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# Growth, Quality and Yield of Barley (*Hordeum vulgare* L.) as Influenced by Varieties and Precision nutrient Management Practices

**Hansram Mali, Jagdish Choudhary, Amit Kumar, Ajeet Singh and Rahul Chopra**

**Abstract**
The study was conducted to evaluate the effect of barley varieties and precision nutrient management practices on growth, quality and yield at 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.

On pooled basis, varieties RD 2552 and RD 2035 recorded significantly higher net assimilation rate over RD 2786 during 2014-15. During both the years, days to 50 per cent heading and maturity were 8 and 2 days earlier in the variety RD 2035 as compared to RD 2786 and RD 2552. The pooled results showed 10.64 and 4.83 per cent increased grain yield in variety RD 2552 over RD 2035 and RD 2786, respectively.

Application of 70 per cent 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 ($PNMP_5$) significantly improve chlorophyll content at 30 and 60 DAS, protein content in grain. on pooled basis STCR based nutrient management ($PNMP_5$) recorded 23.33, 16.20 and 10.66 per cent higher grain yield over RDF- half N, full $P_2O_5$ and $K_2O$ as basal + remaining half N before first irrigation ($PNMP_2$), RDF- half N, full $P_2O_5$ and $K_2O$ as basal + remaining half N before first irrigation ($PNMP_1$) and 50 per cent of recommended N, full $P_2O_5$ and $K_2O$ as basal + Green Seeker based N top dressing ($PNMP_3$), respectively.

**Keywords:** Barley, Varieties, Precision nutrient management, Chlorophyll content, Protein content, Yield

## 1. Introduction

India has made an impressive progress in achieving self-sufficiency in food grain production in last 40 years by increasing productivity of crops. Among them barley is an important crop. It is generally grown in water scarcity areas or limited irrigation facilities, as it can tolerate moisture and salt stress (Yadav *et al.*, 2003) [1]. This suggests very much scope for growing barley for better yield in Rajasthan.

Growing of barley varieties with wider adaptability and responsive to inputs has opened a new avenue for exploiting higher grain yield potential (DWR, 2010) [2]. Thus identification of high yielding responsive varieties is considered to be the first and most important step for the development of production technology.

The yield potentials of barley varieties are realized to the highest extent when they are grown under optimum agro-climatic environment (Singh *et al.*, 2009) [3]. Optimum fertilization is considered to be one of the important pre-requisite in this respect. Amongst mineral nutrients, nitrogen plays an important role in synthesis of chlorophyll, amino acids and other organic compounds of physiological significance in plant (Havlin *et al.*, 2003) [4]. 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 role in formation and translocation of carbohydrates, fatty acids, glyceroids etc. Likewise, potassium works 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 Weil, 2003) [5].

In Udaipur region, general 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) [6] or after first irrigation on heavy soils (Verma and Srivastava, 1995) [7]. Such recommendation assumes that the need of barley crop for nutrients is constant over time and over locations. But the nutrient needs of barley crop can vary greatly among varieties used, fields, seasons and years as due to differences in crop growing conditions, soil management, and climate. Thus, the management of nutrients for barley requires a new approach, which enables adjustments in applying N, P and K as per field specific needs of the crop for nutrients.

A new approach of nitrogen top dressing is Green Seeker which is an integrated optical sensing and application system that measures crop status and variably applies the crop's nitrogen requirements. Crop reflects near infrared radiation (NIR 800-1000 nm) and thus reflectance is recorded by remote sensing tools *viz.* Green Seeker. This reflectance is correlated with plant N status as shown by the greenness of leaves measured as the Normalized Difference Vegetative Index (NDVI) measured with the ground based sensors (Sui *et al*., 1998) [8]. Yield potential for a crop is identified using a vegetative index known as NDVI (Normalized Difference Vegetative Index) and an environmental factor. This sensor technology was applied to predict potential yield in-season and prescribe the accurate amount of top dress N (Raun, *et al*., 2001 [9], Wood *et al*., 2003 [10] and Jiang *et al*., 2007 [11]). Another novel approach is STCR involves science based principals for guiding the judicious and efficient application of fertilizer as and when needed by crop hence making synergy for nutrient demand and supply under certain production system. But, soil testing has the major bottleneck to realized potential benefits of this recent and improved approach (Majumdar *et al*., 2012) [12]. On the basis of soil test values and target yield, we can get fertilizer nutrient dose to be applied for that particular type of soil, variety and season. Using IPNS based equations, required quantity of fertilizer nutrients are to be applied. Thus, it is amply proved that the use of these IPNS recommendations will not only save fertilizers and improving the economy but also improve soil health (IISS, 2014) [13]. Keeping these facts in mind the research study was undertaken on growth, quality and yield of barley as influenced by varieties and precision nutrient management practices.

