International Journal of Advanced Biochemistry Research

ISSN Print: 2617-4693
ISSN Online: 2617-4707
NAAS Rating (2026): 5.29
IJABR 2026; SP-10(1): 686-692
www.biochemjournal.com
Received: 13-10-2025
Accepted: 16-11-2025

Lekhani Soni
M.Sc. Agronomy Scholar, Mandsaur University, Mandsaur, Daulatpura, Madhya Pradesh, India

Matukdhari Singh
Assistant Professor, Faculty of Agriculture Sciences, Mandsaur University, Mandsaur, Daulatpura, Madhya Pradesh, India

Ajanta Borah
Assistant Professor, Faculty of Agriculture, Medicaps University, Pigdamber, Rau, Indore (Madhya Pradesh), India

Ankit Labana
M.Sc. Agronomy Scholar, Mandsaur University, Mandsaur, Daulatpura, Madhya Pradesh, India

Kamal Kumar Suthar
M.Sc. Agronomy Scholar, Mandsaur University, Mandsaur, Daulatpura, Madhya Pradesh, India

Ashutosh Vyas
M.Sc. Agronomy Scholar, Mandsaur University, Mandsaur, Daulatpura, Madhya Pradesh, India

Corresponding Author:
Matukdhari Singh
Assistant Professor, Faculty of Agriculture Sciences, Mandsaur University, Mandsaur, Daulatpura, Madhya Pradesh, India

Physiological growth analysis in Urdbean under Malwa region of Madhya Pradesh

Lekhani Soni, Matukdhari Singh, Ajanta Borah, Ankit Labana, Kamal Kumar Suthar and Ashutosh Vyas

DOI: https://www.doi.org/10.33545/26174693.2026.v10.i1Si.7059

Abstract
The present investigation was conducted at the Research Farm, Mandsaur University, Mandsaur (Madhya Pradesh), India, during the *Kharif* season (June-December 2024). The experiment aimed to evaluate the impact of different sowing methods and spacing treatments on the growth and yield of Urdbean. The experiment was laid out in a split plot design with three replications, comprising two main plot treatments (flat bed and raised bed sowing) and four subplot treatments of spacing (broadcasting, 30×30 cm, 45×30 cm, and 60×30 cm), resulting in eight treatment combinations (T_1-T_8). Urdbean variety T-9 was sown using a seed rate of 15 kg ha^{-1} with a recommended fertilizer dose of 20:40:20 kg N:P:K ha^{-1}. Raised bed sowing recorded a higher plant population compared to flat bed sowing, with 25.01 plants m^{-2} at 30 DAS and 19.36 plants m^{-2} at harvest, while flat bed sowing recorded 19.07 and 13.01 plants m^{-2}, respectively.
Raised bed sowing (B_2) improved nutrient availability, harvest index, and crop growth of Urdbean compared to flat beds (B_1), with the highest N, P, and K recorded at 371.52, 38.00, and 155.01 kg/ha, respectively, under B_2S_2 (Raised bed + 30×30 cm spacing). Among spacing treatments, 30×30 cm (S_2) favored nutrient uptake and harvest index (15.93), while 60×30 cm (S_4) enhanced relative and crop growth rates. Interaction effects highlighted that B_2S_2 consistently achieved maximum harvest index (16.06), relative growth rate (0.059), and crop growth rate (2.981). Overall, raised bed sowing combined with 30×30 cm spacing was most effective for optimizing nutrient availability, growth dynamics, and productivity of Urdbean.

Keywords: Crop growth rate, raised bed, spacing, sowing and Urdbean

Introduction
Urdbean (*Vigna mungo* L. Hepper), commonly called black gram, is a major pulse crop belonging to the family Leguminosae (Fabaceae), subfamily Papilionaceae, and genus *Vigna* (Nair *et al.*, 2024) [31]. It is one of the principal grain legumes grown in the Indian subcontinent and has been cultivated in India since ancient times. Urdbean holds considerable importance in Indian agriculture due to its adaptability to diverse agro-climatic conditions, short crop duration, and ability to enhance soil fertility through biological nitrogen fixation (Giri *et al.*, 2024) [15]. The expansion of Urdbean cultivation has contributed significantly to food security and provided additional income for small and marginal farmers.
Urdbean is a diploid, self-pollinating C_3 plant with a chromosome number of 2n = 22 (Bhattacharjee, 2024) [6]. It is an annual herbaceous crop with a well-developed taproot system and lateral roots that bear nitrogen-fixing nodules (Singh, 2013) [43]. The plant exhibits a dicotyledonous growth habit, and its morphology varies with the variety, ranging from erect and semi-erect to spreading types. The crop thrives under tropical and subtropical climates (Hedayetullah and Zaman, 2018) [21], requiring warm temperatures of 25-35 °C and moderate rainfall between 600-1000 mm. Urdbean is sensitive to frost and prolonged waterlogging. It can grow on a wide range of soils, including loamy, clay loam, and black cotton soils, provided proper drainage is available, with an optimal soil pH of 6.0-7.5 for healthy growth (Sahni *et al.*, 2016) [38].
From a nutritional perspective, Urdbean is an excellent source of plant protein, containing approximately 24-26% protein, 55-60% carbohydrates, 1-1.5% fat, 3-4% minerals, and 4-5% crude fiber (Kole *et al.*, 2002) [26]. It is particularly rich in lysine, an essential amino acid that complements cereal-based diets.

