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Assessment of Dual-purpose Barley Varieties under Varying Nitrogen Management Regimes (*Hordeum vulgare* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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Abstract

A field experiment was conducted during the Rabi season of 2025–26 at the Agriculture Research Farm, Department of Agronomy, Tantia University, Sri Ganganagar, Rajasthan, to assess the performance of dual-purpose barley varieties under varying nitrogen management regimes. The experiment was laid out in a Factorial Randomized Block Design (FRBD) with three replications, comprising three varieties, viz., RD 2715, RD 2786 and RD 2552, and three nitrogen levels, viz., 75%, 100% and 125% of the recommended dose of nitrogen (RDN). Among the varieties, RD 2715 recorded the highest plant height (68.61 cm), number of tillers (7.58 plant^{-1}), dry matter accumulation (25.65 g plant^{-1}), grain yield (4,255 kg ha^{-1}), straw yield (4,690 kg ha^{-1}) and biological yield (8,944 kg ha^{-1}). Among nitrogen treatments, 125% RDN recorded the highest plant height (65.95 cm), number of tillers (7.10

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plant^{-1}), dry matter accumulation (24.90 g plant^{-1}), grain yield (4,135 kg ha^{-1}), straw yield (4,806 kg ha^{-1}) and biological yield (8,942 kg ha^{-1}). Grain yield and biological yield under 125% RDN were statistically at par with those under 100% RDN. The interaction between varieties and nitrogen management regimes was non-significant for all the recorded parameters. The findings indicated that RD 2715 exhibited superior overall performance, while 125% RDN produced the highest numerical values for most growth and yield parameters under the experimental conditions.

Keywords: Barley; Hordeum vulgare L.; dual-purpose barley; nitrogen management; varieties; grain yield; straw yield.

1. Introduction

Barley (*Hordeum vulgare* L.) is one of the oldest cultivated cereal crops in the world and occupies an important position in agricultural production systems due to its wide adaptability, relatively short growing season and tolerance to adverse environmental conditions. The crop is utilised for food, animal feed, fodder and industrial purposes, including malt production. In India, barley is predominantly cultivated during the rabi season and is particularly important in regions characterised by limited water availability, low soil fertility and variable climatic conditions. Its ability to produce satisfactory yields under relatively resource-constrained environments makes it a suitable crop for sustainable agriculture. Furthermore, the integration of barley cultivation with livestock production provides an opportunity to enhance farm productivity and improve the utilisation of available agricultural resources (Kharub *et al*., 2013; Singh *et al*., 2017).

Dual-purpose barley is an important production system in which the crop is harvested at an appropriate vegetative stage to obtain green fodder, after which the remaining crop is allowed to regenerate and produce grain at maturity. This system offers the dual advantage of meeting the fodder requirements of livestock during the winter season and generating an additional source of income through grain production. The importance of dual-purpose barley is particularly evident in mixed farming systems, where the availability of quality green fodder is often limited during certain periods of the year. However, successful dual-purpose cultivation requires careful management of harvesting time, plant population, nutrient availability and varietal selection to maintain an appropriate balance between vegetative biomass production and reproductive growth (Gill *et al*., 2017; Kharub *et al*., 2013; Pal & Kumar, 2009; Sharma, 2009).

In a field study of dual-purpose barley, Sharma *et al*. (2023) examined nitrogen dose and seed rate in relation to green fodder, grain and biological yields.

The selection of suitable varieties is a major determinant of the productivity and profitability of dual-purpose barley. Different varieties exhibit considerable variation in their genetic potential, plant height, tillering ability, leaf area development, biomass accumulation, regrowth capacity and grain-producing ability. These characteristics influence the capacity of a variety to withstand fodder harvesting and subsequently recover to produce an economically acceptable grain yield. Therefore, the comparative evaluation of available barley varieties under different nutrient management regimes is essential for identifying genotypes that can consistently deliver higher combined fodder and grain productivity (Singh *et al*., 2017; Yadav *et al*., 2022).

