International Journal of Advanced Biochemistry Research

ISSN Print: 2617-4693
ISSN Online: 2617-4707
NAAS Rating: 5.29
IJABR 2025; 9(3): 441-446
www.biochemjournal.com
Received: 11-12-2024
Accepted: 15-01-2025

Dheeraj Kumar Gupta
M.Sc. (Ag), Department of Agronomy, A.N.D. University of Agriculture & T., Kumarganj Ayodhya, Uttar Pradesh, India

Premchand Chaurasiya
M.Sc. (Ag), Department of Agronomy, A.N.D. University of Agriculture & T., Kumarganj Ayodhya, Uttar Pradesh, India

Ravi Verma
Assistant Professor (Agronomy), School of Agriculture, Lovely Professional University, Phagwara, Punjab, India

Vinay Kumar Patel
M.Sc. (Ag), Department of Agronomy, A.N.D. University of Agriculture & T., Kumarganj Ayodhya, Uttar Pradesh, India

Rajesh Kumar
Professor, Department of Agronomy, A.N.D. University of Agriculture and T., Kumarganj Ayodhya, Uttar Pradesh, India

Sonu Kumar
M.Sc. (Ag), Amity Institute of Organic Agricultural, Amity University, Noida, Uttar Pradesh, India

Om Chandra Pandey
Research Scholar (Agronomy), IIAST, Integral University Lucknow, Uttar Pradesh, India

Corresponding Author:
Premchand Chaurasiya
M.Sc. (Ag), Department of Agronomy, A.N.D. University of Agriculture & T., Kumarganj Ayodhya, Uttar Pradesh, India

Effect of nutritive additives and sowing dates on growth, yield attributes, and productivity of barley (*Hordeum vulgare* L.)

Dheeraj Kumar Gupta, Premchand Chaurasiya, Ravi Verma, Vinay Kumar Patel, Rajesh Kumar, Sonu Kumar and Om Chandra Pandey

DOI: https://www.doi.org/10.33545/26174693.2025.v9.i3f.3976

Abstract
A field experiment was conducted during rabi seasons 2018-2019 at RS Masodha Research Farm, Under Acharya Narendra Deva University of Agriculture and Technology, Kumarganj Ayodhya (U.P.) to assess the nutritive additives and sowing dates on growth, yield attributes and productivity of barley (*Hordeum vulgare* L.). The experiment was conducted in split plot design which comprised of two different dates of sowing *viz.* 25th November, 24th December and seven nutrient additives *viz.* RDF, T_1 + FYM @ 5 t ha^{-1}, T_1 + mulch @ 6 t ha^{-1}, T_1 + FYM @ 5 t ha^{-1} + mulch @ 6 t ha^{-1}, T_4 + Spray of ZnSO4 @0.5%, T_4 + Two spray of KCl @0.5%, T_5 + Two spray of KCl @0.5%. The study examined the influence of sowing dates and nutrient additives on barley (*Hordeum vulgare* L.) growth and yield. Plant height increased progressively with crop age, peaking between 30 to 90 DAS before slowing toward harvest. Timely sowing (D1) resulted in significantly greater plant height than late sowing. Among nutrient treatments, T_7 (T_5 + two sprays of KCl @ 0.5%) exhibited the highest plant height, followed closely by T_6 (T_4 + two sprays of KCl @ 0.5%) and T_5 (T_4 + ZnSO4 @ 0.5%). Dry matter accumulation followed a similar pattern, increasing with age except at 30 DAS, with T_7 outperforming all other treatments. Yield attributes, including spikes per square meter, spike length, grains per spike, and test weight, were significantly influenced by sowing dates and additives, with T_7 recording the highest values, closely followed by T_6 and T_5. Grain yield (38.00 q ha-1), straw yield (54.39 q ha-1), and biomass yield (92.39 q ha-1) were maximized in T_7, while the harvest index remained unchanged by sowing dates or treatments. The findings emphasize the benefits of timely sowing and optimized nutrient application in improving barley yield and biomass production.

