

## Organic seed production technique with different date of sowing in black cumin (*Nigella sativa* L.)

### ABSTRACT

Field experiments were conducted at the D' block of the Seed Unit, University of Agricultural Sciences, Dharwad, during the rabi seasons of 2021–22 and 2022–23. This study focused on "Organic seed production techniques with different date of sowing in black cumin (*Nigella sativa* L.). Pooled data indicated that irrespective of soil application of organic manures and foliar spray of liquid bio-fertilizer application, the effect of dates of sowing was found significant for the seed yield and its components. Crop sown on November 1<sup>st</sup> fortnight (D<sub>2</sub>) recorded a significantly higher number of capsules per plant (18.14), number of seeds per capsule (90.45), seed yield per plant (3.06 g), thousand seed weight (2.90 g) and seed yield per hectare (849.43 kg) which was superior over October 1<sup>st</sup> fortnight (D<sub>1</sub>) (15.33, 86.93, 2.34g, 2.35g and 768.17kg, respectively). Soil application of 125% N equivalent through vermicompost + foliar application of cow urine spray @ 10% at flowering and 15 days after flowering (N<sub>4</sub>) recorded significantly more number of capsules per plant (22.42), number of seeds per capsule (101.00), seed yield per plant (3.59 g), thousand seed weight (3.32 g) and seed yield per hectare (880.08 kg) superior over (50% N equivalent through FYM + 50% N equivalent through vermicompost)+ Foliar application of cow urine spray @ 10% at flowering and 15 days after flowering (N<sub>6</sub>) (13.33, 78.50, 2.01, 2.22 and 757.67kg, respectively). The results highlighted the profound impact of organic manures and biofertilizers on improving black cumin seed production and quality.

**Key words:** Black cumin, vermicompost, cow urine spray, foliar biofertilizers, seed yield and organic manures.

## 1. INTRODUCTION

Black cumin (*Nigella sativa* L.), also known as Kalaunji, is a valuable minor seed spice crop having a chromosome number of  $2n = 14$  and belonging to the Ranunculaceae family. This winter annual herb grows 20–90 cm tall, featuring finely divided leaves and delicate flowers in white, yellow, pink or pale purple hues. Its black, angular seeds are slightly aromatic, bitter and rich in fixed (36–38%) and volatile oils (0.5–1.0%), containing key bioactive compounds like thymoquinone, nigellidine and alpha-hederin. These compounds make black cumin a cornerstone in traditional medicine systems like Ayurveda, Unani and Siddha, where it is used to treat asthma, bronchitis, skin diseases and digestive disorders. The seeds also hold promise as antibacterial and anticancer agents, underscoring their importance in pharmaceutical applications (Paarakh, 2010).

India, known as the land of spices, grows 76 varieties of spices, with seed spices like coriander, cumin, fennel and fenugreek forming the economic backbone of the industry. Black cumin is cultivated in northern and eastern regions, including Punjab, Gujarat, Bihar and thrives in arid and semi-arid zones. States like Rajasthan and Gujarat dominate seed spice production, contributing over 80% of the country's output. The demand for organic black cumin cultivation is rising, driven by health-conscious consumers and export markets with strict organic standards. Sustainable practices such as crop rotation, vermicomposting, FYM, and organic foliar sprays like Panchagavya and cow urine are gaining prominence for enhancing soil fertility, plant health and seed yield while minimizing environmental impact (Singh and Solanki, 2015).

Seed spices play a significant role in our national economy because of their large domestic consumption and growing demand for export. Presently, a 43.00 lakh ha area is under seed spices cultivation with a production of 10.98 M metric tonnes annually in the country (Anon., 2023). Being seasonal crops, these are grown extensively in rotation with food crops and also as inter/mixed crops under rainfed/irrigated conditions. Seed spices are mainly cultivated in the states of Madhya Pradesh, Gujarat, Andhra Pradesh, Rajasthan whereas Karnataka produces 380.50 thousand ha of area is under seed spices cultivation with a production of 7.63 lakh metric tonnes annually and stands in fifth position in India. They also have sizeable areas in the states of Haryana, Punjab, Uttar Pradesh etc. Though 17 seed spices are grown in the country, coriander, cumin, fennel and fenugreek are pillars of economic importance. Ajwain seed, dill seed, celery, black cumin and poppy seeds also contribute a minor share.

