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# RESEARCH ARTICLE

## REPERCUSSIONS OF BARLEY (*HORDEUM VULGARE* L.)VARIETIES ON GROWTH, YIELD ATTRIBUTES AND YIELD UNDER VARYING PRECISION NUTRIENT MANAGEMENT PRACTICES

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**Abstract:** 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. Pooled results showed that dry matter accumulation, CGR, RGR, effective tillers, grains ear-1, test weight and grain yield were recorded significantly higher in variety RD 2552 over RD 2035 and RD 2786. Similarly, STCR based nutrient management ($PNMP_5$) gave significantly higher dry matter accumulation, CGR, RGR, effective tillers, grains ear-1, test weight and grain yield (50.64 q $ha^{-1}$) which was at par with application of 70 per cent of recommended N and full $P_2O_5$ and $K_2O$ as basal + Green Seeker based N top dressing ($PNMP_4$) while, significantly higher over rest of the nutrient management treatments.

**Keywords:** Barley, Green Seeker, STCR, Yield, Dry matter, CGR, RGR

### INTRODUCTION

Barley (*Hordeum vulgare* L.) is a valuable crop because it is grown for several purposes such as food and processed food products for human being and feed for cattle and poultry birds. Barley grain is also valued for smothering and cooling effect on the human body for easy digestion. Besides these conventional uses, it is an important industrial crop because it is used as raw material for beer, whisky and brewing industries. Each 100 g of barley grain comprises 10.6 g protein, 2.1 g fat, 64.0 g carbohydrate, 50.0 mg calcium, 6.0 mg iron, 31 mg vitamin $B_1$, 0.10 mg vitamin $B_2$ and 50 µg folate (Vaughan *et al*., 2006). 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).

Growing of barley genotypes having wider adaptability and responsive to inputs has opened a new avenue for exploiting higher grain yield potential. 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,

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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 or after first irrigation on heavy soils. 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. Keeping these facts the present study was undertaken on repercussions of varieties and precision nutrient management practices on growth, yield attributes and yield of barley.

## MATERIALS 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. 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 $19^{th}$ and $22^{th}$ 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, DAP 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 (10:80:10 kg N, $P_2O_5$ and $K_2O$ $ha^{-1}$) for yield target of 50 q $ha^{-1}$. The other agronomic practices were carried out as per the package of practices of barley for this zone. The crop was harvested on $24^{th}$ March 2015 and $19^{th}$ March 2016, respectively. The observation for dry matter accumulation were taken by cutting of plants form 0.25 $m^{-1}$ row length at respective stages, effective tillers was manually counted at 50 per cent maturity, grains $ear^{-1}$ counted from 5 randomly selected ears and their mean were used for calculation, test weight were calculated by counting 1000 seeds and their weight used as test weight and grain yield was recorded from each plot (kg $plot^{-1}$) and converted into q $ha^{-1}$.

## RESULTS AND DISCUSSION

### a. Effect of varieties

**Growth attributes**

During both the years and in pooled basis, results (Table 1 and 2) showed that variety RD 2552 recorded significant increases in the growth parameters *viz*. dry matter accumulation at 30, 60, 90 DAS and at harvest, crop growth rate (between 30-60 and 60-90 DAS) and relative growth rate (between 30-60 and 60-90 DAS) over the rest of varieties.

The growth and yield potential of crop variety are the outcome of genomic, environment and agronomic interactions. Since, all the varieties grown under identical agronomic environment, the observed variations in overall growth of varieties could be ascribed to their genetic capabilities to exploit available resources for their growth and external environmental factors to which these were exposed during their life cycle. Marked variations in various growth characters of varieties were also observed by (Sial *et al*., 2010 and Singh *et al*., 2013).

The significantly higher dry matter accumulation at different growth stages in barley variety RD 2552 might be due to more number of tillers and vigorous growth of this variety as compared to other. Verma and Singh (1989) and Alam and Haider (2006) also reported similar results in barley. CGR is regarded as the most meaningful growth function, since it represents the net results of photosynthesis, respiration and canopy area interaction. As noted by Williams et al. (1965), CGR is also representative of the most common agronomic measurement such as yield of dry matter per unit land area. A significant and positive correlation was also recorded in between CGR between 30-60 DAS and dry matter accumulation 60 DAS (r = 0.992**), CGR between 60-90 DAS and dry matter accumulation 90 DAS (r = 0.959**) and RGR between 30-60 DAS and dry matter accumulation 60 DAS (r = 0.823**). The variety which has capacity to accumulate higher dry matter per unit area resulted in higher crop growth rate (Alam and Haider, 2006). Higher Relative growth rate in variety RD 2552 could be due to better assimilatory system and higher accumulation of assimilates. These results agree with the findings of Jat and Singhi (2003) and Hussain *et al*. (2012).