Keywords: Barley, grain yield, growth, nutrient additive, sowing date

Introduction
Barley (*Hordeum vulgare* L.) is one of the world's most important cereal crops, ranking fourth in global production after wheat, rice, and maize. Known as "Jau" in India, it is widely cultivated across diverse climatic conditions, from arid deserts to high-altitude regions. Barley is a crucial component of food security, livestock feed, and industrial applications, with the highest yields recorded in Europe. India ranks seventh in global barley production, with Uttar Pradesh being a key producing state (FAO, 2022) [3].

Barley offers significant nutritional benefits, containing high levels of fiber, protein, and essential minerals. Beta-glucans in barley help lower cholesterol, while its tocotrienol content aids in cardiovascular health. The grain consists of approximately 11.5% protein, 74% carbohydrates, and 3.9% crude fiber (ICAR, 2023) [6]. Barley is widely used in food products such as bread, porridge, and beverages, including malt-based health drinks like Horlicks and Boost. It also serves as a primary ingredient in beer production and animal feed, with its straw used for fodder and organic farming applications.

Agronomically, barley is highly resilient, requiring minimal water and demonstrating better tolerance to salinity compared to wheat. Proper nitrogen fertilization is crucial for maximizing yield, as it influences tillering, leaf area development, and grain quality. Excessive nitrogen application, however, can lead to lodging and delayed maturity (Kumar *et al.*, 2023) [9]. Phosphorus and potassium are equally vital, improving root growth, drought tolerance, and nutrient uptake (Sharma *et al.*, 2022) [19].

Mulching and organic manures enhance soil fertility, conserve moisture, and improve productivity (Singh & Verma, 2022) [20]. Zinc supplementation is essential for optimizing grain quality and crop health (Tahir *et al.*, 2021) [26]. Sustainable cultivation practices integrating organic and inorganic inputs are crucial for enhancing barley productivity and ensuring long-term soil health.

Materials and Methods

The research work was carried at CRS Masodha Research Farm, Under Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya (U.P.), during rabi season 2018-2019. This farm is located on Sultanpur road 5 K.M. from Ayodhya. The experimental site falls under sub-tropical zone in Indo-Gangatic plains, lies between 26.470 Northern latitude, 82.120 Eastern longitudes, at an altitude of about 113.0 meters from mean sea level and is subjected to extremes of weather conditions.

Experimental design and crop management

The experiment was laid out in split plot design with 14 treatments combinations including date of sowing allotted in main plot and additives in (sub plot) and repeated three times. It illustrated in table 1.

Table 1: Treatment combinations with their symbol

	Treatment	Symbols
A.	**Date of sowing (main plot)**	
1.	25th November	D_1
2.	24th December	D_2
B.	**Additives (sub- plot)**	
1.	Recommended dose of fertilizers	T_1
2.	T_1 + FYM @ 5 t ha^{-1}	T_2
3.	T_1 + mulch @ 6 t ha^{-1}	T_3
4.	T_1 + FYM @ 5 t ha^{-1} + mulch @ 6 t ha^{-1}	T_4
5.	T_4 + Spray of ZnSO4 @0.5%	T_5
6.	T_4 + Two spray of KCl @0.5% (Flag leaf and post anthesis)	T_6
7.	T_5 + Two spray of KCl @0.5% (Flag leaf and post anthesis)	T_7

Harvesting of barley was done manually and separately. Total five plants from each plot were selected and used for observations for the evaluation of treatments as per the plan of the experiment. The measured plant growth metrics encompassed plant height, dry matter accumulation, yield attributes and yield parameters.

Statistical analysis

A two-way analysis of variance (ANOVA) was conducted at a significance level of 5% to investigate the different date of sowing in main plot and additives in sub plots. The significance of the difference between treatment means was assessed using an 'F' test. The critical difference (CD) was calculated when the 'F' value indicated a significant treatment impact.