## 2. Material and Methods

The experiment was conducted during *rabi* 2014-15 and 2015-16 seasons at the Instructional Farm, Department of Agronomy, Rajasthan College of Agriculture, MPUAT, Udaipur, An analysis of weather parameters 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 and medium in phosphorus and high in available potassium status.

The experiment was laid out in a RBD (Factorial) with 15 treatment combinations which consisted of fifteen treatment combinations (three of varieties and five levels of precision nutrient management practices). Details of treatments along with their symbols are depicted in Table 1

**Table 1:** Details of treatments with their symbols

| | Treatment | Symbols |
|---|---|---|
| | **A. Varieties** | |
| i. | RD 2035 | $V_1$ |
| ii. | RD 2552 | $V_2$ |
| iii. | RD 2786 | $V_3$ |
| | **B. Precision Nutrient Management Practices** | |
| i. | Recommended dose of fertilizer – half N, full $P_2O_5$ and $K_2O$ as basal. Remaining half N as top dressing after first irrigation | $PNMP_1$ |
| ii. | Recommended dose of fertilizer – half N, full $P_2O_5$ and $K_2O$ as basal. Remaining half N as top dressing before first irrigation | $PNMP_2$ |
| iii. | 50 % of recommended N and full $P_2O_5$ and $K_2O$ as basal + Green Seeker based N top dressing after first irrigation | $PNMP_3$ |
| iv. | 70 % of recommended N and full $P_2O_5$ and $K_2O$ as basal + Green Seeker based N top dressing after first irrigation | $PNMP_4$ |
| v. | STCR (Soil Test Crop Response) | $PNMP_5$ |

**Note:** Recommended dose of fertilizer: 60 kg N, 30 kg $P_2O_5$, 20 kg $K_2O$ $ha^{-1}$

The barley varieties 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.

Fertilizers 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. 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 was 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) [13].

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

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) [13].

Net Assimilation Rate (NAR) was computed between 30-60 and 60-90 DAS by the following formulae. It directly indicates the rate of net photosynthesis. It is expressed as g of dry matter production $m^{-2}$ of leaf area in a day. For calculating NAR, leaf area of individual plant was used.

$$\text{NAR (g m}^{-2}\text{ day}^{-1}) = \frac{(W_2 - W_1)(\text{Log}_e L_2 - \text{Log}_e L_1)}{(t_2 - t_1)(L_2 - L_1)}$$

Where,

$L_1$ and $W_1$ are leaf area and dry weight of plants at time $t_1$.

Whereas, $L_2$ and $W_2$ are leaf area and dry weight of plants at time $t_2$.

Date on which 50 per cent of plants in each experimental unit attained heading initiation were noted and days required for heading was calculated. When plants of the crop turned yellow and fully dried, date was recorded in every plot and days to maturity were counted.Total chlorophyll content of leaves at 30 and 60 DAS were analysed by collecting fresh leaf samples from the crop. These samples were immediately taken to lab, washed with distilled water and dried with blotting paper. A sample of 100 mg was taken from each experimental unit in mortar and pestle. The sample was grinded well with 80 percent acetone and spell in a 25 ml volumetric flask. The volume was raised up to the mark and absorbance was recorded at 645-663 nm using spectrophotometer. The total chlorophyll content was computed by following formula

$$\text{Total chlorophyll (mg g}^{-1}\text{ fresh weight of leaf)} = \frac{20.2(A\ 645) + 8.02\ (A\ 663)}{a \times 1000 \times W} \times V$$

Where,

a = Length of light path in cell (1 cm)

V = Volume of extract and

W = Weight of leaf sample (g)

For protein content procedure suggested by Lowry *et al.* (1951) [14] was used for determination of protein content in grain. For reducing, non-reducing and total sugar content the Lane and Eynon method described by Ruck (1963) [15] was used to estimate reducing, non-reducing and total sugar in the grain. The rain yield was recorded from each plot (kg plot$^{-1}$) and converted into q ha$^{-1}$