**Yield attributes and yield**

The number of effective tillers $m^{-1}$ row length (86.15) was significantly higher in variety RD 2552 as compared to RD 2035 and RD 2786 (Table 3). This might be due to more tillering ability and higher growth of variety RD 2552. Alam *et al*. (2005) reported significant difference for number of effective tillers $m^{-1}$ row length. The number of grains $ear^{-1}$(48.13) also higher in this variety. It might be due to the reason that RD 2552 had higher ear length which contains higher grains as compared to other varieties. Raouf *et al*. (1983) and Chun *et al*. (2000) also reported varietal difference in grains $ear^{-1}$. The test weight of variety RD 2552 was highest which was significantly higher as compared to variety RD 2035 while at par with RD 2786. This might be due to the fact that RD 2552 variety has bolder grains compared to other varieties. The suitable genetic behaviour of RD 2552 variety with environmental factors which, may lead to an increase in photosynthesis process and accumulation of carbohydrates in grains to produce heavy grains and consequently increased the test weight. Similar results were also reported by Alam *et al*., 2007, Ali, 2011 and Ram and Dhaliwal, 2012.

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, grains $ear^{-1}$ and test weight (Table 3). 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 components *viz*., effective tillers, grain $ear^{-1}$ and test weight. A significant and positive correlation was also recorded in between grain yield and yield attributing characters *viz*. effective tillers (r = 0.543*), test weight (r = 0.890**) grain $ear^{-1}$(r = 0.882**) and DMA at harvest (r =0.718**). Similar results were reported by Shirpurkar *et al*. (2008), Ram and Dhaliwal, 2012 and Singh *et al*., 2013.

### b. Effect of precision nutrient management practices

**Growth attributes**

The results of the investigation (Table 1 and 2) reflect that that precision nutrient management through STCR ($PNMP_5$) recorded the maximum growth attributes *viz*. dry matter accumulation (60, 90 DAS and harvest), crop growth rate and relative growth rate (between 30-60 and 60-90 DAS) which were significantly higher over rest of the nutrient management practices. While, dry matter accumulation at 30 DAS was significantly higher with application of 70 per cent of recommended N and full $P_2O_5$ and $K_2O$ as basal + Green Seeker based N top dressing ($PNMP_4$).

In general the overall improvement in growth of barley crop with the addition of N, $P_2O_5$ and $K_2O$ could be ascribed to pivotal role of these nutrients in several physiological and biochemical processes which are of vital importance for development of the plants. It is well established that nitrogen is involved in the synthesis of amino acids (Tandon, 2007). The most important role of N in the plant is its presence in the structure of protein, the important building substances from which the living material or protoplasm of every cell is made (Blumentnal*et al*., 2000 and 2008). This is clearly evinced from the fact that amongst mineral nutrients, N is the most indispensable for growth and development of plants as is fundamental constituents of all living matter *i.e.* proteins and nucleic acid etc. Under STCR based nutrient application $P_2O_5$ was applied 80 kg $ha^{-1}$ which is 50 kg higher than RDF (30 kg). This increased phosphorus ascribed to increased growth. Similar results of higher growth through STCR were also reported by Mohanty *et al*, (2015).

It is an established fact that among nutrients, phosphorus is most important for exploiting genetic potential of crop for its growth and development (Tisdale et al., 2003). In addition to its structural role in nucleic acid, nucleotide and phospholipids, phosphorus has essential regulatory functions in photosynthesis and carbohydrate metabolism in its formation of pyrophosphate bonds which allows energy transfer and is required for all biochemical process which require energy. So, it is considered as energy currency with in plant system (Tisdale et al., 2003). An adequate supply of available phosphorus is required by plants at early growth stage because at this stage rate of metabolism and cell division is high and limited root system which is not capable of drawing sufficiently phosphorus from soil.

The greater availability of N under Green Seeker based top dressing at the time of tillering and their utilization by plants seems to have promoted vegetative growth by promoting greater meristematic activities *i.e.* increase in cell number and their elongation. This might have led in formation and survival of greater number of tillers unit $area^{-1}$ under its influence. Similar results were obtained by Alam and Haider (2006), Singh *et al*. (2013).

