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Original Research Article

Yield, Nutrient Content and Uptake of barley (*Hordium vulgare* L.) as Influenced by Varieties and Precision Nutrient Management Practices

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Keywords

Varieties, Green Seeker, STCR, barley, Yield, NPK content and uptake

A B S T R A C T

A Field experiment was conducted at Instructional Agronomy Farm, Rajasthan College of Agriculture, Udaipur (Rajasthan) during *Rabi* 2014-15 and 2015-16. The experiment was consisted 15 treatment combinations, comprising of three varieties (RD 2035, RD 2552 and RD 2786) and five precision nutrient management practices ($PNMP_1$: RDF – half N, full P_2O_5 and K_2O as basal + remaining half N as top dressing after first irrigation, $PNMP_2$: RDF – half N, full P_2O_5 and K_2O as basal + remaining half N as top dressing before first irrigation, $PNMP_3$: 50 % of recommended N and full P_2O_5 and K_2O as basal + Green Seeker based N top dressing after first irrigation, $PNMP_4$: 70 % of recommended N and full P_2O_5 and K_2O as basal + Green Seeker based N top dressing after first irrigation, $PNMP_5$: Soil Test Crop Response). The experiment was conducted in factorial randomized block design and it was replicated three times. The pooled results showed that significantly higher grain (48.57 q ha^{-1}), straw (70.49 q ha^{-1}), and biological yield (119.06 q ha^{-1}) were recorded in variety RD 2552, while, nutrient content was not affected significantly by varieties. Similarly, STCR based nutrient management gave significantly higher grain (50.64 q ha^{-1}), straw (71.71 q ha^{-1}), and biological yield (122.35 q ha^{-1}) which was at par with $PNMP_4$. Further results showed that, NPK uptake by grain, straw and total uptake was significantly higher in variety RD 2552. $PNMP_4$resulted in significantly higher N content in grain and straw while, P content was highest in $PNMP_5$.Further, $PNMP_5$ and $PNMP_4$ treatment recorded significantly higher NPK uptake by grain, straw and total uptake over rest of the precision nutrient management practices.

Introduction

In recent past, India has made an impressive progress in achieving self-sufficiency in food grain production by elevating productivity of several crops. Among them barley is important crop. It is generally grown in areas where irrigation facilities are limited, as it can tolerate moisture and salt stress to a great extent (Yadav *et al.*, 2003). In India, barley was cultivated on 0.67 m ha area during 2013-14 with 1.83 m t of production at an average productivity status of 27.1 q ha^{-1}. In Rajasthan, barley was cultivated on 0.31 m ha area during 2012-13 with 0.94 m t of production at an average productivity status of 30.4 q ha^{-1} (IIWBR, 2014-15). This suggests an ample scope for growing barley for better yield.

Growing of barley genotypes having wider adaptability and responsive to inputs has

opened a new avenue for exploiting higher grain yield potential (DWR, 2010). Thus identification of high yielding adaptable varieties as per crop growing situation is considered to be the first and foremost step for the development of production technology.

Adequate mineral fertilization is considered to be one of the most important pre-requisite in this respect. Amongst nutrients, nitrogen plays an important role in synthesis of chlorophyll, amino acids and other organic compounds of physiological significance in plant system (Havlin *et al.,* 2003). The timing of N application should be such that it is available close to the time of maximum crop uptake which in cereal grain extends from the start of elongation until heading with peak uptake during flag leaf extension (Bauer *et al.,* 1987). Next to nitrogen, phosphorus is of paramount importance for energy transfer in living cells by mean of high energy phosphate bonds of ATP.

Thus, it plays pivotal role in formation and translocation of carbohydrates, fatty acids, glyceroids and other essential intermediate compounds. It also affects seed plumpness, malting quality and protein content of the barley (Narolia, 2009). Likewise, potassium act as a chemical traffic policeman, root booster, stalk strengthen, food formic, sugar and starch transport, protein builder, breathing regulator, water stretcher and as a disease retarder thus improve grain quality (Brady and Well, 2003)

In Udaipur region, the most acceptable fertilizer recommendation for barley is 60 + 30 + 20 kg N, P_2O_5 and K_2O ha^{-1}. Half of the N and full P_2O_5 and K_2O as basal + remaining half N top dressed either before first irrigation in light sandy soils (Katyal *et al.,* 1987) or after first irrigation on heavy soils (Verma and Srivastava, 1995).

