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Saurabh Bhojwal
M.Sc. Scholar, Department of
Agronomy, Rajasthan College of
Agriculture, MPUAT, Udaipur,
Rajasthan, India

Dr. RP Meena
Professor, Collage of Agriculture,
Dungarpur, MPUAT, Udaipur,
Rajasthan, India

Dr. J Choudhary
Professor, Department of Agronomy,
Rajasthan Collage of Agriculture,
MPUAT, Udaipur, Rajasthan, India

Dr. RK Sharma
Professor, Department of Soil Science
and Agricultural Chemistry, RCA,
MPUAT, Udaipur, Rajasthan, India

Dr. Hari Singh Meena
Assistant Professor Department of
Agricultural Plant Physiology, RCA,
MPUAT, Udaipur, Rajasthan, India

Bajrang Khurkhuriya
M.Sc. Scholar, Department of
Agronomy, Rajasthan College of
Agriculture, MPUAT, Udaipur,
Rajasthan, India

Manish Kumar
Ph.D Scholar, Department of
Agronomy, Rajasthan College of
Agriculture, MPUAT, Udaipur,
Rajasthan, India

Ankit Kumar
Ph.D Scholar, Department of
Agronomy, Rajasthan College of
Agriculture, MPUAT, Udaipur,
Rajasthan, India

Amisha Besharwal
M.Sc. Scholar, Department of
Agronomy, Rajasthan College of
Agriculture, MPUAT, Udaipur,
Rajasthan, India

Corresponding Author:
Saurabh Bhojwal
M.Sc. Scholar, Department of
Agronomy, Rajasthan College of
Agriculture, MPUAT, Udaipur,
Rajasthan, India

Response of various nitrogen levels and foliar application of nano urea plus on Barley (*Hordeum vulgare* L.)

Saurabh Bhojwal, RP Meena, J Choudhary, RK Sharma, Hari Singh Meena Bajrang Khurkhuriya, Manish Kumar, Ankit Kumar and Amisha Besharwal

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Abstract

A field experiment entitled “Response of Various Nitrogen Levels and Foliar Application of Nano Urea Plus on Barley (*Hordeum vulgare* L.)” was conducted during *rabi*, 2025-26 at block B₁, Instructional Farm of Agronomy, Rajasthan College of Agriculture, Udaipur (Rajasthan). The experiment was laid out in a Factorial Randomized Block Design with three nitrogen fertility levels (50RDN, 75RDN and 100% RDN) and six foliar spray treatments of nano urea plus (varying concentrations of 2.0 ml, 4.0 ml, and 6.0 ml applied at tillering at 35 DAS and 60 DAS booting stages) with three replications.

The results revealed that the application of 100% RDN achieved the highest growth parameters, recording significantly higher plant height (96.03 cm), dry matter accumulation (12.89 g plant⁻¹), leaf area (31.71) at 90 DAS and total number of tillers (97.85 m⁻¹ row length) at harvest, remaining statistically at par with 75% RDN but significantly superior over 50% RDN. Yield attributes and overall productivity were maximized under 100% RDN, yielding the maximum number of effective tillers (93.68 m⁻¹ row length), ear length (13.95cm), grains ear⁻¹ (55.27) and test weight (43.09 g). This resulted in a maximum grain yield of 4,543kg ha⁻¹, straw yield of 5,581 kg ha⁻¹ and biological yield of 10,124 kg ha⁻¹. Furthermore, 100% RDN significantly enhanced quality metrics, yielding the maximum grain nitrogen content (1.585%), crude protein (10.31%), protein yield (469 kg ha⁻¹) and total N, P, K uptake. Economically, 100% RDN was the most profitable treatment generating a maximum gross return ₹1,42,005 ha⁻¹, net return of ₹1,03,742 ha⁻¹ and a benefit-cost ratio of 2.71.

Among the foliar spray configurations, the application of nano urea plus @ 6.0 ml l⁻¹ at tillering stage (35 DAS) recorded the maximum vegetative values, including plant height (97.56 cm), dry matter accumulation (12.74 g plant⁻¹) and effective tillers (91.90 m⁻¹ row length), which stood statistically at par with the 4.0 ml l⁻¹ dose at the tillering stage but was significantly superior to booting stage and lower volume treatments. However, from an economic standpoint, the combination of 100% RDN along with foliar application of nano urea plus @ 4.0 ml l⁻¹ at tillering stage (35 DAS) proved to be the most optimal and profitable practice, securing the maximum net returns (₹1,00,327 ha⁻¹) and a superior balance between cultivation cost and high agronomic yield.

