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Nutrient content and uptake as influenced by different varieties and nitrogen levels in barley (*Hordeum vulgare* L.) under saline water irrigation

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Abstract

Due to scarcity of irrigation water in Haryana, the field experiments were conducted during *rabi* seasons of 2017-18 and 2018-19 at Hisar to study the influence of different varieties (BH902, BH 946, BH 885 and DWRB 101) and nitrogen levels (0, 30, 60 and 90 kg ha⁻¹) on nutrient content and uptake in barley under saline water irrigation. Barley variety BH 902 recorded maximum N content in grain and straw (1.67 and 0.51 %, respectively) in comparison to BH 946, BH 885 and DWRB 101. Six rowed barley varieties BH 902 and BH 946 recorded significantly higher N, P and K uptake as compared to two rowed barley varieties BH 885 and DWRB 101. All the nitrogen levels significantly enhanced the N content in grain and straw as compared to control, whereas P and K content in grain and straw was not significantly influenced by different varieties and nitrogen levels. The N uptake by grains, straw and total N uptake increased significantly with each increment of nitrogen dose up to 90 kg ha⁻¹, while total P and K uptake was significantly increased only up to 60 kg ha⁻¹.

Keywords: Barley, nitrogen levels, nutrient content, nutrient uptake, varieties

Introduction

Barley (*Hordeum vulgare* L.) is one of the most important cereal crops in India. This crop is considered as poor man's crop because of its low input requirement and better adaptability to drought, salinity, alkalinity and marginal lands. Due to uncertainty of rainfall and scarcity of water, farmers of Haryana often irrigate the crops with poor quality water and further this situation is likely to become more alarming with the depleting water resources. Thus, there is need to find out the ways to use poor quality saline water for crop production. Different varieties of barley generally differ in their yield potential and malt quality parameters. Ejigu *et al.* (2015) [3] observed that variety Miscal-21 responded up to 30 kg N ha⁻¹ and variety Beka up to 50 kg N ha⁻¹ for achieving higher grain yield of malt barley. The research findings indicated that some varieties respond to higher nitrogen levels but other varieties respond to lower nitrogen level. So, there is a need to evaluate the varieties with matching nitrogen levels and its uptake in grain that give good yield as well as malting characteristics.

The important use of barley throughout the world is as malt for manufacturing beverages and malt enriched food products. It is also extensively used in beer and whiskey production. Nitrogen is the most important element that affects both yield and quality of barley. Grain protein and kernel plumpness are two most important quality parameters of malt barley which are strongly related to nitrogen application. Insufficient nitrogen can reduce grain yield and quality below acceptable levels, while excess nitrogen usually enhances undesirable high protein levels. Applying higher dose of nitrogen for achieving maximum yields may exceed grain protein concentration beyond to the maximum level of acceptable limit of malt barley (Castro *et al.* 2008) [2]. Terefe *et al.* (2018) [10] observed that number of tillers m⁻², number of grains per spike and straw yield of malt barley increased significantly up to 54 kg N ha⁻¹ but the grain yield increased only up to 36 kg N ha⁻¹. Zhao *et al.* (2006) [12] reported that nitrogen content in grain is a determining factor of malt quality, high grain nitrogen content not only lowers the carbohydrate content and malt extract level but also makes the barley grains more

difficult to modify, causing problems for the malt production. They observed that nitrogen level should not be greater than 1.6 -1.8% in grains for malt barley. Therefore nitrogen content in grain and its uptake plays very important role in determining the quality of malt barley. However, information on nutrient content and their uptake particularly under saline water irrigation with respect to different varieties and nitrogen levels is lacking in literature. Keeping the above aspects in view, the study was conducted to study the effect of different varieties and nitrogen levels on nutrient contents and their uptake in barley under saline water irrigation.