The crop is also a source of vitamins such as thiamine, riboflavin, and niacin, making it an important dietary component, especially in vegetarian diets.

Urdbean is widely used in traditional Indian cuisine. Its split seeds are consumed as dal, while the flour is used to prepare a variety of fermented foods, including idli, dosa, vada, and papad. Beyond human consumption, Urdbean residues serve as nutritious fodder for livestock and contribute to soil health by increasing organic matter and nitrogen content.

India is the world's largest producer and consumer of Urdbean, with major cultivation in Madhya Pradesh, Uttar Pradesh, Maharashtra, Rajasthan, Andhra Pradesh, Karnataka, and Tamil Nadu. In Maharashtra, Urdbean is mainly grown in the Vidarbha and Marathwada regions, where climatic conditions and soil types are favorable (Nair *et al.*, 2024) [31]. Adoption of improved agronomic practices such as ridge and furrow and Broad Bed Furrow (BBF) methods enhances moisture conservation and crop performance under rainfed conditions.

Plant spacing is a key factor influencing Urdbean growth and yield, as it affects light interception, air circulation, nutrient uptake, and moisture utilization (Kole *et al.*, 2002) [26]. Proper plant geometry ensures efficient growth, reduces competition, and enhances yield potential while minimizing the need for excessive inputs (Wasay *et al.*, 2024) [45]. Assessing available nutrients (N, P, K), relative growth rate (RGR), and crop growth rate (CGR) is essential to understand Urdbean growth and productivity under different sowing methods and spacing. N, P, and K are vital for vegetative growth, root and pod development, and stress tolerance (Sharkey *et al.*, 2025) [41]. RGR indicates early growth efficiency, while CGR reflects overall biomass accumulation per unit area (Lamont *et al.*, 2023) [28]. Together, these parameters help identify the best sowing and spacing practices to optimize nutrient uptake, growth, and yield in Urdbean cultivation.

Materials and Methods

The present investigation titled "Physiological growth analysis in Urdbean under Malwa Region of Madhya Pradesh". The present experiment was conducted at at Crop Research Cafeteria, under Mandsaur University, Mandsaur (Madhya Pradesh). Mandsaur (Madhya Pradesh) which is situated at latitude 24 °C 4'36.61''N, longitude $75^0$4'9.46'' E and at an altitude of 442.16 meters above the mean sea level. The experiment involved two main plot treatments: B_1 for flat bed sowing and B_2 for raised bed sowing. There were four sub-plot treatments based on spacing: S1 for broadcasting, S_2 for 30×30 cm spacing, S_3 for 45×30 cm spacing, and S_4 for 60×30 cm spacing. The treatment combinations were as follows: T_1: Flat bed + Broadcasting (B_1S_1),T_2: Flat bed + 30×30 cm spacing (B_1S_2),T_3: Flat bed + 45×30 cm spacing (B_1S_3),T_4: Flat bed + 60×30 cm spacing (B_1S_4),T_5: Raised bed + Broadcasting (B_2S_1),T_6: Raised bed + 30×30 cm spacing (B_2S_2), T_7: Raised bed + 45×30 cm spacing (B_2S_3) andT_8: Raised bed + 60×30 cm spacing (B_2S_4). The experiment was laid out using a split plot design with three replications. There were eight treatments in total, and the experiment was conducted in 24 plots. The gross plot size was 3.60 × 3.90 meters, which equals 14.40 m², while the net plot size was 3.0 × 3.90 meters, totaling 11.70 m². The gross plot area was calculated to be 424.70 m². For the Urdbean crop, the recommended fertilizer doses were 20 kg N, 40 kg P, and 20 kg K per hectare. The seed rate used for the experiment was 80 kg per hectare.

Relative Growth Rate (RGR): Relative Growth Rate (RGR) expresses the total plant dry weight increase in a time interval in relation to the initial weight or Dry matter increment per unit biomass per unit time or grams of dry weight increase per gram of dry weight and expressed as unit dry weight/unit dry weight/unit time (g $g^{-1}day^{-1}$).

