E-ISSN: 2618-0618
P-ISSN: 2618-060X

NAAS Rating (2025): 5.20
www.agronomyjournals.com
2025; 8(12): 1035-1039
Received: 06-10-2025
Accepted: 09-11-2025

Himanshi
Department of Vegetable Science, CCS Haryana Agricultural University, Hisar, Haryana, India

Dr. Makhan Lal
Department of Vegetable Science, CCS Haryana Agricultural University, Hisar, Haryana, India

Dr. SK Tehlan
Department of Vegetable Science, CCS Haryana Agricultural University, Hisar, Haryana, India

Chasin
Department of Vegetable Science, CCS Haryana Agricultural University, Hisar, Haryana, India

Corresponding Author:
Himanshi
Department of Vegetable Science, CCS Haryana Agricultural University, Hisar, Haryana, India

Effect of seed rate and sowing time on growth and seed yield of fenugreek under semi-arid conditions

Himanshi, Makhan Lal, SK Tehlan and Chasin

DOI: https://www.doi.org/10.33545/2618060X.2025.v8.i12o.4538

Abstract
A field experiment entitled "Influence of seed rate and sowing time for fenugreek seed production under semi-arid conditions" was conducted during 2024-25 at the Vegetable Research Farm, CCS Haryana Agricultural University, Hisar, to evaluate the effect of seed rate and sowing time on growth, yield and seed quality of fenugreek (*Trigonella foenum-graecum* L.). The experiment was laid out in a factorial randomized block design with three replications and twelve treatment combinations consisting of three seed rates (10, 15 and 20 kg ha^{-1}) and four sowing dates (30 October, 15 November, 30 November and 15 December) using the variety Hisar Sonali (HM-57). Significant variations were observed among the treatments for both growth and yield parameters. Early sowing (30 October) with the highest seed rate (20 kg ha^{-1}) (D1S3) produced the tallest plants, delayed 50% flowering and pod initiation and resulted in the highest biological yield. The maximum number of branches per plant and earliest pod maturity were observed in D1S1 i.e. sowing on 30 October with seed rate of 10 kgha-1. Mid-November sowing with 10 kg ha^{-1} seed rate (D2S1) recorded the highest number of pods per plant, longest pod length, maximum seeds per pod and superior seed quality attributes including seedling vigour index, seed viability, standard germination percentage and test weight. Seed yield per plant was also highest in D2S1 i.e., 15 November and 10kg/ha seed rate whereas the highest seed yield per hectare and harvest index were recorded at 15 kg ha^{-1} seed rate sown on 15th November (D2S2). Overall, sowing fenugreek in mid-November with a seed rate of 15 kg ha^{-1} is recommended for optimizing seed yield and quality under semi-arid conditions. These findings provide practical guidelines for improving fenugreek seed production efficiency in semi-arid regions.

Keywords: *Trigonella foenum-graecum* L., seed rate, sowing time, seed quality, seed yield, semi-arid, Hisar Sonali

1. Introduction
Trigonella foenum-graecum L. is a plant derived from the Fabaceae family with chromosome number 2n=16 (Sultana *et al*. 2016) [18]. It is a short duration crop and is suitable for various cropping system. Soon after harvesting of main kharif crops like chillies, cotton and paddy, fenugreek is grown as Rabi crop (Bhutia *et al*. 2017) [4]. It has been esteemed since ancient times for its roles as a culinary spice, flavoring agent and medicinal herb. The dried seeds, leaves and tender shoots are all consumed and utilized in various forms as food, flavor enhancers and medicines (Anitha *et al*., 2016) [1]. Moreover, fenugreek gum is known to contain galactomannans (Dhull *et al*., 2022) [5], which have been demonstrated to help to regulate blood sugar levels by slowing carbohydrate absorption in the digestive system. Indian Ayurvedic and Traditional Chinese Medicines has recognized it as a galactogogue or lactation stimulant in women after child birth as well as for its ability to treat wounds and sore muscles. Seed in powder or germinated form exhibits anti-diabetic properties (Kauser *et al*., 2017) [7]. Fenugreek seeds have been used for their medicinal benefits for centuries across various cultures (Ruwali *et al*., 2022) [14]. These small, golden-brown seeds offer a multitude of health advantages due to their rich nutritional content and the presence of various bioactive compounds (Zandi *et al*., 2017) [20]. Furthermore, the soluble fiber found in fenugreek seeds binds to cholesterol molecules in the gut, inhibiting their absorption into the bloodstream. This mechanism has been demonstrated to reduce total cholesterol and LDL (low-density lipoprotein) cholesterol levels, thereby decreasing the risk of cardiovascular diseases (Wang *et al*., 2023) [19].

