Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2017; 6(5): 1363-1366
Received: 05-07-2017
Accepted: 06-08-2017

Atul Galav
Department of Agro meteorology, Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad, Uttar Pradesh, India

Ram Bharose
Department of Agro meteorology, Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad, Uttar Pradesh, India

Correspondence
Atul Galav
Department of Agro meteorology, Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad, Uttar Pradesh, India

Effect of dates of sowing, varieties, irrigation schedule and agro meteorological indices on growth and yield attributes of barley varieties under Allahabad conditions

Atul Galav and Ram Bharose

Abstract
A field experiment was conducted at the Forestry Nursery and Research Farm of Department of Environmental Sciences & NRM, College of forestry, SHUATS, Allahabad during Rabi 2016-17. The experiment was conducted in 3^3 factorial randomized complete block design with three dates of sowing (viz. 25 oct, 10 Nov and 25nov), 3varieties (RD-2035, JYOTI, RD 2035 and BH-393) and 3irrigation (5,4 and 3 irrigation) with 3replications. The interaction effects of date of sowing and irrigation schedule on yield attributes of barley varieties. The results revealed that spike length of barley crop was significantly influenced by different dates of sowing, varieties and irrigation schedules. the maximum number of spike and grain yield spike length were recorded with variety JYOTI, sowing of barley on 25thNov and 3 irrigations. Sowing of barley variety jyoti on 25th Nov along with 3 irrigations resulted in maximum spike length (15.27 cm), number of spike (29.16) and grain yield (55.31 q/ha).The lowest agro meteorology parameter was recorded in 25th Nov.

Keywords: barley, irrigation schedule, sowing date, variety agro meteorology indices.

Introduction

Barley is the most important cereal crops in the world. As a food barley is used in preparing chapattis sattu. Barley has been used as animal fodder, as a source of fermentable material for beer and certain distilled beverages, and as a component of various health foods. Barley contains about 78% carbohydrates, 1% fat, 10% protein and 10% water (DWR, annual report 2015) [3]. Barley is an important rabi crop, which is grown in between october & December & harvested between February & May. It is grown in diverse agro-climatic conditions from 11^{0}N -35^{0}N latitude and 72^{0}E-92^{0}E longitudes. The major production states of Barley in India are Rajasthan, Uttar Pradesh, Madhya Pradesh, Haryana, Punjab, West Bengal, Jammu & Kashmir, Some regions in Bihar, Uttaranchal and Himachal Pradesh. The total area under barley cultivation last season was about 1.2 million hectares against 31 million hectares under wheat, as per the IIWBR. In 2015-16, total production of barley was 1.44 million Tones. (FAOSTAT 2016) [4]. The difference in production of timely sown and late sown crops may be attributed to the unfavorable temperature prevailing at different growth stages, such as low temperature at the time of germination which may delay crop emergence. Low temperature may also slow down the growth and development of the crop, resulting in the accumulation of insufficient biomass and shortening of crop duration (Alam *et al.* 2006). Different varieties have different yield potential requiring variable nitrogen dose. All the varieties may not be suitable for timely as well as the late sowing (hari ram *et al.* 2014) [5]. Moreover, varieties also vary both in yield and nutrient uptake under late sown condition (Singh *et al.*, 1997) [9]. Effect of various scheduling of irrigation on initial plant population shows non- significance result. 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 Prakash jai *et al*. 2015 [6]. Barley is the main cereal crop grown under arid and semi arid condition, because it shows a conservative strategy in water use when compared to other species (Janieson *et al*. 2005). Ouda *et al.* also showed that, skipping the last irrigation in barley could be useful in saving irrigation water, however it could reduce final yield due to incomplete development of barley grains. Dawood and Kheiralla (1994) [1] and Bankar *et al*. (2008) [2] observed that five irrigations at crown root initiation, tillering, jointing, flowering and milking stages, led to the highest yield. This difference in productivity of early and late sown crops may be due to favourable temperature at different growth stages, which

may increase photosynthetic rate, supply of assimilates for seed and increased seed growth rate in early sown crops (hari ram *et al.* 2014) [5]. Keeping this in view, the present investigation was aimed to study the influence of sowing time on phenology, agro meteorological indices and productivity of different varieties of barley under allahabhad conditions Keeping in view of the aforesaid facts, the present study was undertaken to evaluate the performance and adaptability of newly developed varieties of barley to a wider range of sowing dates in irrigated conditions under Allahabad conditions.