Results and Discussion

Growth parameters

Plant height (cm)

Plant height increased with advancement of the age. Data presented in Table 2, and depicted in Fig: 1 revealed that the rate of growth was rather slow during the initial stage up to 30 DAS thereafter, a rapid increase in plant height observed till 90 DAS, referring to its grand growth period. Plant height increased successively till the harvest stage but the increase was rather slow after 90 DAS. Date of sowing and additives had significant effect on Plant height at all stages of crop growth except 30 DAS. Maximum plant height recorded with timely sowing which was under treatment D1 timely sowing which was significantly superior over treatments late sowing at all growth stage of crop except 30 DAS. There was rapid increased in height of plant from 30 to 90 days after sowing thereafter, increased in height was rather slow (Singh & Kumar, 2020) [10].

Among the additives the maximum plant height was recorded in T_7: T_5 + Two spray of KCl @ 0.5% (Flag leaf and post anthesis) which was at par with T_6: T_4 + Two spray of KCl @ 0.5% (Flag leaf and post anthesis) and T_5: T_4 + spray of ZnSO4 @ 0.5% while significantly superior to rest of additives at 60, 90 DAS and at harvest stages whereas 30 DAS result was found nonsignificant. While significant increase in plant height of barley due to application of increasing levels of nitrogen from 0 to 80 kg ha-1 reported by Sharma and Verma, 2021.

Table 2: Different date of sowing and additives influences on plant height in Barley

Treatment	Plant height (cm)			
	30 DAS	60 DAS	90 DAS	At Harvest
Date of sowing (main plot)				
D_1: 25th November	25.80	55.10	88.16	89.04
D_2: 24th December	23.60	46.70	74.72	75.47
SEm ±	0.39	0.83	1.33	1.34
CD (P=0.05)	NS	5.06	8.10	8.18
Additives (sub- plot)				
T_1: Recommended dose of fertilizers	23.80	47.00	75.20	75.95
T_2: T_1 + FYM @ 5 t ha^{-1}	24.30	48.70	77.92	78.70
T_3: T_1 + mulch @ 6 t ha^{-1}	24.00	48.30	77.28	78.05
T_4: T_1 + FYM @ 5 t ha^{-1}+ mulch @ 6 t ha^{-1}	24.80	51.00	81.60	82.42
T_5: T_4 + Spray of ZnSO4 @0.5%	25.00	52.27	83.92	84.47
T_6: T_4 + Two spray of KCl @0.5% (Flag leaf and post anthesis	25.20	54.10	86.56	87.43
T_7: T_5 + Two spray of KCl @0.5% (Flag leaf and post anthesis)	25.80	55.00	88.00	88.88
SEm ±	0.47	0.95	1.52	1.53
CD (P=0.05)	NS	2.74	4.39	4.43

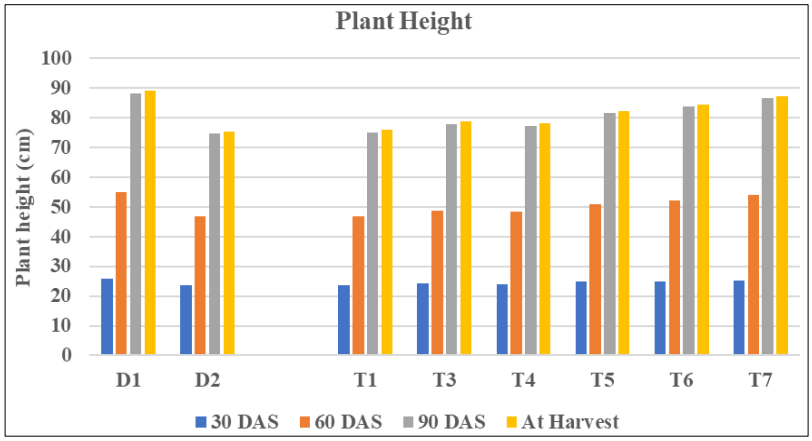

Fig 1: Different date of sowing and additives influences on plant height in Barley

Dry matter accumulation (gm^{-2})

The data indicate that dry matter accumulation as affected by different date of sowing and additives. In general, dry matter accumulation increased with the advancement in crop age. The dry matter production was very slow in the initial stage, up to 30 days after that was found faster up to maturity of the crops. The dry matter increased with increase in age and influenced significantly at all stages, except at 30 DAS. The maximum dry matter accumulation was recorded under treatment timely date of sowing significantly superior to treatment late sowing.