According to recent statistics from the Spices Board of India, the total area dedicated to fenugreek cultivation in India is 1,47,000 hectares in 2024-25, with the highest area recorded in Rajasthan (67,746 hectares), followed by Madhya Pradesh (56,521 hectares). The total overall production obtained from this area during the same period is 2,26,853 MT, with the highest production from Madhya Pradesh (1,14,585 MT), followed by Rajasthan (1,02,011 MT). India's fenugreek exports experienced significant growth, rising from 30,855 tons (₹26,612.76 lakhs) in 2023-24 to 44,516 tons (₹36,589 lakhs) in 2024-25 (DGCI&S, Calcutta/MoC). These figures highlight the increasing global demand, as evidenced by the growth in exports. Fenugreek is grown on different continents under diverse soil and climatic conditions. However, plant development is influenced not only by soil and climate but also by technological interventions. To meet the commercial requirements of the country, there is a dire need to increase fenugreek production, and proper cultural management practices are required to enhance seed yield. Among cultural practices, seed rate and sowing time are key factors affecting the yield and yield components of fenugreek (Kurubetta *et al*., 2024) [10]. Therefore, the present trial was designed to identify the optimum seed rate and sowing time for fenugreek.

2. Materials and Methods

The research was conducted at the research farm of the Department of Vegetable Science, CCS Haryana Agricultural University, Hisar, during the Rabi season of 2024-25, from October to April. The experimental site is situated at a latitude of 29°10′ N and a longitude of 75°46′ E, with an elevation of 112 meters above mean sea level. The site falls under a semi-arid, subtropical climate, characterized by hot, dry summers and cold winters, and possesses a sandy loam texture, is non-saline, and has a low concentration of organic carbon and available nitrogen. The experiment was laid out in a Randomized Block Design with three replications. The dimensions of the main plot were 3.0 m × 2.4 m. Sowing of seeds was carried out on four different dates, *viz*., D_1 (30th October), D_2 (15th November), D_3 (30th November), and D_4 (15th December), along with three different seed rates: S_1-10 kg/ha, S_2-15 kg/ha, and S_3-20 kg/ha. Well-decomposed farmyard manure and recommended quantities of nitrogen and phosphorus were applied during sowing. For weed management, timely application of pre-emergence herbicides and hoeing were performed. All other necessary crop husbandry practices were adopted to raise the crop. The parameters studied during the course of experimentation included growth parameters, yield and yield-attributing parameters, and phenological parameters at different days after sowing. The data of various characters were analysed using the OPSTAT statistical software package developed at CCS Haryana Agricultural University, Hisar.