A further field evaluation documented differences in green fodder and grain yields among dual-purpose barley varieties under different sowing and fodder-harvesting schedules (Chauhan *et al*., 2025).

Nitrogen management involves not only determining the appropriate fertilizer dose but also selecting suitable timing and methods of application. The availability of nitrogen during early crop growth supports tiller establishment and vegetative biomass production, while its availability during subsequent growth stages contributes to crop recovery, canopy development and grain formation (Demirkiran & Uslu, 2010; Ali *et al*., 2026). Fodder harvesting changes the crop's growth pattern and nutrient requirements, making the timing of nitrogen application particularly important in dual-purpose barley. Appropriate nitrogen application after cutting may facilitate the emergence of new tillers, promote leaf development and support the recovery of the remaining crop. Meena *et al*. (2012) investigated the effects of nitrogen levels and methods of nitrogen application on dual-purpose barley under semi-arid conditions, highlighting the importance of nutrient management in such production systems (Hajighasemi *et al*., 2016; Yadav *et al*., 2022).

An investigation of integrated nutrient management also examined barley growth and yield under different combinations of fertilizer and farmyard manure (Shivani *et al*., 2024).

In irrigated hull-less barley, Rogers *et al*. (2025) assessed the response of grain yield to nitrogen supply, although their production system differs from dual-purpose barley cultivation.

In addition to yield enhancement, nitrogen management has important implications for fodder quality, grain quality and the economic sustainability of barley cultivation. Nitrogen nutrition influences the protein concentration of plant tissues and can contribute to improving the nutritional value of green fodder for livestock. The combined production of fodder and grain can provide economic advantages by generating multiple outputs from the same cultivated area. However, the profitability of the system depends on the cost of fertilizer, the value of fodder and grain, the extent of yield recovery following cutting and the efficiency with which applied nitrogen is utilized by the crop. Therefore, the assessment of different nitrogen management regimes should consider crop growth, fodder yield, grain yield and, where relevant, nutrient content and economic returns rather than relying on a single yield parameter (Hundal *et al*., 2014; Sharma *et al*., 2023).

More recently, Salve *et al*. (2026) evaluated nitrogen fertilization and cutting management in dual-purpose barley variety RD 2715 in relation to nutrient uptake and crop quality.

The studies cited above do not directly compare the growth and yield responses of RD 2715, RD 2786 and RD 2552 to 75%, 100% and 125% of the recommended dose of nitrogen under the field conditions of Sri Ganganagar, Rajasthan.

1.1 Objective of the Study

The objective of the present study was to evaluate growth attributes and green fodder, grain, straw and biological yields of three barley varieties (RD 2715, RD 2786 and RD 2552) under 75%, 100% and 125% of the recommended dose of nitrogen in Sri Ganganagar, Rajasthan, and to assess the variety-by-nitrogen interactions.

2. Materials and Methods

The present investigation was carried out during 2025–2026. The field experiment was conducted during the *Rabi* season of 2025–2026 at the Agriculture Research Farm, Department of Agronomy, Tantia University, Sri Ganganagar, Rajasthan, India. The site is located at 28.4° N latitude, 72.2° E longitude and 178 m above mean sea level.

2.1 Experimental Details

The field experiment was conducted to evaluate the performance of different barley varieties under varying nitrogen management regimes. The experiment was laid out in a Factorial Randomized Block Design (FRBD) with three replications. The treatments comprised two factors, viz., varieties and nitrogen levels. Factor A consisted of three barley varieties, namely V_1: RD 2715, V_2: RD 2786 and V_3: RD 2552. Factor B consisted of three nitrogen levels, namely N_1: 75% of the recommended dose of nitrogen (RDN), N_2: 100% RDN and N_3: 125% RDN, resulting in a total of nine treatment combinations.

The crop was sown at a seed rate of 100 kg ha^{-1} with a spacing of 22 × 10 cm (row × plant spacing). The recommended fertiliser dose was 80:40:40 kg ha^{-1}. The treatment combinations were randomly allocated within each replication. Thus, the experiment comprised nine treatment combinations and three replications. Observations on growth, yield and yield attributes were recorded at appropriate crop growth stages and subjected to statistical analysis using the appropriate analysis of variance technique for FRBD. The significance of treatment effects was tested at the 5% level of probability.