## 3. Results and Discussion

### 3.1. Effect of Varieties

Varieties of barley exert no significant effect on the net assimilation rate between 30 to 60 DAS and 60 to 90 DAS in either year of experimentation. While, on pooled basis, varieties RD 2552 and RD 2035 recorded significantly higher net assimilation rate over RD 2786 during 2014-15. During both the years, days to 50 per cent heading and maturity were 8 and 2 days earlier in the variety RD 2035 as compared to RD 2786 and RD 2552 (Table 4). At the same time days to 50 per cent heading and maturity were 5 days earlier in variety RD 2552 compared to RD 2786. Same trend also observed on pooled basis. The difference in days to 50 per cent heading and maturity of different varieties is due to genetic characteristics of variety. These results confirm the findings of Fishar *et al.* (2005) [16] and Bakht *et al*. (2007) [17].

Across the years and on pooled basis, barley varieties failed to record perceptible variation in total chlorophyll content at 30 and 60 DAS. Varieties had no significant effect on the protein content, reducing sugar, non-reducing sugar and total sugar content of grain during both the years of study and on pooled basis. Grain yield of barley was influenced significantly by varieties during both the years of experimentation. During both the years of experimentation, variety RD 2552 resulted in significant higher grain yield over RD 2035. However, during first year grain yield of RD 2786 and RD 2035 were at par with each other and during second year RD 2552 and RD 2786 were at par with each other (Table 7). The pooled results showed 10.64 and 4.83 per cent increased grain yield in variety RD 2552 over RD 2035 and RD 2786, respectively. Further on pooled basis, all three varieties were statistically significant with each other. 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 higher yield of barley variety RD 2552 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 *i.e.* effective tillers, ear length, grains ear$^{-1}$, grains weight and test weight. Chakravarty and Kushwah (2007) [18] 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 components *viz.*, effective tillers, grain ear$^{-1}$, grain weight ear$^{-1}$ and test weight.

### 3.2. Effect of Precision Nutrient Management Practices

The net assimilation rate of barley between 30-60 and 60-90 DAS was not influenced significantly by different nutrient management practices during 2014-15 and 2015-16. While, on pooled basis, STCR based nutrient management ($PNMP_5$) recorded significantly higher net assimilation rate over RDF- half N, full $P_2O_5$ and $K_2O$ as basal + remaining half N after first irrigation ($PNMP_1$) which was at par with rest of the treatments. No significant variation registered in days to 50 per cent flowering and maturity due to nutrient management practices in both the years of study and on pooled basis.

The plant analysis at harvest (Table 5) clearly indicated that application of 70 per cent 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 ($PNMP_5$) significantly improve chlorophyll content at 30 and 60 DAS, protein content in grain. The chlorophyll is the most important compound that contain N in their structure which carried out photosynthesis. The chlorophyll content in leaves increased significantly probably due to better uptake of nitrogen and phosphorus from the soil in proper quantity (Prasad, 2007) [19].

On pooled basis, 70 per cent of recommended N, full $P_2O_5$ and $K_2O$ as basal + Green Seeker based N top dressing ($PNMP_4$) recorded 7.39, 5.50 and 3.56 per cent higher protein content in grain over RDF- half N, full $P_2O_5$ and $K_2O$ as basal + remaining half N before first irrigation ($PNMP_2$), RDF- half N, full $P_2O_5$ and $K_2O$ as basal + remaining half N after first irrigation ($PNMP_1$) and 50 per cent of recommended N, full $P_2O_5$ and $K_2O$ as basal + Green Seeker based N top dressing ($PNMP_3$), respectively (Table 6). Protein consists of amino acids. Nitrogen is critical for protein synthesis as a part of basic structure of all amino acids (Brown *et al*., 2005) [20]. In addition, nitrogen is also found in chlorophyll, the green coloring matter of leaves (Bajavic and Markovic, 2009) [21]. Chlorophyll enables the plant to transfer energy from sunlight by photosynthesis. Therefore, the nitrogen supply to the plant will influence the amount of protein, protoplasm and chlorophyll formed. In turn, this influences cell size, leaf area and photosynthetic activity. Various authors have reported increase in protein content Mattas *et al.* (2011) [22] and Abedi *et al*. (2011) [23].