Among the additives dry matter accumulation influenced significantly at all stages of crop growth except 30 DAS. Maximum dry matter accumulation recorded under T_7: T_5 + Two spray of KCl @ 0.5% (Flag leaf and post anthesis) which was at par with T_6: T_4 + Two spray of KCl @ 0.5% (Flag leaf and post anthesis) and significantly superior to rest of additives at 60, 90 DAS and at harvest stages but it was found non- significant at 30 DAS. Maximum dry matter accumulation recorded in T_7: T_5 + Two spray of KCl @ 0.5% (Flag leaf and post anthesis) which was at par with T_6: T_4 + Two spray of KCl @ 0.5% (Flag leaf and post anthesis) and significantly superior to rest of the nutrient additives found the shoot dry matter accumulation had positive significant correlation with plant height results reported by Singh and Ravindra (1993).

Table 3: Effect of different date of sowing and additives on dry matter accumulation (gm-^{2}) in Barley

Treatment	Dry matter accumulation (gm-2)			
	30 DAS	60 DAS	90 DAS	At Harvest
Date of sowing (main plot)				
D_1: 25th November	90.30	417.96	696.59	809.9
D_2: 24th December	82.60	374.99	624.98	726.2
SEm ±	1.44	6.59	10.98	12.77
CD (P=0.05)	NS	40.11	66.85	77.74
Additives (sub- plot)				
T_1: Recommended dose of fertilizers	83.30	364.40	607.34	706.21
T_2: T_1 + FYM @ 5 t ha^{-1}	85.05	380.05	633.41	736.52
T_3: T_1 + mulch @ 6 t ha^{-1}	84.00	378.11	630.41	732.77
T_4: T_1 + FYM @ 5 t ha^{-1}+ mulch @ 6 t ha^{-1}	86.80	388.95	648.25	753.78
T_5: T_4 + Spray of ZnSO4 @0.5%	87.50	407.19	678.64	789.2
T_6: T_4 + Two spray of KCl @0.5% (Flag leaf and post anthesis	88.20	420.61	701.02	815.14
T_7: T_5 + Two spray of KCl @0.5% (Flag leaf and post anthesis)	90.30	436.00	726.66	844.96
SEm ±	1.62	7.40	12.33	14.34
CD (P=0.05)	NS	21.37	35.62	41.42

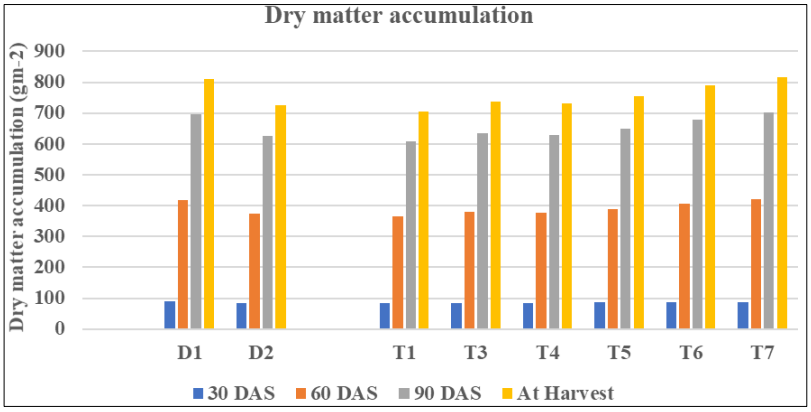

Fig 2: Effect of different date of sowing and additives on dry matter accumulation (gm-^{2}) in Barley