Such recommendation assumes that the need of barley crop for nutrients is constant over time and over large areas. But the needs of barley crop for supplemental nutrients can vary greatly among varieties used, fields, seasons and years as a result of differences in crop growing conditions, soil management, and climate. Hence, the management of nutrients for barley requires a new approach, which enables adjustments in applying N, P and K to accommodate the field specific needs of the barley crop for nutrients.

The novel approach of nitrogen management is Green Seeker which is an integrated optical sensing and application system that measures crop status and variably applies the crop's nitrogen requirements. Using STCR based equations, required quantity of fertilizer nutrients are to be applied. Thus, these fertilizer target yield equations would take care of fertilizer use efficiency, soil use efficiency, farmers' available resources which is not possible with other conventional methods. Thus, it is amply proved that the use of these IPNS recommendations will not only help in saving of fertilizers and improving the economy but also help in improvement of soil health (IISS, 2014).Keeping these facts the present study was undertaken on effect of varieties and precision nutrient management practices on yield, nutrient content and uptake by barley.

Materials and Methods

The experiment was conducted during *rabi* 2014-15 and 2015-16 seasons at the Instructional Farm (Field Number B_1), Department of Agronomy, Rajasthan College of Agriculture, MPUAT, Udaipur. The region falls under NARP agro-climatic zone IV a (Sub- Humid Southern Plains and Arawali Hills) of Rajasthan.

An analysis of weather data reveal that maximum and minimum temperature ranged between 21.4 to 36.6°C and 6.4 to 18.1°C during *rabi*2014-15, respectively. The corresponding temperature fluctuations during second year (2015-16) of experimentation were 23.7 to 36.6°C and 4.0 to 20.0°C, respectively. Mean weekly maximum and minimum relative humidity ranged between 44.3 to 89.7 per cent and 19.0 to 52.0 per cent, respectively during 2014-15 and the corresponding values in the year 2015-16 were 39.7 to 83.6 per cent and 16.9 to 35 per cent. Total rainfall received during the crop season was 7.9 mm during 2014-15 and 0.0 mm in 2015-16, respectively. The soil of experimental site was clay loam in texture slightly alkaline in reaction, low in available nitrogen (287.60 and 288.30 kg ha^{-1}), medium in phosphorus (18.8 and 20.5 kg ha^{-1}) and high in available potassium (338.7 and 346.4 kg ha^{-1}) status during, 2014-15 and 2015-16, respectively.

The experiment was laid out in a RBD (Factorial) with 15 treatment combinations which consisted of three varieties (RD 2035, RD 2552 and RD 2786) and five precision nutrient management levels ($PNMP_1$: RDF – half N, full P_2O_5 and K_2O as basal + remaining half N as top dressing after first irrigation, $PNMP_2$: RDF – half N, full P_2O_5 and K_2O as basal + remaining half N as top dressing before first irrigation, $PNMP_3$: 50 % of recommended N and full P_2O_5 and K_2O as basal + Green Seeker based N top dressing after first irrigation, $PNMP_4$: 70 % of recommended N and full P_2O_5 and K_2O as basal + Green Seeker based N top dressing after first irrigation, $PNMP_5$: STCR (Soil Test Crop Response) were replicated three times. * RDF= 60 kg N, 30 kg P_2O_5, 20 kg K_2O ha^{-1}.

The barley varieties *viz.* RD 2035, RD 2552 and RD 2786 were sown on 19th and 22th November during 2014 and 2015 as per treatments. A uniform seed rate of 100 kg ha^{-1} was used at inter row spacing of 22.5 cm.

Fertilizer treatments were applied to different plots at basal as per treatment through urea, SSP and MOP. N top dressing was done as per treatment through urea. The Green Seeker readings were collected by holding the Green Seeker sensor approximately 0.7–0.9 m above the canopy and walking at a constant speed in all experimental plots. The sensor path was parallel to the seed rows or the beam of light was perpendicular to the seed row. The Green Seeker sensor uses built-in software to calculate NDVI directly. Green seeker based N (46 kg ha^{-1} and 41 kg N ha^{-1}) top dressed with 50 per cent and 70 per cent recommended N as basal, respectively. The fertilizer adjustment equation (STCR) for yield target of 50 q ha^{-1} in NCR of Delhi without FYM is used because the fertilizer adjustment equation for Udaipur region is not available and soil available NPK and Soil type of Udaipur are quite similar to that of NCR Delhi (IISS, 2014)