Materials & Methods

The field experiment was conducted during Rabi 2016-17 at the Forestry Nursery and Research Farm of Department of Environmental Sciences & Natural Resource Management, College of forestry, Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad. Soil of this region is sandy loam and slightly alkaline. The site of experiment was located at 25º.57' N latitude, 81º.51' E longitude and 90 meters above the sea level. This region has sub-tropical climate with extremes of summer and winter. The experiment was laid out using three factors Randomized Block Design, replicated thrice. There were 27 treatment combinations comprised of three dates of sowing (D_1 = 25th Oct., D_2 =10th Nov., D_3 = 25th Nov.), three varieties (V_1 = RD-2035, V_2 = Jyoti, V_3 = BH-393) and three irrigation schedules (I_1 = 5 irrigations, I_2 = 4 irrigations, I_3 = 3irrigations). The total rainfall was received 0.03 mm in 2016-17. The following agro-meteorological indices viz. growing degree days (GDD), photo-thermal unit (PTU) and helio-thermal unit (HTU) were measured in each replicate during earring and maturity of barley crop, using the daily meteorological data

$$\text{GDD (°C day)} = \Sigma \left(\frac{T_{MAX}+T_{MIN}}{2}\right) - 4.5 \text{ m}$$

$$\text{PTU (°C day hour)} = \Sigma\,(\text{GDD} \times \text{D})$$

$$\text{HTU (°C day hour)} = \Sigma\,(\text{GDD} \times \text{SS})$$

Observations of different yield attributes including spike length was counted separately which were obtained randomly from five tagged plants and their averages were recorded. For determining number of spike per plant and number of grains per spike, five spikes were selected at random from each plot and their mean was recorded. The data were analyzed statistically using standard tools**.**

Results and Discussion

Spike length (cm)

The data on spike length of barley which was affected by date of sowing, varieties and irrigation schedule was presented in table (1 & 2). Among different varieties, maximum spike length was found in variety jyoti (12.77 cm) and minimum was found in BH-393(10.73 cm). Maximum spike length was recorded in barley sown on 25th Nov (12.89 cm) whereas minimum spike length was found in barley sown on 25th oct (10.32 cm). Among irrigation schedules, maximum number of spikes was found with 3 irrigations (12.37 cm) and minimum was found in 5irrigations (10.78cm).The interaction effect of date of sowing, varieties and irrigation schedule on spike length (cm) was also found significant. Spike length was found maximum with treatments D_3V_2 (14.48cm), D_3 I_3 (13.19cm) and V_2 I_2 (13.47cm). The data in table 2 revealed that the treatment D_3V_2 I_3 recorded significantly maximum spike length (15.27cm) which was statistically at par with $D_3V_1I_2$ and significantly higher as compared to other treatments.

Table 1: Effect of different dates of sowing, varieties and irrigation schedule on spike length (cm) of barley crop

T/C	V_1	V_2	V_3	Mean		I_1	I_2	I_3	Mean		I_1	I_2	I_3	Mean
D_1	10.12	11.61	9.23	10.32	D1	8.65	11.22	11.1	10.32	V1	10.85	11.92	12.48	11.75
D_2	12.2	12.22	11.68	12.03	D2	11.25	12.04	12.81	12.03	V2	12.03	12.81	13.47	12.77
D_3	12.93	14.48	11.26	12.89	D3	12.44	13.04	13.19	12.89	V3	9.46	11.57	11.15	10.73
Mean	11.75	12.77	10.73		Mean	10.78	12.1	12.37		Mean	10.78	12.1	12.37	
CD				0.75					0.75			N/A		

Table 2: Interaction effect of different dates of sowing, varieties and irrigation schedule on spike length (cm) of barley crop.