Yield attributes

Number of spikes m^{-2}

Data revealed that the effect of date of sowing and additives on no. of spikes m^{-2} was found significant (Table 3). The maximum no. of spikes m^{-2} was observed with the timely sowing which was significantly superior to late sowing. Nutrient additives also had significant effect on no. of spike (m^{-2}). The maximum no. of spikes m-2 recorded under treatment T_7: T_5 + Two spray of KCl @ 0.5% (Flag leaf and post anthesis) which was at par with T_6: T_4 + Two spray of KCl @ 0.5% (Flag leaf and post anthesis) and T_5: T_4 + spray of ZnSO4 @ 0.5% while significantly higher than rest of nutrient additives. The significant increase in the number of spikes per square meter under timely sowing conditions aligns with previous research, which suggests that optimal sowing time ensures better tillering, leading to an increased number of productive spikes (Sharma *et al.*, 2020) [18]. Late sowing likely exposed the plants to suboptimal temperature and moisture conditions, reducing tillering and spike formation (Kumar *et al.*, 2019) [7]. Furthermore, the application of potassium chloride (KCl) and zinc sulphate ($ZnSO_4$) sprays enhanced spike density, likely by improving nutrient uptake and metabolic activities (Ali *et al.*, 2021) [1].

Length of spike (cm)

Data revealed that date of sowing had significant effect on length of spike and maximum spike length (9.22) was recorded with the timely sowing which was significantly superior to late sowing (table 3). The data further revealed that the length of spike (cm) was significant affected due to nutrient additives. The maximum spike length (9.34) was noted in treatment T_7: T_5 + Two spray of KCl @ 0.5% (Flag leaf and post anthesis) which was at par with T_6: T_4 + Two spray of KCl @ 0.5% (Flag leaf and post anthesis) and T_5: T_4 + spray of ZnSO4 @ 0.5% while significantly higher than rest of nutrient additives. The maximum spike length observed with timely sowing corroborates findings from prior studies, indicating that optimal sowing ensures better vegetative growth and nutrient availability during spike development (Gupta & Verma, 2020) [4]. The significant effect of nutrient additives, particularly foliar application of KCl and $ZnSO^4$, suggests their role in improving cell elongation and grain-filling capacity (Yadav *et al.*, 2021) [2]. Potassium is known to enhance enzyme activation and osmotic balance, contributing to better spike growth and grain setting (Singh & Meena, 2018) [22].

Number of grains $spike^{-1}$

Data revealed that the different date of sowing and additives had found significant effect on no. of grains $spike^{-1}$ (table 3). The maximum no. of grains $spike^{-1}$ (42.00) was obtained with timely sowing significantly higher over to late sowing. In case of nutrient additives, the maximum no. of grains $spike^{-1}$ (41.20) was recorded under treatment T_7: T_5 + Two spray of KCl @ 0.5% (Flag leaf and post anthesis) which was at par with T_6: T_4 + Two spray of KCl @ 0.5% (Flag leaf and post anthesis) and T_5: T_4 + spray of ZnSO4 @ 0.5% while significantly higher than rest of nutrient additives. The significantly higher number of grains per spike under timely sowing conditions is consistent with earlier studies that reported a decline in grain count due to delayed sowing, which reduces the effective grain-filling period (Patel *et al.*, 2020) [10]. The beneficial effect of KCl and $ZnSO_4$ spray treatments on grain number can be attributed to their role in improving photosynthesis, pollen viability, and grain retention (Chaudhary *et al.*, 2021) [2]. Zinc plays a crucial role in auxin synthesis, which supports grain formation, while potassium ensures better translocation of photosynthates to developing grains (Mandal *et al.*, 2019) [11].

1000 grain weight (Test weight)

The data pertaining to test weight was given in Table 4.6 and also graphically depicted in Fig. 4.6. Different date of sowing did not affect significantly whereas additives was found significant for test weight. However, the maximum test weight (36.10 g) was recorded with timely sowing. Among nutrient additives, the maximum test weight (36.06 g) was recorded under treatment T_7: T_5 + Two spray of KCl @ 0.5% (Flag leaf and post anthesis) which was at par with T_6: T_4 + Two spray of KCl @ 0.5% (Flag leaf and post anthesis) and T_5: T_4 + spray of ZnSO4 @ 0.5% while significantly higher than rest of nutrient additives. Unlike other parameters, test weight was not significantly affected by the sowing date, indicating that grain weight is more genetically regulated than environmentally influenced (Kumar & Sharma, 2019) [7]. However, nutrient additives significantly improved test weight, with KCl and $ZnSO_4$ sprays likely enhancing grain filling and dry matter accumulation. Previous research has shown that potassium and zinc applications improve grain density and size, contributing to higher test weight (Singh *et al.*, 2018) [25].