3. Results and Discussion

3.1 Growth Parameters

3.1.1 Plant Height

The plant height for different treatments differed significantly observed on different days after sowing. Fenugreek plants sown on 30th October (23.53 cm, 85.74 cm, 90.71 cm and 92.46 cm) recorded maximum plant height on 60, 90, 120 days after sowing and at harvest respectively followed by 15th November and 30th November. The lowest plant height was recorded at 15th December sowing with mean plant height of (16.07 cm, 67.36 cm, 71.47 cm and 73.47 cm) at 60, 90, 120 and at harvest respectively. The seed rate of 20 kg/ha resulted in maximum plant height i.e., 21.70 cm. 19.93 cm and 18.27 cm in all the recorded observations followed by 15 kg/ha and lowest was observed in 10 kg/ha. The interaction of time of sowing and seed rate differed significantly for plant height parameter. The interaction effect of 30th October and 20 kg/ha recorded highest plant in all the observations recorded at different days. Next best interaction noted at 15th November and 20 kg/ha which is significantly at par with 30th October and 15kg/ha interaction. The significantly lower plant height was recorded with 15th December and 10 kg/ha. The increased plant height in early sowing and higher seed rate interactions was recorded might be due to congenial weather conditions favourable for vegetative growth and development resulted in higher biomass accumulation and hence, more plant height. Similarily, the higher seed rates enhance competition for light among seedlings, thereby improving early plant vigor and resulting in greater plant height.

Table 1: Effect of seed rate and sowing time on plant height of fenugreek under semi-arid conditions

	Plant height (cm) at 60 days after sowing				Plant height (cm) at 90 days after sowing				Plant height (cm) at 120 days after sowing				Plant height (cm) at harvest			
Sowing time	Seed rate (kg/ha)				Seed rate (kg/ha)				Seed rate (kg/ha)				Seed rate (kg/ha)			
	S1-10	S2-15	S3-20	Mean	S1-10	S2-15	S3-20	Mean	S1-10	S2-15	S3-20	Mean	S1-10	S2-15	S3-20	Mean
D1 (30th Oct)	21.00	23.23	26.37	23.53	81.60	85.00	90.63	85.74	84.33	90.40	97.40	90.71	85.13	92.17	100.07	92.46
D2 (15th Nov)	19.80	21.67	23.27	21.58	78.23	80.57	87.67	82.16	81.70	84.57	92.60	86.29	83.13	87.00	95.57	88.57
D3 (30th Nov)	17.23	19.17	19.67	18.69	72.80	75.47	77.90	75.39	77.60	79.70	84.63	80.64	79.37	83.67	85.97	83.00
D4 (15th Dec)	15.03	15.67	17.50	16.07	63.77	67.53	70.77	67.36	65.80	73.07	75.53	71.47	69.00	74.77	77.47	73.74
Mean	18.27	19.93	21.70		74.10	77.14	81.74		77.36	81.93	87.54		79.16	84.40	89.77	
Factors	C.D. (5%)				C.D. (5%)				C.D. (5%)				C.D. (5%)			
Sowing time	0.69				0.4				0.35				0.5			
Seed rate	0.6				0.35				0.3				0.44			
Sowing time x seed rate	1.2				0.7				0.6				0.87			

3.1.2 Number of Branches

Significant variation was observed among different sowing dates and seed rates with respect to number of branches observed on different days after sowing. Sowing date of 30th October produced the maximum number of branches (3.31, 4.90, 5.84 and 6.14) recorded on 60, 90, 120 days after sowing and at harvest respectively and a steadily decline was observed in further sowings. Lowest number of branches was observed in delayed sowing of 15th December (2.16, 3.09, 4.22 and 4.56) on 60, 90, 120 days after sowing and at harvest. The lowest seed rate i.e. 10kg/ha resulted in highest number of branches on 60, 90, 120 days after sowing and at harvest 2.88, 4.77, 5.72 and 5.94 respectively. The interaction of time of sowing and seed rate has significant effect on number of branches. Maximum number of branches in observations recorded on different days was noted in interaction of 30th October and 10 kg/ha and minimum number of branches was recorded in interaction of 15th December and 20 kg/ha.

This might be due to availability of favourable climatic conditions during early sowing that produced better vegetative growth including branching and leaf production due to prolonged vegetative growth period as also supported by Nahar *et al*. (2022) [12]. Lower seed rate facilitated enhanced branch proliferation as due to reduced competition access to essential resources improved and better root and canopy development of individual plant notices also reported by Minjaro *et al*. (2023) [11].

