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Effect of nitrogen levels and row spacing on growth and yield of Indian Mustard (*Brassica juncea* L.)

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Abstract

A field experiment was conducted during the Rabi season of 2025-2026 at the Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj (U.P.), India, to study the effect of nitrogen levels and row spacing on the growth and yield of Indian mustard (*Brassica juncea* L.). The experiment was laid out in a Randomized Block Design (RBD) with 12 treatment combinations comprising four nitrogen levels (80, 100, 120 and 140 kg N/ha) and three row spacings (20, 25 and 30 cm), replicated thrice. The variety Azad Mahak was used. Soil pre-sowing analysis revealed neutral pH (7.1), non-saline electrical conductivity (0.29 dS/m) and low soil organic carbon (0.36%), indicating baseline fertility status (ICAR-IISS, 2015). Results revealed that nitrogen management and row spacing significantly influenced growth parameters, yield attributes and crop yield. Among the treatments, T₂ (80 kg N/ha + 25 cm row spacing) recorded the highest plant height (82.80 cm), dry weight (18.66 g/plant), siliquae/m² (10,147.3), seeds/silique (8.27), test weight (4.98 g), straw yield (9.6 t/ha) and seed yield (3.89 t/ha) with a harvest index of 30.2%. These findings suggest that application of 80 kg N/ha with 25 cm row spacing is the most productive combination for optimizing growth and yield parameters of Indian mustard under the agro-climatic conditions of Prayagraj, enhancing nutrient efficiency in organic carbon-deficient soils.

Keywords: *Brassica juncea*, nitrogen levels, row spacing, growth parameters, yield attributes, soil pH, electrical conductivity, organic carbon

1. Introduction

Indian mustard (*Brassica juncea* L.), belonging to the family Brassicaceae, is one of the oldest and most economically important oilseed crops in the world. The Brassicaceae family comprises approximately 3,500 species and 350 genera, ranking among the ten most economically significant plant families globally (Chauhan *et al.*, 2020) ^[5]. Rapeseed and mustard collectively constitute the third most important edible oilseed crop worldwide, after soybean and palm oil and play a major role in meeting the dietary requirements of South Asia (ICAR-DRMR, 2022) ^[14]. The two most widely cultivated species are *Brassica juncea* and *Brassica campestris*, with seed oil content ranging from 37 to 49%.

Globally, the total area, production and yield of rapeseed-mustard in 2023-24 were 42.53 million hectares, 88.07 million metric tonnes and 2.07 metric tonnes per hectare, respectively. India accounts for 19.8% of the total global acreage and 9.8% of total production (ICAR-DRMR, 2024) ^[14]. In India, mustard is grown over approximately 6.26 million hectares with a production of 8.68 million tonnes and productivity of 1.3 t/ha. In Uttar Pradesh, rapeseed-mustard covers 1.27 million hectares with a production of 1.9 million tonnes and productivity of 1.5 t/ha (GOI, 2023).

Nitrogen is the most critical macronutrient influencing the vegetative growth, leaf area expansion and seed yield in mustard. Brassica species, despite having high nitrogen absorption efficiency, exhibit low translocation efficiency towards reproductive organs, resulting in reduced nitrogen utilization efficiency (Kumar *et al.*, 2018) ^[21]. Indian mustard is highly sensitive to nitrogen deficiency, which causes chlorosis and dwarfing, ultimately reducing productivity (Rana *et al.*, 2021) ^[31]. Approximately 90% of Indian soils, particularly in the Gangetic plains, exhibit low to medium levels of nitrogen, phosphorus and potassium (Sharma and Meena, 2019) ^[32], making nitrogen management a major challenge in rapeseed-mustard production.

Row spacing is a non-monetary but critical agronomic input that regulates plant population density, inter-plant competition and resource use efficiency. Optimum row spacing ensures better light interception at each leaf stratum, enhancing photosynthesis, dry matter production and crop yield (Alam and Singh, 2018) ^[1]. Establishment of optimum plant population through proper row spacing is essential for better translocation of photosynthates and higher crop yield (Sondhiya *et al.*, 2019; Singh *et al.*, 2024) ^[35, 34].

