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**Research Article**

# Nitrogen Management Strategies for Enhancing Yield of Barley in South Western and Central Zone of Punjab

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## ABSTRACT

Nitrogen (N) plays a key role in determining crop yield, and is involved in various developmental and metabolic activities. The present investigation was carried to assess the impact of different nitrogen levels and timing of their application on yield and yield attributing characteristics of barley in south western (Bathinda) and central zone (Ludhiana) of Punjab during the *rabi season of* 2017-18. The results revealed that the application of 125% RDN produced maximum effective tillers, spike length, spike weight, grains per spike and yield in the both zones i.e. south western zone (Bathinda) and central zone (Ludhiana). Application of 100% RDN was also equally efficient with the 125% RDN in increasing yield traits and yield (35.16q/ha at south western zone and 43.81 q/ha at central zone). The application of half of nitrogen dose at pre-sowing irrigation and half at tillering stage gave significantly higher yield as compared to the other nitrogen levels. The optimum yields may be achieved with 100% RDN on applying half of the nitrogen dose at pre-sowing irrigation and remaining half at tillering stage in coarse texture soils.

**Key words:** Barley, Nitrogen levels, Time of N application, Yield attributing characters, Grain yield

## Introduction

Barley (*Hordeum vulgare* L.) is the world's fourth important cereal crop after wheat, maize and rice (Shafi *et al.,* 2011). In India, barley crop was grown over an area of 656 thousand hectares with average productivity of 26.63 q $ha^{-1}$ during 2016-17 (Anonymous, 2017). In India, Rajasthan is leading barley producing state followed by U.P., Haryana and Punjab. In Punjab, barley was grown on 6.8 thousand hectares with an average productivity of 37.77 q $ha^{-1}$ in 2020-21(Anonymous, 2022).

Nitrogen is the key nutrient input for achieving higher yield of barley. Barley is very sensitive to insufficient nitrogen and very responsive to nitrogen fertilization. Nitrogen is involved in various metabolic processes; and its rate of uptake and partitioning is determined by supply and demand during the different plant growth stages. The crop response to applied N fertilizer depends mainly on the soil type and its fertility, soil and crop management practices (Singh and Hadda, 2018), cultivar and method of N application (Singh *et al.,* 2016). Nitrogen is needed for early tiller development of barley to set up the crop for a high yield potential. On the other hand; nitrogen fertilization has an important effect on the final harvest, thus if this element is not take from soil, yield decreases (Moreno *et al*., 2003).

Knowledge of the stage at which application of N fertilizer is more effective for achieving maximum

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grain yield would be highly useful for improving N management. Therefore, to get maximum benefit from the fertilizer use and optimize nitrogen use efficiency, fertilizer should not only be applied in optimum quantity but also at right time. Splitting N fertilizer application in order to follow the nitrogen requirements by the crop throughout the growing season is probably the best strategy to achieve high grain yields than basal N application of all fertilizer (Rehman *et al.,* 2011). Soil N supply must be high at tillering, stem elongation, booting, grain filling stages for better growth and development (Shafi *et al*., 2011). The identification of factors contributing to growth and productivity is also an important aspect of yield improvement in cereal crops. Grain yield in barley depends largely on spikes per square meter and kernels per spike (Sinebo *et al*., 2004). Therefore, its yield can be improved by understanding the interrelationships among yield and yield related traits.

Nitrogen application at proper dose and stage is the most important for increasing crop production. Adequate information is not available on N requirements at differing growth stages of barley under conditions of Punjab. Keeping this in view, the present study was planned to find optimum N fertilizer dose with appropriate time (stage) of N application for barley crop under the climatic conditions of southwestern and central zone of Punjab.

