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Effect of seed rate and nitrogen on growth and yield of barley (*Hordeum vulgare* L.)

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ABSTRACT

A field experiment was conducted to study the effect of seed rate and nitrogen levels on growth, yield attributes and productivity of barley (*Hordeum vulgare* L.). The experiment comprised four seed rates (80, 90, 100 and 120 kg ha⁻¹) and four nitrogen levels (50, 60, 70 and 80 kg N ha⁻¹), evaluated in a factorial randomized block design. Plant population at 20 days after sowing (DAS) and at harvest was not significantly influenced by either seed rate or nitrogen level. However, seed rate and nitrogen significantly affected plant height and dry matter accumulation at 30, 60 DAS and harvest. The maximum plant height (26.52, 58.84 and 92.53 cm) and dry matter accumulation (4.54, 7.89 and 13.61 g plant⁻¹) were recorded with 80 kg seed ha⁻¹, whereas nitrogen application at 80 kg N ha⁻¹ produced the maximum plant height (30.41, 58.87 and 92.89 cm) and dry matter accumulation (4.86, 8.46 and 14.59 g plant⁻¹). The highest number of effective tillers (107.87 m⁻²), spike length (8.55 cm), grains spike⁻¹ (47.28), and grain yield (43.77 q ha⁻¹) were obtained with 100 kg seed ha⁻¹. Nitrogen at 80 kg ha⁻¹ recorded maximum effective tillers (98.01 m⁻²), spike length (8.15 cm), grains spike⁻¹ (43.28) and grain yield (39.68 q ha⁻¹). The interaction between seed rate and nitrogen significantly influenced grains spike⁻¹ and grain, straw and biological yields. The maximum grain yield (45.32 q ha⁻¹) was obtained with 120 kg seed ha⁻¹ + 70 kg N ha⁻¹. Straw and biological yields were highest with 120 kg seed ha⁻¹ combined with 80 kg N ha⁻¹ (71.85 and 113.10 q ha⁻¹, respectively). Test weight and harvest index remained unaffected.

Keywords: Barley, Seed rate, Nitrogen levels, Growth, Grain yield

1. Introduction

Barley (*Hordeum vulgare* L.) is an important cereal crop grown during the rabi season and is valued for food, feed, fodder and malting purposes. Its adaptability to diverse agro-climatic conditions, relatively short duration and efficient utilization of available resources make it an important crop in cereal-based production systems. However, achieving higher and stable productivity requires appropriate crop establishment and balanced nutrient management. Among the major agronomic factors, seed rate and nitrogen nutrition have considerable influence on crop growth, yield attributes and grain yield.

Seed rate determines the plant population and spatial arrangement of plants, thereby affecting competition for light, moisture and nutrients. An inadequate seed rate may result in poor plant stand and inefficient utilization of available resources, whereas excessive seed rate can intensify inter-plant competition and adversely affect individual plant performance and yield components. Studies have demonstrated that appropriate seed rates can improve grain and malt yield in barley (Dahiya *et al.*, 2019) [1]. Similarly, seed rate has been reported to interact with nitrogen fertilization, with optimum combinations depending on environmental and crop-growing conditions (Papastylianou, 1995) [2].

Nitrogen is one of the most important nutrients governing vegetative growth, tiller formation, dry matter accumulation and reproductive development in barley. Adequate nitrogen availability promotes plant height, effective tillers, spike development and grain formation, ultimately contributing to higher grain yield. Research has shown that increasing nitrogen application can improve growth and yield attributes of barley, although the optimum level varies with cultivar, soil fertility and environmental conditions (Singh *et al.*, 2013; Tehulie *et al.*, 2021) [3, 4].

The combined management of seed rate and nitrogen is therefore important for achieving efficient resource utilization and higher productivity. Previous research has confirmed that both seed rate and nitrogen can significantly influence yield and yield components of barley (Sharma *et al.*, 2023) [5]. Therefore, the present investigation was undertaken to study the effect of different seed rates and nitrogen levels on growth, yield attributes and yield of barley (*Hordeum vulgare* L.) under the prevailing agro-climatic conditions.

2. Materials and methods

A field experiment was conducted during the rabi season to evaluate the effect of different seed rates and nitrogen levels on growth, yield attributes and yield of barley (*Hordeum vulgare* L.). The experiment was laid out in a factorial randomized block design (FRBD) with three replications. The treatments consisted of four

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seed rates, viz., 80, 90, 100 and 120 kg ha⁻¹, and four nitrogen levels, viz., 50, 60, 70 and 80 kg N ha⁻¹, resulting in 16 treatment combinations. The crop was sown using the recommended agronomic practices, while other cultural operations were carried out uniformly for all treatments. Plant population was recorded at 20 days after sowing (DAS) and at harvest. Plant height and dry matter accumulation were measured at 30 and 60 DAS and at harvest. Yield attributes including effective tillers per metre row length, spike length, number of grains per spike and test weight were recorded at harvest. Grain, straw and biological yields were recorded and expressed in q ha⁻¹. Harvest index was calculated from grain and biological yield using the standard formula. The experimental data were statistically analyzed using analysis of variance appropriate for factorial randomized block design, and treatment means were compared using the critical difference (CD) at the 5% level of significance.