The Relative Growth Rate (RGR) is calculated using the following formula:

$$RGR = \frac{\text{In } (W_2)\text{-In } (W_2)}{t_2\text{-}t_1}$$

Where

W_1 = Initial weight (height or leaf area) at time t_1

W_2 = Final weight (or size) at time t_2

$t_2 – t_1$ = Time interval between the two measurements (typically in days or weeks)

ln = Natural logarithm

Crop Growth Rate (CGR) (g m^{-2} day^{-1}): is a measure of the total amount of biomass (usually expressed in grams per square meter per day) produced by a crop over a specific period of time. It is a key parameter used to assess the productivity of a crop during its growth cycle. The CGR explains the dry matter accumulated per unit land area per unit time (g m^{-2} day^{-1}).

$$RGR = \frac{\text{In } (W_2)\text{-}(W_2)}{\rho\ (t_2\text{-}t_1)}$$

Where: W_1 = Initial weight (height or leaf area) at time t_1

W_2 = Final weight (or size) at time t_2

ρ = is the ground area on which W_1 and W_2 are recorded.

$t_2 – t_1$ = Time interval between the two measurements (typically in days or weeks)

ln = Natural logarithm

Results and Discussion

1. Available nutrients N (kg/ha), P (kg/ha) and K (kg/ha) of Urdbean

Main Effect of Sowing Methods

The data in Table 1 present the main effects of sowing methods (flat bed and raised bed) on the available nutrients (N, P, and K) in Urdbean cultivation. The raised bed method (B_2) resulted in slightly higher values for all nutrients compared to the flat bed method (B_1). Specifically, raised beds recorded 362.09 kg/ha for nitrogen (N), 36.67 kg/ha for phosphorus (P), and 149.33 kg/ha for potassium (K), whereas flat beds had 340.11 kg/ha for N, 34.53 kg/ha for P, and 144.11 kg/ha for K. The 30×30 cm spacing (S_2) and 45×30 cm spacing (S_3) both showed a slightly lower growth rate. Earlier studies have also highlighted results similar to those we report (Ghasemi *et al.*, 2017 and Chavan *et al.*, 2025) [13, 7].

Main Effect of Spacing

Among the different spacing treatments, the 30×30 cm spacing (S_2) resulted in the highest values for available nitrogen (361.55 kg/ha), phosphorus (35.80 kg/ha), and potassium (148.66 kg/ha). The 45×30 cm spacing (S_3)

recorded 351.49 kg/ha for nitrogen, 35.77 kg/ha for phosphorus, and 145.61 kg/ha for potassium. The 60×30 cm spacing (S_4) resulted in 339.44 kg/ha for nitrogen, 35.44 kg/ha for phosphorus, and 147.77 kg/ha for potassium. The broadcasting method (S_1) recorded the lowest nitrogen (335.20 kg/ha) and potassium (143.23 kg/ha) values, while phosphorus was 35.20 kg/ha.

Interaction Effects of Sowing Method and Spacing:

The interaction between sowing methods and spacing treatments showed significant differences in nutrient availability. The treatment T_6 (B_2S_2-Raised bed + 30×30 cm spacing) recorded the highest values for nitrogen (371.52 kg/ha), phosphorus (38.00 kg/ha), and potassium (155.01kg/ha), suggesting that this combination is particularly effective for nutrient availability. Among flat bed treatments, T_2 (B_1S_2-Flat bed + 30×30 cm spacing) recorded 365.00 kg/ha for nitrogen, 36.44 kg/ha for phosphorus, and 146.07 kg/ha for potassium, which was the highest for the flat bed combinations. The lowest nitrogen value (316.75 kg/ha) was observed in treatment T_1 (B_1S_1-Flat bed + Broadcasting), while the lowest potassium value (142.55 kg/ha) was observed in the same treatment. The current findings are consistent with the observations made by Lamont *et al.,* (2023) [28] and Wasay *et al.,* (2024) [45].

2. Harvest Index of Urdbean

Main Effect of Sowing Methods

The data in Table 2 show the main effects of sowing methods (flat bed and raised bed) on the harvest index of Urdbean. The raised bed method (B_2) resulted in a higher harvest index of 14.60, compared to the flat bed method (B_1), which recorded a harvest index of 13.93. This suggests that the raised bed method is more effective in optimizing the harvest index. The present investigation partially concurs with earlier findings by Seleiman *et al.,* (2020) [10] and Monzon *et al.,* (2021) [30] in Urdbean.

Main Effect of Spacing

Among the different spacing treatments, the 30×30 cm spacing (S_2) resulted in the highest harvest index of 15.93, followed by the 45×30 cm spacing (S_3) with a harvest index of 13.66. The 60×30 cm spacing (S_4) showed the lowest harvest index of 12.66, while the broadcasting method (S_1) had a harvest index of 14.04, indicating it was also quite efficient. Past research indicates results that are comparable to our study's findings Saleem *et al.,* (2021) [39] and Naithani *et al.,* (2023) [32] in Urdbean.