T/C	D_1			D_2			D_3		
	V_1	V_2	V_3	V_1	V_2	V_3	V_1	V_2	V_3
I_1	8.65	9.91	7.39	11.58	12.11	10.06	12.34	14.07	10.91
I_2	10.08	12.35	11.23	11.91	11.98	12.22	13.77	14.11	11.25
I_3	11.64	12.59	9.08	13.1	12.57	12.76	12.7	15.27	11.61
CD	1.30								

Number of spike per plant

The data on number of spike per plant of barley which was affected by date of sowing, varieties and irrigation schedule was presented in table (3 & 4). Among different varieties, maximum number of spike per plant was found in variety jyoti (26.52) and minimum was found in BH-393 (24.60). Maximum number of spike per plant was recorded in barley sown on 25th Nov (26.75) whereas minimum number of spike per plant was found in barley sown on 25th oct (22.92). Among irrigation schedules, maximum number of spikes was found with 4 irrigations (25.22) and minimum was found in 5irrigations (24.67). The interaction effect of date of sowing, varieties and irrigation schedule on number of spike per plant was also found significant. number of spike per plant was found maximum with treatments D_3V_1 (28.66), D_3 I_1 (27.12) and V_2I_2(27.54). The data in table 4 revealed that the treatment D_3V_2 I_3 recorded significantly maximum number of spike per plant (29.16) which was statistically at par with $D_3V_1I_2$ and significantly higher as compared to other treatments.

Table 3: Effect of different dates of sowing, varieties and irrigation schedule on Number of spike per plant of barley crop

T/C	V_1	V_2	V_3	Mean		I_1	I_2	I_3	Mean		I_1	I_2	I_3	Mean
D_1	20.23	26.09	22.44	22.92	D1	22.23	24.06	22.46	22.92	V1	23.16	25.94	24.70	24.60
D_2	24.91	25.64	25.23	25.26	D2	24.67	25.16	25.95	25.26	V2	25.76	26.26	27.54	26.52
D_3	28.66	27.83	23.77	26.75	D3	27.12	26.45	26.70	26.75	V3	25.09	23.48	22.87	23.81
Mean	24.60	26.52	23.81		Mean	24.67	25.22	25.04		Mean	24.67	25.22	25.04	
CD				1.07					1.07					1.07

Table 4: Interaction effect of different dates of sowing, varieties and irrigation schedule on Number of spike per plant of barley crop

T/C	D_1			D_2			D_3		
	V_1	V_2	V_3	V_1	V_2	V_3	V_1	V_2	V_3
I_1	18.82	24.50	23.37	21.34	26.29	26.37	29.33	26.51	25.52
I_2	23.32	26.42	22.45	26.50	24.51	24.46	27.99	27.83	23.52
I_3	18.54	27.34	21.49	26.90	26.11	24.86	28.65	29.16	22.28
CD									1.85

Grain yield (q/h)

The result of experiment in presented in tables (5 & 6) Showed that the effect of date of sowing, varieties and irrigation schedule significantly affected the grain yield. Among different varieties, maximum grain yield was found in jyoti (50.82q/ha) and minimum was found in BH-393 (44.22q/ha). Among date of sowing, the maximum grain yield was recorded in barley sown on 25th Nov (49.68q/ha) and minimum was found in wheat sown on 25th Oct (44.05q/ha). Among irrigation schedules, maximum grain yield was found in 3 Irrigation (49.56q/ha) and minimum was found in 5 Irrigation (45.78q/ha). The interaction effect of date of sowing, varieties and irrigation schedule on grain yield was also found significant. Maximum grain yield was found in interaction of D_3V_2 (53.84q/ha), D_2 I_3 (51.80q/ha) and V_2I_3 (52.87q/ha) and minimum was found in the in D_1V_3 (40.57q/ha) D_1I_1(43.26q/ha) and V_3I_1(41.6q/ha). The maximum grain yield was recorded in D_3 V_2 I_3(55.31q/ha) and minimum was found in D_1V_3 I_1 (3.64q/ha).From the above result it was concluded that PBW-343 cultivar had produced more grain yield than the RD-2035 & BH-393. Lower grain yield in late sowing was mainly due to lower germination count, less number of tillers, less number of grains per spike and lower 1000-grain weight. These results are in accordance with those of Spink *et al.,* (2000) [10]. They also reported that late sowing results in less grain yield per hectare. Higher grain yield was mainly due to higher number of tillers and higher 1000-grain weight. These results are similar to Shahzad *et al.,* (2002). Grain yield of wheat crop is the result of combined effect of various yield contributing components. It is evident from the above data that sowing date & varieties affected significantly the grain yield. These results are in line with Joshi *et al* (2016) [11].

