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Response of barley (*Hordeum vulgare* L.) varieties to different dates of sowing under irrigated conditions

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Abstract
Investigation entitled "Response of barley (*Hordeum vulgare* L.) varieties to different date of sowing under irrigation conditions" was carried out at Agricultural Research Farm of Raja Balwant Singh College, Bichpuri Agra, during *Rabi* season of 2022-23. The Variables involved in this study were four dates of sowing D_1 (Nov. 16^{th}) and D_2 (Dec. 10^{th}) and four varieties of barley *viz.* SLS-67 (V_1), BH-946 (V_2), WRB-160 (V_3) and DWRB-137 (V_4). Thus, in all 8 treatment and combinations were compared in a split plot design having dates of sowing in main plots and varieties in sub plots with three replications. The soil of experimental field was sandy loam in texture with a pH 8.45. The soil was low in available nitrogen (181.49 Kg ha^{-1}), medium in available phosphorus (27.86 PO, ha^{-1}) and potash (279.37 kg K_2O ha^{-1}). The field capacity was 18.64 per cent. During *Rabi* reason of 2022-23, only 9.7 mm rainfall was received. Result reveled that November (16^{th}) sowing date was found best for different varieties of barley under irrigated conditions. Among the tested barley varieties, BH-946 exhibited superior performance concerning grain and straw yield. Based on the highest net return and B:C ratio.

Keywords: *Agronomic, Barley,* Dates of sowing, Phosphorus, Varieties and Yield

Introduction
Barley (*Hordeum vulgare* L.) is widely grown across a range of environments as a rain-fed or irrigated crop. (Singh *et al.* 2024) [20]. Globally 70% of barley production is used as animal fodder, while 30% as a source of fermentable material for beer and certain distilled beverages and as a component of various foods. It is used in soups and stews and in barley bread of various cultures, barley grains are commonly made into malt in al traditional and ancient method of preparation. Every farmer concentrates on crop production to feed the family. (Harish *et al.*, 2023) [5]. Barley has a long history of cultivation and is recognized as one of the oldest cultivated grains. (Singh *et al.*, 2023) [11]. The limited availability of water resources in arid and semi-arid regions poses a significant challenge to sustainable agriculture, with drought stress projected to cause up to a 30% reduction in global crop production by 2025. (Singh *et al.*, 2024) [20]. Most agricultural soils contain larger amount of fixed form of P than available P, a considerable part of which has accumulated as a consequence of regular applications of P fertilizers. (Ramesh *et al.*, 2023, Sonia, *et al.*, 2023 and Sonia, *et al.*, 2023) [17, 18]. Phosphorus is also important in cell division and development of new tissues. (Singh *et al.*, 2022) [14]. On the other hand, enhanced cultivars that have been chosen for high yields under high nutrient input circumstances are frequently generated without taking into account their capacity to grow and yield under low soil nutrient status. (Lokendra *et el.*, 2024) [8]. In spite of a changing climate, climate-resilient agronomy aims to maintain sustainable food production and stable livelihoods for farmers. (Singh *et al.*, 2023) [11].

Presently, development of new varieties for higher yields has reached a plateau and no further increase is achieved unless biotechnological interventions are made. (Archna, *et al.*, 2023) [2]. As mineral nitrogen is easily lost by leaching or de-nitrification, the N rate needs to be optimized for the actual year, while application of P and K can be based on the principles of substitution of harvest P and K because soil available P and K changes slowly. (Virendra, *et al*., 2024) [8]. For sustainable production under arid climatic conditions, the crop/variety should be resistant to abiotic stresses. In some parts of arid region, occurrence of frost is also a common feature during winter season, which affects vegetative growth of plants, fruits quality as well as productivity. (Babu, and Singh 2024) [4]. Agra district is situated in South-West semi-arid zone of UP. It is located at altitude of 27.20 North and longitude of 77.90 easts. River Chambal makes the southern boundary of district and flows from West to East separating district Bhind (M.P) In the North Agra is bounded by districts of Firozabad and Etawah. The average rainfall (annual) of the district is 750 mm. Temperature varies from 40C (During December-January) to 480C (During May-June) respectively. (Babu, and Singh 2024) [4]. The sowing date is one of the most important factors affecting grain production and quality. The optimum sowing date depends on rainfall and temperature to maintain high grain yields. It has been realized that the average yield of wheat in this region, sown during November, is well comparable to the state average, but the declining trend in wheat yield has been noticed with delayed sowing i.e. in December and January. It is mostly due to the shorter growth period available to late sown wheat coupled with high temperature and hot winds during the reproductive growth period, which leads to forced maturity and ultimately poor grain yield.