3. Results and discussion

5.1 Growth attributes

Plant population per metre row length at 20 DAS and harvest was not significantly influenced by either seed rate or nitrogen level. Under seed-rate treatments, plant population increased numerically from 8.25 and 8.02 plants m⁻¹ at 80 kg seed ha⁻¹ to 9.25 and 8.95 plants m⁻¹ at 120 kg seed ha⁻¹ at 20 DAS and harvest, respectively. Similarly, nitrogen application increased plant population numerically from 8.42 and 8.12 plants m⁻¹ at 50 kg N ha⁻¹ to 9.56 and 8.98 plants m⁻¹ at 80 kg N ha⁻¹. The absence of significant differences indicates that final crop establishment was comparatively stable across the tested treatments. Similar observations regarding the limited effect of seed rate on yield components under adequate establishment conditions have been reported in barley, although responses may vary with environment and nitrogen supply (Papastylianou, 1995) [2].

Seed rate significantly affected plant height at 30, 60 DAS and harvest. The maximum plant height of 26.52, 58.84 and 92.53 cm was recorded with 80 kg seed ha⁻¹, whereas the minimum values of 23.28, 47.52 and 85.23 cm were recorded with 120 kg seed ha⁻¹. The greater plant height at the lower seed rate may be attributed to reduced competition among plants for light, moisture and nutrients, allowing greater individual plant growth. Similar effects of crop establishment and nutrient availability on barley growth have been documented in earlier studies.

Nitrogen application also significantly increased plant height at all stages. The maximum values of 30.41, 58.87 and 92.89 cm were recorded with 80 kg N ha⁻¹, while the minimum values of 19.61, 51.93 and 82.17 cm were recorded with 50 kg N ha⁻¹. Increased nitrogen availability promotes vegetative growth, leaf development and photosynthetic activity, resulting in greater plant height. Singh *et al.* (2013) [3] reported that increasing nitrogen supply enhanced plant height and dry matter accumulation in barley.

Dry matter accumulation was significantly influenced by both seed rate and nitrogen level at 30, 60 DAS and harvest. The maximum dry matter accumulation under seed-rate treatments was recorded with 80 kg seed ha⁻¹ (4.54, 7.89 and 13.61 g plant⁻¹), while the minimum was recorded with 120 kg seed ha⁻¹ (3.96, 6.89 and 11.88 g plant⁻¹). The higher dry matter accumulation at the lower seed rate may be associated with reduced intra-crop competition and greater availability of growth resources to individual plants.

Among nitrogen treatments, 80 kg N ha⁻¹ produced the maximum dry matter accumulation (4.86, 8.46 and 14.59 g plant⁻¹), whereas 50 kg N ha⁻¹ recorded the minimum (3.48, 6.06 and 10.44 g plant⁻¹). Increased nitrogen availability enhances vegetative growth, leaf area development and assimilate production, thereby increasing dry matter accumulation. Singh *et al.* (2012/2013) similarly observed significant improvement in plant height and dry matter accumulation with increasing nitrogen levels in barley.

5.2 Yield attributes and yield

The number of effective tillers was significantly influenced by seed rate and nitrogen level. The maximum number of effective tillers (107.87 m⁻¹) was recorded with 100 kg seed ha⁻¹, followed by 120 kg seed ha⁻¹ (99.29 m⁻¹), whereas the minimum (79.89 m⁻¹) was observed with 80 kg seed ha⁻¹. The increase in effective tillers with increasing seed rate up to 100 kg ha⁻¹ may be attributed to better crop establishment and greater population available for tiller production.

Nitrogen also significantly increased effective tillers, with the maximum value (98.01 m⁻¹) under 80 kg N ha⁻¹ and the minimum (89.95 m⁻¹) under 50 kg N ha⁻¹. Nitrogen promotes tiller initiation and sustains productive tillers through improved plant nutrition. Singh *et al.* (2013) [3] reported significant increases in effective tillers with increasing nitrogen supply in barley.

Spike length and number of grains per spike were significantly affected by seed rate and nitrogen level. The longest spike (8.55 cm) and maximum number of grains per spike (47.28) were recorded with 100 kg seed ha⁻¹, whereas the minimum values (6.41 cm and 36.87) were obtained with 80 kg seed ha⁻¹. Nitrogen at 80 kg ha⁻¹ produced the longest spikes (8.15 cm) and maximum grains per spike (43.28), while the corresponding minimum values were observed with 50 kg N ha⁻¹.