3. Results and Discussion

3.1 Growth Attributes

3.1.1 Plant Height (cm)

Plant height differed significantly among the barley varieties (Table 1). Variety RD 2715 recorded the maximum plant height (68.61 cm), followed by RD 2786 (63.00 cm), whereas RD 2552 recorded the minimum plant height (59.50 cm). The plant height of RD 2715 was statistically at par with RD 2786 but significantly higher than RD 2552. The greater plant height of RD 2715 may be attributed to its genetic potential for vigorous vegetative growth and efficient utilisation of available resources.

Table 1. Effect of Varieties and Nitrogen Management Regimes on Growth Attributes of Dual-Purpose Barley

Treatments	Plant height (cm) 60 DAS	Number of tillers plant^{-1} 60 DAS	Dry matter accumulation (g plant^{-1})
Varieties			
RD 2715	68.61	7.58	25.65
RD 2786	63.00	6.45	23.83
RD 2552	59.50	6.19	20.81
SEm(±)	1.90	0.45	0.62
CD (P=0.05)	5.71	1.35	1.85
Nitrogen Level			
75 % RDN	57.00	6.43	22.25
100 % RDN	62.15	6.69	23.15
125 % RDN	65.95	7.10	24.90
SEm(±)	1.90	0.45	0.62
CD (P=0.05)	5.71	1.35	1.85
Interaction (Factor A and Factor B)			
SEm(±)	3.42	0.87	1.12
CD (P=0.05)	NS	NS	NS

Nitrogen application also influenced plant height. The maximum plant height (65.95 cm) was recorded with 125% of the recommended dose of nitrogen (RDN), followed by 100% RDN (62.15 cm) and 75% RDN (57.00 cm). The difference between 125% and 75% RDN was significant, whereas the other pairwise differences were non-significant. The increase in plant height with increasing nitrogen application may be attributed to improved cell division, cell elongation and vegetative growth. Similar effects of nitrogen fertilization on barley growth have been discussed by Kumawat *et al*. (2006) and Narolia and Yadva (2013).

The interaction between variety and nitrogen level was non-significant, indicating that the response of the tested varieties to nitrogen management was statistically similar.

3.1.2 Number of Tillers per Plant

The number of tillers per plant varied among the barley varieties. RD 2715 recorded the maximum number of tillers (7.58 plant^{-1}), followed by RD 2786 (6.45 plant^{-1}) and RD 2552 (6.19 plant^{-1}). RD 2715 produced significantly more tillers than RD 2552, whereas the differences between RD 2715 and RD 2786 and between RD 2786 and RD 2552 were non-significant. The higher tillering capacity of RD 2715 may be associated with its inherent genetic characteristics and vigorous vegetative growth.

Among the nitrogen management treatments, the maximum number of tillers (7.10 plant^{-1}) was recorded with 125% RDN, followed by 100% RDN (6.69 plant^{-1}) and 75% RDN (6.43 plant^{-1}). However, the differences among nitrogen treatments were statistically non-significant. The numerical increase in tiller production with higher nitrogen application may be attributed to improved nitrogen availability during vegetative growth, supporting tiller initiation and development. Kumawat *et al*. (2006) and Shekhawat *et al.* (2013) have also discussed the influence of nitrogen nutrition on barley growth and tillering.

The interaction between variety and nitrogen level was non-significant, suggesting that the effect of nitrogen treatments on tiller production did not differ significantly among the tested varieties.

3.1.3 Dry Matter Accumulation (g plant^{-1})

Dry matter accumulation differed significantly among the barley varieties. RD 2715 recorded the highest dry matter accumulation (25.65 g plant^{-1}), followed by RD 2786 (23.83 g plant^{-1}) and RD 2552 (20.81 g plant^{-1}). RD 2715 was statistically at par with RD 2786, whereas both varieties recorded significantly higher dry matter accumulation than RD 2552. The higher dry matter accumulation in RD 2715 may be associated with its superior plant height and tillering ability, which may have contributed to greater biomass production.