**Yield attributes and Yield**

Results (Table 3) 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 the yield attributes (effective tillers $m^{-1}$ row length, ear length, grains $ear^{-1}$ and test weight) and yield as compared to other nutrient management practices (Table 3). It is established fact that photosynthesis together with availability of assimilates (source) and storage organs (sink) exert an important regulative function on complex process of yield formation. The regulatory function of phosphorus in photosynthesis and carbohydrate metabolism of leaves can be considered to be the important factor that limits plant growth particularly during reproductive phase. The level of phosphorus during this period regulates starch/sucrose ratio in the leaves and reproductive organs (Giaquinta and Quebedeaux, 1980).

Results clearly indicate that nutrient management through STCR ($PNMP_5$) increased the yield attributes and yield significantly because based on the soil test and target yield of this zone required quantity of N (10 kg $ha^{-1}$), $P_2O_5$ (80 kg $ha^{-1}$) and $K_2O$ (10 kg $ha^{-1}$) were applied. 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. Due to high phosphorus more assimilates are transferred into the storage organ (seeds) ultimately increase the number of grains $ear^{-1}$ and test weight. 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 (Table 3). Mohanty *et al*, (2015) also reported increased yield with nutrient management through STCR in wheat. Similar results were obtained by researchers in chickpea and Gautam *et al*. (2013) in pea. The application of 70 per cent of recommended N and full $P_2O_5$ and $K_2O$ as basal + Green Seeker based N top dressing ($PNMP_4$), provide the nitrogen to the crop in greater amount at the time of sowing and remaining N to the standing crop according to the actual need of crop which facilitate in improvement in plant growth, vigour and production of sufficient photosynthesis through increased leaf area by higher tillering. Botella *et al*, (1993) also reported stimulation of tillering with optimal application of N might be due to its positive effect on cytokinin synthesis. A faster growth rate in terms of increased dry matter production with the precise application of nitrogen might have played a significant role in production of higher number of tillers and their development through reduction in competition for photosynthates with mother shoots and thus helped in survival till harvest. Increase in the number of spiklets and proper development of individual components of ear productivity *viz.*grains $ear^{-1}$ and test weight might have been due to increased nitrogen content and nitrogen along with greater availability of photosynthates due to application of nitrogen. The combined effect of optimum amount of fertilizer at right time has significant effect on ear length (Abebe and Abebe, 2016). Alcoz *et al*. (1993) also reported higher spike length by application of N fertilizer at one month later of sowing. Under the present investigation, profound effect of nitrogen on crop growth and subsequently on yield attributes and yield seems to be due to maintenance of congenial nutritional environment in barley plants on account of their greater availability from soil at the time of greatest demand.

**Table 1.** Effect of varieties and precision nutrient management practices on dry matter accumulation of barley

| Treatments | Dry matter accumulation (g) 0.25 $m^{-1}$ row length | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 30 DAS | | | 60 DAS | | | 90 DAS | | | At harvest | | |
| | 2014-15 | 2015-16 | Pooled | 2014-15 | 2015-16 | Pooled | 2014-15 | 2015-16 | Pooled | 2014-15 | 2015-16 | Pooled |
| **Varieties** | | | | | | | | | | | | |
| RD 2035 | 3.07 | 3.04 | 3.05 | 12.26 | 12.96 | 12.61 | 51.29 | 46.08 | 48.68 | 77.29 | 72.35 | 74.82 |
| RD 2552 | 3.36 | 3.35 | 3.35 | 15.06 | 16.06 | 15.56 | 56.15 | 53.55 | 54.85 | 88.19 | 81.66 | 84.93 |
| RD 2786 | 3.36 | 3.24 | 3.30 | 14.67 | 14.83 | 14.75 | 51.40 | 48.98 | 50.19 | 86.63 | 77.64 | 82.14 |
| SEm± | **0.05** | **0.06** | **0.04** | **0.17** | **0.20** | **0.13** | **0.77** | **0.78** | **0.55** | **1.74** | **1.35** | **1.10** |
| CD (P=0.05) | **0.16** | **0.17** | **0.11** | **0.50** | **0.59** | **0.38** | **2.23** | **2.26** | **1.55** | **5.05** | **3.90** | **3.12** |
| **Nutrient Management** | | | | | | | | | | | | |
| $PNMP_1$ | 3.06 | 3.19 | 3.13 | 13.70 | 14.13 | 13.92 | 50.09 | 46.80 | 48.44 | 84.42 | 74.44 | 79.43 |
| $PNMP_2$ | 3.15 | 3.16 | 3.15 | 12.86 | 13.60 | 13.23 | 48.42 | 46.29 | 47.36 | 78.58 | 74.21 | 76.39 |
| $PNMP_3$ | 3.47 | 3.21 | 3.34 | 13.83 | 14.27 | 14.05 | 52.54 | 48.28 | 50.41 | 81.74 | 74.34 | 78.04 |
| $PNMP_4$ | 3.45 | 3.53 | 3.49 | 14.59 | 15.01 | 14.80 | 54.10 | 51.72 | 52.91 | 87.15 | 80.91 | 84.03 |
| $PNMP_5$ | 3.17 | 2.97 | 3.07 | 15.00 | 16.08 | 15.54 | 59.60 | 54.59 | 57.09 | 88.31 | 82.19 | 85.25 |
| SEm± | **0.07** | **0.08** | **0.05** | **0.22** | **0.26** | **0.17** | **0.99** | **1.01** | **0.71** | **2.25** | **1.74** | **1.42** |
| CD (P=0.05) | **0.20** | **0.23** | **0.15** | **0.65** | **0.76** | **0.49** | **2.88** | **2.92** | **2.00** | **6.51** | **5.04** | **4.03** |