Table 5: Effect of different dates of sowing, varieties and irrigation schedule on grain yield (q/ha) of barley crop

T/C	V_1	V_2	V_3	Mean		I_1	I_2	I_3	Mean		I_1	I_2	I_3	Mean
D_1	44.36	47.24	40.57	44.05	D1	43.26	43.36	45.55	44.05	V1	45.64	46.86	48.81	47.10
D_2	48.02	51.39	45.82	48.41	D2	46.07	47.36	51.80	48.41	V2	50.02	50.18	52.27	50.82
D_3	48.94	53.84	46.28	49.68	D3	48.02	49.69	51.34	49.68	V3	41.68	43.37	47.61	44.22
Mean	47.10	50.82	44.22		Mean	45.78	46.80	49.56		Mean	45.78	46.80	49.56	
CD				1.03					1.03					1.03

Table 6: Interaction effect of different dates of sowing, varieties and irrigation schedule on grain yield (q/ha)of barley crop

T/C	D_1			D_2			D_3		
	V_1	V_2	V_3	V_1	V_2	V_3	V_1	V_2	V_3
I_1	43.50	47.64	38.64	45.87	49.99	42.35	47.56	52.44	44.07
I_2	43.95	45.80	40.32	47.83	50.97	43.27	48.78	53.76	46.52
I_3	45.63	48.28	42.74	50.34	53.22	51.85	50.46	55.31	48.25
CD									1.78

Agrometeorology Indices

Different agro meteorological parameters such as helio-thermal unit (HTU) at maturity and growing degree days (GDD), photothermal unit (PTU) both at earing and maturity were significantly influenced by time of sowing in barley crop (Table-7&8). All these parameters were significantly higher in timely sown crop as compared to late sown crop, and being highest at maturity stage. It might be due to longer periods for all the phenological stages and more solar radiations available in timely sowing of the crop. Delayed sowing decreased the duration of phenology as compared to normal sowing due to fluctuated unfavorable high temperature during the growing period (Ram *et al* 2012) [7]. Among date of sowing, GDD, HTU and PTU at early stage were differed significantly. GDD requirement was higher in D_1 (991.4°c) as compared to D_2 (910.6°c) and D_3 (794°c) at different phenology stage. HTU requirement was higher in D_1 (6471.6°c) as compared to D_2 (5635°c) and D_3 (3778.2°c) at different phenology stage. PTU requirement was higher in D_1 (10705.6°c) as compared to D_2 (9957°c) and D_3 (8766.2°c) at different phenology stage.

Growing Degree Day (GDD)

Treatments	P1	P2	P3	P4	P5	Mean
D_1	495	681	1027	1257	1497	991.4
D_2	480	610	906	1163	1394	910.6
D_3	352	477	757	1066	1318	794

P1=CRI, P2= TLLERING, P3= JOINTING, P4= FLOWERING, P5= MILKING,

Helio thermal unit (HTU)

Treatments	P1	P2	P3	P4	P5	Mean
D_1	4187	5438	6847	7362	8524	6471.6
D_2	3785	4025	5060	6772	8533	5635
D_3	1703	2156	3002	4972	7058	3778.2

Photo thermal unit (PTU)

Treatments	P1	P2	P3	P4	P5	Mean
D_1	5743	7425	10884	13456	16020	10705.6
D_2	5238	6651	9695	12442	15759	9957
D3	3732	5059	8100	12044	14896	8766.2

Conclusion

From this study it can be concluded that for producing higher grain per spike, spike length (cm) and grain yield (q/ha), it is advocated to sowing of jyoti barley variety on 25 November with providing 3 irrigations. On the basis of agro meteorological indices like growing degree day (GDD), Photo thermal unit (PTU) and helio thermal unit (HTU) requirement jyoti variety of barley performed best on 25 november 2016 and 3 irrigation.

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