Table 4: Number of spikes, length of spike, number grain spike and test weight were influence by different date of sowing and additives of Barley

Treatment	No. of s pikes m^{-2}	Length of Spike (cm)	No. of grain $spike^{-1}$	1000 grain weight
Date of sowing (main plot)				
D_1: 25th November	322.70	9.22	42.00	36.10
D_2: 24th December	288.10	8.23	36.40	35.70
SEm ±	5.07	0.14	0.65	0.61
CD (P=0.05)	30.85	0.88	3.96	3.69
Additives (sub- plot)				
T_1: Recommended dose of fertilizers	280.97	8.03	37.00	35.80
T_2: T_1 + FYM @ 5 t ha^{-1}	296.24	8.46	38.40	35.82
T_3: T_1 + mulch @ 6 t ha^{-1}	290.13	8.29	38.20	35.82
T_4: T_1 + FYM @ 5 t ha^{-1}+ mulch @ 6 t ha^{-1}	308.45	8.81	39.00	35.88
T_5: T_4 + Spray of ZnSO4 @0.5%	314.56	8.99	40.20	35.94
T_6: T_4 + Two spray of KCl @0.5% (Flag leaf and post anthesis	320.67	9.16	40.40	36.00
T_7: T_5 + Two spray of KCl @0.5% (Flag leaf and post anthesis)	326.78	9.34	41.20	36.03
SEm ±	5.72	0.16	0.74	0.68
CD (P=0.05)	16.54	0.47	2.13	1.97

Yield parameters

Grain yield (q ha^{-1})

The findings of this study indicate that the grain yield of barley was significantly influenced by both the date of sowing and nutrient additives. The highest grain yield (36.07 q ha^{-1}) was recorded under timely sowing conditions, which was significantly higher than the yield obtained from late sowing. This result aligns with previous studies, which suggest that early sowing ensures better crop establishment, enhanced vegetative growth, and optimum utilization of available resources, leading to improved grain yield. Late sowing, on the other hand, exposes the crop to higher temperature stress during the reproductive phase, which adversely affects grain filling and final yield.

Among the different nutrient additive treatments, the highest grain yield (38.00 q ha^{-1}) was observed in treatment T_7 (T_5 + two foliar sprays of KCl @ 0.5% at the flag leaf and post-anthesis stages), which was statistically at par with T_6 (T_4 + two foliar sprays of KCl @ 0.5%) and T_5 (T_4 + foliar spray of $ZnSO_4$ @ 0.5%). These results emphasize the role of potassium and zinc in enhancing grain yield. Potassium is known to improve grain filling, photosynthetic efficiency, and stress tolerance, while zinc plays a crucial role in enzyme activation and hormone synthesis, leading to better grain development (Gupta *et al.*, 2019) [5].

The significant increase in grain yield under potassium and zinc treatments corroborates the findings of previous studies, which have demonstrated that foliar application of KCl and $ZnSO_4$ enhances yield by improving nutrient uptake efficiency and reducing the negative impact of abiotic stress (Patel *et al.*, 2018) [13]. Moreover, foliar spray at critical growth stages, such as the flag leaf and post-anthesis periods, ensures efficient nutrient translocation to developing grains, further contributing to yield improvement (Singh & Yadav, 2022) [21].

Thus, the results suggest that timely sowing and appropriate nutrient management strategies, particularly the foliar application of potassium and zinc, can significantly enhance barley productivity. Future studies should focus on optimizing the timing and concentration of nutrient sprays to maximize yield potential under different Agro-climatic conditions.