Interaction Effects of Sowing Method and Spacing

The interaction between sowing methods and spacing treatments revealed significant effects on the harvest index. The treatment T_6 (B_2S_2-Raised bed + 30×30 cm spacing) resulted in the highest harvest index of 16.06, which was the highest among all treatments. The treatment T_7 (B_2S_3-Raised bed + 45×30 cm spacing) had a harvest index of 15.09, while T_8 (B_2S_4-Raised bed + 60×30 cm spacing) recorded 13.76. Among flat bed treatments, T_1 (B_1S_1-Flat bed + Broadcasting) and T_4 (B_1S_4-Flat bed + 60×30 cm spacing) both showed a harvest index of 14.55, which was higher than T_3 (B_1S_3-Flat bed + 45×30 cm spacing) with 12.47. Earlier studies have also highlighted results similar to those we report Gupta *et al.,* (2018) [18] and Naithani *et al.,* (2023) [32] in Urdbean.

3. Relative growth rate of Urdbean

Main Effect of Sowing Methods

The data in Table 3 show the relative growth rates of Urdbean for the two sowing methods (flat bed and raised bed). Both sowing methods (B_1 and B_2) resulted in a relative growth rate of 0.0535, indicating no significant difference in growth rate between the two sowing methods. (Egli, 2019) [9] in Urdbean.

Main Effect of Spacing

Among the different spacing treatments, the 60×30 cm spacing (S_4) resulted in the highest relative growth rate of 0.055, followed by the broadcasting method (S_1) with 0.053. The 30×30 cm spacing (S_2) and 45×30 cm spacing (S_3) both showed a slightly lower growth rate of 0.052. Earlier studies have also highlighted results similar to those we report (Chavan *et al.,* 2025) [7].

Interaction Effects of Sowing Method and Spacing

The interaction between sowing methods and spacing treatments revealed varying relative growth rates. The highest relative growth rate was observed in treatment T_6 (B2S2-Raised bed + 30×30 cm spacing) with 0.059, followed by T_7 (B_2S_3-Raised bed + 45×30 cm spacing) at 0.053. The lowest growth rate was found in treatments T_1 (B_1S_1-Flat bed + Broadcasting) and T_5 (B_2S_1-Raised bed + Broadcasting), both with 0.013. Additionally, treatments T_2 (B_1S_2-Flat bed + 30×30 cm spacing) and T_3 (B_1S_3-Flat bed + 45×30 cm spacing) showed relative growth rates of 0.029 and 0.020, respectively. T_4 (B_1S_4-Flat bed + 60×30 cm spacing) had a growth rate of 0.041, while T_8 (B_2S_4-Raised bed + 60×30 cm spacing) recorded a growth rate of 0.047.The current findings are consistent with the observations made by Rajonee *et al.,* (2017) [36] and Qureshi *et al.,* (2018) [35].

4. Crop growth rate of Urdbean

Main Effect of Sowing Methods

The data in Table 4 show the crop growth rates of Urdbean for the two sowing methods (flat bed and raised bed). The raised bed method (B_2) resulted in a higher crop growth rate of 1.94, compared to the flat bed method (B_1), which recorded a crop growth rate of 1.56. This suggests that the raised bed method enhances crop growth more effectively. Previous research also supports the results observed in our study (Prasad *et al.,* 2012; Kumar *et al.,* 2016 and Singh *et al.,* 2018) [34, 27, 42].

Main Effect of Spacing

Among the different spacing treatments, the 60×30 cm spacing (S_4) resulted in the highest crop growth rate of 3.455, followed by the 30×30 cm spacing (S_2) with a crop growth rate of 2.271. The 45×30 cm spacing (S_3) had a crop growth rate of 1.375, and the broadcasting method (S1) recorded the lowest crop growth rate of 1.259. These findings are consistent with those observed in earlier studies as per (Agarwal and Singh 2014 and Kumar *et al.,* 2016) [2, 27].

Interaction Effects of Sowing Method and Spacing

The interaction between sowing methods and spacing treatments revealed significant effects on crop growth rates. The highest crop growth rate was observed in treatment T_6 (B_2S_2-Raised bed + 30×30 cm spacing) with 2.981, followed

by T_3 (B_1S_3-Flat bed + 45×30 cm spacing) with 2.223. The lowest crop growth rates were observed in treatments T_1 (B_1S_1-Flat bed + Broadcasting) and T_5 (B_2S_1-Raised bed + Broadcasting), both with 1.901. Other treatments, such as T_4 (B_1S_4-Flat bed + 60×30 cm spacing) and T_7 (B_2S_3-Raised bed + 45×30 cm spacing), showed crop growth rates of 2.261 and 2.259, respectively. Our results corroborate the observations made by (Mehta and Bharat, 2017; Asewar *et al.*, 2017 and Taksalkar *et al.*, 2024) [29, 3, 44].