$FN = 3.69T-0.64SN$, $FP_2O_5 = 2.93T-5.24SP$, $FK_2O = 2.22T- 0.31SK$

Where,

FN= Fertilizer N requirement (kg ha^{-1})

SN= Soil available N (kg ha^{-1})

FP_2O_5 = Fertilizer P_2O_5 requirement (kg ha^{-1})

SP = Soil available P (kg ha^{-1})

FK_2O = Fertilizer K_2O requirement (kg ha^{-1})

SK = Soil available K (kg ha^{-1})

T= yield target (q ha^{-1})

On the basis of these equation, ready reckoners on soil test based fertilizer requirement was (10:95:10 kg N, P_2O_5 and K_2O ha^{-1}) for yield target of 50 q ha^{-1} (IISS, 2014).

The other agronomic practices were carried out as per the package of practices of barley for this zone. The crop was harvested on 24th March 2015 and 19th March 2016, respectively. The observation for yield were taken from the biological yield of each plot and threshed individually, grain yield was recorded from each plot (kg $plot^{-1}$) and converted into q ha^{-1}. The nutrient content in grain and straw were estimated after harvest and further nutrient uptake were calculated from the data on nutrient content and yield.

Results and Discussion

Effect of varieties

Yield

The grain yield of barley is the sum total of different yield contributing factors controlled both genetically and agronomical manipulation. Since barley yield formation is a complex process and interaction governed by complimentary interaction between source (photosynthesis and availability of assimilates) and sink component (storage organs). In the present study, the pooled data revealed that (Table 1) variety RD 2552 recorded significantly higher grain (48.57 q ha^{-1}), straw (70.49 q ha^{-1}) and biological (119.06 q ha^{-1}) yield over RD 2035 and RD 2786. It may be attributed to its higher biomass accumulation due to higher number of tillers and its proper partitioning as evident from equally higher yield attributes. Chakravarty and Kushwah (2007) also reported highest grain yield of variety RD 2552 among three varieties *i.e*. RD 2552, K 560 and DL 88. Variety RD 2035 recorded lowest grain yield due to lower biomass accumulation as a result of least number of tillers, DMA and yield component *viz.*, effective tillers, grain ear^{-1}, grain weight ear and test weight. Similar results were reported by Singh *et al.*, 2013 & Ram and Dhaliwal, 2012.

Nutrient content and uptake

The results (Table 1) revealed that NPK content of grain and PK content of straw were not varied significantly between varieties of barley. While, N content in straw of variety RD 2552 was significantly higher over RD 2035 and RD 2786. These results were in close conformity with Ram and Dhaliwal, 2012.

The improvement in N status of straw under this genotype might be due to their genetic makeup. It is generally believed that plant extracted nutrients are used for maintaining their critical concentration that can be used for plant growth or development structures. Thus greater availability of nitrogen with variety RD 2552 seems to have critical concentration of cellular level and fulfilled their requirement for profuse plant growth. The results are in accordance with the finding of Sirohi (2001).

The pooled nutrient (N, P and K) uptake by grain (77.03, 20.0 and 30.15 kg ha^{-1}), straw (18.48, 10.26 and 92.71 kg ha^{-1}) and total uptake (95.48, 30.26 and 122.85 kg ha^{-1}), respectively were recorded by variety RD 2552 which was significantly higher over variety RD 2035 and RD 2786 (Table 2). As the uptake is a product of the yield and nutrient content, considerable increase in either of components may increase the uptake. Thus improvement in grain, straw yield in both varieties RD 2552 and RD

2786 led to higher nutrient uptake by crop. The results are in close agreement with finding of Singh *et al.,* 2013 and Verma and Sarkar, 2010.

Effect of precision nutrient management practices

Yield

The pooled results of experiment (Table 1) revealed that STCR based nutrient management ($PNMP_5$) significantly improve the grain (50.64 q ha^{-1}), straw (71.71 q ha^{-1}) and biological (122.35 q ha^{-1}) yield which was statistically at par with $PNMP_4$:70 % of recommended N and full P_2O_5 and K_2O as basal + Green Seeker based N top dressing after first irrigation but significantly higher over $PNMP_2$: RDF- half N, full P_2O_5 and K_2O as basal + remaining half N before first irrigation, $PNMP_1$: RDF- half N, full P_2O_5 and K_2O as basal + remaining half N after first irrigation and $PNMP_3$: 50 % of recommended N and full P_2O_5 and K_2O as basal + Green Seeker based N top dressing after first irrigation

Results clearly indicate that nutrient management through STCR increased the yield significantly because based on the soil test and target yield of this zone required quantity of N (10 kg ha^{-1}), P_2O_5 (95 kg ha^{-1}) and K_2O (10 kg ha^{-1}) were applied.