Materials and methods

The field experiments were conducted during *rabi* seasons of 2017-18 and 2018-19 at Research Farm, Department of Soil Science, CCS Haryana Agricultural University, Hisar. The soil of the experimental site was sandy loam in texture, alkaline in reaction (pH 8.3), low in available nitrogen (175.0 kg ha^{-1}), medium in available phosphorus (17.0 kg ha^{-1}) and high in available potassium (320.0 kg ha^{-1}). The experiment was laid out in split plot design by keeping four varieties (BH 902, BH 946, BH 885 and DWRB 101) in main plots and four nitrogen levels (0, 30, 60 and 90 kg ha^{-1}) in sub plots with four replications. At proper moisture condition, the field was ploughed twice with a tractor drawn disc harrow and twice with a cultivator followed by planking. The crop was sown by pora method on 22 and 26 November during 2017 and 2018, respectively using 90 kg ha^{-1} seed rate and row spacing of 22 cm. Half dose of nitrogen as per treatments and full dose of phosphorus (P_2O_5) and potassium (K_2O) was applied in the form of Urea, Single super phosphate (SSP) and Muriate of Potash (MOP) fertilizers at the time of sowing. The remaining half dose of nitrogen was top dressed after 1st irrigation as per treatments. The crop was irrigated with saline water of EC_{iw} 7.5-8.0 dSm^{-1} . Two irrigations were applied in both the seasons. Harvesting was done manually and threshing was done with the help of mini plot thresher. The grains collected from each net plot were weighed. To determine total nitrogen, phosphorus and potassium in plant samples, 0.2 g of dry material of grains and 0.5 g straw were digested with di-acid mixture of H_2SO_4 and HClO_4 of 9:1 (v/v) ratio. After digestion, the volume was raised to 50 ml with distilled water. This digested material was stored in plastic bottles after filtering through whatman filter paper no. 42 for further analysis. Nitrogen in plant samples was determined from the digested material by using Colorimetric (Nessler's reagent) method. Phosphorus in plant samples was determined from the digested material by using Vanadomolybdophosphoric yellow color method. Potassium in plant samples was determined from the digested material by using flame photometer (directly). NPK Uptake was worked out by multiplying per cent content of nutrient in plant parts with their respective dry yield. Data were statistically analyzed by using the technique of analysis of variance (ANOVA) described by Fischer (1950)^[4].

Results and Discussion

Nitrogen content in grain and straw of barley

Nitrogen content in grain affects the amount of protein content in barley grain. The results showed that among different varieties, BH 902 recorded maximum N content in grain and straw (1.67 and 0.51 %, respectively) which was followed by BH 946 (1.61 and 0.49 %), BH 885 (1.50 and 0.45 %) and DWRB 101 (1.47 and 0.47 %). Higher N content in the grain than in the straw might be due to the fact that

more N was partitioned towards the grains at the expense of vegetative parts of the plant. Singh (2018)^[7] and Shafi *et al.* (2011)^[6] also observed significant variation in nitrogen content in grains and straw with respect to different genotypes. However, Kassie and Tesfaye (2019) observed that malt barley variety Miscal-21 recorded higher nitrogen content in grains, while variety Holker recorded greater nitrogen content in straw. They reported that differences between varieties in grain nitrogen content might be associated to differences in nitrogen partitioning to the grains. Among different nitrogen levels, maximum nitrogen content in grain and straw (1.66 and 0.55 %, respectively) was observed with application of nitrogen at 90 kg ha^{-1} followed by 60 kg N ha^{-1} (1.61 and 0.53 %), 30 kg N ha^{-1} (1.54 and 0.48 %) and control (1.45 and 0.39 %), thus indicating that nitrogen application enhanced the nitrogen content in grain and straw as compared to control treatment. The higher N concentration with increasing level of N fertilization was due to enhanced supply of N to the crop. Similarly, Kassie and Tesfaye (2019)^[5], Yousif and Evans (2018)^[11], Singh *et al.* (2012)^[8] and Shafi *et al.* (2011)^[6] concluded that N concentration in grain and straw increased with increasing nitrogen levels in barley. Alghabari and Al-Solaimani (2015)^[1] and Taalab *et al.* (2015)^[9] also observed a linear increase of grain nitrogen concentration with increasing nitrogen rates. Zhao *et al.* (2006)^[12] observed that nitrogen content in grain is a determining factor of malt quality, high grain nitrogen content not only means lower the carbohydrate content and malt extract level but also makes the barley more difficult to modify, causing problems for the malt production. They reported that nitrogen level should not be greater than 1.6–1.8% in grains for malt barley.

Effect of different varieties on N uptake by grain, straw and total N uptake:

Nitrogen uptake depends upon nitrogen content and biological yield produced by the crop. More the biological yield produced more will be the nitrogen uptake and more the content in grain and straw more will be the nitrogen uptake. The present study showed that highest N uptake by grain, straw and total N uptake was attained by variety BH 902 which was statistically at par with BH 946 but was significantly higher than BH 885 and DWRB 101, the latter two also remained statistically at par with each other. The data showed that both 6 rowed barley varieties BH 902 and BH 946 recorded significantly higher N uptake by grain, straw and total N uptake as compared to both 2 rowed barley varieties BH 885 and DWRB 101. Higher total nitrogen uptake by 6 rowed barley varieties BH 902 and BH 946 might be due to the higher biological yield under these varieties as compared to 2 rowed barley varieties BH 885 and DWRB 101. Varietal differences with respect to N uptake by grain, straw and total N uptake were also reported by Singh (2018)^[7] who observed that nitrogen uptake in DWRUB 52 was statistically at par with PL 807 and significantly higher than PL 426.