Table 1: Available nutrients N (kg/ha), P (kg/ha) and K (kg/ha) of Urdbean

		Main Plot					
S. No.	**Treatments**	**Sowing method**	**N(kg/ha)**		**P(kg/ha)**		**K(kg/ha)**
1	B_1	Flat bed	340.11		34.53		144.08
2	B_2	Raised bed	362.09		36.67		149.33
		Sub plot treatments					
1	S_1	Broadcasting	335.20		35.20		143.23
2	S_2	30×30 cm	361.55		35.80		148.66
3	S_3	45×30 cm	351.49		35.77		145.61
4	S_4	60×30 cm	339.44		35.44		147.77
S. No.	**Treatments**	**Treatment combination**	**N(kg/ha)**		**P(kg/ha)**		**K(kg/ha)**
1.	T_1	B_1S_1 (Flat bed + Broadcasting)	316.75		35.33		142.55
2.	T_2	B_1S_2 (Flat bed + 30×30 cm spacing)	365.00		36.44		146.07
3.	T_3	B_1S_3 (Flat bed + 45×30 cm spacing)	323.00		34.00		143.66
4.	T_4	B_1S_4 (Flat bed + 60×30 cm spacing)	358.66		36.00		144.00
5.	T_5	B_2S_1 (Raised bed + Broadcasting)	342.33		33.66		142.66
6.	T_6	B_2S_2 (Raised bed + 30×30 cm spacing)	371.52		38.00		155.01
7.	T_7	B_2S_3 (Raised bed + 45×30 cm spacing)	353.00		36.33		151.00
8.	T_8	B_2S_4 (Raised bed + 60×30 cm spacing)	**347.33**		34.33		146.00
		Factors	**C.D.**	**SE (m) ±**	**C.D.**	**SE (m) ±**	**C.D.**	**SE(m) ±**
		Factor A (Sowing methods)	2.12	1.19	2.64	1.32	1.22	0.61
		Factor B (Spacing)	2.26	1.13	2.08	1.04	2.2	1.28
		Factor (A×B)	2.28	1.15	2.02	1.01	2.41	1.22

Table 2: Harvest Index of Urdbean

		Main Plot		
S. No.	**Treatments**	**Sowing method**	**Harvest index**	
1	B_1	Flat bed	13.93	
2	B_2	Raised bed	14.60	
		Sub plot treatments		
1	S_1	Broadcasting	14.04	
2	S_2	30×30 cm	15.93	
3	S_3	45×30 cm	13.66	
4	S_4	60×30 cm	12.66	
S. No.	**Treatments**	**Treatment combination**	**N(kg/ha)**	
1.	T_1	B_1S_1 (Flat bed + Broadcasting)	14.33	
2.	T_2	B_1S_2 (Flat bed + 30×30 cm spacing)	14.00	
3.	T_3	B_1S_3 (Flat bed + 45×30 cm spacing)	12.47	
4.	T_4	B_1S_4 (Flat bed + 60×30 cm spacing)	14.55	
5.	T_5	B_2S_1 (Raised bed + Broadcasting)	13.76	
6.	T_6	B_2S_2 (Raised bed + 30×30 cm spacing)	16.06	
7.	T_7	B_2S_3 (Raised bed + 45×30 cm spacing)	15.09	
8.	T_8	B_2S_4 (Raised bed + 60×30 cm spacing)	13.66	
		Factors	**C.D.**	**SE (m) ±**
		Factor A (Sowing methods)	0.77	0.11
		Factor B (Spacing)	1.21	0.63
		Factor (A×B)	0.45	0.23

Table 3: Available nutrients N (kg/ha), P (kg/ha) and K (kg/ha) of Urdbean

		Main Plot					
S. No.	**Treatments**	**Sowing method**	**N(kg/ha)**		**P(kg/ha)**		**K(kg/ha)**
1	B_1	Flat bed	340.11		34.53		144.08
2	B_2	Raised bed	362.09		36.67		149.33
		Sub plot treatments					
1	S_1	Broadcasting	335.20		35.20		143.23
2	S_2	30×30 cm	361.55		35.80		148.66
3	S_3	45×30 cm	351.49		35.77		145.61
4	S_4	60×30 cm	339.44		35.44		147.77
S. No.	**Treatments**	**Treatment combination**	**N(kg/ha)**		**P(kg/ha)**		**K(kg/ha)**
1.	T_1	B_1S_1 (Flat bed + Broadcasting)	316.75		35.33		142.55
2.	T_2	B_1S_2 (Flat bed + 30×30 cm spacing)	365.00		36.44		146.07
3.	T_3	B_1S_3 (Flat bed + 45×30 cm spacing)	323.00		34.00		143.66
4.	T_4	B_1S_4 (Flat bed + 60×30 cm spacing)	358.66		36.00		144.00
5.	T_5	B_2S_1 (Raised bed + Broadcasting)	342.33		33.66		142.66
6.	T_6	B_2S_2 (Raised bed + 30×30 cm spacing)	371.52		38.00		155.01
7.	T_7	B_2S_3 (Raised bed + 45×30 cm spacing)	353.00		36.33		151.00
8.	T_8	B_2S_4 (Raised bed + 60×30 cm spacing)	**347.33**		34.33		146.00
		Factors	**C.D.**	**SE (m) ±**	**C.D.**	**SE (m) ±**	**C.D.**	**SE(m) ±**
		Factor A (Sowing methods)	2.12	1.19	2.64	1.32	1.22	0.61
		Factor B (Spacing)	2.26	1.13	2.08	1.04	2.2	1.28
		Factor (A×B)	2.28	1.15	2.02	1.01	2.41	1.22