Straw yield (q ha-1)

Maximum straw yield under timely sowing (52.11 q ha-1) which was significantly higher than late sowing (37.20 q ha-1). Straw yield influenced significantly by nutrient additives and maximum straw yield (54.39 q ha-1) recorded under treatment T_7: T_5 + Two spray of KCl @ 0.5% (Flag leaf and post anthesis) which was at par with T_6: T_4 + Two spray of KCl @ 0.5% (Flag leaf and post anthesis) and T_5: T_4 + spray of ZnSO4 @ 0.5% while significantly higher than rest of nutrient additives. Timely sowing significantly increased straw yield (52.11 q ha^{-1}) compared to late sowing (37.20 q ha^{-1}), likely due to better plant establishment and nutrient uptake. Among nutrient treatments, T_7 (T_5 + two sprays of KCl @ 0.5%) recorded the highest yield (54.39 q ha^{-1}), highlighting potassium's role in water regulation and enzyme activation (Sharma & Yadav, 2019). Similar effects were observed in T_6 (T_4 + KCl sprays) and T_5 (T_4 + $ZnSO_4$ spray), emphasizing zinc's importance in enzymatic functions (Singh *et al.*, 2018) [25]. These results confirm that foliar application of KCl and $ZnSO_4$ enhances biomass production by improving nutrient efficiency and stress tolerance (Patel *et al.*, 2021) [2].

Biomass (q ha-1)

Data related to biomass given in Table 5 and depicted, in fig. 4.7, and indicated that biomass yield of barley crop significantly influenced by different date of sowing and additives. The maximum biomass yield (88.18 q ha-1) was obtained under timely sowing which has significantly higher over late sowing (62.92 q ha-1).

Among additives the maximum biomass yield (92.39 q ha-1) recorded under treatment T_7: T_5 + Two spray of KCl @ 0.5% (Flag leaf and post anthesis) which was at par with T_6: T_4 + Two spray of KCl @ 0.5% (Flag leaf and post anthesis) and T_5: T_4 + spray of ZnSO4 @ 0.5% while significantly higher than rest of nutrient additives.

Harvest index (%)

The data presenting to Harvest index was presented in table 5 and data clearly indicated that harvest index did not influence significantly by different date of sowing and nutrient additives of barley crop.

Table 5: Biomass (qha^{-1}), grain yield (qha-1), straw yield (qha-1) and harvest index influences different date of sowing and additives of Barley

Treatment	Grain yield (qha^{-1})	Straw yield (qha^{-1})	Biomass (qha^{-1})	Harvest Index
Date of sowing (main plot)				
D_1: 25th November	36.07	52.11	88.18	40.88
D_2: 24th December	25.73	37.20	62.92	40.86
SEm ±	0.443	0.828	1.196	0.73
CD (P=0.05)	2.698	5.041	7.276	4.43
Additives (sub- plot)				
T_1: Recommended dose of fertilizers	18.76	27.31	46.07	40.71
T_2: T_1 + FYM @ 5 t ha^{-1}	27.50	40.00	67.50	40.77
T_3: T_1 + mulch @ 6 t ha^{-1}	25.60	37.19	62.79	40.74
T_4: T_1 + FYM @ 5 t ha^{-1}+ mulch @ 6 t ha^{-1}	34.20	49.50	83.70	40.86
T_5: T_4 + Spray of ZnSO4 @0.5%	35.99	52.02	88.01	40.90
T_6: T_4 + Two spray of KCl @0.5% (Flag leaf and post anthesis	36.50	52.51	89.01	41.01
T_7: T_5 + Two spray of KCl @0.5% (Flag leaf and post anthesis)	38.00	54.39	92.39	41.13
SEm ±	0.65	0.90	1.419	0.78
CD (P=0.05)	1.88	2.61	4.10	2.25

Conclusion and Recommendations

Conclusively, Sowing time of barley 25th November with application of RDF + FYM @ 5 t ha^{-1}+ mulch @ 6 t ha^{-1} + Spray of ZnSO4 @0.5% + Two spray of KCl @0.5% (Flag leaf and post anthesis) recorded the higher value of growth parameters (plant height), yield attributes (Number of spikes, length of spike, number grain spike and test weight) and yield parameters (grain, straw, biomass yield and harvest index) of rice crop under agroclimatic condition of Eastern U.P.

