International Journal of Agriculture and Food Science 2026; 8(4): 373-376

ISSN Print: 2624-844X
ISSN Online: 2624-8458
NAAS Rating (2026): 4.97
IJAFS 2026; 8(4): 373-376
www.agriculturaljournals.com
Received: 09-03-2026
Accepted: 11-03-2026

VR Sule
M.Sc. Student, Department of Genetics and Plant Breeding, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra, India

SS Dodake
Head, Department of agricultural Botany, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra, India

PK Lokhande
Head, Department of Biochemistry, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra, India

ST Pagar
M.Sc. Student, Department of Genetics and Plant Breeding, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra, India

Corresponding Author:
VR Sule
M.Sc. Student, Department of Genetics and Plant Breeding, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra, India

Assessment of nutritional composition of barley genotypes under late sown irrigated condition

VR Sule, SS Dodake, PK Lokhande and ST Pagar

DOI: https://www.doi.org/10.33545/2624844X.2026.v8.i4e.1332

Abstract
Barley (*Hordeum vulgare* L.) is an important cereal crop recognized for its nutritional and functional food properties. Barley is a highly nutritious cereal grain that provides a wide range of health benefits, including enhanced digestion, improved cardiovascular health, effective weight management, and better regulation of blood sugar levels. The present study was conducted to determine the nutritional composition of thirty-six barley genotypes obtained from the Indian Institute of Wheat and Barley Research, Karnal, Haryana. The grains were analyzed for crude protein, total sugar, crude fiber, crude fat, zinc, and iron content using standard analytical procedures including Micro-Kjeldahl method, phenol–sulphuric acid method, acid–alkali digestion, Soxhlet extraction, and Atomic Absorption Spectrophotometry.

The results revealed that barley grains contained crude protein ranging from 9.05% (DWRUB 52) to 13.32% (BH 902) with a mean of 11.41%. Total sugar content varied from 1.61% (VLB 118) to 2.69% (RD 2668) with mean 2.17%, while crude fiber ranged between 3.13% (UPB 1008) and 5.45% (BHS 352) with an average of 4.33%. Crude fat content ranged from 1.31% (DWRUB 160) to 2.18% (DWRUB 52), averaging 1.86%. The micronutrient composition showed zinc content ranging from 1.48 (DWRUB 52) to 3.05 (HBL 713) mg/100 g (mean 2.16 mg/100 g) and iron content from 2.33 (NB2) to 4.63 (K 603) mg/100 g with a mean value of 3.57 mg/100 g. The findings demonstrate that barley grains possess appreciable levels of protein, dietary fiber, essential fatty components, and important micronutrients such as zinc and iron, highlighting their nutritional significance for human consumption and functional food applications.

Keywords: Barley (*Hordeum vulgare* L.), nutritional composition, crude protein

1. Introduction

Barley (*Hordeum vulgare* L.) is a major cereal crop grown across diverse agro-ecological regions of the world and is recognized for its stable productivity and nutritional value. Traditionally utilized as livestock feed and for malting industries, barley has recently attracted attention because of its nutritional value and health benefits. The grain contains appreciable levels of total protein, typically varying between 11 and 14 per cent depending on genetic makeup and environmental influences, thereby contributing significantly to plant-based protein intake in cereal diets (Baik and Ullrich, 2008) [2]. Barley is a nutritionally important cereal grain composed predominantly of carbohydrates and characterized by a relatively low fat content. In addition, it contains significant amounts of protein, essential minerals, and vitamins, particularly vitamin E. It is also a rich source of dietary fiber and bioactive compounds, especially antioxidants such as polyphenols, which contribute to its overall nutritional and health-promoting value (Das *et al.*, 2016) [6]. Barley also contains relatively low levels of total fat, generally less than 3 per cent, predominantly consisting of unsaturated fatty acids that enhance its dietary value while supporting grain storage stability (Newman and Newman, 2006) [13]. In addition to these macronutrients, barley grains supply essential trace elements such as zinc and iron, which are vital for metabolic processes, immune function and oxygen transport, and play an important role in addressing micronutrient malnutrition (Graham *et al.*, 2007) [7]. The crop exhibits significant nutritional value along with functional properties that contribute to health promotion (Cook, 2013; Idehen *et al.*, 2017) [4, 10]. It is well established that diets rich in β-glucan enhance immune function and offer protection against conditions such as hypertension, stroke, cardiovascular diseases, and type 2 diabetes (Maheshwari *et al.*, 2019; Tosh and Bordenave, 2020) [12, 16].