## Materials and Methods

### *Experimental site and treatment details*

The field experiments were conducted at PAU, Regional Research Station, Bathinda (30°12′ N, 74°56′ E and 226 m above mean sea level) representing south western zone and Research farm of Department of Soil Science, Punjab Agricultural University (PAU), Ludhiana (30°54′ N, 75°48′ E and 247 m above mean sea level) representing central zone of Punjab during *rabi* season of 2017-18.The experiments were initiated in November 2017 at PAU Regional Research Station, Bathinda and PAU Ludhiana. The initial basic soil physical and chemical properties of the experimental site are summarized in Table 1. The experiment was laid out in a factorial randomized block design with three nitrogen levels, four levels of nitrogen applications and replicated thrice. The three N levels comprised of $N_1$- 75% of recommended dose of N (RDN), $N_2$- 100% RDN and $N_3$- 125% RDN)(factor A) and four times of N application ($T_1$- full dose at pre-sowing irrigation, $T_2$- ½ N at pre sowing irrigation + ½ tillering stage (main shoot and one tiller), $T_3$- ½ N at pre sowing irrigation + ¼ tillering stage (main shoot and one tiller) + ¼ stem elongation (first node detectable) and $T_4$ - ½ N at pre sowing irrigation + ¼ tillering stage (main shoot and one tiller) + ¼ flowering stage (half inflorescence emerged) (factor B).

**Table 1.** Initial soil physico-chemical properties of experimental sites

| Properties | Locations | |
|---|---|---|
| | RRS, Bathinda | PAU, Ludhiana |
| Texture | Loamy sand | Sandy loam |
| pH | 8.09 | 7.15 |
| EC (dS/m) | 0.42 | 0.35 |
| Soil organic carbon (%) | 0.34 | 0.45 |
| Available N (kg/ha) | 164.6 | 184.4 |
| Available P (kg/ha) | 18.1 | 20.6 |
| Available K (kg/ha) | 224.9 | 209.6 |

### *Crop management practices*

Barley variety 'DWRUB 52'was sown at row spacing of 22.5 cm using 87.5 kg seeds ha$^{-1}$. The 187 kg per single superphosphate was applied at sowing, whereas nitrogen was applied as per treatments. The weeds, insect-pest, and diseases were controlled following recommended package of practice of Punjab Agricultural University. The crop was harvested at physiological maturity in month of April at both locations.

### *Observation recorded at time of harvesting*

The effective tillers, average spike weight, spike length and number of grains per spike were measured from randomly selected five plants at harvesting. The average weight of 1000 grains selected from the grain samples from each treatment was recorded. The grain and straw yield from the net harvested area within each plot was recorded after threshing using mechanical thresher. Harvest index was calculated from the ratio of grain yield to biomass yield.

***Statistical analysis of field data***

Data on crop yields and were statistically analyzed by using statistical methods as per by Gomez and Gomez (1984) and the software used was SAS 9.1 (SAS Institute, CA).

## Results and discussion

***Effect of different nitrogen levels and time of their application on yield attributing characters***

The different nitrogen levels and time of application significantly increased the number of effective tillers, ear length, ear weight, number of grains per ear, 1000-grain weight in both locations, Bathinda and Ludhiana as given in Table 2. The yield attributing characters of barley increased as the nitrogen level increased from 75% RDN to 125% RDN. Due to utilization of least amount of available N under lowest N level and reduced translocation of photosynthates from source to sink gives poor growth and yield attributing characteristics (Dubey, 2018). Treatments 100% RDN and 125% RDN were statistically at par with each other, but the highest values of all the yield attributing characters were obtained by plant grown on soil that was supplied with 125% RDN. As compared to 75% RDN, at Bathinda, 125% RDN increased the number of effective tillers by 16.6%, ear length by 14.2%, grains per ear by 15.2%, 1000 grain weight by 13.8% and ear weight by 37.8%, while at Ludhiana, 125% RDN increased the number of effective tillers by 9.4%, ear length by 26.6%, grains per ear by 8.36%, ear weight by 33.7% and 1000 grain weight by 12.3%. Increasing dose of N fertilizer resulted higher yield attributes as N plays an important role in tissue development, cell division and enhance plant growth (Sahoo *et al*., 2020).