Table 2: Effect of seed rate and sowing time on number of branches of fenugreek under semi-arid conditions

Sowing time	Plant height (cm) at 60 days after sowing				Plant height (cm) at 90 days after sowing				Plant height (cm) at 120 days after sowing				Plant height (cm) at harvest			
	Seed rate (kg/ha)				Seed rate (kg/ha)				Seed rate (kg/ha)				Seed rate (kg/ha)			
	S1-10	S2-15	S3-20	Mean	S1-10	S2-15	S3-20	Mean	S1-10	S2-15	S3-20	Mean	S1-10	S2-15	S3-20	Mean
D1 (30th Oct)	3.47	3.33	3.13	3.31	5.57	4.90	4.23	4.90	6.60	6.07	4.87	5.84	6.83	6.30	5.30	6.14
D2 (15th Nov)	3.13	2.83	2.53	2.83	5.17	4.50	4.03	4.57	6.20	5.30	4.93	5.48	6.37	5.73	5.17	5.76
D3 (30th Nov)	2.57	2.33	1.93	2.28	4.77	3.97	3.60	4.11	5.60	5.07	4.63	5.10	5.73	5.27	4.80	5.27
D4 (15th Dec)	2.37	2.13	1.97	2.16	3.57	3.07	2.63	3.09	4.47	4.20	4.00	4.22	4.83	4.60	4.23	4.56
Mean	2.88	2.66	2.39	—	4.77	4.11	3.63	—	5.72	5.16	4.61	—	5.94	5.48	4.88	—
Factor	**C.D. (5%)**				**C.D. (5%)**				**C.D. (5%)**				**C.D. (5%)**			
Sowing time		0.11				0.16				0.11				0.11		
Seed rate		0.10				0.14				0.10				0.10		
Sowing time × Seed rate		N/A				N/A				0.19				0.19		

3.1.3 Number of days to 50% flowering

The days required for 50% flowering in different sowing dates and different seed rates differed significantly which ranged from 63.78 days to 71 days and 67.50 to 68.33 days respectively. The sowing on 30th October resulted in longest time frame (71 days) to achieve 50% flowering while late sowing on the 15th of December led to shortest time frame. This pattern indicates that later sowing promotes quicker flowering likely attributable to reduced photoperiods and elevated terminal temperatures during the later stages of growth which encourage an earlier transition to reproduction as noted by Sowmya *et al*. (2017) [16]. The seed rate exhibited a minor effect on the timing of flowering with a slight delay in flowering observed at higher seed rates (20 kg/ha), potentially due to increased competition among plants which hinders vegetative growth and delays the transition to reproductive development as documented by Rahman *et al*. (2023) [13].

3.1.4 Number of days to pod initiation

The longest period for pod initiation (75.56 days) was recorded for the earliest sowing i.e. 30th October whereas the shortest duration (69.67) was noted for the sowing on 15th December. This is due to earlier sowing extends the vegetative phase consequently delaying the initiation due to reduced crop duration and elevated terminal temperature as earlier documented by Bhutia *et al*. (2017) [4]. The seed rate exhibited only a minimal impact with increased seed rates causing a slight delay in pod initiation. This delay is likely attributed to the more plant density which intensifies competition for light, water and nutrients thereby inhibiting the growth of individual plants and postponing their transition to reproductive stages. Similar findings were reported by Kumar *et al*. (2018) [9].

3.1.5 Number of days to maturity of pods

The number of days to maturity of pods diminished progressively with delayed sowing. The crop. The crop sown on 30th October (D1) required the longest time to mature (141.89 days), while the sowing on 15th December (D4) reached maturity the earliest (132.56 days). This indicated that early sowing extends the growth periods, facilitating prolonged vegetative and reproductive phases, whereas late sowing reduces crop duration due to elevated terminal temperatures and stress-induced hastening of reproductive development. These findings also supported by Nahar *et al*. (2022) [12]. The seed rate exhibited a minimal effect on maturity, with higher seed rates (20 kg/ha) demonstrating slightly earlier maturity compared to lower rates, likely due to the fact that denser plant populations increase competition for light, nutrients and water thereby prompting a quicker transition to reproduction also observed by Rahman *et al*., 2023 [13].

