Irrigation at tillering stage	71.7	18.0	4.94	7.38	40.1	65.6	39.0
Irrigation at tillring and flag-leaf stage	77.8	19.7	5.48	8.95	44.4	75.2	39.9
Irrigation at tillering, flag-leaf and milking stage	82.9	22.1	6.55	9.19	48.4	82.1	40.3
SEm±	1.0	0.3	0.16	0.11	0.5	1.1	0.1
CD (P=0.05)	2.85	0.85	0.45	0.32	1.6	3.0	0.5
Fertility levels (kg/ha)							
RDF (60 kg N : 30 kg P_2O_5 : 30 kg K_2O/ha)	72.3	17.6	4.64	7.94	41.3	65.4	38.9
RDF + biofertilizer (*Azatobacter* +PSB)	77.6	19.3	5.5	8.21	43.3	71.4	39.3
RDF + biofertilizer + vermicompost (2.5 t/ha)	78.8	20.7	6.03	8.81	45.2	77.5	39.9
RDF + biofertilizer + FYM (5 t/ha)	81.2	22.0	6.45	9.07	47.4	82.6	40.8
SEm±	1.8	0.53	0.27	0.2	0.9	1.8	0.3
CD (P=0.05)	3.8	1.12	0.57	0.43	1.9	3.9	0.7

RDF, Recommended dose of fertilizer; PSB, phosphate-solubilizing bacteria

Table 2. Effect of irrigation scheduling and fertilizer levels on uptake, protein and economics of barley

Treatment	Grain yield (t/ha)	Straw yield (t/ha)	Biological yield (t/ha)	N uptake		Protein yield (kg/ha)	Economics		
				Grain (kg/ha)	Straw (kg/ha)		Gross returns ($\times 10^3$ ₹/ha)	Net returns ($\times 10^3$ ₹/ha)	Benefit: cost ratio
Irrigation schedule									
Irrigation at tillering stage	3.56	5.38	8.96	43.6	18.9	249.7	55.3	32.9	2.40
Irrigation at tillering and flag-leaf stage	3.82	5.59	9.41	50.4	22.6	312.4	61.7	36.6	2.57
Irrigation at tillering and flag-leaf stage milking stage	4.04	5.67	9.72	56.0	27.7	348.9	61.9	37.7	2.66
SEm±	0.05	0.03	0.042	0.77	0.34	3.61	0.11	0.24	0.01
CD (P=0.05)	0.15	0.09	0.118	2.14	0.93	9.99	0.32	0.69	0.02
Fertility (kg/ha)									
RDF (60 kg N : 30 kg P: 30 kg K/ha)	3.56	54.76	9.04	43.7	17.6	269.8	54.6	33.2	2.47
RDF + biofertilizer (*Azatobacter* +PSB)	3.74	55.25	9.27	48.9	22.1	304.2	57.7	35.3	2.55
RDF + biofertilizer + vermicompost (2.5 t/ha)	3.86	56.62	9.53	51.7	25.2	323.3	59.8	36.3	2.57
RDF + biofertilizer + FYM (5 t/ha)	4.07	57.67	9.84	56.2	27.4	350.8	66.5	38.1	2.58
SEm±	0.08	0.06	0.081	1.31	0.54	5.65	0.13	0.20	0.01
CD (P=0.05)	0.18	0.13	0.170	2.77	1.14	11.88	0.28	0.42	0.01

RDF-Recommended dose of fertilizers; PSB-phosphate solubilizing baceria

tillering, flag leaf and milking stage than the other irrigation levels. Significant increase in length of ear/plant, grains/ear, ears/m row length and 1,000-grain weight were noticed with 3 irrigations given at tillering, flag-leaf and milking stage over other levels might have resulted in significantly higher grain yield. The adequate availability of irrigation water and plant nutrients with frequent, early and more number of irrigations applied might resulted in higher yields than delayed and lesser number of irrigation applied in other treatments. Almost similar results were also reported by Sharma and Verma (2010).

The combined application of RDF + biofertilizer + FYM (5 t/ha) resulted in significantly highest grain, straw and biological yields of barley compared with the application of rest fertility levels in the study. Application of RDF + biofertilizers + vermicompost (2.5 t/ha) was the second best treatment and superior to the recommended dose of inorganic fertilizers. The increase in grain, straw yield with the application of higher dose of fertilizers might be owing to higher growth and yield attributed on account of balance nutrition resulted in better source-sink relationship of the crop, which finally improved the grain and straw yields of barley. These results are in close conformity with the findings of Sharma and Verma (2010).

Nitrogen uptake and protein yield of barley was significantly increased with the application of irrigation water applied thrice at tillering, flag leaf and milking stages as compared lesser irrigation application (Table 2). The uptake in the function of dry-matter yield and nutrient content and hence higher dry-matter yield by 3 irrigation application increased the nutrient content. Similarly, higher protein yield was attributed to higher dry-matter yield with three irrigation levels. Similar results were also observed by Pessarakli *et al.* (2005). The RDF + biofertilizers + FYM (5 t/ha) exhibited significantly highest protein yield as well as nitrogen uptake as compared to RDF + biofertilizer and only RDF. Minimum nitrogen uptake in grain and straw of barley was obtained with the application of RDF. The balanced nutrition resulted in nutrient content and yield enhancement which might gave higher uptake of nutrients.

Three irrigations applied at tillering, flag leaf and flag-leaf stage registered the maximum gross and net returns from barley, followed by irrigation given twice at tillering and flag leaf and one at tillering stage of crop growth. Benefit: cost ratio of barley was the maximum with 3 irrigations followed by 2 irrigations and least with 1 irrigation only. The increase in gross and net returns might be owing to increase in grain and straw yields of barley under the same treatments. Application of RDF + biofertilizers + FYM (5 t/ha) registered the 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 returns/rupee invest and benefit: cost ratio. While minimum gross and net returns and benefit : cost ratio of barley was recorded in RDF.

Thus, it can be inferred that for getting higher yield and net returns in barley, 3 irrigations should be applied at tillering, flag-leaf and milking-leaf stage and crop should

be fertilized with recommended dose of fertilizer + biofertilizer + FYM (5 t/ha).

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