Materials and Methods

The field experiment was carried out during winter (*Rabi*) season of 2022-23 at Agricultural Research Farm, Department of Agronomy, R.B.S. College, Bichpuri, Agra (U.P.). The Barley varieties were procured from the Indian Institute of Wheat and Barley Research (IIWBR), Karnal, Haryana, through the all-India Co-ordinated Wheat and Barley Improvement Project, and treated with Agrosan GN @ 2g kg^{-1} seed. The sowing was accomplished in furrows 5 cm. depth at a distance of 18 cm. apart, employing a seed rate of 100 kg ha^{-1} (seed rate was adjusted by considering the weight of 1000 seeds 40 g). The sowing was performed with the aid of kudali and was covered by light planking. The Variables involved in this study were four dates of sowing D_1 (Nov. 16^{th}) and D_2 (Dec. 10^{th}) and four varieties of barley viz. SLS-67 (V_1), BH-946 (V_2), WRB-160 (V_3) and DWRB-137 (V_4). Thus, in all 8 treatment and combinations were compared in a split plot design having dates of sowing in main plots and varieties in sub plots with three replications. Thus, in all 8 treatment and combinations were compared in a split plot design having dates of sowing in main plots and varieties in sub plots with three replications. Half of recommended dose of nitrogen (30 kg ha^{-1}), full doses of phosphorus (30 kg P_2O_5 ha^{-1}) and potash (20 kg K_2O ha^{-1}) were supplied through DAP and MOP, respectively rest N through urea as basal dose at sowing time. Remaining half nitrogen was applied through urea top dressing after 1^{st} irrigation.

Results and Discussion

Yield attributes (Effect of Dates of Sowing)

The data summarized in Table-1 indicated that dates of sowing had significant effect on 75 per cent spike emergence and to complete maturity of the crop. 16^{rd} November sowing dates required significantly 8-9 less days to 75 per cent spike emergence than 10^{th} Dec. dates of sowing. Crop sown on 16^{rd} Nov. also attained full maturity 6-8 days earlier than a crop sown on 10^{th} December. The data presented in Table-1 shows that the date of sowing has a significant impact on the number of spikelets $spike^{-1}$, length of spike (cm), number of grains $spike^{-1}$, number of Grain weight $spike^{-1}$ and 1000-grain weight decreased significantly with each delay in the sowing date. Comparing the 16^{th} November sowing (D_1) with the later sowing dates, the number of spikelets $spike^{-1}$ increased by approximately 20.17, 26.40 and 15.88 4.78, 8.87 per cent for the 10^{th} December (D_2) sowing dates, respectively. The data presented in Table 1 indicates that each delay in sowing from November 16^{th} significantly decreased the biological yield. Consequently, the November 16^{th} sowing produced a significantly higher biological yield per hectare compared to the December 10^{th}. The trends of yield factors to biological yield, such as the growth and yield attributing characteristics number of spikes m^{-2}, length of spike (cm), number of spikelets $spike^{-1}$, number of grains $spike^{-1}$, weight of grains $spike^{-1}$ and 1000-grain weight were similar to those of the biological yield. These factors may be responsible for the higher biological yield per hectare observed in the aforementioned seeding dates. Similar results were also reported by Alam *et al.* (2013) [1], Singh *et al.*, (2024) [20] and Singh *et al.* (2024) [12].