These results indicated that, the timing of N application had significant effect on grain yielding attributes of barley. N application in split doses at different growth stages had positive effect on yield attributing characteristics. At both locations, Bathinda and Ludhiana, split application of N under $T_2$, $T_3$, $T_4$ treatments increased the yield attributing characteristics such as number of effective tillers ranged from 7.5-12.9%, ear length from 15.7-36.2%, grains per ear from 6.5-19.5%, ear weight from 23-

**Table 2.** Yield attributing characteristics of barley under different nitrogen levels and time of their application at Bathinda and Ludhiana

| Treatment | Ear length (cm) | | Ear weight (g) | | Grain per ear | | 1000 grain wt | | Effective tillers | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Bathinda | Ludhiana | Bathinda | Ludhiana | Bathinda | Ludhiana | Bathinda | Ludhiana | Bathinda | Ludhiana |
| **Nitrogen levels** | | | | | | | | | | |
| 75% recommended dose of nitrogen($N_1$) | 5.51 | 6.58 | 0.82 | 1.04 | 23.61 | 27.75 | 36.73 | 40.24 | 282 | 319 |
| 100% Recommended dose of nitrogen ($N_2$) | 6.18 | 7.59 | 1.07 | 1.27 | 26.59 | 29.21 | 40.72 | 43.78 | 325 | 345 |
| 125% recommended dose of nitrogen ($N_3$) | 6.29 | 8.33 | 1.13 | 1.39 | 27.20 | 30.07 | 41.83 | 45.19 | 329 | 349 |
| CD (p=0.05) | 0.57 | 0.98 | 0.15 | 0.18 | 1.36 | 1.41 | 1.56 | 1.41 | 7.0 | 6.0 |
| **Time of nitrogen application** | | | | | | | | | | |
| Full dose at pre sowing irrigation ($T_1$) | 5.17 | 6.16 | 0.81 | 1.00 | 22.91 | 27.17 | 35.42 | 39.39 | 293 | 310 |
| ½ Nitrogen at pre sowing irrigation + ½ tillering stage ($T_2$) | 6.54 | 8.39 | 1.13 | 1.39 | 27.37 | 30.25 | 42.08 | 45.02 | 321 | 350 |
| ½ Nitrogen at pre sowing irrigation + ¼ tillering stage +¼ stem elongation ($T_3$) | 6.30 | 7.99 | 1.08 | 1.30 | 27.04 | 29.67 | 41.12 | 44.25 | 319 | 347 |
| ½ Nitrogen at pre sowing irrigation + ¼ tillering stage +¼ flowering stage ($T_4$) | 5.98 | 7.46 | 1.00 | 1.23 | 25.88 | 28.94 | 40.40 | 43.62 | 315 | 343 |
| CD (p=0.05) | 0.66 | 1.13 | 0.17 | 0.21 | 1.57 | 1.63 | 1.80 | 1.62 | 8.0 | 7.0 |

39.5%, and 1000 grain weight from 10.7-18.8% as compared to $T_1$ treatment where all nitrogen was applied at sowing as shown in Table 2. The highest yield attributing characteristics were obtained in $T_2$ treatment where N was applied at pre-sowing irrigation and tillering stage. Results revealed that the treatment $T_2$ was statistically at par with $T_3$ and $T_4$ treatments. Similar results were also reported by Rahman *et al.* (2002).

### *Effect of different nitrogen levels and time of their application on grain yield*

Both N application rate and its time of application not only independently and significantly influenced barley grain yield, but also exhibited a significant interaction at both the experimental sites. Interaction table for nitrogen levels and time of nitrogen application revealed that grain yields increased significantly by 32.2% for the south western (Table 3) and 27.4% for central (Table 4) zones of Punjab as the rate of N fertilizer increased from 75% RDN to 125% RDN. Singh *et al*. (2012) also reported increase in grain yield of barley with application of 125% of RDN on a loamy sand soil at Ludhiana, Punjab. The results were also in agreement with Koushik *et al*. (2019) who reported that application of 180 kg N/ha significantly increased grain yield of wheat by 7.2 and 35.5% than that of 120 kg N/ha and 60 kg N/ha during the year 2017-18 and by 10.1 and 41.1% than that of 120 kg N/ha and 60 kg N/ha during the year 2018-19, respectively. Applications of N from 100% RDN to 125% RDN gave non-significant grain yield increments of 4.1% and 3.3% at south western and central zones, respectively. Kaur *et al*. (2020) also reported highest increase in yield of wheat with 150% RDN (46.68 q/ha) followed by 125% RDN.