The interaction between seed rate and nitrogen was significant for grains per spike. The maximum value (49.25 grains spike⁻¹) was recorded with S₃N₂, whereas the minimum (35.12 grains spike⁻¹) occurred with S₀N₀. Improved nitrogen nutrition supports spike development and grain formation, while appropriate plant density provides a favourable balance between plant competition and reproductive growth. Papastylianou (1995) [2] also reported that nitrogen and seed rate influenced barley yield components, particularly tiller and grain formation.

Test weight was not significantly influenced by seed rate, nitrogen level or their interaction. Although numerical differences were observed, values ranged from 36.64 to 39.47 g under different seed rates and from 37.60 to 38.37 g under nitrogen treatments. This suggests that variation in seed rate and nitrogen primarily affected tillering, spike development and grain number rather than individual grain weight. Papastylianou (1995) [2] similarly reported that excessive nitrogen or seed rate could influence grain weight depending on growing conditions.

Grain yield was significantly influenced by seed rate and nitrogen level. Among seed rates, the maximum grain yield (43.77 q ha⁻¹) was obtained with 100 kg seed ha⁻¹, followed by 120 kg ha⁻¹ (39.82 q ha⁻¹), whereas the minimum (33.50 q ha⁻¹) was recorded with 80 kg ha⁻¹. The higher yield at 100 kg ha⁻¹ was associated with improved effective tillers, spike length and grains per spike. The decline at 120 kg ha⁻¹ may indicate greater inter-plant competition at excessive plant density.

Nitrogen application increased grain yield progressively, with the maximum yield (39.68 q ha⁻¹) under 80 kg N ha⁻¹ and minimum yield (37.12 q ha⁻¹) under 50 kg N ha⁻¹. Nitrogen-induced improvement in tiller number, spike development and grain formation contributed to higher grain production. Singh *et al.* (2013) [3] reported significant improvement in barley grain yield with increasing nitrogen application, while Papastylianou (1995) [2] observed that nitrogen could increase barley grain yield substantially when supplied at appropriate levels.

The interaction effect was significant, with the maximum grain yield (45.32 q ha⁻¹) recorded under S₃N₂ and the minimum (32.36 q ha⁻¹) under S₀N₀. This indicates that the response of barley yield to nitrogen was influenced by seed rate and that balanced combinations of plant density and nitrogen availability are important for achieving higher productivity.

Straw yield was significantly influenced by both factors. The maximum straw yield (69.52 q ha⁻¹) was recorded with 120 kg seed ha⁻¹, while the minimum (54.11 q ha⁻¹) was obtained with 80 kg seed ha⁻¹. Among nitrogen levels, 80 kg N ha⁻¹ produced the maximum

straw yield (64.13 q ha⁻¹), compared with 59.95 q ha⁻¹ under 50 kg N ha⁻¹. The interaction was significant, and the maximum straw yield (71.85 q ha⁻¹) was obtained with S₃N₃.

Biological yield followed a similar trend. The highest biological yield under seed-rate treatments was 109.34 q ha⁻¹ with 120 kg seed ha⁻¹, while 80 kg seed ha⁻¹ recorded the minimum (87.61 q ha⁻¹). Nitrogen at 80 kg ha⁻¹ produced the highest biological yield (103.81 q ha⁻¹). The maximum interaction value (113.10 q ha⁻¹) was recorded under S₃N₃. Increased biomass production with higher nitrogen availability has also been reported in barley by Singh *et al.* (2012/2013).

Harvest index was not significantly affected by seed rate, nitrogen level or their interaction. The values ranged from 36.41 to 40.24% under different seed rates and from 38.14 to 38.38% under nitrogen levels. The non-significant response suggests that changes in grain and total biomass production occurred in a relatively balanced manner, resulting in limited variation in partitioning efficiency. Similar findings have been reported where nitrogen treatments altered biomass and

grain yield without necessarily producing proportional changes in harvest index.

Conclusion

The present study revealed that seed rate and nitrogen levels significantly influenced the growth, yield attributes and productivity of barley, while plant population, test weight and harvest index remained unaffected. Among seed rates, 100 kg seed ha⁻¹ recorded the highest grain yield (43.77 q ha⁻¹), along with superior effective tillers, spike length and grains per spike. Nitrogen application at 80 kg N ha⁻¹ resulted in maximum plant height, dry matter accumulation, effective tillers, spike length and grain yield (39.68 q ha⁻¹). The interaction between seed rate and nitrogen significantly influenced grains per spike and grain, straw and biological yields. The highest grain yield (45.32 q ha⁻¹) was obtained with 120 kg seed ha⁻¹ + 70 kg N ha⁻¹, while the maximum straw and biological yields (71.85 and 113.10 q ha⁻¹, respectively) were recorded with 120 kg seed ha⁻¹ + 80 kg N ha⁻¹.