Table.1 Effect of varieties and precision nutrient management practices on yields and NPK content of barley (Pooled)

Treatments	Yield (q ha^{-1})			NPK content (%)					
				N		P		K	
	Grain	Straw	Biological	Grain	Straw	Grain	Straw	Grain	Straw
Varieties									
RD 2035	43.90	64.49	108.39	1.565	0.257	0.4005	0.1423	0.614	1.304
RD 2552	48.57	70.49	119.06	1.584	0.262	0.4106	0.1453	0.621	1.316
RD 2786	46.33	67.22	113.55	1.579	0.259	0.4048	0.1440	0.615	1.313
SEm±	**0.47**	**0.79**	**0.98**	**0.006**	**0.001**	**0.0029**	**0.0009**	**0.002**	**0.004**
CD (P=0.05)	**1.33**	**2.23**	**2.77**	**NS**	**0.002**	**NS**	**NS**	**NS**	**NS**
Nutrient Management									
$PNMP_1$	43.58	64.25	107.83	1.547	0.257	0.3943	0.1416	0.612	1.313
$PNMP_2$	41.06	62.84	103.90	1.519	0.256	0.3882	0.1383	0.617	1.314
$PNMP_3$	45.76	67.06	112.82	1.576	0.260	0.4069	0.1438	0.622	1.321
$PNMP_4$	50.29	71.15	121.44	1.631	0.262	0.4173	0.1466	0.626	1.330
$PNMP_5$	50.64	71.71	122.35	1.609	0.263	0.4197	0.1491	0.607	1.277
SEm±	**0.61**	**1.02**	**1.26**	**0.007**	**0.001**	**0.0037**	**0.0011**	**0.003**	**0.006**
CD (P=0.05)	**1.72**	**2.88**	**3.57**	**0.020**	**0.003**	**0.0106**	**0.0031**	**NS**	**NS**

$PNMP_1$: RDF – half N, full P_2O_5 and K_2O as basal. Remaining half N as top dressing after first irrigation.
$PNMP_2$: RDF – half N, full P_2O_5 and K_2O as basal. Remaining half N as top dressing before first irrigation.
$PNMP_3$: 50 % of recommended N and full P_2O_5 and K_2O as basal + Green Seeker based N top dressing after first irrigation.
$PNMP_4$: 70 % of recommended N and full P_2O_5 and K_2O as basal + Green Seeker based N top dressing after first irrigation.
$PNMP_5$: STCR (Soil Test Crop Response).

Table.2 Effect of varieties and precision nutrient management practices on NPK uptake by barley at harvest (Pooled)

Treatments	NPK uptake (kg ha^{-1})								
	N uptake			P uptake			K uptake		
	Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total
Varieties									
RD 2035	68.98	16.58	85.56	17.65	9.19	26.84	26.99	84.10	111.09
RD 2552	77.00	18.48	95.48	20.00	10.26	30.26	30.15	92.71	122.85
RD 2786	73.29	17.42	90.71	18.77	9.70	28.47	28.52	88.29	116.81
SEm±	**0.75**	**0.21**	**0.82**	**0.25**	**0.13**	**0.29**	**0.32**	**1.12**	**1.23**
CD (P=0.05)	**2.14**	**0.58**	**2.32**	**0.71**	**0.38**	**0.83**	**0.91**	**3.17**	**3.50**
Nutrient Management									
$PNMP_1$	67.39	16.51	83.89	17.18	9.10	26.28	26.70	84.33	111.03
$PNMP_2$	62.47	16.06	78.53	15.94	8.69	24.63	25.34	82.59	107.93
$PNMP_3$	72.12	17.42	89.54	18.65	9.65	28.31	28.50	88.67	117.16
$PNMP_4$	82.04	18.64	100.68	20.99	10.44	31.43	31.49	94.66	126.15
$PNMP_5$	81.44	18.84	100.29	21.27	10.70	31.97	30.73	91.58	122.31
SEm±	**0.97**	**0.27**	**1.06**	**0.32**	**0.17**	**0.38**	**0.41**	**1.44**	**1.59**
CD (P=0.05)	**2.76**	**0.75**	**3.00**	**0.91**	**0.49**	**1.07**	**1.17**	**4.09**	**4.52**