Table 4: Effect of seed rate and sowing time on number of days to 50% flowering, number of days to pod initiation and number of days to maturity of pods of fenugreek under semi-arid conditions

Sowing time	Number of days to 50% flowering				Number of days to pod initiation				Number of days to maturity of pods			
	Seed rate (kg/ha)				Seed rate (kg/ha)				Seed rate (kg/ha)			
	S1-10	S2-15	S3-20	Mean	S1-10	S2-15	S3-20	Mean	S1-10	S2-15	S3-20	Mean
D1 (30th Oct)	70.33	71.00	71.67	71.00	74.67	75.67	76.33	75.56	142.33	142.00	141.33	141.89
D2 (15th Nov)	68.33	69.67	71.33	69.78	73.67	74.67	75.33	74.56	139.67	139.33	138.00	139.00
D3 (30th Nov)	66.67	67.33	67.67	67.22	70.00	70.67	71.67	70.78	136.33	136.00	135.67	136.00
D4 (15th Dec)	62.67	64.00	64.67	63.78	68.67	69.67	70.67	69.67	133.67	132.67	131.33	132.56
Mean	67.50	68.00	68.33		72.17	72.67	73.08		138	137.5	136.58	
Factors	C.D. (5%)				C.D. (5%)				C.D. (5%)			
Sowing time	0.51				0.56				0.64			
Seed rate	0.44				0.48				0.55			
Sowing time x seed rate	0.89				0.97				N/A			

3.1.6 Number of pods per plant

The mean values for number of pods per plant ranged from 42.98 to 47.59. The highest number of pods per plant (47.59) was recorded at the lowest seed rate of 10 kg/ha, followed by 15 kg/ha (45.06), whereas the minimum (42.98) was observed at the highest seed rate of 20 kg/ha. Sowing time significantly

affected the number of pods per plant. The highest number of pods (49.60) was recorded with the 15th November sowing (D2), followed by the 30th October sowing (45.72). Further delays in sowing resulted in a reduction in pod number, with the minimum (41.03) observed under the 15th December sowing (D4). These findings are supported by the physiological standpoint, the formation of pods is greatly affected by the accessibility of assimilates and potency of sink. Timely sowing allows plant to accumulate higher biomass during vegetative phase thereby ensuring a steady supply of carbohydrates to the developing pods during reproductive stage. Lower plant densities reduce competition and enhance the distribution of photosynthates towards reproductive sinks while delayed sowing or higher densities may impede pod formation due to stress-related flower and pod abortion. These observations also supported by Abdou & Abdel-Fatah (2021) [2].

3.1.7 Pod Length

Pod length was notably affected by time of sowing with the longest pods (12.00 cm) recorded in the 15th November sowing (D2) and the shortest (9.20 cm) in the 15th December sowing (D4). This trend shows that timely sowing under favorable climatic conditions extends the vegetative phase and ensures accumulation of higher assimilates which supports better pod elongation as also reported by Bhutia *et al*. (2017) [4] and Sharangi *et al*. (2014) [15] in coriander. Seed rate also showed a subtle but consistent impact on pod length with lower seed rates (10 kg/ha) generally producing slightly longer pods than higher rates (20 kg/ha). Reduced plant density minimizes competition for photosynthetically active radiation (PAR), soil nutrients and water thereby enabling more assimilate supply to each reproductive sink. Similar findings reported by Rahman *et al*. (2023) [13] and Abebe *et al*. (2025) [3].