$PNMP_1$: 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 CGR and RGR of barley

| Treatments | CGR (g $m^{-1}$ row length $day^{-1}$) | | | | | | RGR (g $g^{-1}$ $day^{-1}$) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Between 30-60 DAS | | | Between 60-90 DAS | | | Between 30-60 DAS | | | Between 60-90 DAS | | |
| | 2014-15 | 2015-16 | Pooled | 2014-15 | 2015-16 | Pooled | 2014-15 | 2015-16 | Pooled | 2014-15 | 2015-16 | Pooled |
| **Varieties** | | | | | | | | | | | | |
| RD 2035 | 1.23 | 1.32 | 1.27 | 5.20 | 4.42 | 4.81 | 0.0462 | 0.0481 | 0.0472 | 0.0476 | 0.0424 | 0.0450 |
| RD 2552 | 1.56 | 1.69 | 1.63 | 5.48 | 5.00 | 5.24 | 0.0501 | 0.0523 | 0.0512 | 0.0437 | 0.0400 | 0.0419 |
| RD 2786 | 1.51 | 1.55 | 1.53 | 4.90 | 4.55 | 4.73 | 0.0491 | 0.0508 | 0.0499 | 0.0418 | 0.0397 | 0.0407 |
| SEm± | **0.02** | **0.03** | **0.02** | **0.09** | **0.11** | **0.07** | **0.0005** | **0.0007** | **0.0004** | **0.0003** | **0.0007** | **0.0004** |
| CD (P=0.05) | **0.06** | **0.08** | **0.05** | **0.25** | **0.31** | **0.19** | **0.0013** | **0.0021** | **0.0012** | **0.0008** | **0.0019** | **0.0010** |
| **Nutrient Management** | | | | | | | | | | | | |
| $PNMP_1$ | 1.42 | 1.46 | 1.44 | 4.85 | 4.36 | 4.60 | 0.0498 | 0.0495 | 0.0496 | 0.0433 | 0.0398 | 0.0415 |
| $PNMP_2$ | 1.29 | 1.39 | 1.34 | 4.74 | 4.36 | 4.55 | 0.0468 | 0.0483 | 0.0476 | 0.0444 | 0.0411 | 0.0427 |
| $PNMP_3$ | 1.38 | 1.48 | 1.43 | 5.16 | 4.53 | 4.85 | 0.0460 | 0.0496 | 0.0478 | 0.0446 | 0.0408 | 0.0427 |
| $PNMP_4$ | 1.48 | 1.53 | 1.51 | 5.27 | 4.89 | 5.08 | 0.0480 | 0.0483 | 0.0482 | 0.0436 | 0.0412 | 0.0424 |
| $PNMP_5$ | 1.58 | 1.75 | 1.66 | 5.95 | 5.13 | 5.54 | 0.0518 | 0.0563 | 0.0540 | 0.0460 | 0.0406 | 0.0433 |
| SEm± | **0.03** | **0.03** | **0.02** | **0.11** | **0.14** | **0.09** | **0.0006** | **0.0009** | **0.0006** | **0.0004** | **0.0009** | **0.0005** |
| CD (P=0.05) | **0.07** | **0.10** | **0.06** | **0.32** | **0.40** | **0.25** | **0.0017** | **0.0027** | **0.0016** | **0.0010** | **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 3.** Effect of varieties and precision nutrient management practices on effective tillers, grains ear$^{-1}$, test weight and grain yield of barley