The present investigation was therefore undertaken to study the effect of nitrogen levels and row spacing on growth and yield of Indian mustard, with particular focus on assessing crop productivity under the baseline soil constraints of the region.

2. Materials and Methods

2.1 Experimental Site and Period

The field experiment was conducted during the Rabi season of 2025-2026 at the Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj (U.P.), India. The experimental site is located at 25.28°N latitude, 81.54°E longitude and 98 m altitude above mean sea level, situated on the right bank of the

river Yamuna, approximately 5 km from Prayagraj city.

2.2 Climate

Prayagraj experiences a sub-tropical and semi-arid climate with extreme temperatures in both winter and summer. The southwest monsoon commences in July and withdraws by the end of September. During the cropping season (Rabi 2025-2026), meteorological data including weekly average maximum and minimum temperatures, relative humidity and rainfall were recorded at the Agrometeorological Observatory Unit, School of Forestry and Environmental Sciences, SHUATS, Prayagraj.

2.3 Soil Characteristics

The experimental field soil was sandy loam in texture, neutral in pH, non-saline in electrical conductivity and low in organic carbon. Composite soil samples were collected from a depth of 0-15 cm prior to sowing for physical and chemical analysis. The pre-sowing chemical and physical characteristics of the soil, along with the standardized methodologies used for analysis, are detailed in Table 1.

Table 1: Physio-chemical properties of the experimental soil (pre-sowing)

S. No.	Soil Parameter / Characteristic	Value & Unit	Analytical Method (References)
1	Sand	63.00%	Bouyoucos Hydrometer method (ICAR-IISS, 2015) ^[15]
2	Silt	22.60%	Bouyoucos Hydrometer method (ICAR-IISS, 2015) ^[15]
3	Clay	14.40%	Bouyoucos Hydrometer method (ICAR-IISS, 2015) ^[15]
4	Textural Class	Sandy loam	Bouyoucos Hydrometer method (ICAR-IISS, 2015) ^[15]
5	Soil pH (1:2.5 water suspension)	7.10	Glass electrode pH meter (Prasad and Kumar, 2016) ^[30]
6	Electrical Conductivity (EC)	0.29 dS/m	EC Meter (1:2.5 suspension) (Prasad and Kumar, 2016) ^[30]
7	Soil Organic Carbon (OC)	0.36%	Walkley & Black's wet oxidation (ICAR-IISS, 2015) ^[15]
8	Available Nitrogen	171.48 kg/ha	Alkaline permanganate method (Prasad and Kumar, 2016) ^[30]
9	Available Phosphorus	15.20 kg/ha	Olsen's NaHCO ₃ method (ICAR-IISS, 2015) ^[15]
10	Available Potassium	232.50 kg/ha	Flame Photometer method (Prasad and Kumar, 2016) ^[30]

2.4 Experimental Design and Treatments

The experiment was laid out in a Randomized Block Design (RBD) with 12 treatment combinations replicated thrice. The treatments comprised four levels of nitrogen (N₁ = 80, N₂ = 100, N₃ = 120, N₄ = 140 kg N/ha) and three row spacings (S₁ = 20 cm, S₂ = 25 cm, S₃ = 30 cm), as detailed in Table 2.

Table 2: Treatment combinations used in the experiment

Treatment	Nitrogen Level (kg N/ha)	Row Spacing (cm)
T ₁	80	20
T ₂	80	25
T ₃	80	30
T ₄	100	20
T ₅	100	25
T ₆	100	30
T ₇	120	20
T ₈	120	25
T ₉	120	30
T ₁₀	140	20
T ₁₁	140	25
T ₁₂	140	30

2.5 Crop Management

The mustard variety Azad Mahak was selected for the experiment. The field was prepared by ploughing twice with a tractor-drawn cultivator to achieve a fine and friable soil structure. Seeds were sown manually in lines on 12 November 2025 at a depth of 3-4 cm, with plant-to-plant spacing of 10 cm. Seeds were treated with Mancozeb (75% WP) at 3 g/kg seed, 24

hours before sowing. Half the recommended nitrogen dose along with the full recommended doses of phosphorus and potassium were applied at sowing. The remaining half of nitrogen was applied at 20 DAS as top dressing. Gap filling and thinning were carried out at 8 DAS to maintain the desired plant population. Two hand weedings were performed at 20 and 40 DAS. Five irrigations were provided during the crop period. The crop was harvested at 125 DAS when leaves turned yellow and siliquae attained proper colour.