Table 1: Yield attributing characters of Barley as influenced by different treatments

Treatments		Days to 75% spike emergence	Days to maturity	Number of spikelets $spike^{-1}$	Length of spike (cm)	Number of grains $spike^{-1}$	Weight of grains $spike^{-1}$	1000 grain weight (g)
Dates of sowing								
16^{rd} Nov.	D_1	92.35	118.33	56.58	7.66	48.58	1.97	44.08
10^{th} Dec.	D_1	83.90	111.01	47.08	6.06	41.92	1.88	40.17
SEm±		1.39	1.12	0.71	0.15	0.12	0.01	0.51
CD (p=0.05)		8.45	6.81	4.35	0.92	0.72	0.04	3.13
Varieties								
SLS-67	V_1	88.37	116.08	53.80	7.00	46.67	1.94	42.83
BH-946	V_2	94.92	119.56	55.00	7.53	47.50	1.97	44.17
WRB-160	V_3	86.64	112.61	50.00	6.81	44.17	1.91	41.00
DWRB-137	V_4	82.56	110.43	48.50	6.10	42.67	1.88	40.50
SEm±		2.54	1.89	1.09	0.20	0.74	0.01	0.76
CD (p=0.05)		7.84	5.82	3.37	0.62	2.29	0.04	2.35

Effect of Varieties

It is clear in Table-1 that the both variety had significant impact on days to 75 per cent spike emergence and maturity. The data clearly indicate that Variety BH-946 (V_2) took significantly more time to reach 75% spike emergence and full maturity as compared to Variety WRB-160 (V_3), DWRB-137 (V_4) but at par with variety SLS-67 (V_1). The number of days taken for 75 percent spike emergence and days to maturity were significantly affected by different varieties. DWBH-946 (V_2) required approximately 10-12 more days for 75 percent spike emergence and 7-9 days' maturity compared to WBR-160 (V_3), DWBR-137(V4) but at par with SLS-67(V_1). The genetic behavior of the varieties may be responsible for the observed trend in the number of days taken for 75 percent spike emergence and days to maturity of the barley crop. Similar results were also reported by Alam *et al.* (2013) [1] and Kumar *et al.* (2025) [6]. Variety BH-946 (V_2) displays a significantly higher number of spikelets spike^{-1} and longest Length of spike (cm) as compared to varieties WRB-160, DWRB-137 but at par with SLS- 67. Variety BH-946 (V_1) have 55.00 number of spikelets spike^{-1} and 7.53 (cm) Length of spike followed by varieties SLS-67, WRB-160, DWRB-137(53.80, 50.00 and 48.50) and (7.00.74, 6.81and 6.10) respectively. Variety BH-946 (V_2) had a significantly higher number of grains spike^{-1}, Grain weight spike^{-1} and 1000-grain weight as compared to varieties WRB-160, DWRB-137 but at par with SLS- 67. Variety BH-946 (V_1) have 47.50 number of grains spike^{-1}, 1.97 g Grain weight spike^{-1} and 44.17(g) 1000-grain weight followed by varieties SLS-67, WRB-160, DWRB-137(46.67, 44.17 and 42.67), (1.97, 1.91 and 1.88) and (42.83, 41.00 and 40.50) respectively.

Yield (q ha^{-1})

Effect of Dates of Sowing

The data presented in Table-2 significant effect of sowing dates on biological yield and grain yield. The highest biological (138.74 qha^{-1}) and grain yield of (54.59 qha^{-1}) was observed with the 16rd November (D_1) sowing, which was significantly superior to 10th December. Sowing on the 16rd November (D_1) yield 6.68 and 7.73 per cent higher biological and grain yield compared to the 10th December (D_2) sowing dates, respectively. It can be observed that the dates of sowing had a significant impact on the straw yield of the crop. The crop sown on 16rd November (D_1) resulted in a significantly higher straw yield as compared to 10th December. The increase in straw yield with the 16th November sowing date 6.00 percent as compared to the yields obtained from the 10th December. Date of Sowing did not significant influence the harvest index. Specifically, 16th November displayed 39.33 harvest index followed by the 10th December 38.92.