Keywords: Barley crop, nitrogen levels, nano urea plus, growth parameters

Introduction

Barley (*Hordeum vulgare* L.) is one of the earliest domesticated cereal crop belongs to the poaceae (grass) family. It has been cultivated since ancient times and remains a crop of global importance due to its adaptability, nutritional value and industrial uses. Globally, barley ranks as the fourth most important cereal crop after wheat, rice and maize and is cultivated across temperate, tropical and subtropical regions (Vaughan *et al.*, 2006) [10]. Its ability to tolerate adverse agro-climatic conditions such as drought, salinity and alkalinity makes it particularly suitable for marginal and sub-marginal lands, where input requirements are relatively low. In Rajasthan alone, barley is grown on approximately 0.34 million hectares with a production of 0.94 million tonnes and productivity of 2815 kg ha⁻¹.

Nitrogen is an essential macronutrient that significantly influences crop growth and productivity. It is a fundamental component of amino acids, proteins, nucleic acids and chlorophyll, thereby playing a pivotal role in photosynthesis and plant metabolism. Adequate nitrogen supply enhances

leaf area, cell division and overall biomass production. However, conventional nitrogen fertilizers such as urea often exhibit low nitrogen use efficiency (30-40%) due to losses through leaching, volatilization and denitrification, which not only increase production costs but also contribute to environmental pollution and soil degradation.

Recently, nano urea plus, an advanced formulation developed by IFFCO, has been introduced as an alternative to conventional nitrogen fertilizers. It contains approximately 20 per cent nitrogen in multiple forms, including amide, ammonical and amino nitrogen, activated with biopolymers. Its nano sized particles (<100 nm) enable uniform distribution and rapid absorption, making it highly efficient for foliar application (IFFCO, 2025) [2].

Materials and Methods

A field experiment was conducted at block B₁, Instructional Farm, Department of Agronomy, Rajasthan College of Agriculture, MPUAT, Udaipur during *rabi*, 2025-26. The experimental soil was clay-loam in texture, slightly alkaline in reaction (pH 7.6), low in organic carbon and available nitrogen, medium in available phosphorus and high in available potassium. The experiment was laid out in Factorial randomized block with three nitrogen fertility levels (50RDN, 75 RDN and 100% RDN) and six foliar spray treatments of nano urea plus (varying concentrations of 2.0 ml, 4.0 ml, and 6.0 ml applied at tillering at 35 DAS and 60 DAS booting stages) with three replications. The test crop was barley variety RD-2899, sown at a spacing of 20 cm × 10 cm with a seed rate of 100 kg ha⁻¹. The recommended dose of fertilizer was 40:60:00 kg N:P₂O₅:K₂O ha⁻¹ and half nitrogen with full phosphorus and potassium were applied at sowing through urea, SSP and MOP. The crop was managed through thinning, hand weeding at 30 DAS, post-emergence 2,4-D. Observations were recorded on plant height, dry matter accumulation, leaf area, total number of tillers, crop growth rate and relative growth rate and net assimilation rate using standard procedures and the data were analyzed by ANOVA as per factoria randomized block (Panse and Sukhantme, 1985) [6].

Results and Discussion

Nitrogen levels: During *rabi* 2025-26, nitrogen levels had a significant effect on all growth parameters of finger millet including plant height, dry matter accumulation, leaf area, total number of tiller number, crop growth rate and relative growth rate. Application of 100% RDN recorded the tallest plants at 90 DAS and at harvest (Table 1) with 94.24 and 96.02 cm, but higher than 50% RDN and 75% RDN. This is due to nitrogen, being the primary building block of protoplasm, vitally promotes cell division at apical meristems and cell enlargement through enhanced synthesis of gibberellic acid (GA₃) and cytokinins. These phytohormones stimulate internodal elongation and leaf expansion resulting in taller plants with greater canopy coverage (Xing *et al.*, (2023) [11]. Phosphorus plays crucial role in root development through enhanced ATP synthesis and energy transfer processes. Well-developed root system under higher phosphorus availability facilitates superior water and nutrient absorption from soil profile, particularly important under rainfed conditions. Potassium ions maintain cellular turgor through osmotic regulation and activate over 60 enzymes involved in photosynthesis, protein synthesis and starch formation. The synergistic NPK interaction creates optimal physiological environment for maximum vegetative growth expression.