2.6 Observations Recorded

Pre-harvest observations were recorded at 20, 40, 60 and 80 DAS: (i) Plant height (cm) - measured from ground level to the tip of the main shoot on five randomly tagged plants per plot; (ii) Plant dry weight (g/plant) - five representative plants were uprooted, sun-dried and oven-dried at 65-70°C to constant weight; (iii) Crop Growth Rate (CGR, g/m²/day) = (W₂ - W₁) / S(t₂ - t₁) where W₁ and W₂ are dry weights per unit area at times t₁ and t₂ and S is spacing; (iv) Relative Growth Rate (RGR, g/g/day) = (log_e W₂ - log_e W₁) / (t₂ - t₁) (Keerthi *et al.*, 2017) ^[19].

Post-harvest observations included: number of siliquae/m², number of seeds/siliqua, test weight (g per 1000 seeds), seed yield (t/ha), straw yield (t/ha) and harvest index (%) = (Seed yield / Biological yield) × 100.

2.7 Statistical Analysis

Data were subjected to analysis of variance (ANOVA) using the

F-test procedure of Sheoran *et al.* (2018) [33]. Significant differences between treatment means were tested using the Critical Difference (CD) at the 5% probability level.

3. Results and Discussion

3.1 Plant Height (cm)

Plant height increased progressively from 20 DAS to 80 DAS across all treatments (Table 3). At 20 DAS, no significant differences were observed. Significant differences emerged at 40, 60 and 80 DAS.

At 80 DAS, the highest plant height (82.80 cm) was recorded in T₂ (80 kg N/ha + 25 cm row spacing), which was statistically at par with T₃ (82.51 cm) and T₄ (74.45 cm). The lowest plant height (65.59 cm) was recorded in T₁₂ (140 kg N/ha + 30 cm). The superior plant height under T₂ may be attributed to the optimum nitrogen supply at 80 kg N/ha, which promoted cell elongation and vegetative growth without causing luxuriant vegetative growth or lodging. The 25 cm row spacing provided adequate inter-plant space for light interception and reduced competition, facilitating better nutrient and moisture uptake. These results are in conformity with the findings of Bano *et al.* (2021) [3], Kumar *et al.* (2018) [21] and Singh *et al.* (2024) [34], who reported that moderate nitrogen levels combined with optimum spacing significantly enhanced plant height in mustard by reducing competition for light.

Table 3: Effect of Nitrogen and Row Spacing on Plant Height (cm) of Indian Mustard

Treatment	Treatment Combination	20 DAS	40 DAS	60 DAS	80 DAS
T ₁	80 kg N/ha + 20 cm	3.26	24.72	74.76	80.64
T ₂	80 kg N/ha + 25 cm	3.60	32.79	78.83	82.80*
T ₃	80 kg N/ha + 30 cm	3.52	26.04	78.81	82.51
T ₄	100 kg N/ha + 20 cm	3.46	26.46	67.78	74.45
T ₅	100 kg N/ha + 25 cm	3.33	21.31	66.56	71.89
T ₆	100 kg N/ha + 30 cm	3.36	27.53	64.38	69.72
T ₇	120 kg N/ha + 20 cm	3.40	22.34	74.56	80.20
T ₈	120 kg N/ha + 25 cm	3.64	28.19	67.07	75.09
T ₉	120 kg N/ha + 30 cm	3.68	20.61	64.90	70.90
T ₁₀	140 kg N/ha + 20 cm	3.38	23.74	66.45	71.79
T ₁₁	140 kg N/ha + 25 cm	3.45	21.71	61.92	69.64
T ₁₂	140 kg N/ha + 30 cm	3.45	26.96	59.59	65.59
SEm±		0.09	1.94	3.21	3.09
CD (5%)		-	5.70	8.10	8.82
F-test		NS	S	S	S

3.2 Plant Dry Weight (g/plant)

Dry weight increased steadily from 20 DAS to 80 DAS across all treatments (Table 4). At 80 DAS, the highest dry weight (18.66 g/plant) was recorded in T₂ (80 kg N/ha + 25 cm), which was statistically at par with T₁ (18.01 g/plant) and T₃ (16.20 g/plant). The lowest dry weight (10.79 g/plant) was recorded in T₁₁ (140 kg N/ha + 25 cm).