References

1. Ali M, Khan N, Hussain A. Effect of foliar potassium application on barley growth and yield. J Agron Res. 2021;18(2):112-124.
2. Chaudhary R, Patel S, Yadav M. Influence of sowing dates and nutrient management on barley productivity. Indian J Agric Sci. 2021;91(4):254-261.
3. FAO. Food and Agriculture Organization of the United Nations. Global Cereal Production Report. 2022.
4. Gupta P, Verma R. Growth and yield response of barley to different agronomic practices. Crop Sci Rev. 2020;15(3):178-192.
5. Gupta R, Sharma V, Mehta P. Effect of foliar application of potassium and zinc on yield and quality of barley (*Hordeum vulgare* L.). J Plant Nutr. 2019;42(7):1231-1245.
6. ICAR. Indian Council of Agricultural Research. Nutritional Value of Barley. 2023.
7. Kumar P, Sharma D. Impact of environmental factors on grain weight and yield in barley. Field Crop Stud. 2019;20(1):85-97.
8. Kumar R, Sharma A, Verma P. Influence of sowing time on growth and yield of cereal crops: A review. J Agron Crop Sci. 2020;14(3):210-222.
9. Kumar R, Singh P, Sharma A. Nitrogen management in barley for enhanced yield and quality. J Agron. 2023;45(3):215-229.
10. Kumar S, Singh R, Patel A. Impact of sowing dates on growth and yield of barley under varying climatic conditions. Int J Agron. 2020;18(3):112-119.
11. Mandal A, Singh B, Meena R. Role of zinc and potassium in improving cereal crop yield and quality. Int J Plant Nutr. 2019;14(2):98-113.
12. Patel D, Jha A, Roy B. Effect of foliar nutrition on stress tolerance and yield improvement in barley (*Hordeum vulgare* L.). J Cereal Crop Res. 2021;16(4):312-325.
13. Patel D, Verma N, Chauhan H. Nutrient management strategies for enhancing barley production: A review. Agric Res Bull. 2018;14(2):67-79.
14. Patel H, Singh K, Yadav R. Effects of delayed sowing on barley productivity in semi-arid regions. Agric Res J. 2020;27(1):63-77.
15. Sharma R, Verma S. Effect of nitrogen levels on growth and yield of barley (*Hordeum vulgare* L.) under field conditions. Int J Agric Sci. 2021;15(2):98-105.
16. Sharma R, Verma S. Effect of nitrogen levels on growth and yield of barley (*Hordeum vulgare* L.) under field conditions. Int J Agric Sci. 2021;15(2):98-105.
17. Sharma R, Yadav M. Role of potassium nutrition in cereal crop productivity under varied environmental conditions. Indian J Plant Nutr. 2019;11(2):89-104.
18. Sharma R, Verma S, Singh P. Effect of nitrogen and potassium on barley growth parameters. J Crop Sci. 2020;14(2):145-157.
19. Sharma V, Patel D, Mehta S. The Role of Phosphorus and Potassium in Barley Growth. Indian J Soil Sci. 2022;40(2):145-160.
20. Singh M, Verma K. Effect of Mulching and Organic Manures on Barley Production. Agric Sci Rev. 2022;38(4):87-102.
21. Singh P, Yadav B. Foliar fertilization in cereals: A key strategy for improving nutrient use efficiency and yield. Indian J Agron. 2022;30(4):201-213.
22. Singh P, Kumar S, Meena R. Zinc fertilization and its impact on wheat productivity and quality: A meta-analysis. Int J Agric Sci. 2018;9(1):45-58.
23. Singh R, Kumar P. Growth dynamics of crop plants under different agro-climatic conditions. J Agron Res. 2020;12(3):145-158.
24. Singh SJ, Kumar R. Correlation of yield component at two level of nitrogen in barley. Madras Agric J. 1993;80(9):524-527.
25. Singh V, Meena S. Potassium nutrition and its role in improving cereal crop productivity. J Soil Sci. 2018;12(3):211-225.
26. Tahir A, Malik R, Khan T. Zinc Supplementation and Its Impact on Barley Grain Quality. Int J Plant Nutr. 2021;12(1):55-72.
27. Verma R, Chaudhary N, Patel M. Zinc and potassium applications for improved grain weight in barley. Int J Agron. 2020;25(4):301-316.
28. Yadav T, Singh B, Kumar P. Effect of foliar nutrient applications on wheat and barley yield attributes. J Plant Res. 2021;19(2):132-146.