A similar trend was observed for dry matter accumulation, where 100% RDN recorded the highest values of 9.96 and 12.89 g plant⁻¹ at 90 DAS and at harvest (Table 2), respectively followed by

75% RDN with 9.79 and 12.40 g plant⁻¹. The reason is that adequate supply of nitrogen. Leaf area (Table 1) also improved with nitrogen levels and was maximum under 100% RDN at 90 DAS with 31.71. The number of tillers m⁻¹ row length (Table 2) was highest under 100% RDN (97.85) followed by 75% RDN (93.18). Adequate nitrogen supply during active tillering phase (30-35 DAS) activates axillary buds through localized cytokinin accumulation and prevents apical dominance. Enhanced leaf area resulted from increased tiller number coupled with larger individual leaf size, creating expansive photosynthetic canopy for superior light interception and CO₂ assimilation. Adequate nitrogen supply through split application during active tillering phase activates axillary buds through localized cytokinin accumulation and prevents apical dominance thereby promoting a higher number of total tillers per unit areathat optimized chemical nitrogen fertility levels significantly enhance the vegetative vigour structural leaf parameters and biomass accumulation of malting and feed barley. These findings are in close conformity with the results reported by Singh *et al.* (2023 and Kumar *et al.*, 2024) [9, 4].

Crop growth rate under 100% RDN was also superior between 30-60 (Table 2) with 8.076 g m⁻² day⁻¹, relative growth rate followed the same trend. This is due to exponential dry matter synthesis driven by peak photosynthetic activity. Relative growth rate (Table 2) superiority during early vegetative phase reflects nitrogen ability to maximize growth per unit existing biomass when plants have small initial size. These results indicate in adequate nitrogen supply under 100% RDN promoted better vegetative growth through greater availability of nitrogen throughout the crop growth period. These findings are in close conformity with the results reported by (Seerat *et al.*, 2026) [8] who demonstrated that optimized fertility levels significantly enhance the vegetative vigor and biomass accumulation of barley.

Nano urea plus: Among the foliar spray of nano urea plus @ 6.0 ml at tillering stage at 35 DAS recorded the best growth performance for almost all parameters. It produced the highest plant height at 60, 90 DAS and at harvest (Table 1) with 55.17, 90.60 and 92.58 cm, respectively and these values were statistically at par with @ 4.0 ml at tillering stage at 35 DAS and dry matter accumulation followed the same trend of 5.69, 9.99 and 12.74 g plant⁻¹ at 60, 90 DAS and at harvest (Table 1), respectively. The highest leaf area (Table 1) under nano urea plus @ 6.0 ml at tillering stage 35 DAS was 23.99, 31.36, and 30.88 (dm²) at 60, 90 DAS and at harvest, respectively, while total number of tillers m⁻¹ row length (Table 2) were also maximum under nano urea plus @ 6.0 ml at tillering stage @ 35 DAS (96.17). Crop growth rate (Table 2) under nano urea plus @ 6.0 ml at tillering stage @ 35 DAS between 30-60 and 60-90 DAS was 7.75 g m⁻² day⁻¹, under 4.0 ml between 60-90 DAS 4.46 g m⁻² day⁻¹, respectively. These findings are supported by (Egli, 2019) [1] who noted significant enhancements in growth parameters and dry matter distribution in small millets and barley under nano fertilizer regimes. The foliar application of nano urea on leaves allow penetration of nutrients mainly by stomata and cuticle pathways. Enhanced plant growth with nitrogen from urea in different forms like basal, foliar application of nano urea at panicle initiation as well as flag leaf stage could be linked to better nutrient absorption, leading to optimal development of plant parts and metabolic activities like photosynthesis (Raliya *et al.*, 2017) [7]. The superior crop growth rate was due to the nitrogen supplied through foliage, which mobilized more efficiently by the plant resulting in enhanced growth attributes and ultimately enhanced the crop growth rate. The high leaf area index under this treatment

provided an expansive photosynthetic canopy for superior light interception. This can result in increased accumulation and movement of photosynthates to the valuable parts of the plants,

possibly due to enhanced source and sink strength (Midde *et al.*, 2021) ^[5].

Table 1: 100% RDN and Nano Urea Plus significantly improved barley growth parameters.