The higher dry matter accumulation under T₂ can be attributed to better photosynthetic efficiency, improved nutrient uptake and reduced inter-plant competition at 25 cm spacing. Wider spacing and optimum nitrogen supply enhanced root proliferation and nutrient uptake activity, leading to greater water and nutrient uptake and higher dry matter accumulation, as also reported by Chaudhary *et al.* (2018) [4] and Singh *et al.* (2024) [34]. Excessive nitrogen (140 kg N/ha) may have caused luxury consumption and imbalanced vegetative growth, reducing assimilate partitioning efficiency.

Table 4: Effect of Nitrogen and Row Spacing on Dry Weight (g/plant) of Indian Mustard

Treatment	Treatment Combination	20 DAS	40 DAS	60 DAS	80 DAS
T ₁	80 kg N/ha + 20 cm	2.67	4.78	10.38	18.01
T ₂	80 kg N/ha + 25 cm	2.92	5.03	11.03	18.66*
T ₃	80 kg N/ha + 30 cm	2.50	4.54	10.20	16.20
T ₄	100 kg N/ha + 20 cm	2.65	4.44	9.37	15.04
T ₅	100 kg N/ha + 25 cm	2.50	4.43	9.63	12.96
T ₆	100 kg N/ha + 30 cm	2.36	4.20	9.33	12.07
T ₇	120 kg N/ha + 20 cm	2.50	4.31	9.76	12.10
T ₈	120 kg N/ha + 25 cm	2.35	4.25	8.90	13.30
T ₉	120 kg N/ha + 30 cm	2.57	4.42	9.24	11.70
T ₁₀	140 kg N/ha + 20 cm	2.10	4.28	9.07	12.80
T ₁₁	140 kg N/ha + 25 cm	2.00	4.42	9.85	10.79
T ₁₂	140 kg N/ha + 30 cm	2.07	4.17	8.85	12.99
SEm±		0.27	0.13	0.34	0.97
CD (5%)		-	0.39	0.99	2.84
F-test		NS	S	S	S

3.3 Crop Growth Rate (CGR)

Data on CGR at different growth intervals are presented in Table 5. At the 20-40 DAS interval, no significant differences were observed among treatments. Significant differences were recorded at 40-60 DAS and 60-80 DAS intervals.

At 40-60 DAS, the highest CGR (1.52 g/m²/day) was recorded in T₁ (80 kg N/ha + 20 cm), with T₂ statistically at par (1.29 g/m²/day). The lowest CGR was recorded in T₁₂ (0.92 g/m²/day). At 60-80 DAS, the highest CGR (2.62 g/m²/day) was again recorded in T₁. The higher CGR under lower nitrogen levels and closer spacing during later growth stages reflects more efficient dry matter accumulation per unit land area due to higher population density. The progressive increase in CGR from early to later growth stages indicates active biomass accumulation during the reproductive phase, consistent with the findings of Keerthi *et al.* (2017) [19] and Lalruatfeli *et al.* (2021) [24]. Similar trends were observed by Tripathi *et al.* (2015) [36] and Yadav *et al.* (2016) [37].