$PNMP_1$: RDF – half N, full P_2O_5 and K_2O as basal. Remaining half N as top dressing after first irrigation.
$PNMP_2$: RDF – half N, full P_2O_5 and K_2O as basal. Remaining half N as top dressing before first irrigation.
$PNMP_3$: 50 % of recommended N and full P_2O_5 and K_2O as basal + Green Seeker based N top dressing after first irrigation.
$PNMP_4$: 70 % of recommended N and full P_2O_5 and K_2O as basal + Green Seeker based N top dressing after first irrigation.
$PNMP_5$: STCR (Soil Test Crop Response).

The higher quantity of phosphorus applied through STCR as compared to conventional application, which increased the root biomass, effective tillers and grains ear^{-1} and test weight due to adequate supply of phosphorus to the crop which ultimately results in increased grain, straw and biological yield. Mohanty *et al.,* (2015) also reported increased yield with nutrient management through STCR in wheat. Similar results were obtained by Mishra *et al.,* (2015) in chickpea.

The significant increase in grain, straw and biological yield due to application of 70% of recommended N and full P_2O_5 and K_2O as basal + Green Seeker based N top dressing appears to be due to proper quantity of N top dressing as per crop need and at proper time had direct positive effect on dry matter production at successive stages and increased photosynthetic efficiency and nutrient uptake. While indirect influences seem to be due to increase in yield attributes. Puniya, *et al.,* (2015) and Mattas *et al.,* (2011) have also documented significant positive influence of nitrogen application on yield attributes and yield of cereals.

Nutrient content and uptake

The pooled results on nutrient content (Table 1) clearly indicated that application of 70 % of recommended N and full P_2O_5 and K_2O as basal + Green Seeker based N top dressing ($PNMP_4$) and STCR based nutrient management ($PNMP_5$) were at par with each other but recorded the significant increase nutrient content in grain (1.631 and 1.609 % N), (0.4173 and 0.4197 % P) and straw (0.262 and 0.263 % N), (0.1466 and 0.1491 % P), respectively. While, K content in grain and straw was not affected

significantly by precision nutrient management practices. At harvest significant increase in nutrient status of grain, straw and total were appears to be on account of their higher concentration in vegetative parts which might have efficiently translocated to reproductive parts. The other probable reason seems to be higher functional activity of roots for longer duration under N and P fertilization might have maintained nutrient status at critical level in vegetative parts as well as their adequate supply to the developing reproductive structures. Similar results were seems by Khan *et al.,* (2008) and Singh *et al.,* (2013).

The pooled results on nutrient uptake (Table 2) clearly indicated that application of 70% of recommended N and full P_2O_5 and K_2O as basal + Green Seeker based N top dressing ($PNMP_4$) and STCR based nutrient management ($PNMP_5$) were at par with each other but both were recorded the significant increase in N uptake by grain (82.04 and 81.44 kg ha^{-1}), straw (18.64 and 18.84 kg ha^{-1}) and total uptake (100.68 and 100.29 kg ha^{-1}), P uptake by grain (20.99 and 21.27 kg ha^{-1}), straw (10.44 and 10.70 kg ha^{-1}) and total uptake (31.43 and 31.97 kg ha^{-1}) and K uptake by grain (31.49 and 30.73 kg ha^{-1}), straw (94.66 and 91.58 kg ha^{-1}) and total uptake (126.15 and 122.31 kg ha^{-1}), respectively.

The nutrient uptake by the crop is largely dependent on biological yield (Total biomass), nutrient and concentration of nutrient in plant at cellular level. The improvement its uptake of nutrients balanced under the timely availability of nutrients for crop uptake could be ascribed to increase is the aforesaid factors contributing to the uptake of nutrients by the crop. The uptake of nutrients usually follows the yield pattern the amount of nutrient taken up per unit amount of biomass production determine the yields, since the essential nutrients are involved in the metabolism of the plants. These findings are in close conformity with those of Imran *et al.,* (2005) and Zebarth *et al.,* (2009).

From results of experiment it may be conclude that growing of high yielding variety RD 2552 resulted in highest yield and nutrient uptake while, precision nutrient management through STCR ($PNMP_5$) or 70 per cent of recommended N and full P_2O_5 and K_2O as basal + Green Seeker based N top dressing ($PNMP_4$) gave the highest yield, nutrient content and uptake by the barley crop.

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