At Bathinda (south western zone), grain yield was increased by 25.8, 23.2 and 19.9% with split application of N under $T_2$, $T_3$ and $T_4$ as compared with $T_1$ treatment where N was applied in single dose. However, treatments $T_2$, $T_3$ and $T_4$ were statistically at par with each other. So the best treatment combination is application of 100% RDN ($N_2$) in two equal splits ($T_2$) (Table 3). Neelam *et al*. (2018) also reported higher grain yield with 100% of RDN when applied half at basal dose and half at first irrigation on sandy loam soils of Hisar, Haryana. At Ludhiana, N application in 2 or 3 split doses increased the grain yield by 38.4, 34.2 and 32.1% under (Table 4) $T_2$, $T_3$ and $T_4$ treatments as compared with $T_1$. The differences between $T_2$, $T_3$ and $T_4$ treatments were also not significant. Like at Bathinda, significant interaction effect of N dose and time of application revealed that 100% RDN ($N_2$) applied in two splits ($T_2$) was optimum for realizing high grain yield of barley. Derebe *et al*. (2022) also reported application of half urea at 50% emergence and other half at tillering with the application of DAP at sowing gave maximum wheat grain yield. The higher grain yield observed in 100% RDN as compared to 75% RDN ($N_1$) was mainly due to higher tiller density. Split application of N ($^1/_2$ at sowing and $^1/_2$ at tillering) in coarse textured soils (loamy sand at RRS Bathinda and sandy loam at Ludhiana) increased N use efficiency possibly by decreasing leaching losses thus resulted an increase in yield. The results were in confirmation with findings of Shajaripour and Mojaddam (2015) who also reported increase in barley yield with split application of the N. Coarse

**Table 3.** Interaction effect of different nitrogen levels and time of their application on grain yield of barley at Bathinda

| Treatments | Grain yield (q/ha) | | | | |
|---|---|---|---|---|---|
| | Time of application | | | | |
| Nitrogen level | $T_1$ | $T_2$ | $T_3$ | $T_4$ | Mean |
| $N_1$ | 20.03 | 30.72 | 30.13 | 29.89 | 27.69 |
| $N_2$ | 31.53 | 37.08 | 36.65 | 35.38 | 35.16 |
| $N_3$ | 33.27 | 38.96 | 37.71 | 36.46 | 36.60 |
| Mean | 28.28 | 35.59 | 34.83 | 33.91 | |
| CD (p=0.05) | N × T = 3.02, N = 1.51, T = 1.75 | | | | |

**Table 4.** Interaction effect of different nitrogen levels and time of their application on grain yield of barley at Ludhiana

| Treatments | Grain yield (q/ha) | | | | |
|---|---|---|---|---|---|
| | Time of application | | | | |
| Nitrogen level | $T_1$ | $T_2$ | $T_3$ | $T_4$ | Mean |
| $N_1$ | 31.16 | 37.53 | 37.11 | 36.38 | 35.54 |
| $N_2$ | 32.63 | 48.96 | 47.46 | 46.18 | 43.81 |
| $N_3$ | 34.97 | 50.20 | 48.00 | 47.89 | 45.27 |
| Mean | 32.92 | 45.56 | 44.19 | 43.48 | |
| CD (p=0.05) | N × T = 4.54, N = 2.27, T = 2.62 | | | | |

texture soil at both experimental sites (Bathinda and Ludhiana) supported $N_2T_2$ treatment for obtaining higher yield attributing characters and grain yield of barley.