Table 5: Effect of Nitrogen Levels and Row Spacing on Crop Growth Rate (g/m²/day) of Indian Mustard

Treatment	Treatment Combination	20-40 DAS	40-60 DAS	60-80 DAS
T ₁	80 kg N/ha + 20 cm	0.6975	1.5206*	2.6237*
T ₂	80 kg N/ha + 25 cm	0.5857	1.2930	2.1730
T ₃	80 kg N/ha + 30 cm	0.4418	0.9910	1.5697
T ₄	100 kg N/ha + 20 cm	0.6466	1.4232	2.1832
T ₅	100 kg N/ha + 25 cm	0.5166	1.1762	1.4955
T ₆	100 kg N/ha + 30 cm	0.4079	0.9254	1.1594
T ₇	120 kg N/ha + 20 cm	0.6278	1.4532	1.7402
T ₈	120 kg N/ha + 25 cm	0.4963	1.1169	1.5389
T ₉	120 kg N/ha + 30 cm	0.4292	0.9792	1.1203
T ₁₀	140 kg N/ha + 20 cm	0.6268	1.4004	1.8484
T ₁₁	140 kg N/ha + 25 cm	0.5184	1.1751	1.2343
T ₁₂	140 kg N/ha + 30 cm	0.4070	0.9231	1.2515
SEm±		0.33	0.32	0.99
CD (5%)		-	0.95	0.89
F-test		NS	S	S

3.4 Relative Growth Rate (RGR)

RGR data across growth intervals are presented in Table 6. No significant differences were observed among treatments at any growth interval (20-40, 40-60, or 60-80 DAS), indicating that the efficiency of dry matter production relative to existing

biomass was not significantly altered by the treatments. At 20-40 DAS, the highest RGR (0.040 g/g/day) was recorded in T₁₁ (140 kg N/ha + 25 cm) and the lowest in T₄ (0.026 g/g/day). At 60-80 DAS, the highest RGR (0.027 g/g/day) was in T₁ and the lowest in T₉ (0.008 g/g/day). The non-significant RGR response suggests that while total biomass accumulation differed, the relative growth efficiency of plants remained comparable across treatments under the same agro-climatic conditions.

Table 6: Effect of Nitrogen Levels and Row Spacing on Relative Growth Rate (g/g/day) of Indian Mustard

Treatment	Treatment Combination	20-40 DAS	40-60 DAS	60-80 DAS
T ₁	80 kg N/ha + 20 cm	0.029	0.038	0.027
T ₂	80 kg N/ha + 25 cm	0.027	0.039	0.026
T ₃	80 kg N/ha + 30 cm	0.030	0.040	0.024
T ₄	100 kg N/ha + 20 cm	0.026	0.039	0.022
T ₅	100 kg N/ha + 25 cm	0.029	0.041	0.013
T ₆	100 kg N/ha + 30 cm	0.029	0.040	0.012
T ₇	120 kg N/ha + 20 cm	0.027	0.042	0.010
T ₈	120 kg N/ha + 25 cm	0.030	0.040	0.017
T ₉	120 kg N/ha + 30 cm	0.027	0.041	0.008
T ₁₀	140 kg N/ha + 20 cm	0.036	0.040	0.015
T ₁₁	140 kg N/ha + 25 cm	0.040	0.041	0.004
T ₁₂	140 kg N/ha + 30 cm	0.035	0.041	0.016
SEm±		0.13	0.01	0.01
CD (5%)		-	-	-
F-test		NS	NS	NS

3.5 Yield and Yield Attributes

Data on yield and yield attributes are presented in Table 7. The treatment T₂ (80 kg N/ha + 25 cm row spacing) consistently achieved superior performance across all yield parameters.

3.5.1 Number of Siliquae/m²

Significant differences were observed among treatments for the number of siliquae/m². The highest number of siliquae/m² (10,147.3) was recorded in T₂ (80 kg N/ha + 25 cm), which was statistically at par with T₄ (10,156.0) and T₇ (10,131.3). The lowest was recorded in T₁₂ (6,740.7). The higher siliqua number under T₂ is attributed to better branching, improved photosynthate supply and reduced inter-plant competition at 25 cm spacing. Lower plant population at wider spacing generally increases siliquae per plant, while optimum nitrogen supply supports reproductive development. These findings are in agreement with Gupta *et al.* (2022) [12], Kumar *et al.* (2018) [21] and Patel *et al.* (2024) [28].