The improvement in protein content (Table 4.17) under the influence of N and P well known fact that N is a constituent of protein, enzymes and chlorophyll and participate in several biochemical processes for the metabolism of carbohydrate, fat and protein in plant system. The regression studies (Table 2) also affirmed profound influence of N (r = 1.00**) and P (r = 0.874**) content of grain and protein content. These results are in close agreement with finding of Lafond *et al*. (2009) [24], Kumar *et al*. (2011) [25] and Alazmani (2015) [26]. Different precision nutrient management practices did not influence the reducing, non-reducing and total sugar content in grain over the years of study and on pooled basis.

In both the years of study and on pooled basis, compared to STCR based nutrient application ($PNMP_5$) and 70 per cent of recommended N, full $P_2O_5$ and $K_2O$ as basal + Green Seeker based N top dressing ($PNMP_4$), significant reduction in grain yield was brought about by RDF- half N, full $P_2O_5$ and $K_2O$ as basal + remaining half N before first irrigation ($PNMP_2$), RDF- half N, full $P_2O_5$ and $K_2O$ as basal + remaining half N before first irrigation ($PNMP_1$) and 50 per cent of recommended N, full $P_2O_5$ and $K_2O$ as basal + Green Seeker based N top dressing ($PNMP_3$). Further, on pooled basis STCR based nutrient management ($PNMP_5$) recorded 23.33, 16.20 and 10.66 per cent higher grain yield over RDF- half N, full $P_2O_5$ and $K_2O$ as basal + remaining half N before first irrigation ($PNMP_2$), RDF- half N, full $P_2O_5$ and $K_2O$ as basal + remaining half N before first irrigation ($PNMP_1$) and 50 per cent of recommended N, full $P_2O_5$ and $K_2O$ as basal + Green Seeker based N top dressing ($PNMP_3$), respectively (Table 5). The significant increase in grain yield as a result of STCR based nutrient application ($PNMP_5$) could be ascribed to the fact that yield of crop is resultant of several component characteristics which are interrelated. Mohanty *et al*, (2015) [27] also reported increased yield with nutrient management through STCR in wheat. Similar results were obtained by Mishra *et al*. (2015) [28] in chickpea and Gautam *et al*. (2013) [29] in pea.

With precise N application effective tillers $m^{-1}$ row length, grain $ear^{-1}$ and ear weight were increased due to proper nutrition, better vegetative growth which led to higher reproductive growth and improved the productivity of individual ear. This ultimately results in significantly increased grain yield of barley (Table 7). ). Abedi *et al.* (2011) [23], Mattas *et al.* (2011) [22] and Puniya, *et al*. (2015) [30] have also documented significant positive influence of nitrogen application on yield of cereals.

**Table 2:** Correlation coefficient and regression equation showing relationship between independent (X) and dependent (Y) variables on the mean basis

| Dependent variables (Y) | Independent variable (X) | Correlation coefficient (r) | Regression line Y = a + bX |
|---|---|---|---|
| Grain yield (q $ha^{-1}$) | Protein content in grain (%) | 0.856** | Y = -94.89 + 14.37X |
| Protein content in grain (%) | N content in grain (%) | 1.00** | Y = 1.00 + 6.244X |
| Protein content in grain (%) | P content in grain (%) | 0.874** | Y = 0.764 + 16.76X |

**Table 3:** Effect of varieties and precision nutrient management practices on NAR of barley

| Treatments | NAR (g $m^{-2}$ $day^{-1}$) | | | | | |
|---|---|---|---|---|---|---|
| | Between 30-60 DAS | | | Between 60-90 DAS | | |
| | 2014-15 | 2015-16 | Pooled | 2014-15 | 2015-16 | Pooled |
| **Varieties** | | | | | | |
| RD 2035 | 0.0298 | 0.0323 | 0.0310 | 0.1098 | 0.1039 | 0.1069 |
| RD 2552 | 0.0300 | 0.0320 | 0.0310 | 0.1104 | 0.1009 | 0.1057 |
| RD 2786 | 0.0278 | 0.0304 | 0.0291 | 0.1134 | 0.1104 | 0.1119 |
| SEm ± | 0.0008 | 0.0009 | 0.0006 | 0.0028 | 0.0033 | 0.0022 |
| CD (P=0.05) | NS | NS | 0.0017 | NS | NS | NS |
| **Nutrient Management** | | | | | | |
| $PNMP_1$ | 0.0274 | 0.0322 | 0.0298 | 0.1036 | 0.0981 | 0.1009 |
| $PNMP_2$ | 0.0274 | 0.0311 | 0.0293 | 0.1106 | 0.1058 | 0.1082 |
| $PNMP_3$ | 0.0310 | 0.0331 | 0.0320 | 0.1120 | 0.1090 | 0.1105 |
| $PNMP_4$ | 0.0293 | 0.0311 | 0.0302 | 0.1109 | 0.1059 | 0.1084 |
| $PNMP_5$ | 0.0306 | 0.0304 | 0.0305 | 0.1190 | 0.1066 | 0.1128 |
| SEm ± | 0.0010 | 0.0012 | 0.0008 | 0.0036 | 0.0043 | 0.0028 |
| CD (P=0.05) | NS | NS | NS | NS | NS | .0080 |