Nitrogen management also influenced dry matter accumulation. The maximum value (24.90 g plant^{-1}) was recorded under 125% RDN, followed by 100% RDN (23.15 g plant^{-1}) and 75% RDN (22.25 g plant^{-1}). Dry matter accumulation under 125% RDN was significantly higher than under 75% RDN, while the remaining pairwise differences were non-significant. The increase in dry matter accumulation with higher nitrogen application may be explained by enhanced leaf development, photosynthetic activity and vegetative biomass production. Similar responses of barley to nitrogen fertilization have been reported by Kumawat *et al*. (2006) and Singh *et al*. (2013).

The interaction between variety and nitrogen level was non-significant, indicating that the response of dry matter accumulation to nitrogen management was statistically similar across the varieties.

3.2 Yield Attributes

3.2.1 Green Fodder Yield (kg ha^{-1})

The higher green fodder yield recorded in some varieties could be associated with their superior vegetative growth and greater biomass accumulation during the crop growth period. RD 2715 recorded the highest green fodder yield (5699 kg ha$^{-1;}$ Table 2), which was significantly higher than that of RD 2552 (4625 kg ha-1); however, the green fodder yield of RD 2786 was statistically at par with that of RD 2715.

Table 2. Effect of Varieties and Nitrogen Management Regimes on Grain Yield, Straw Yield and Biological Yield of Dual-Purpose Barley

Treatments	Green Fodder yield (kg ha^{-1})	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Biological yield (kg ha^{-1})
Varieties				
RD 2715	5699	4255	4690	8944
RD 2786	5295	3776	4218	7994
RD 2552	4625	3484	3619	7103
SEm(±)	148	164	161	336
CD (P=0.05)	455	493	483	1008
Nitrogen Level				
75 % RDN	4944	3505	3495	7001
100 % RDN	5144	3874	4223	8097
125 % RDN	5533	4135	4806	8942
SEm(±)	148	164	161	336
CD (P=0.05)	444	493	483	1008
Interaction (Factor A and Factor B)				
SEm(±)	161	242	231	1123
CD (P=0.05)	NS	NS	NS	NS

The 125% RDN treatment recorded the maximum green fodder yield (5533 kg ha^{-1}), which was significantly higher than the yield of 4944 kg ha^{-1} recorded under 75% RDN.

3.2.2 Grain Yield (kg ha^{-1})

Grain yield varied significantly among the barley varieties. RD 2715 recorded the highest grain yield (4,255 kg ha^{-1}), followed by RD 2786 (3,776 kg ha^{-1}), whereas RD 2552 recorded the lowest grain yield (3,484 kg ha^{-1}). The grain yield of RD 2715 was statistically at par with RD 2786 but significantly higher than RD 2552. The higher grain yield of RD 2715 may be associated with its superior growth characteristics, greater tiller production and higher dry matter accumulation, which may have contributed to improved assimilate production and grain development.

Nitrogen management significantly influenced grain yield. The maximum grain yield (4,135 kg ha^{-1}) was recorded with 125% RDN, followed by 100% RDN (3,874 kg ha^{-1}) and 75% RDN (3,505 kg ha^{-1}). The difference between 125% and 75% RDN was significant, whereas the differences between 125% and 100% RDN and between 100% and 75% RDN were non-significant. The increase in grain yield under higher nitrogen application may be attributed to improved crop growth, greater dry matter production and better support for grain development. Singh *et al*. (2013) reported that nitrogen management influenced barley productivity and yield attributes.

The interaction between variety and nitrogen level was non-significant, indicating that the grain yield response to nitrogen management did not vary significantly among the tested varieties.

3.2.3 Straw Yield (kg ha^{-1})

Straw yield differed significantly among the barley varieties. RD 2715 recorded the highest straw yield (4,690 kg ha^{-1}), followed by RD 2786 (4,218 kg ha^{-1}) and RD 2552 (3,619 kg ha^{-1}). The straw yield of RD 2715 was statistically at par with RD 2786 but significantly higher than RD 2552. RD 2786 also produced significantly higher straw yield than RD 2552. The higher straw yield of RD 2715 may be attributed to its greater vegetative growth and dry matter accumulation.