Table 4: Relative growth rate of Urdbean

		Main Plot		
S. No.	**Treatments**	**Sowing method**	**Relative growth rate**	
1	B_1	Flat bed	0.053	
2	B_2	Raised bed	0.053	
		Sub plot treatments		
1	S_1	Broadcasting	0.055	
2	S_2	30×30 cm	0.052	
3	S_3	45×30 cm	0.052	
4	S_4	60×30 cm	0.055	
S. No.	**Treatments**	**Treatment combination**	**Relative growth rate**	
1.	T_1	B_1S_1 (Flat bed + Broadcasting)	0.013	
2.	T_2	B_1S_2 (Flat bed + 30×30 cm spacing)	0.029	
3.	T_3	B_1S_3 (Flat bed + 45×30 cm spacing)	0.020	
4.	T_4	B_1S_4 (Flat bed + 60×30 cm spacing)	0.041	
5.	T_5	B_2S_1 (Raised bed + Broadcasting)	0.013	
6.	T_6	B_2S_2 (Raised bed + 30×30 cm spacing)	0.059	
7.	T_7	B_2S_3 (Raised bed + 45×30 cm spacing)	0.053	
8.	T_8	B_2S_4 (Raised bed + 60×30 cm spacing)	0.047	
		Factors	**C.D.**	**SE (m) ±**
		Factor A (Sowing methods)	0.8	0.12
		Factor B (Spacing)	1.25	0.65
		Factor (A×B)	0.5	0.25

Table 5: Crop growth rate of Urdbean

		Main Plot		
S. No.	**Treatments**	**Sowing method**	**Crop growth rate**	
1	B_1	Flat bed	1.56	
2	B_2	Raised bed	1.94	
		Sub plot treatments		
1	S_1	Broadcasting	1.259	
2	S_2	30×30 cm	2.271	
3	S_3	45×30 cm	1.375	
4	S_4	60×30 cm	3.455	
S. No.	**Treatments**	**Treatment combination**	**Crop growth rate**	
1.	T_1	B_1S_1 (Flat bed + Broadcasting)	1.901	
2.	T_2	B_1S_2 (Flat bed + 30×30 cm spacing)	1.973	
3.	T_3	B_1S_3 (Flat bed + 45×30 cm spacing)	2.223	
4.	T_4	B_1S_4 (Flat bed + 60×30 cm spacing)	2.247	
5.	T_5	B_2S_1 (Raised bed + Broadcasting)	1.901	
6.	T_6	B_2S_2 (Raised bed + 30×30 cm spacing)	2.981	
7.	T_7	B_2S_3 (Raised bed + 45×30 cm spacing)	2.261	
8.	T_8	B_2S_4 (Raised bed + 60×30 cm spacing)	2.243	
		Factors	**C.D.**	**SE (m) ±**
		Factor A (Sowing methods)	0.4	0.18
		Factor B (Spacing)	1.3	0.65
		Factor (A×B)	0.45	0.33

Conclusion

The study revealed that raised bed sowing (B_2) significantly improved nutrient availability, harvest index, and crop growth of Urdbean compared to flat bed sowing (B1). Among spacing treatments, 30×30 cm (S_2) favored maximum nutrient uptake (N, P, K) and harvest index, while 60×30 cm (S_4) enhanced relative and crop growth rates. The interaction effects highlighted that the combination of raised bed + 30×30 cm spacing (B_2S_2, T_6) consistently recorded the highest values for available nutrients (N: 371.52 kg/ha, P: 38.00 kg/ha, K: 155.01 kg/ha), harvest index (16.06), relative growth rate (0.059 g g^{-1} day^{-1}), and crop growth rate (2.981 g m^{-2} day^{-1}). In contrast, broadcasting under flat bed (B_1S_1, T_1) showed the lowest performance across most parameters. Overall, the findings indicate that raised bed sowing combined with 30×30 cm spacing is the most effective strategy for optimizing nutrient uptake, growth dynamics, and productivity of Urdbean in the Malwa region.