$PNMP_1$: 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 4:** Effect of varieties and precision nutrient management practices on days to 50 per cent flowering and maturity of barley

| Treatments | Days to 50 per cent heading | | | Days to 50 per cent maturity | | |
|---|---|---|---|---|---|---|
| | 2014-15 | 2015-16 | Pooled | 2014-15 | 2015-16 | Pooled |
| **Varieties** | | | | | | |
| RD 2035 | 63 | 61 | 62 | 108 | 109 | 108 |
| RD 2552 | 65 | 63 | 64 | 114 | 114 | 114 |
| RD 2786 | 71 | 69 | 70 | 115 | 115 | 115 |
| SEm ± | 0.3 | 0.3 | 0.2 | 0.5 | 0.6 | 0.4 |
| CD (P=0.05) | 1.0 | 0.9 | 0.7 | 1.4 | 1.6 | 1.1 |
| **Nutrient Management** | | | | | | |
| $PNMP_1$ | 66 | 64 | 65 | 112 | 112 | 112 |
| $PNMP_2$ | 66 | 64 | 65 | 112 | 113 | 113 |
| $PNMP_3$ | 67 | 65 | 66 | 112 | 113 | 112 |

| | | | | | | |
|---|---|---|---|---|---|---|
| $PNMP_4$ | 66 | 64 | 65 | 112 | 113 | 113 |
| $PNMP_5$ | 67 | 65 | 66 | 112 | 112 | 112 |
| SEm ± | 0.4 | 0.4 | 0.3 | 0.6 | 0.7 | 0.5 |
| CD (P=0.05) | NS | NS | NS | NS | 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 5:** Effect of varieties and precision nutrient management practices on total chlorophyll content of barley

| Treatments | Total chlorophyll content (mg $g^{-1}$ fresh weight) | | | | | |
|---|---|---|---|---|---|---|
| | At 30 DAS | | | At 60 DAS | | |
| | 2014-15 | 2015-16 | Pooled | 2014-15 | 2015-16 | Pooled |
| **Varieties** | | | | | | |
| RD 2035 | 1.408 | 1.413 | 1.410 | 2.201 | 2.261 | 2.231 |
| RD 2552 | 1.425 | 1.409 | 1.417 | 2.197 | 2.268 | 2.232 |
| RD 2786 | 1.423 | 1.407 | 1.415 | 2.207 | 2.245 | 2.226 |
| SEm ± | 0.008 | 0.008 | 0.006 | 0.013 | 0.012 | 0.009 |
| CD (P=0.05) | NS | NS | NS | NS | NS | NS |
| **Nutrient Management** | | | | | | |
| $PNMP_1$ | 1.382 | 1.364 | 1.373 | 2.151 | 2.226 | 2.188 |
| $PNMP_2$ | 1.367 | 1.356 | 1.361 | 2.129 | 2.206 | 2.167 |
| $PNMP_3$ | 1.419 | 1.429 | 1.424 | 2.222 | 2.270 | 2.246 |
| $PNMP_4$ | 1.476 | 1.454 | 1.465 | 2.251 | 2.297 | 2.274 |
| $PNMP_5$ | 1.450 | 1.445 | 1.447 | 2.256 | 2.292 | 2.274 |
| SEm ± | 0.010 | 0.011 | 0.007 | 0.016 | 0.016 | 0.011 |
| CD (P=0.05) | 0.029 | 0.031 | 0.021 | 0.047 | 0.046 | 0.032 |