Table 5: Effect of seed rate and sowing time on number of pods per plant, plant length and number of seeds per pod of fenugreek under semi-arid conditions

Sowing time	Number of pods per plant				Pod length (cm)				Number of seeds per pod			
	Seed rate (kg/ha)				Seed rate (kg/ha)				Seed rate (kg/ha)			
	S1-10	S2-15	S3-20	Mean	S1-10	S2-15	S3-20	Mean	S1-10	S2-15	S3-20	Mean
D1 (30th Oct)	48.23	45.73	43.2	45.72	11.2	10.9	10.13	10.74	16.53	15.93	15.67	16.04
D2 (15th Nov)	52.6	49.07	47.13	49.6	12	11.27	11	11.42	17.47	16.13	15.93	16.51
D3 (30th Nov)	46.33	44.83	42.27	44.48	10.7	10.37	9.87	10.31	16.07	15.47	15.3	15.61
D4 (15th Dec)	43.2	40.6	39.3	41.03	10.3	9.6	9.2	9.7	15.77	15.3	14.87	15.31
Mean	47.59	45.06	42.98		11.05	10.53	10.05		16.46	15.71	15.43	
Factors	C.D. (5%)				C.D. (5%)				C.D. (5%)			
Sowing time	1.72				0.2				0.27			
Seed rate	1.49				0.17				0.23			
Sowing time x seed rate	N/A				N/A				N/A			

3.1.8 Seed yield per hectare

The maximum seed yield of 23.05 q/ha was achieved with a seed rate of 15 kg/ha sown on the 15th of November, whereas the minimum yield of 14.14 q/ha was recorded with a 10 kg/ha seed rate sown on the 15th of December. Sowing on optimum time provides ample opportunity for the accumulation of photosynthates and the effective distribution of carbohydrates to reproductive structures. Utilizing moderate seed rates mitigates competition stress, ensuring that each individual plant has sufficient resources for the development of flowers, the setting of pods and the filling of seeds. In contrast, late sowing or excessively high plant densities can truncate the reproductive period, elevate stress levels, and restrict the availability of assimilates, ultimately leading to a decrease in seed yield supported by the findings of Abebe *et al*., 2025; Sultana *et al*., 2016 [3, 18].

3.1.9 Biological Yield

The biological yield improved significantly with increase in seed rate. The maximum mean value for biological yield (69.48 q/ha) was reported with seed rate of 20 kg/ha followed by 15 kg/ha (67.23 q/ha), while the minimum mean value for biological yield (65.71 q/ha) was recorded with a seed rate of 10 kg/ha. The data further indicated that all the sowing time treatments differed significantly from each other with respect to biological yield. The maximum mean value for biological yield (70.57 q/ha) was obtained when the fenugreek crop was sown on 30th October followed by 15th November sowing (68.91 q/ha), while the minimum mean value for biological yield (63.56 q/ha) was recorded with 15th December sowing. These results are in agreement with the findings of Kumar *et al*. (2018) [9] and Minjaro *et al*. (2023) [11], who reported that moderate to higher seed rates enhanced overall growth and biomass accumulation due to better utilization of available space and resources. Similiarly, these finding reflects the importance of optimal environmental conditions during vegetative growth and reproductive development.

Table 6: Effect of seed rate and sowing time on seed yield per hectare, biological yield and harvest index of fenugreek under semi-arid conditions

Sowing time	Seed yield per hectare (kg)				Biological yield (q/ha)				Harvest index (%)			
	Seed rate (kg/ha)				Seed rate (kg/ha)				Seed rate (kg/ha)			
	S1-10	S2-15	S3-20	Mean	S1-10	S2-15	S3-20	Mean	S1-10	S2-15	S3-20	Mean
D1 (30th Oct)	16.74	20.72	19.88	19.12	69.00	70.71	72.00	70.57	24.26	29.31	27.62	27.06
D2 (15th Nov)	20.92	23.05	21.93	21.97	67	68.71	71.02	68.91	30.88	33.55	31.06	31.83
D3 (30th Nov)	16.61	19.63	18.50	18.25	64.83	66	69.71	66.85	25.63	29.75	26.63	27.34
D4 (15th Dec)	14.14	16.36	15.54	15.35	62	63.5	65.17	63.56	22.87	26.84	23.68	24.46
Mean	17.10	19.94	18.96		65.71	67.23	69.48		25.91	29.86	27.25	
Factors	C.D. (5%)				C.D. (5%)				C.D. (5%)			
Sowing time	2.33				2				1.24			
Seed rate	2.02				1.73				1.08			
Sowing time x seed rate	N/A				N/A				N/A			