Among the nitrogen treatments, the maximum straw yield (4,806 kg ha^{-1}) was recorded under 125% RDN, followed by 100% RDN (4,223 kg ha^{-1}) and 75% RDN (3,495 kg ha^{-1}). All three nitrogen treatments differed significantly from one another. The progressive increase in straw yield with increasing nitrogen application may be attributed to enhanced vegetative growth, tiller development and biomass accumulation. These findings emphasise the importance of adequate nitrogen nutrition for increasing the vegetative biomass of barley.

The interaction between variety and nitrogen level was non-significant, indicating that the effects of nitrogen treatments on straw yield were statistically similar among the tested varieties.

3.2.4 Biological Yield (kg ha^{-1})

Biological yield was significantly influenced by varietal differences. RD 2715 recorded the highest biological yield (8,944 kg ha^{-1}), followed by RD 2786 (7,994 kg ha^{-1}) and RD 2552 (7,103 kg ha^{-1}). RD 2715 produced significantly higher biological yield than RD 2552, whereas the differences between RD 2715 and RD 2786 and between RD 2786 and RD 2552 were non-significant. The higher biological yield of RD 2715 may be attributed to its superior vegetative growth, greater tiller production and higher biomass accumulation.

Nitrogen management also influenced biological yield. The maximum biological yield (8,942 kg ha^{-1}) was recorded under 125% RDN, followed by 100% RDN (8,097 kg ha^{-1}) and 75% RDN (7,001 kg ha^{-1}). The biological yield under 125% RDN was statistically at par with 100% RDN but significantly higher than 75% RDN. Similarly, 100% RDN produced significantly higher biological yield than 75% RDN. The increase in biological yield may be associated with improved vegetative growth and greater accumulation of total crop biomass under adequate nitrogen nutrition.

The interaction between variety and nitrogen level was non-significant, suggesting that the response of biological yield to nitrogen management was statistically similar across the tested varieties.

4. Conclusion

The field evaluation identified differences among the three dual-purpose barley varieties in growth and yield performance under the tested nitrogen management regimes. RD 2715 recorded the greatest plant height, number of tillers and dry matter accumulation, together with the highest green fodder, grain, straw and biological yields. RD 2786 generally showed intermediate values, whereas RD 2552 recorded lower values for the reported parameters. Increasing nitrogen application from 75% to 125% of the recommended dose was accompanied by higher numerical values for the principal growth and yield measurements. The highest green fodder, grain, straw and biological yields were recorded at 125% RDN. Nevertheless, grain and biological yields at 125% RDN were not significantly different from those at 100% RDN, indicating that the numerical advantage of the higher dose did not represent a statistically demonstrable improvement for these outcomes. The variety-by-nitrogen interaction was non-significant for all assessed parameters. Thus, RD 2715 performed favourably under the conditions of the single-season field experiment at Sri Ganganagar. These findings describe the tested varieties and nitrogen levels without establishing responses beyond the experimental conditions.

5. Limitations

The experiment was undertaken at one location during a single rabi season, limiting the extent to which the observed responses can be generalised across environments or years. Only three barley varieties and three nitrogen levels were included; therefore, the findings do not describe responses beyond these treatments. Although the results report growth, green fodder, grain, straw and biological yields, the presented evidence does not establish the most economical nitrogen rate or its performance across multiple seasons. Interpretation should consequently remain restricted to the recorded parameters and experimental conditions.

Declaration of AI Use

This manuscript was prepared through the intellectual contributions of the author(s) to the study design, data analysis, interpretation of results, and scholarly content. ChatGPT, Claude and Perplexity were used solely to assist with grammatical refinement and reference formatting during manuscript revision. The author(s) accept full responsibility for the accuracy, integrity, and final content of the manuscript.

Competing Interests

Authors have declared that they have no known competing financial interests or non-financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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