$PNMP_1$: 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 6:** Effect of varieties and precision nutrient management practices on protein content, reducing, non-reducing and total sugar of grain

| Treatments | Protein content (%) | | | Sugar content (%) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Reducing | | | Non reducing | | | Total | | |
| | 2014-15 | 2015-16 | Pooled | 2014-15 | 2015-16 | Pooled | 2014-15 | 2015-16 | Pooled | 2014-15 | 2015-16 | Pooled |
| **Varieties** | | | | | | | | | | | | |
| RD 2035 | 9.80 | 9.72 | 9.76 | 0.991 | 0.982 | 0.987 | 1.978 | 2.005 | 1.992 | 2.969 | 2.987 | 2.978 |
| RD 2552 | 9.92 | 9.83 | 9.87 | 0.980 | 0.988 | 0.984 | 1.981 | 1.918 | 1.950 | 2.961 | 2.906 | 2.934 |
| RD 2786 | 9.88 | 9.81 | 9.85 | 0.986 | 0.990 | 0.988 | 1.973 | 1.985 | 1.979 | 2.959 | 2.975 | 2.967 |
| SEm ± | 0.04 | 0.05 | 0.03 | 0.006 | 0.006 | 0.004 | 0.016 | 0.027 | 0.016 | 0.018 | 0.029 | 0.017 |
| CD (P=0.05) | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |
| **Nutrient Management** | | | | | | | | | | | | |
| $PNMP_1$ | 9.72 | 9.57 | 9.64 | 0.990 | 0.998 | 0.994 | 1.987 | 1.989 | 1.988 | 2.977 | 2.987 | 2.982 |
| $PNMP_2$ | 9.54 | 9.39 | 9.47 | 0.987 | 0.983 | 0.985 | 1.966 | 2.017 | 1.991 | 2.952 | 3.000 | 2.976 |
| $PNMP_3$ | 9.84 | 9.80 | 9.82 | 0.970 | 0.977 | 0.973 | 1.977 | 1.879 | 1.928 | 2.947 | 2.856 | 2.901 |
| $PNMP_4$ | 10.18 | 10.15 | 10.17 | 0.992 | 0.981 | 0.987 | 1.982 | 1.980 | 1.981 | 2.974 | 2.961 | 2.968 |
| $PNMP_5$ | 10.05 | 10.02 | 10.03 | 0.990 | 0.994 | 0.992 | 1.977 | 1.983 | 1.980 | 2.967 | 2.978 | 2.972 |
| SEm ± | 0.06 | 0.07 | 0.05 | 0.007 | 0.007 | 0.005 | 0.020 | 0.035 | 0.020 | 0.023 | 0.037 | 0.022 |
| CD (P=0.05) | 0.17 | 0.20 | 0.13 | NS | NS | NS | NS | NS | NS | NS | 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 7:** Effect of varieties and precision nutrient management practices on yield of barley

| Treatments | Grain Yield (q $ha^{-1}$) | | |
|---|---|---|---|
| | 2014-15 | 2015-16 | Pooled |
| **Varieties** | | | |
| RD 2035 | 44.97 | 42.83 | 43.90 |
| RD 2552 | 49.43 | 47.71 | 48.57 |
| RD 2786 | 46.78 | 45.88 | 46.33 |
| SEm ± | 0.64 | 0.69 | 0.47 |

| | | | |
|---|---|---|---|
| CD (P=0.05) | 1.87 | 1.99 | 1.33 |
| **Nutrient Management** | | | |
| $PNMP_1$ | 45.38 | 41.77 | 43.58 |
| $PNMP_2$ | 41.68 | 40.43 | 41.06 |
| $PNMP_3$ | 45.79 | 45.73 | 45.76 |
| $PNMP_4$ | 51.13 | 49.45 | 50.29 |
| $PNMP_5$ | 51.31 | 49.97 | 50.64 |
| SEm $\pm$ | 0.83 | 0.89 | 0.61 |
| CD (P=0.05) | 2.41 | 2.57 | 1.72 |

$PNMP_1$: 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).

## 4. Conclusion

On the basis of the result emanated from present investigation conducted during *rabi* season 2014-15 and 2015-16, it is concluded that under agro-climatic conditions of South-East Rajasthan, barley varieties had no significant effect on NAR, chlorophyll, protein and sugar content of barley. 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 total chlorophyll, protein content in grain and yield.

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