Given the widespread occurrence of zinc and iron deficiencies in many developing regions, characterization of barley genotypes for these nutritional traits is crucial.
Hence, systematic evaluation of Crude protein, total sugar, fiber, fat, zinc and iron content under late sown irrigated condition is instrumental in identifying nutritionally superior genotypes and facilitating breeding efforts aimed at grain quality enhancement and biofortification.

2. Materials and Methods

36 barley genotypes were obtained from Indian Institute of Wheat and Barley Research, Karnal, Haryana. The experiment was conducted using a Randomized Block Design (RBD) with two replications under late sown irrigated condition.

Table 1: List of 36 barley genotypes

SN	Genotype	SN	Genotype	SN	Genotype	SN	Genotype
1	BH 393	10	DWRB 160	19	NB 2	28	RD 2552
2	BHS 400	11	HBL 276	20	NB 3	29	RD 2592
3	BH 902	12	HBL 713	21	NDB 1173	30	RD 2624
4	BHS 352	13	JB 58	22	PL 426	31	RD 2660
5	BHS 380	14	K 508	23	PL 751	32	RD 2668
6	DWR 28	15	K 551	24	PL 891	33	RD 2715
7	DWRUB 52	16	K 560	25	PRB 502	34	UPB 1008
8	DWRUB 64	17	K 603	26	RD 2035	35	VLB 118
9	DWRB 73	18	NB 1	27	RD 2508	36	VLB 130

2.1 Chemical analysis

Crude protein content was determined by the Micro-Kjeldahl method (A.O.A.C., 2000). A 200 mg defatted sample was digested with concentrated sulphuric acid in the presence of a catalyst mixture until a clear solution was obtained. The digest was diluted, made alkaline with sodium hydroxide, and the liberated ammonia was distilled and trapped in boric acid solution containing mixed indicator. The distillate was titrated against standard 0.02 N hydrochloric acid. Nitrogen content was calculated from the titration value, and crude protein percentage was obtained by multiplying nitrogen percentage with a conversion factor of 5.83.
Total sugar was determined using the phenol–sulphuric acid method. Barley grain sample (0.5 g) was extracted with 80 per cent ethanol, and an aliquot of the extract was reacted with phenol and concentrated sulphuric acid. After colour development, absorbance was measured at 490 nm. Total sugar content was quantified using a glucose standard curve and expressed as percentage.
Crude fiber content was determined according to AOAC (2000) [1] by acid–alkali digestion method. A 2 g fat-free dried sample was sequentially digested with 1.25 per cent sulphuric acid and 1.25 per cent sodium hydroxide under controlled boiling conditions. The residue was filtered, thoroughly washed, dried to constant weight at 100°C and then ashed at 550°C in a muffle furnace. Crude fiber percentage was calculated from the loss in weight after ashing and expressed on sample weight basis.
Crude fat content was determined by Soxhlet extraction method using petroleum ether (40–60°C) as solvent (A.O.A.C., 2000). Approximately 5 g of powdered sample was extracted in a Soxhlet apparatus until complete siphoning cycles were achieved. The solvent was evaporated and the flask containing extracted fat was dried to constant weight. Crude fat percentage was calculated from the difference in weight of the flask before and after extraction and expressed on sample weight basis.
Zinc content was estimated using Atomic Absorption Spectrophotometry (AAS). One gram of finely powdered barley seed sample was digested with a nitric acid and perchloric acid mixture (5:1) and heated until complete digestion was achieved. The digest was cooled, diluted to a known volume with distilled water and filtered. The filtrate was analyzed for zinc concentration using an atomic absorption spectrophotometer and results were expressed as mg per 100 g of sample.
Iron content was determined by Atomic Absorption Spectrophotometry (AAS). One gram of finely powdered barley seed sample was digested with a nitric acid and perchloric acid mixture (5:1) until a clear solution was obtained. The digest was cooled, diluted to a known volume with distilled water and filtered. The filtrate was analyzed for iron concentration using an atomic absorption spectrophotometer and the results were expressed as mg per 100 g of sample.