Treatments	Plant height (cm)			Dry matter accumulation (g plant ⁻¹)			Leaf area (dm ²)		
	60 DAS	90 DAS	At harvest	60 DAS	90 DAS	At harvest	60 DAS	90 DAS	At harvest
N ₁ : 50% RDN	51.51	83.12	88.39	4.06	8.26	10.50	20.51	27.76	26.89
N ₂ : 75% RDN	56.53	90.86	94.57	5.53	9.79	12.40	23.07	30.25	29.66
N ₃ : 100% RDN	57.49	94.24	96.03	5.90	9.96	12.89	24.89	31.71	31.61
S.Em.±	0.23	0.32	0.36	0.062	0.050	0.060	0.08	0.06	0.08
C.D. (P=0.05)	0.67	0.92	1.04	0.177	0.145	0.173	0.24	0.16	0.24
Foliar spray									
Nano urea plus @ 2.0 ml at tillering stage (35 DAS)	54.45	87.47	92.08	4.94	8.94	11.70	22.24	28.92	27.91
Nano urea plus @ 2.0 ml at booting stage (60 DAS)	52.05	84.87	87.30	4.79	8.60	10.82	21.39	27.93	27.26
Nano urea plus @ 4.0 ml at tillering stage (35 DAS)	56.88	91.21	96.30	5.21	9.65	12.53	23.29	31.32	30.46
Nano urea plus @ 4.0 ml at booting stage (60 DAS)	53.63	87.72	92.18	5.06	9.08	11.21	22.39	29.80	29.51
Nano urea plus @ 6.0 ml at tillering stage (35 DAS)	58.86	94.57	97.56	5.69	9.99	12.74	23.99	31.36	30.88
Nano urea plus @ 6.0 ml at booting stage (60 DAS)	55.17	90.60	92.58	5.28	9.76	12.57	23.64	30.11	30.31
S.Em.±	0.47	0.64	0.72	0.031	0.101	0.120	0.17	0.11	0.16
C.D. (P=0.05)	1.35	1.84	2.08	0.088	0.290	0.346	0.49	0.33	0.47

Table 2: Effect of different fertility levels and organic sources on crop growth rate, relative growth rate and number of tillers

Treatments	Crop Growth rate (g m ⁻² day ⁻¹)			Relative Growth Rate (g g ⁻¹ day ⁻¹)			Total number of tillers (m ⁻¹ row length)
	60 DAS	90 DAS	At harvest	60 DAS	90 DAS	At harvest	
50% RDN	5.215	7.000	3.732	0.016	0.020	0.013	82.97
75% RDN	7.513	7.104	4.346	0.022	0.021	0.013	93.18
100% RDN	8.076	6.757	4.880	0.023	0.020	0.014	97.85
S.Em.±	0.038	0.074	0.117	0.0001	0.002	0.0001	0.33
C.D. (P=0.05)	0.109	0.213	0.337	0.0003	0.004	NS	0.94
Foliar spray							
Nano urea plus @ 2.0 ml at tillering stage (35 DAS)	6.540	6.671	4.593	0.019	0.019	0.014	86.49
Nano urea plus @ 2.0 ml at booting stage (60 DAS)	6.398	6.345	3.706	0.019	0.019	0.014	83.97
Nano urea plus @ 4.0 ml at tillering stage (35 DAS)	6.963	7.398	4.790	0.020	0.021	0.014	94.83
Nano urea plus @ 4.0 ml at booting stage (60 DAS)	6.764	6.689	3.555	0.020	0.020	0.011	93.51
Nano urea plus @ 6.0 ml at tillering stage (35 DAS)	7.759	7.158	4.583	0.022	0.021	0.013	96.02
Nano urea plus @ 6.0 ml at booting stage (60 DAS)	7.185	7.462	4.688	0.021	0.022	0.014	93.17
S.Em.±	0.076	0.148	0.235	0.0002	0.003	0.0002	0.65
C.D. (P=0.05)	0.219	0.427	0.674	0.001	0.009	NS	1.87

Conclusion

Based on findings, it is proposed that application of 100% RDN recorded the best growth performance in barley, with the highest plant height, dry matter accumulation, leaf area index, total number of tillers, crop growth rate and relative growth rate. Among the foliar spray of nano urea plus, @ 6.0 ml performed best which was statistically at par with @ 4.0 ml at 35 DAS. Overall, the combined use of 100% RDN with foliar spray of nano urea plus @ 4.0 ml at the tillering stage at 35 DAS was most effective for improving growth of barley in southern (Udaipur), Rajasthan.

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