Table 2: Biological, Grain and straw yields (qha^{-1}) and harvest index of barley as affected by various treatments

Treatments		Biological yield (qha^{-1})	Grain Yield (qha^{-1})	Straw yield (qha^{-1})	Harvest index (%)
Dates of Sowing					
16rd Nov.	D_1	138.74	54.59	84.15	39.33
10th Dec.	D_2	130.05	50.67	79.38	38.92
SEm±		0.98	0.28	0.72	0.12
CD (p=0.05)		5.96	1.72	4.36	NS
Varieties					
SLS-67	V_1	137.21	53.83	83.37	39.24
BH-946	V_2	141.31	57.15	84.16	40.43
WRB-160	V_3	131.35	50.85	80.49	38.71
DWRB-137	V_4	127.72	48.68	79.04	38.12
SEm±		1.50	0.60	1.05	0.24
CD (p=0.05)		4.61	1.86	3.23	0.75

The harvest index reflects the conversion efficiency of non-grain to grain portions by optimizing nutrient uptake and utilization. In this study, the crop sown on November 16th exhibited there was no significant difference in harvest index between the November 16th and 10th sowing dates. With the delay in sowing grain and straw both was decrease so harvest index was not influence by the delay in sowing. Similar findings have also been reported by Singh *et al.*, (2023) [11], Singh *et al.*, (2024) [12], Lokendra *et el.*, (2024) [8], Singh *et al.* (2024) [2], Kumar *et al.* (2025) [6], Kumar *et al.* (2025) [7] and Verma *et al.* (2025) [19].

Effect of Varieties

Table 2 presented that the variety BH-946 (V_2) recorded the highest biological yield of barley 141.31(q ha^{-1}). This yield was significantly superior to the biological yield of varieties WRB-160, DWRB-137, which produced (131.35 and 127.72) qha^{-1} but at par with SLS- 67(137.21) qha^{-1}. These results highlight the superior performance of BH-946 (V_1) over DWRB-160 (V_2) in terms of biological yield in the barley crop. The variety BH-946 (V_2) produce the higher grain yield of barley 57.15 (q ha^{-1}), was significantly superior to the grain yield of varieties SLS- 67(V_1), WRB-160, DWRB-137, which produced (53.83, 50.85 and 48.68) qha^{-1}. The variety BH-946 (V_2) produce the higher straw yield of barley 84.16 (q ha^{-1}), was significantly superior to the straw yield of varieties WRB-160, DWRB-137, which produced (80.49 and 79.04) qha^{-1} but at par with SLS- 67(83.37) qha^{-1}. Variety BH-946 (V_2) recorded the highest harvest index of barley 40.43. This was significantly superior to the harvest index of varieties SLS- 67, WRB-160 and DWRB-137 (39.24, 38.71 and 38.12) respectively.

All these grain yield attributes likely contributed to the higher grain yield observed with variety BH-946 (V_2). Similar trends were also observed for straw yield, with variety BH-946 (V_2) achieving a significantly higher straw yield as compared to varieties WBR-160 (V_3), DWBR-137(V_4) but at par with SLS-67(V_1). Variety BH-946 (V_2) also exhibited a significantly higher harvest index compared to varieties SLS-67 (V_1), WBR-160 (V_3), DWBR-137(V_4). These results align with the findings of Archna, *et al.* (2023) [2], Alam *et al.* (2013) [1] and Singh, *et al.* (2025) [10]. Previous studies have reported that barley varieties with high biomass production, harvest index, and number of spikelets per spike are important factors for selecting improved grain yield. Additionally, the final grain yield of barley is determined by the product of three components: the number of ears per square meter, the number of grains per earhead, and individual grain weight, which greatly contribute to crop yield. These pieces of evidence suggest that higher yields in barley varieties are a result of the superiority of yield attributes of one cultivar over another, ultimately leading to higher yields.

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