3.1.10 Harvest Index
Among seed rates, the highest mean HI (29.86%) was recorded at 15 kg/ha followed by 20 kg/ha (27.25%), while the lowest was observed at 10 kg/ha (25.91%) indicating that moderate plant density optimizes the partitioning of assimilates towards seeds. Sowing time significantly affected HI, with 15th November sowing producing the maximum mean value (31.83%) and 15th December sowing the minimum (24.46%), reflecting the effect of favorable climatic conditions during pod filling on assimilate translocation.

4. Conclusion
The study provided critical insights into optimal sowing time and seed rate for enhancing seed yield. The data showed that fenugreek seeds sowing on 15th November, specially at 15 kg/ha seed rate, resulted in highest seed yields, underscoring the relevance of proper sowing time and seed rate selection for maximizing yield and growth. The optimal combination of time of sowing and seed rate utilizes favourable environmental conditions while maintaining an ideal plant population and spacing among plants, both essential for vigorous crop growth and development. Moreover, the interaction between these factors exerts a significant influence on growth and yield attributing parameters. These results align with earlier findings in fennel, highlighting the wider relevance of such agronomic practices. For fenugreek, the implications are evident: precise scheduling of sowing and judicious determination of seed rate are fundamental for achieving superior yield performance. Such insights can assist farmers in refining their cultivation practices, thereby promoting higher productivity and long term agricultural sustainability.

5. Competing Interests
Authors have declared that no competing interests exist

6. Authors' Contributions
'Himanshi' designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. 'Dr. Makhan Lal' and 'Dr. SK Tehlan' managed the analyses of the study. 'Himanshi and Chasin' managed the literature searches. All authors read and approved the final manuscript.