| Treatments | Effective tillers ($m^{-1}$ row) | | | Grains ear$^{-1}$ | | | Test weight (g) | | | Grain yield (q $ha^{-1}$) |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2014-15 | 2015-16 | Pooled | 2014-15 | 2015-16 | Pooled | 2014-15 | 2015-16 | Pooled | |
| **Varieties** | | | | | | | | | | |
| RD 2035 | 77.97 | 77.65 | 77.81 | 42.72 | 41.56 | 42.14 | 46.52 | 45.59 | 46.05 | 44.97 |
| RD 2552 | 86.33 | 85.98 | 86.15 | 48.87 | 47.40 | 48.13 | 48.74 | 47.82 | 48.28 | 49.43 |
| RD 2786 | 81.87 | 80.46 | 81.16 | 47.71 | 45.00 | 46.36 | 47.11 | 46.89 | 47.00 | 46.78 |
| SEm± | **1.10** | **1.07** | **0.77** | **0.73** | **0.73** | **0.52** | **0.62** | **0.61** | **0.44** | **0.64** |
| CD (P=0.05) | **3.19** | **3.09** | **2.17** | **2.13** | **2.12** | **1.47** | **1.81** | **1.76** | **1.23** | **1.87** |
| **Nutrient Management** | | | | | | | | | | |
| $PNMP_1$ | 80.43 | 79.92 | 80.18 | 42.70 | 41.71 | 42.21 | 46.14 | 45.97 | 46.05 | 45.38 |
| $PNMP_2$ | 78.57 | 78.06 | 78.31 | 41.81 | 40.17 | 40.99 | 45.54 | 44.31 | 44.93 | 41.68 |
| $PNMP_3$ | 83.22 | 82.23 | 82.73 | 47.11 | 43.71 | 45.41 | 47.94 | 46.76 | 47.35 | 45.79 |
| $PNMP_4$ | 83.90 | 82.69 | 83.29 | 50.13 | 48.59 | 49.36 | 48.42 | 47.82 | 48.12 | 51.13 |
| $PNMP_5$ | 84.14 | 83.92 | 84.03 | 50.42 | 49.09 | 49.75 | 49.24 | 48.98 | 49.11 | 51.31 |
| SEm± | **1.42** | **1.38** | **0.99** | **0.95** | **0.95** | **0.67** | **0.81** | **0.78** | **0.56** | **0.83** |
| CD (P=0.05) | **4.12** | **3.99** | **2.80** | **2.75** | **2.74** | **1.90** | **2.33** | **2.27** | **1.59** | **2.41** |

$PNMP_1$: 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.** 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 $ha^{-1}$) | DMA at 90 DAS (g) | 0.555* | Y= 23.35 + 0.45X |
| Grain yield (q $ha^{-1}$) | DMA at harvest (g) | 0.718** | Y = 3.73 + 0.53X |
| Grain yield (q $ha^{-1}$) | Effective tillers | 0.543* | Y = 8.40 + 0.47X |
| Grain yield (q $ha^{-1}$) | Grains ear$^{-1}$ | 0.882** | Y = 6.72 + 0.87X |
| Grain yield (q $ha^{-1}$) | Test weight (g) | 0.890** | Y = -55.49 + 2.16X |
| CGR 30-60 DAS (g $m^{-1}$row length $day^{-1}$) | DMA at 60 DAS (g) | 0.992** | Y = 0.984 + 0.124 X |
| CGR 60-90 DAS (g $m^{-1}$row length $day^{-1}$) | DMA at 90 DAS (g) | 0.959** | Y = 0.919 + 0.110X |
| RGR 30-60 DAS (g $g^{-1}$ $day^{-1}$) | DMA at 60 DAS (g) | 0.823** | Y = 0.677 + 0.002X |

*Significant at 5% level of significance
*Significant at 1% level of Significance

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 3). Further, the correlation analysis also substantiated strong dependence of grain yield on yield attributes *viz*. effective tillers (r = 0.543*), grains ear$^{-1}$ (r = 0.882**) and test weight (r = 0.890**).
From results of experiment it may be conclude that growing of high yielding variety RD 2552 resulted in highest dry matter accumulation, CGR, RGR, effective tillers, grains ear$^{-1}$, test weight and grain while, precision nutrient management through STCR ($PNMP_5$) recorded the highest dry matter accumulation, CGR, RGR, yield attributes and grain yield.

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