Effect of nitrogen levels on N uptake by grain, straw and total N uptake:

The nitrogen uptake by grains, straw and total N uptake increased significantly with each increment of nitrogen dose up to 90 kg ha^{-1} . Maximum values of nitrogen uptake by grains, straw and total uptake were attained under 90 kg N ha^{-1} which showed its significant superiority as compared to 60 kg N ha^{-1} , 30 kg N ha^{-1} and control treatment. On an average, application of 30, 60 and 90 kg N ha^{-1} recorded 27.3, 41.5 and 46.8 kg ha^{-1} , respectively more total

N uptake over the control treatment. Higher nitrogen uptake was mainly due to higher N content, grain yield and straw yield which were increased with increasing levels of nitrogen. These results are in conformity with the findings of Taalab *et al.* (2015) [9] and Singh *et al.* (2012) [8] who also reported significant increase in N uptake in grain and straw with increased nitrogen rates.

Phosphorus content in grain and straw of barley: P content in grain and straw was not significantly influenced by different varieties and nitrogen levels; however its values varied between 0.30 to 0.36 % in grain and 0.15 to 0.18 % in straw among different treatments.

Effect of different varieties on P uptake by grain, straw and total P uptake: P uptake by grain, straw and total uptake was significantly affected by different varieties. BH 946 recorded maximum P uptake by grain, straw and total uptake which was statistically at par with BH 902 and significantly higher than BH 885 and DWRB 101, the latter two remained statistically at par with each other. The results showed that both 6 rowed barley varieties BH 902 and BH 946 recorded significantly higher P uptake by grain, straw and total uptake as compared to both 2 rowed barley varieties BH 885 and DWRB 101. Higher P uptake by grain, straw and total uptake under 6 rowed barley varieties BH 902 and BH 946 was attributed to the higher biological yield as compared to 2 rowed barley varieties BH 885 and DWRB 101. Singh (2018) [7] also reported varietal differences with respect to P uptake by grain, straw and total uptake.

Effect of nitrogen levels on P uptake by grain, straw and total P uptake: Among different nitrogen levels, P uptake by grains was significantly increased with each increment of nitrogen dose up to 90 kg ha⁻¹, whereas P uptake by straw and total P uptake was significantly increased only up to 60 kg ha⁻¹. The results further revealed that application of nitrogen at 30, 60 and 90 kg ha⁻¹ recorded 3.4, 4.9 and 5.3 kg ha⁻¹, respectively more P uptake in grain, 3.4, 4.9 and 5.3 kg ha⁻¹, respectively more P uptake by straw and 4.9, 7.5 and 8.2 kg ha⁻¹, respectively more total P uptake over the control. Increased P uptake by grain, straw and total P uptake was due to increased grain and straw yield with application of different nitrogen levels. Similar results were reported by Singh *et al.* (2012) [8] who also observed significant increase in P uptake

by grains and straw in barley with increased nitrogen application.

Potassium content in grain and straw of barley: K content in grain and straw was not significantly affected by different varieties and nitrogen levels, however, its values ranged between 0.41 to 0.44 % in grains and 1.51 to 1.57 % in straw under different treatments.

Effect of different varieties on K uptake by grain, straw and total K uptake

Various varieties differed significantly with respect to K uptake by grain during both the years. The results showed that varieties BH 946 and BH 902 being statistically at par with each other recorded significantly higher K uptake by grain, straw and total uptake than BH 885 and DWRB 101, the latter two also remained statistically at par with each other. Thus the results showed that both 6 rowed barley varieties BH 902 and BH 946 recorded significantly higher K uptake by grain, straw and total uptake as compared to both 2 rowed barley varieties BH 885 and DWRB 101. Increased K uptake by grains, straw and total K uptake under 6 rowed barley varieties BH 902 and BH 946 was due to higher biological yield as compared to 2 rowed barley varieties BH 885 and DWRB 101. Varietal differences with respect to K uptake by grain, straw and total uptake were also reported by Singh (2018) [7] who obtained highest K uptake in variety DWRUB 52 as compared to PL 426 and PL 807.