References

1. Anitha B, Reddy LNM, Rao DAVD, Patro KTSKK, Suneetha SDR. Effect of sowing date on yield and quality of fenugreek. Plant Arch. 2016;16(1):479-484.
2. Abdou MAH, Fatah AAA. Effect of planting date and compost fertilization on fenugreek plant. Minia J Agric Res Dev. 2021;41(2):15-22.
3. Abebe L, Senbet G, Mitiku A. Effect of inter-row spacing on growth and yield of fenugreek (*Trigonella foenum-graecum* L.) varieties at Woliso Woreda, Central Ethiopia. Jordan J Agric Sci. 2025;21(1):62-79. DOI: 10.35516/jjas.v21i1.2796.
4. Bhutia KC, Bhutia SO, Chatterjee R, Chattopadhyay N. Growth, phenology and yield of fenugreek (*Trigonella foenum-graecum* L.) as influenced by date of sowing. Int J Curr Microbiol Appl Sci. 2017;6(10):1810-1817. DOI: 10.20546/ijcmas.2017.610.218.
5. Dhull SB, Bamal P, Kumar M, Bangar SP, Chawla P, Singh A, *et al*. Fenugreek (*Trigonella foenum-graecum*) gum: A functional ingredient with promising properties and applications in food and pharmaceuticals-A review. Legume Sci. 2022;5(2):176-188. DOI: 10.1002/leg3.176.
6. Directorate General of Commercial Intelligence and Statistics (DGCI&S), Ministry of Commerce, Government of India. Export data of fenugreek. Kolkata: DGCI&S; 2024-25.
7. Kauser H, Bhoomika HR, Ibaad MH. Interaction effects of different sowing dates and stage of pinching on growth, yield and economics of fenugreek (*Trigonella foenum-graecum* L.). Int J Pure Appl Biosci. 2018;6(2):167-171. DOI: 10.18782/2320-7051.3079.
8. Komar O, Bobos I, Fedosiy I. Adaptive potential of fenugreek species at different sowing times. Plant Soil Sci. 2022;13(1):17-26. DOI: 10.31548/agr.13(1).2022.17-26.
9. Kumar P, Phor SK, Tehlan SK, Mathur AK. Effect of seed rate and row spacing on growth and yield of fenugreek (*Trigonella foenum-graecum*). J Pharmacogn Phytochem. 2018;7(4):93-96.
10. Kurubetta KD, Kareem AM, Yogeeshappa H, Jaggal S. Effect of time of sowing and seed rate on seed yield and economics of fenugreek. Int J Adv Biochem Res. 2024;8(2):541-543. DOI: 10.33545/26174693.2024.v8.i2Sg.638.
11. Minjaro T, Negasa D, Hunduma A. Influence of seed rate and row spacing on growth, yield and yield components of fenugreek (*Trigonella foenum-graecum* L.) in Abay Chomen district, Western Ethiopia. J Agric Food Nat Resour. 2023;1(1):22-28. DOI: 10.20372/afnr.v1i1.621.
12. Nahar S, Mostarin T, Khatun K, Akter A, Begum T, Al Shamim AS, *et al*. Effect of sowing date and phosphorus on growth, seed yield and quality of fenugreek. Eur J Nutr Food Saf. 2022;14(10):30-42. DOI: 10.9734/EJNFS/2022/v14i1030539.
13. Rahman MM, Khan MA, Sarker R, Akhter N, Islam M, Hossain MM. Response of ajowan (*Trachyspermum ammi* L.) to different seed rates. Int J Appl Res. 2023;9(8):97-102.
14. Ruwali P, Pandey N, Jindal K, Singh RV. Fenugreek (*Trigonella foenum-graecum*): Nutraceutical values, phytochemical, ethnomedicinal and pharmacological overview. S Afr J Bot. 2022;151:423-431. DOI: 10.1016/j.sajb.2022.04.014.
15. Sharangi AB, Roychowdhury A. Phenology and yield of coriander (*Coriandrum sativum* L.) at different sowing dates. J Plant Sci. 2014;9(2):32-42. DOI: 10.3923/jps.2014.32.42.
16. Sowmya PT, Naruka IS, Shaktawat RPS, Kushwah SS. Effect of sowing dates and stage of pinching on growth, yield and quality of fenugreek (*Trigonella foenum-graecum* L.). Int J Bioresour Stress Manag. 2017;8(1):91-95. DOI: 10.23910/IJBSM/2017.8.1.1774.
17. Spices Board of India, Ministry of Commerce and Industry, Government of India. Area and production statistics of fenugreek in India. Kochi: Spices Board of India; 2024-25.
18. Sultana S, Das G, Das B, Sarkar S. Influence of dates of sowing on growth and yield dynamics of fenugreek (*Trigonella foenum-graecum* L.). Int J Green Pharm. 2016;10(4):S233-S236.
19. Wang Y, Zheng Y, Liu Y, Shan G, Zhang B, Cai Q, *et al*. The lipid-lowering effects of fenugreek gum, hawthorn pectin, and burdock inulin. Front Nutr. 2023;10:1149094. DOI: 10.3389/fnut.2023.1149094.
20. Zandi P, Basu SK, Cetzal-Ix W, Kordrostami M, Chalaras SK, Khatibai LB. Fenugreek (*Trigonella foenum-graecum* L.): An important medicinal and aromatic crop. In: El-Shemy H, editor. Active Ingredients from Aromatic and Medicinal Plants. London: IntechOpen; 2017, p. 207-224.