Competing Interest

The authors declare that there are no competing interests regarding the publication of this research. The study was conducted without any financial or personal relationships that could have influenced the results or interpretation of the findings.

References

1. Adhikari T, Ramana S. Nano fertilizer: its impact on crop growth and soil health. J Res PJTSAU. 2019;47(3):1-11.
2. Agarwal PK, Singh OP. An economic analysis of soybean cultivation in Narsinghpur district of Madhya Pradesh, India. Indian J Agric Res. 2014;48(3):185-191.
3. Asewar BV, Gore AK, Pendke MS, Waskar DP, Gaikwad GK, Chary GR. Broad bed and furrow technique: a climate smart technology for rainfed urdbean of Marathwada region. J Agric Res Technol. 2017;42(3):5-9.
4. Assefa A, Abate M, Haile M, Hunegnaw Y. Optimization of seed proportions of mung bean (*Vigna radiata* L.) and planting patterns for sorghum (*Sorghum bicolor* L.)-mung bean intercropping in Lasta district, Ethiopia. Int J Food Agric Nat Resour. 2025;6(2):45-54.
5. Bansal KK, Sandhu KS, Bharti V, Saha A, Srivastava H, Nesar NA, *et al.* Influence of varieties and spacings on growth, yield attributes and productivity of pigeonpea. Indian J Agric Res. 2024;58(6):1-6.
6. Bhattacharjee S. Breeding for biotic stress in urdbean through genomics-enabled strategies. In: Genomics-aided breeding strategies for biotic stress in grain legumes. Singapore: Springer Nature; 2024. p. 163-187.
7. Chavan RV, Zanzad RV, Gawande VV, Rathod PGT. Effects of plant growth regulators and micronutrients on quality parameters of soybean (*Glycine max* L. Merr.). Plant Arch. 2025;25(1):216-222.
8. dos Santos Cunha V, Fipke GM, Conceição GM, Müller TM, Pires JLF, Fulaneti FS, *et al.* Intraspecific competition in row spacings in urdbean. Emir J Food Agric. 2024;36:1-8.
9. Egli DB. Crop growth rate and the establishment of sink size: a comparison of maize and soybean. J Crop Improv. 2019;33(3):346-362.
10. El-Sayed SA, Algarni AA, Shaban KAH. Effect of NPK nano-fertilizers and compost on soil fertility and root rot severity of urdbean plants caused by *Rhizoctonia solani*. Plant Pathol J. 2020;19:140-150.
11. Eseigbe OB, Kamara AY, Miko S, Omoigui LO, Solomon R, Adeleke MA, *et al.* Impact of planting dates on the performance of urdbean varieties (*Glycine max* L. Merr.) in the Nigerian savannas. Agronomy. 2024;14(10):2198.
12. Essilfie ME. Effect of varietal combination and relative time of planting on yield productivity of maize and urdbean intercrop in the forest-savannah transition zone of Ghana. J Agric Res. 2024;18(6):60-74.
13. Ghasemi M, Ghorban N, Madani H, Mobasser H, Nouri MZ. Effect of foliar application of zinc nano oxide on agronomic traits of two varieties of rice. Crop Res. 2017;52(6):239-247.
14. Ghormade V, Deshpande MV, Paknikar KM. Perspectives for nano-biotechnology enabled protection and nutrition of plants. Biotechnol Adv. 2011;29:792-803.
15. Giri MD, SJ SN. Enhancing urdbean (*Vigna mungo*) yield, nutrient uptake and protein content: impact of fertilizer levels, farmyard manure and biofertilizers. J Food Legumes. 2024;37(4):396-403.
16. Grassini P, La Menza NC, Edreira JIR, Monzón JP, Tenorio FA, Specht JE. Urdbean. In: Crop physiology case histories for major crops. Academic Press; 2021. p. 282-319.
17. Gulser F. Effects of iron sources and doses on plant growth criteria in soybean seedlings. Eurasian J Soil Sci. 2019;8(4):298-303.
18. Gupta R, Kulmi GS, Basediya AL, Jadhav M. Influence of furrow irrigated raised bed seed drill on growth and yield of soybean (*Glycine max* L.). Plant Arch. 2018;18(1):320-324.
19. Gupta S, Das A, Pratap A, Gupta DS. Urdbean. In: The beans and the peas. 2021. p. 33-54.
20. Habde S, Dhanasekar P, Souframanien J. Urdbean (*Vigna mungo* (L.) Hepper) breeding. In: Fundamentals of legume breeding. Singapore: Springer Nature; 2025. p. 101-119.
21. Hedayetullah M, Zaman P. Urd bean (black gram). In: Forage crops of the world, Vol II. Apple Academic Press; 2018. p. 175-188.
22. Joseph J, Ganga WJ, Hettiarachchi M. A review of the latest in phosphorus fertilizer technology: possibilities and pragmatism. J Environ Qual. 2019;48(1):1300-1313.
23. Kaur D, Singh A, Singh UK. Effect of land configuration and nutrient management on blackgram (*Vigna mungo* L.) in the trans-Gangetic region. J Food Legumes. 2025;38(3):481-485.
24. Kaysha K, Shanka D, Bibiso M. Performance of mung bean (*Vigna radiata* L.) varieties at different NPS rates and row spacing. Cogent Food Agric. 2020;6(1):1771112.
25. Keisham M, Zimik L, Laishram B, Hajarimayum SS, Khumukcham PS, Yambem S, *et al.* Effect of varieties and spacing on yield of soybean (*Glycine max* L. Merr.). Pharma Innov J. 2021;10(1):262-267.
26. Kole C, Mohanty SK, Pattanayak SK. Selection of protein rich genotypes in urdbean (*Vigna mungo* (L.)