Table 1. Effect of seed rate and nitrogen on growth attributes of barley

S. No.	Treatments	Plant population per m row length		Plant height (cm)			Dry matter accumulation (g/plant)		
		At 20 DAS	At harvest	30 DAS	60 DAS	At harvest	30 DAS	60 DAS	At harvest
A.	Seed Rate								
1.	80 kg/ha	8.25	8.02	26.52	58.84	92.53	4.54	7.89	13.61
2.	90 kg/ha	8.85	8.35	25.31	57.63	90.43	4.33	7.54	12.99
3.	100 kg/ha	9.02	8.75	24.18	56.50	86.41	4.23	7.33	12.68
4.	120 kg/ha	9.25	8.95	23.28	47.52	85.23	3.96	6.89	11.88
	<i>S.Em.</i> [±]	0.25	0.21	0.52	1.17	1.63	0.09	0.16	0.27
	CD	NS	NS	1.49	3.39	4.71	0.26	0.46	0.79
B.	Nitrogen levels								
1.	50 kg/ha	8.42	8.12	19.61	51.93	82.17	3.48	6.06	10.44
2.	60 kg/ha	8.95	8.42	22.72	54.65	87.96	4.07	7.06	12.22
3.	70 kg/ha	9.35	8.78	26.55	55.04	91.57	4.64	8.07	13.91
4.	80 kg/ha	9.56	8.98	30.41	58.87	92.89	4.86	8.46	14.59
	<i>S.Em.</i> [±]	0.25	0.21	0.52	1.17	1.63	0.09	0.16	0.27
	CD	NS	NS	1.49	3.39	4.71	0.26	0.46	0.79
A × B	Seed Rate × Nitrogen levels								
	<i>S.Em.</i> [±]	0.50	0.42	1.03	2.35	3.26	0.18	0.32	0.54
	CD	NS	NS	NS	NS	NS	NS	NS	NS
	CV%	6.25	6.08	7.22	7.38	6.38	7.33	7.42	7.36

Table 2. Effect of seed rate and nitrogen on yield attributes of barley

S. No.	Treatments	Effective tillers per m row length	Spike length (cm)	Number of grains per spike	Test weight (g)
A. Seed Rate					
1.	80 kg/ha	79.89	6.41	36.87	36.64
2.	90 kg/ha	89.71	7.43	40.33	37.44
3.	100 kg/ha	107.87	8.55	47.28	39.47
4.	120 kg/ha	99.29	8.10	43.15	38.37
	<i>S.Em.</i> [±]	1.69	0.16	0.75	0.88
	CD	4.89	0.47	2.15	NS
B. Nitrogen levels					
1.	50 kg/ha	89.95	7.18	40.41	37.60
2.	60 kg/ha	93.08	7.39	41.46	37.82
3.	70 kg/ha	95.72	7.77	42.48	38.13
4.	80 kg/ha	98.01	8.15	43.28	38.37
	<i>S.Em.</i> [±]	1.69	0.16	0.75	0.88
	CD	4.89	0.47	2.15	NS
A × B Seed Rate × Nitrogen levels					
	<i>S.Em.</i> [±]	3.39	0.33	1.41	1.75

(continued on next page)

S. No.	Treatments	Effective tillers per m row length	Spike length (cm)	Number of grains per spike	Test weight (g)
	CD	NS	NS	4.08	NS
	CV%	6.23	7.47	6.16	7.32

Table 3. Effect of seed rate and nitrogen on yield and harvest index of barley

S. No.	Treatments	Grain yield (q/ha)	Straw yield (q/ha)	Biological yield (q/ha)	Harvest index (%)
A.	Seed Rate				
1.	80 kg/ha	33.50	54.11	87.61	38.23
2.	90 kg/ha	36.44	59.51	95.95	38.09
3.	100 kg/ha	43.77	64.84	108.61	40.24
4.	120 kg/ha	39.82	69.52	109.34	36.41
	<i>S.Em.</i> [±]	0.65	0.99	1.66	0.94
	CD	1.89	2.85	4.80	NS
B.	Nitrogen levels				
1.	50 kg/ha	37.12	59.95	97.07	38.23
2.	60 kg/ha	37.89	61.30	99.19	38.14
3.	70 kg/ha	38.84	62.61	101.44	38.38
4.	80 kg/ha	39.68	64.13	103.81	38.21
	<i>S.Em.</i> [±]	0.65	0.99	1.66	0.94
	CD	1.89	2.85	4.80	NS
A × B	Seed Rate × Nitrogen levels				
	<i>S.Em.</i> [±]	1.31	1.97	3.32	1.88
	CD	3.77	5.69	9.60	NS
	CV%	5.90	5.51	5.74	8.53

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