3. Results and Discussion

The chemical composition of different barley genotypes is presented in table 2.
The crude protein content of barley genotypes ranged from 9.05% to 13.32%, with an overall mean of 11.41%. The highest protein concentration was recorded in BH 902 (13.32%), followed by RD 2624 (12.86%), DWRUB 64 (12.72%), and BHS 352 (12.57%). Lower protein levels were observed in DWRUB 52 (9.05%) and DWR 28 (9.46%). The results indicate that barley grains possess appreciable protein content, with certain genotypes exhibiting relatively higher protein concentration. These findings are accordance with the Yadav *et al* (2000) [20], Dabas *et al.* (2005) [5], Singh (2005) [15], Saharan (2009) [14].
Total sugar content ranged from 1.61% to 2.69%, with a mean value of 2.17%. RD 2668 recorded the highest sugar content (2.69%), followed by UPB 1008 (2.53%), NB 3 (2.52%), and DWRB 73 (2.50%). Lower sugar concentrations were observed in VLB 118 (1.61%), PRB 502 (1.86%), and BH 902 (1.91%). The findings demonstrate that barley grains contain moderate levels of total sugars contributing to the carbohydrate fraction. These results are in agreement with the Vasan *et al.* (2015) [18].
Crude fiber content varied from 3.13% to 5.45%, with a mean of 4.33%. The highest fiber content was recorded in BHS 352 (5.45%), followed by K 603 (5.40%), NB 1 (5.27%), and PRB 502 (5.10%). Lower fiber levels were observed in UPB 1008 (3.13%), RD 2624 (3.21%), and RD 2715 (3.33%). The results indicate that barley grains contain considerable fiber content as part of their structural carbohydrate composition. Similar results were obtained by Varsha *et al.* (2006) [17], Saharan (2009) [14], Biel and Jacyno (2013) [3].
Crude fat content ranged from 1.31% to 2.18%, with an overall mean of 1.86%. lower fat levels were recorded in DWRB 160 (1.31%), HBL 276 (1.39%), and BHS 400 (1.47%). Similar results were obtained by Singh (2005) [15], Varsha *et al.* (2006) [17].
Zinc content ranged from 1.48 to 3.05 mg/100 g, with a mean of 2.16 mg/100 g. JB 58 recorded the highest zinc concentration (3.05 mg/100 g), followed by DWR 28 (2.78 mg/100 g).

and RD 2624 (2.63 mg/100 g). Lower zinc levels were observed in DWRUB 52 (1.48 mg/100 g) and PL 751 (1.54 mg/100 g). The results indicate that barley grains contain appreciable amounts of zinc as part of their mineral composition, with certain genotypes exhibiting relatively higher zinc concentration. Iron content ranged from 2.33 to 4.63 mg/100 g, with a general mean of 3.57 mg/100 g. The highest iron content was recorded in NB 1 (4.63 mg/100 g), followed by RD 2715 (4.50 mg/100 g) and HBL 713 (4.44 mg/100 g), whereas lower values were observed in NB 2 (2.33 mg/100 g) and K 560 (2.90 mg/100 g). Similar results were obtained by a Hussain *et al.* (2021) [9], Kaur *et al.* (2024) [11], Wotango *et al.* (2024) [19], Yiblet *et al.* (2024) [21].

Table 2: Proximate composition of 36 genotypes for a six nutritional characters in barley