Effect of nitrogen levels on K uptake by grain, straw and total K uptake: Nitrogen application significantly enhanced the K uptake by grain, straw and total K uptake only up to 60 kg ha⁻¹ and further increasing the nitrogen dose did not influence these parameters. However, maximum K uptake by grain, straw and total K uptake was recorded under 90 kg N ha⁻¹ treatment which was statistically similar with 60 kg N ha⁻¹ and both these nitrogen levels showed their significant superiority over 30 kg N ha⁻¹ and control. The results showed that application of nitrogen at 30, 60 and 90 kg ha⁻¹ recorded 17.4, 28.2 and 31.3 kg ha⁻¹, respectively more total K uptake over the control. Higher K uptake under different nitrogen levels was attributed to higher grain and straw yield as compared to control. Similarly, Singh *et al.* (2012) [8] also observed that potassium uptake by grain and straw of malt barley significantly increased with increase in nitrogen levels.

Table 1: Effect of different varieties and nitrogen levels on nitrogen content and its uptake in barley grain and straw

Treatment	N content in grain (%)			N uptake by grain (kg ha ⁻¹)			N content in straw (%)			N uptake by straw (kg ha ⁻¹)		
	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled
Varieties												
BH 902	1.68	1.66	1.67	81.4	78.6	80.0	0.52	0.50	0.51	34.3	32.1	33.2
BH 946	1.62	1.60	1.61	84.8	81.9	83.3	0.51	0.48	0.49	33.1	30.1	31.6
BH 885	1.51	1.50	1.50	67.2	65.4	66.3	0.47	0.44	0.45	26.8	24.7	25.8
DWRB 101	1.48	1.46	1.47	73.1	71.3	72.2	0.49	0.46	0.47	29.1	26.9	28.0
SEm ±	0.02	0.01	0.01	2.4	2.2	2.0	0.01	0.01	0.01	1.0	0.8	0.7
CD (p= 0.05)	0.06	0.05	0.04	7.5	6.6	6.0	0.03	0.04	0.03	3.3	2.5	2.3
Nitrogen levels (kg ha⁻¹)												
Control	1.45	1.44	1.45	57.2	55.4	56.3	0.40	0.37	0.39	21.1	18.7	19.9
30	1.55	1.53	1.54	76.3	73.7	75.0	0.49	0.47	0.48	29.6	27.4	28.5
60	1.62	1.60	1.61	85.0	82.6	83.8	0.54	0.51	0.53	35.1	32.8	34.0
90	1.66	1.65	1.66	88.0	85.6	86.8	0.56	0.53	0.55	37.6	34.9	36.2
SEm ±	0.01	0.01	0.01	1.1	0.6	0.6	0.01	0.01	0.01	0.7	0.6	0.4
CD (p= 0.05)	0.04	0.02	0.02	3.2	1.8	1.8	0.03	0.03	0.02	2.0	1.8	1.3

Table 2: Effect of different varieties and nitrogen levels on phosphorus content and its uptake in barley grain and straw

Treatment	P content (%) in grain			P uptake by grain (kg ha ⁻¹)			P content (%) in straw			P uptake by straw (kg ha ⁻¹)		
	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled
Varieties												
BH 902	0.34	0.33	0.34	16.8	15.7	16.3	0.18	0.17	0.17	11.3	10.6	10.9
BH 946	0.35	0.34	0.35	18.4	17.3	17.8	0.18	0.17	0.17	11.4	10.7	11.0
BH 885	0.34	0.32	0.33	15.2	13.9	14.5	0.17	0.16	0.17	9.8	8.9	9.4
DWRB 101	0.34	0.30	0.32	16.6	14.7	15.7	0.17	0.15	0.16	9.9	8.8	9.3
SEm ±	0.01	0.01	0.01	0.6	0.5	0.5	0.02	0.01	0.01	0.3	0.4	0.2
CD (p= 0.05)	NS	NS	NS	1.8	1.7	1.6	NS	NS	NS	1.0	1.1	0.7
Nitrogen levels (kg ha⁻¹)												
Control	0.33	0.32	0.33	13.3	12.1	12.7	0.17	0.16	0.16	8.9	8.0	8.5
30	0.34	0.32	0.33	16.9	15.2	16.1	0.17	0.16	0.17	10.4	9.3	9.9
60	0.34	0.33	0.34	18.0	17.2	17.6	0.17	0.17	0.17	11.2	10.7	11.0
90	0.36	0.33	0.34	18.8	17.1	18.0	0.18	0.17	0.17	11.9	10.8	11.4
SEm ±	0.01	0.01	0.01	0.4	0.4	0.2	0.03	0.01	0.01	0.3	0.3	0.2
CD (p= 0.05)	NS	NS	NS	1.0	1.1	0.7	NS	NS	NS	0.8	0.7	0.5