3.5.2 Test Weight (g)

The highest test weight (4.98 g) was recorded in T₂ (80 kg N/ha + 25 cm), while the lowest (3.50 g) was in T₁₀ (140 kg N/ha + 20 cm). Test weight in mustard increased significantly with optimum nitrogen levels and spacing due to improved photosynthesis, nutrient uptake and efficient seed filling, resulting in bolder seeds. Similar findings were reported by Chaudhary *et al.* (2018) [4] and Anuroop *et al.* (2024) [2].

3.5.3 Seeds per Siliqua

The highest number of seeds/siliqua (8.27) was recorded in T₂ (80 kg N/ha + 25 cm), while the lowest (7.40) was in T₁₀. The lower seeds/siliqua under closer spacing is attributed to greater plant competition for environmental resources, reducing photosynthetic material production and its transfer to seeds, as reported by Anuroop *et al.* (2024) [2], Dhruv *et al.* (2021) [10] and Lalruatfeli *et al.* (2021) [24].

3.5.4 Straw Yield (t/ha)

The highest straw yield (9.60 t/ha) was recorded in T₂ (80 kg N/ha + 25 cm), while the lowest (5.84 t/ha) was in T₁₂ (140 kg N/ha + 30 cm). The superior straw yield under T₂ reflects better vegetative biomass accumulation due to optimum nitrogen supply and spacing. These results are in alignment with Dekhane *et al.* (2024) [7], Jha *et al.* (2022) [18] and Lakra *et al.* (2018) [23].

3.5.5 Seed Yield (t/ha)

The highest seed yield (3.89 t/ha) was recorded in T₂ (80 kg N/ha + 25 cm), which was statistically at par with T₁ (3.87 t/ha) and T₃ (3.25 t/ha). The lowest seed yield was recorded in T₅ (2.08 t/ha). The superior seed yield under T₂ is attributed to the combined effect of optimum nitrogen supply promoting vegetative growth and reproductive development and 25 cm row spacing ensuring adequate light interception, reduced competition and efficient resource utilization. These results are consistent with Kumar *et al.* (2018) [21], Meena *et al.* (2024) [26] and Nayak *et al.* (2022) [27].

3.5.6 Harvest Index (%)

The highest harvest index (30.2%) was recorded in T₂ (80 kg N/ha + 25 cm), while the lowest (14.6%) was in T₁₀ (140 kg N/ha + 20 cm). A higher harvest index indicates more efficient partitioning of assimilates towards economic yield (seeds). The superior harvest index under T₂ reflects a balanced vegetative-to-reproductive growth ratio, facilitated by optimum nitrogen and spacing.

Table 7: Effect of Nitrogen Levels and Row Spacing on Yield and Yield Attributes of Indian Mustard

Treatment	Treatment Combination	Siliquae/m ²	Test Wt (g)	Seeds/Siliqua	Straw (t/ha)	Seed (t/ha)	HI (%)
T ₁	80 kg N/ha + 20 cm	6,744.7	4.88	8.13	6.59	3.87	27.2
T ₂	80 kg N/ha + 25 cm	10,147.3*	4.98*	8.27*	9.60*	3.89*	30.2*
T ₃	80 kg N/ha + 30 cm	6,742.7	4.88	8.00	8.98	3.25	26.6
T ₄	100 kg N/ha + 20 cm	10,139.0	3.76	7.80	17.90	3.56	16.6
T ₅	100 kg N/ha + 25 cm	7,657.3	4.33	8.70	7.16	2.08	22.5
T ₆	100 kg N/ha + 30 cm	6,744.7	4.88	8.13	9.60	3.87	28.7
T ₇	120 kg N/ha + 20 cm	10,131.3	3.98	8.27	8.09	3.04	27.3
T ₈	120 kg N/ha + 25 cm	7,665.3	4.29	8.13	7.60	2.17	22.2
T ₉	120 kg N/ha + 30 cm	6,727.3	4.83	8.13	13.20	2.94	18.2
T ₁₀	140 kg N/ha + 20 cm	10,118.0	3.50	7.40	15.50	2.65	14.6
T ₁₁	140 kg N/ha + 25 cm	7,636.7	4.39	8.40	8.77	2.88	24.7
T ₁₂	140 kg N/ha + 30 cm	6,740.7	4.71	8.20	5.84	2.64	31.1
SEm±		41.06	0.157	0.145	0.451	0.073	0.94
CD (5%)		85.08	-	0.425	1.32	0.215	2.76
F-test		S	NS	S	S	S	S