### *Straw yield*

Barley grown under 100% RDN and 125% RDN treatments showed significantly higher straw yield than those under 75% RDN at both experimental sites, as given in Table 5. Plants were more flourishing under the higher N treatments. At Bathinda, the straw yield increased by 22.1% with the application of nitrogen under $N_3$ compared to $N_1$. Similar responses to rate of N application in straw yield of barley were observed at Ludhiana. The significantly higher straw yield (16%) under $N_3$ was recorded as compared to $N_1$ treatment. Kalra and Sharma (2015) also reported that an increase in biomass yield of maize fodder with addition of N may be attributed to the fact that N is an important constituent of amino acids and chloroplasts which directly influenced plant growth and development through greater photosynthates. At Bathinda, split application of N treatments increased the straw yield from14.7-22.5%, as compared to single N application, whereas at Ludhiana it varies from 12.0-17.2%. Shajaripour and Mojaddam (2015) also reported that the split application of 130 kg N/ha, 25% at planting stage and 75% at stem elongation stage gives highest straw yield.

**Table 5.** Straw yield and harvest index of barley under different nitrogen levels and time of their application at Bathinda and Ludhiana

| Treatment | Straw yield (q/ha) | | Harvest Index | |
|---|---|---|---|---|
| | Bathinda | Ludhiana | Bathinda | Ludhiana |
| **Nitrogen levels** | | | | |
| 75% recommended dose of nitrogen ($N_1$) | 38.26 | 48.41 | 0.42 | 0.43 |
| 100% Recommended dose of nitrogen ($N_2$) | 44.37 | 55.02 | 0.44 | 0.44 |
| 125% recommended dose of nitrogen ($N_3$) | 46.72 | 56.14 | 0.44 | 0.45 |
| CD (p=0.05) | 4.66 | 4.92 | NS | NS |
| **Time of Application** | | | | |
| Full dose at pre sowing irrigation ($T_1$) | 37.75 | 48.01 | 0.42 | 0.41 |
| ½ Nitrogen at pre sowing irrigation + ½ tillering ($T_2$) | 46.26 | 56.27 | 0.44 | 0.45 |
| ½ Nitrogen at pre sowing irrigation + ¼ tillering stage +¼ stem elongation ($T_3$) | 45.16 | 54.70 | 0.44 | 0.45 |
| ½ Nitrogen at pre sowing irrigation + ¼ tillering stage +¼ flowering stage ($T_4$) | 43.29 | 53.77 | 0.44 | 0.45 |
| CD (p=0.05) | 5.38 | 5.68 | NS | 0.02 |

### *Harvest index (HI)*

At Bathinda, the results revealed that the harvest index was non significantly influenced by N rates and their application time (Table 5). At Ludhiana different N levels, non significantly affected the harvest index but time of N application had significant affect on harvest index (Table 5). At both locations HI increased with increase in N fertilization and split application afterward, it remained constant. Similar findings were reported by Singh *et al*. (2012).

## Conclusion

The results from the present study revealed that rate and timing of N application positively affected the grain yield and yield attributing characteristics of barley crop. The results suggested that application of 125% RDN ($N_3$) in two splits (½ N at pre sowing irrigation + ½ tillering stage) ($T_2$) produced significantly higher yield attributing characteristics (effective tiller, spike length, spike weight, grains per spike, 1000 grain weight) and yield at both locations i.e south western (Bathinda) and central (Ludhiana) zones of Punjab. Application of 100% RDN ($N_2$) at stem elongation ($T_3$) or flowering stage ($T_4$) was also equally efficient in increasing yield attributing characteristics and yield of barley. Application of 100% RDN by spliting into pre-sowing irrigation and tillering stage could be the better N management strategy for obtaining best yield results in case of coarse textured soils of Punjab, as compared to recommended practices in which full dose of N usually applied at pre sowing irrigation. Higher N application at tillering stage is required to support the grand growth period of development. Split application in light textured soils provides N according to crop need and check losses, therefore better utilization of applied N in achieving higher grain yield.

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