Table 3: Effect of different varieties and nitrogen levels on potassium content and its uptake in barley grain and straw

Treatment	K content (%) in grain			K uptake by grain (kg ha ⁻¹)			K content (%) in straw			K uptake by straw (kg ha ⁻¹)		
	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled
Varieties												
BH 902	0.44	0.43	0.43	21.3	21.1	20.7	1.56	1.54	1.55	101.5	98.2	99.9
BH 946	0.44	0.42	0.43	23.0	21.6	22.3	1.56	1.53	1.55	99.7	95.9	97.8
BH 885	0.43	0.42	0.43	19.2	18.3	18.7	1.54	1.51	1.53	87.5	83.9	85.7
DWRB 101	0.43	0.41	0.42	21.0	20.0	20.5	1.56	1.52	1.54	92.5	88.5	90.5
SEm ±	0.01	0.01	0.01	0.8	0.7	0.6	0.02	0.02	0.02	1.9	1.7	1.6
CD (p= 0.05)	NS	NS	NS	2.5	2.0	1.9	NS	NS	NS	5.9	5.3	4.9
Nitrogen levels (kg ha⁻¹)												
Control	0.43	0.41	0.42	16.8	15.7	16.3	1.54	1.51	1.52	80.2	76.9	78.5
30	0.43	0.42	0.43	21.2	20.4	20.8	1.55	1.52	1.54	93.5	89.4	91.4
60	0.44	0.42	0.43	23.0	21.7	22.3	1.57	1.53	1.55	102.4	98.8	100.6
90	0.44	0.43	0.44	23.4	22.2	22.8	1.57	1.55	1.56	105.5	101.5	103.3
SEm ±	0.01	0.01	0.01	0.6	0.5	0.4	0.02	0.02	0.02	1.6	1.3	2.0
CD (p= 0.05)	NS	NS	NS	1.7	1.5	1.1	NS	NS	NS	4.5	3.8	2.9

Table 4: Effect of different varieties and nitrogen levels on total NPK uptake in barley

Treatment	Total N uptake (kg ha ⁻¹)			Total P uptake (kg ha ⁻¹)			Total K uptake (kg ha ⁻¹)		
	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled
Varieties									
BH 902	115.8	110.8	113.3	28.1	26.3	27.2	122.8	118.4	120.6
BH 946	117.9	112.0	114.9	29.8	28.0	28.9	122.7	117.5	120.1
BH 885	94.0	90.1	92.0	25.0	22.9	23.9	106.7	102.2	104.4
DWRB 101	102.2	98.2	100.2	26.5	23.4	25.0	113.5	108.5	111.0
SEm ±	1.8	1.8	1.3	0.6	0.8	0.5	1.6	1.8	1.2
CD (p= 0.05)	5.9	5.9	3.9	1.9	2.6	1.8	5.0	5.7	3.5
Nitrogen levels (kg ha⁻¹)									
Control	78.3	74.0	76.2	22.2	20.1	21.1	97.0	92.6	94.8
30	105.9	101.2	103.5	27.3	24.6	26.0	114.7	109.8	112.2
60	120.0	115.4	117.7	29.2	27.9	28.6	125.4	120.5	123.0
90	125.6	120.5	123.0	30.7	28.0	29.3	128.5	123.7	126.1
SEm ±	1.1	0.9	0.7	0.4	0.6	0.3	1.7	1.4	1.0
CD (p= 0.05)	3.2	2.5	2.0	1.1	1.7	1.0	4.7	4.1	3.1

Conclusion

Based on the findings of this study it may be concluded that compared to two rowed barley varieties BH 885 and DWRB 101, the six rowed barley varieties BH 902 and BH 946 exhibited higher N, P and K content in grain, straw and their total uptake. Different varieties and nitrogen levels significantly enhanced the N content in grain and straw whereas P and K content in grain and straw were not significantly influenced under saline water irrigation. The total N uptake was significantly increased with each increment of nitrogen dose up to 90 kg ha⁻¹, while total P and K uptake was significantly improved only up to 60 kg ha⁻¹.

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