SN	Genotype	Crude protein (%)	Total sugar (%)	Crude fiber (%)	Crude fat (%)	Zinc (mg/100 g)	Iron (mg/100 g)
1	BH 393	10.23	1.93	4.23	1.60	2.45	3.81
2	BHS 400	11.22	2.09	4.75	1.47	2.12	4.33
3	BH 902	13.32	1.91	5.06	1.95	2.08	3.52
4	BHS 352	12.57	1.98	5.45	2.13	2.05	3.61
5	BHS 380	11.56	2.00	4.46	1.84	1.60	3.04
6	DWR 28	9.46	2.23	3.98	1.48	2.78	3.95
7	DWRUB 52	9.05	2.43	4.27	2.18	1.48	3.66
8	DWRUB 64	12.72	2.23	3.74	2.11	2.48	3.89
9	DWRB 73	10.79	2.50	4.95	1.91	2.23	3.45
10	DWRB 160	9.74	2.49	4.47	1.31	2.05	2.95
11	HBL 276	12.26	1.95	4.92	1.39	2.08	3.26
12	HBL713	11.82	2.36	3.88	1.55	1.65	4.44
13	JB 58	12.29	2.34	4.67	1.72	3.05	3.49
14	K 508	11.24	2.21	4.15	1.92	2.46	3.51
15	K 551	12.28	2.33	4.50	2.06	2.29	3.74
16	K 560	11.52	2.28	4.31	1.79	2.30	2.90
17	K 603	12.48	2.17	5.40	1.81	2.21	3.40
18	NB 1	10.68	1.97	5.27	1.97	2.32	4.63
19	NB 2	11.89	2.34	4.68	1.58	2.00	2.33
20	NB 3	10.10	2.52	4.43	1.79	2.24	3.79
21	NDB 1173	11.47	1.93	4.11	1.89	2.05	3.74
22	PL 426	11.22	2.13	4.35	1.83	2.12	3.95
23	PL 751	11.48	2.13	4.28	2.14	1.54	3.88
24	PL 891	10.02	2.43	3.98	1.99	1.87	3.41
25	PRB 502	12.21	1.86	5.10	1.89	2.48	3.46
26	RD 2035	12.26	2.14	4.20	2.15	2.23	3.31
27	RD 2508	11.93	2.04	4.19	2.18	2.31	2.91
28	RD 2552	11.31	2.07	3.95	1.95	2.04	3.39
29	RD 2592	11.78	2.12	4.01	1.52	2.12	3.46
30	RD 2624	12.86	2.07	3.21	2.05	2.63	3.76
31	RD 2660	11.41	2.18	4.66	2.11	2.03	3.06
32	RD 2668	9.67	2.69	4.29	1.85	2.05	3.52
33	RD 2715	11.27	2.16	3.33	1.99	2.34	4.50
34	UPB 1008	10.92	2.53	3.13	2.08	1.81	3.33
35	VLB 118	12.06	1.61	4.03	1.92	1.79	3.23
36	VLB 130	11.70	1.88	3.58	1.82	2.51	3.82
	Minimum	9.05	1.61	3.13	1.31	1.48	2.33
	Maximum	13.32	2.69	5.45	2.18	3.05	4.63
	General mean	11.41	2.17	4.33	1.86	2.16	3.57

Overall, the results demonstrate that barley grains possess substantial levels of protein, sugars, fiber, fat, zinc, and iron, indicating their nutritionally rich compositional profile and significance of nutritional characteristics is growing in plant breeding initiatives focused on enhancing crop quality. In barley, differences in protein, fiber, and essential micronutrients such as zinc and iron provide opportunities for selection and genetic enhancement. Recognizing genotypes that are high in nutrients can help in creating biofortified varieties, thus improving both productivity and nutritional security.

4. Conclusion

The present investigation evaluated the nutritional composition of barley genotypes in terms of crude protein, total sugar, crude fiber, crude fat, zinc, and iron content. The results indicated that barley grains possess appreciable levels of both macronutrients and micronutrients, confirming their high nutritional value. Higher protein content was observed in genotypes such as BH 902 and RD 2624, while RD 2668 recorded higher total sugar content. The genotype BHS 352 exhibited relatively higher crude fiber, whereas DWRB 160 and HBL 276 showed comparatively lower crude fat content. Among micronutrients, JB 58 recorded higher zinc content and NB 1 exhibited higher iron concentration. Overall, the variation among genotypes reflects distinct nutritional profiles, highlighting the potential of barley as a nutrient-rich cereal crop.

5. Acknowledgment

The authors gratefully acknowledge the Head, Department of Agricultural botany, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra and Head Department of Biochemistry, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra for extending the necessary facilities and constant encouragement throughout the course of the investigation.

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