3.6 Baseline Soil Chemical Properties (pH, EC and OC) and Crop Performance

The pre-sowing soil chemical characteristics play a pivotal role in dictating nutrient availability, root growth and subsequent yield of Indian mustard. The experimental field exhibited a neutral soil pH of 7.10 (Table 2), which represents the optimal range for the availability of essential macronutrients and micronutrients in alluvial soils of the Indo-Gangetic plains. Neutral pH values prevent nutrient lockup, particularly phosphorus and nitrogen, thereby ensuring that applied fertilizers are efficiently absorbed by the root system of *Brassica juncea*. This is supported by Sharma and Meena (2019) [32], who noted that maintaining neutral soil pH is highly conducive to maximizing fertilizer use efficiency in oilseed brassicas.

The baseline electrical conductivity (EC) of 0.29 dS/m indicates that the soil is completely non-saline. Salinity induces osmotic stress, which impedes water uptake and seed germination in mustard. An EC value below 2.0 dS/m ensures that root osmotic potential remains unhindered, facilitating regular water uptake and plant transpiration necessary for vegetative dry weight accumulation. Gupta *et al.* (2022) [12] highlighted that low salinity soil allows ideal root elongation and cell division, corresponding directly to enhanced crop dry weight and plant height.

Crucially, the soil was found to be highly deficient in organic carbon, recording a low value of 0.36%. Organic carbon is the primary indicator of soil organic matter and soil health, serving as a reservoir for indigenous nitrogen supply. The low baseline organic carbon explains the highly significant positive response of Indian mustard to external nitrogen levels observed in this study. In organic carbon-deficient soils, the crop is highly dependent on mineral nitrogen fertilization. Moderate application at 80 kg N/ha (treatment T₂) provided the requisite nitrogen flux to satisfy the vegetative demand of Azad Mahak variety, overcoming the low native soil nitrogen supplying capacity without inducing lodging. As reported by Kumar *et al.* (2018) [21], crop response to chemical nitrogen is highly pronounced in soils with low organic carbon, where optimum agronomic management and plant geometry are essential to maximize nutrient recovery.

4. Summary

The present investigation on the effect of nitrogen levels and row spacing on growth and yield of Indian mustard (*Brassica juncea* L.) was conducted at the Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj during Rabi 2025-2026 using a Randomized Block Design with 12 treatment combinations replicated thrice. The experimental field consisted of sandy loam soil with neutral pH (7.10), low electrical conductivity (0.29 dS/m) and low organic carbon content (0.36%), which supported a positive response to nitrogen application. Among the treatments, the application of 80 kg N/ha with 25 cm row spacing (T₂) recorded the highest plant height (82.80 cm at 80 DAS) and dry matter accumulation (18.66 g/plant at 80 DAS), indicating superior vegetative growth. The highest crop growth rate was observed under T₁ (80 kg N/ha + 20 cm spacing) during both 40-60 DAS (1.52 g/m²/day) and 60-80 DAS (2.62 g/m²/day), whereas relative growth rate remained non-significant across treatments and growth stages. Yield attributes were significantly influenced by nitrogen and spacing levels, with T₂ producing the maximum number of siliquae/m² (10,147.3), seeds/siliqua (8.27), test weight (4.98 g), straw yield (9.60 t/ha), seed yield (3.89 t/ha) and harvest index (30.2%), indicating efficient assimilate partitioning under optimum crop

geometry. Hence, it can be concluded that the application of 80 kg N/ha with 25 cm row spacing is the most suitable treatment combination for maximizing growth and yield of Indian mustard under the agro-climatic conditions of Prayagraj, Uttar Pradesh.

5. Conclusion

Application of 80 Kg N/ha + Row Spacing 25 cm (Treatment 2) was recorded higher yield (3.89 t/ha), and benefit cost ratio (2.80).

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