Hepper). Indian J Genet Plant Breed. 2002;62(4):345-346.
27. Kumar DM, Ullasa MY, Girijesh GK. Effect of fertilizer levels and foliar nutrition on yield and nutrient uptake of maize (*Zea mays* L.). Int J Appl Agric Hortic Sci. 2016;7(6):1-6.
28. Lamont BB, Williams MR, He T. Relative growth rate and confounded variables: mathematical problems and biological solutions. Ann Bot. 2023;131(4):555-568.
29. Mehta S, Bharat R. Effect of integrated use of nano and non-nano fertilizers on nutrient use efficiency of wheat. J Pharmacogn Phytochem. 2017;8(6):2156-2158.
30. Monzón JP, La Menza NC, Cerrudo A, Canepa M, Edreira JIR, Specht J, *et al.* Critical period for seed number determination in soybean. Field Crops Res. 2021;261:108016.
31. Nair RM, Chaudhari S, Devi N, Shivanna A, Gowda A, Boddepalli VN, *et al.* Genetics, genomics and breeding of black gram (*Vigna mungo* (L.) Hepper). Front Plant Sci. 2024;14:1273363.
32. Naithani P, Kumar A, Mahapatra BS, Bisht P, Shukla DK, Sharma RK, *et al.* Growth, rainfall use efficiency and economics of soybean (*Glycine max* L. Merr.) under intense spacing. Biol Forum. 2023;15(8A):414-420.
33. Pereyra VM, Hefley T, Prasad PV, Ciampitti IA. Urdbean seed yield, protein and oil concentration under varying row spacings. Heliyon. 2024;10(15):eXXXXX.
34. Prasad TNVKV, Sudhakar P, Sreenivasulu Y, Latha P, Munaswamy V, Reddy KR, *et al.* Effect of nanoscale zinc oxide on peanut. J Plant Nutr. 2012;35(6):905-927.
35. Qureshi A, Singh DK, Dwivedi S. Nano-fertilizers: a novel way for enhancing nutrient use efficiency. Int J Curr Microbiol Appl Sci. 2018;7(2):2319-2326.
36. Rajonee AA, Niger F, Ahmed S, Huq SI. Synthesis of nitrogen nano fertilizer and its efficacy. Can J Pure Appl Sci. 2017;10(2):3913-3919.
37. Rathnayaka RMNN, Iqbal YB, Rifnas LM. Influence of urea and nano-nitrogen fertilizers on rice growth and yield. Int J Res Publ. 2018;5(2):7-7.
38. Sahni S, Prasad BD, Kumari S. Diseases of urd/mung bean crops and their management. In: Crop diseases and their management. 2016. p. 57-72.
39. Saleem I, Maqsood MA, Aziz T, Bhatti IA, Jabbar A. Potassium ferrite nano-coated DAP fertilizer improves wheat growth. Pak J Agric Sci. 2021;58(2):485-492.
40. Seo J, Park J, Choi M, Jung K, Chun H, Lee S, *et al.* Growth and yield response of soybean (*Glycine max* L.) to sowing date. Agronomy. 2024;14(11):2624.
41. Sharkey A, Altman A, Sun Y, Igou TK, Chen Y. Temporally dynamic nature of relative growth rates. Agriculture. 2025;15(15):1641.
42. Singh AK, Singh CS, Singh AK, Karmakar S. Urdbean productivity influenced by foliar application of nutrients. J Pharma Phyto. 2018;SP1:413-415.
43. Singh RP. Status paper on pulses. New Delhi: Ministry of Agriculture, Government of India; 2013. p. 1-215.
44. Taksalkar BP, Satale BM, Pawar SG. Impact of plant spacing on blackgram cultivars (*Vigna mungo* (L.) Hepper). J Exp Agric Int. 2024;46(10):665-670.
45. Wasay A, Ahmed Z, Abid AU, Sarwar A, Ali A. Optimizing crop yield through precision agronomy techniques. Trends Biotechnol Plant Sci. 2024;2(1):25-35.