Despite its growing importance, research and development on black cumin cultivation remain limited, especially in South India, where scientific guidance on optimized practices is scarce. Farmers in

Karnataka's Northern Transition Zone are eager to adopt this high-value crop due to its rising global demand and premium pricing. Studies are now focusing on developing agro-techniques for organic seed production and identifying ideal sowing periods, typically October–November, to ensure optimal growth and yield. Such efforts aim to expand the cultivation of black cumin beyond its traditional northern strongholds, making it a significant contributor to sustainable agriculture and economic development in southern regions.

## 2. MATERIALS AND METHODS

The field experiment was conducted in during *rabi* season of 2021-22 and 2022-23 in split plot design involving with two dates of planting *viz.*, October-I fortnight (D<sub>1</sub>) and November-I fortnight (D<sub>2</sub>) and seven nutrition application *viz.*, 100% N equivalent through FYM + Foliar application of Panchagavya @ 3% at flowering and 15 daysafter flowering (N<sub>1</sub>), 125% N equivalent through FYM + Foliar application of Cow urine spray @ 10% at flowering and 15 daysafter flowering (N<sub>2</sub>), 100% N equivalent through vermicompost + Foliar application of Panchagavya @ 3% at flowering and 15 daysafter flowering (N<sub>3</sub>), 125% N equivalent through vermicompost + Foliar application of Cow urine spray @ 10% at flowering and 15 daysafter flowering (N<sub>4</sub>), (50% N equivalent through FYM + 50% N equivalent through vermicompost) + Foliar application of Panchagavya @ 3% at flowering and 15 daysafter flowering (N<sub>5</sub>), (50% N equivalent through FYM + 50% N equivalent through vermicompost)+ foliar application of cow urine spray @ 10% at flowering and 15 days after flowering (N<sub>6</sub>) and 100% recommended dose of fertilizers (Control) (N<sub>7</sub>) in three replications.

### 2.1 Observations recorded

Observations on yield parameters were recorded using five labeled plants per plot selected randomly by avoiding the border plants. Observations on the following yield parameters *viz.*, Number of capsules per plant, number of seeds per capsules, seed yield per plant (g), thousand seed weight (g) and seed yield per plot (kg) were recorded at harvest. The seed yield obtained per plot was converted into seed yield per hectare and expressed in (kg ha<sup>-1</sup>).

## 3. RESULTS AND DISCUSSION

In a crop like black cumin, seed yield is a function of yield attributes, irrespective of soil application of organic manures and foliar spray of liquid bio fertilizer application. Irrespective of soil application of organic manures and foliar spray of liquid bio fertilizer application, pooled data indicated that the effect of dates of sowing was found significant for the marked and consistent variation due to date of sowing that was observed for the seed yield and its components. Crops sown on November 1<sup>st</sup> fortnight (D<sub>2</sub>) recorded a significantly higher number of capsules per plant (18.14), number of seeds per capsule (90.45), seed yield

per plant (3.06 g), thousand seed weight (2.90 g) and seed yield per hectare (849.43 kg) superior over October 1<sup>st</sup> fortnight (D<sub>1</sub>) (15.33, 86.93, 2.34g, 2.35g and 768.17kg, respectively). It might be attributed to better growth and development of plants in the optimum planting and it resulted into in a better source to sink relationship due to the availability of balanced plant nutrition and adequate soil moisture unlike early October 1<sup>st</sup> planting, which experienced adverse growth conditions and yielded less seed per hectare. Similar results were also observed by Kadhum (2009) while studying the effect of different sowing dates (15<sup>th</sup> October, 1<sup>st</sup> November, 15<sup>th</sup> November, 1<sup>st</sup> December, 15<sup>th</sup> December and 1<sup>st</sup> January) on yield and its components in nigella in Abu– Ghraib, Iraq. Vaseghiet *al.* (2013) also found that the planting dates had a substantial impact on the majority of attributes, with the first planting date (16<sup>th</sup> November) producing the highest yield in Isfahannian and Indian black cumin kinds. Kauser *et al.* (2016) also found similar results with fenugreek crop.

Seed yield components differed significantly due to soil application of organic manures and foliar spray of liquid manures in pooled data and individual two years experiments. Soil application of 125% N equivalent through vermicompost + foliar application of cow urine spray @ 10% at flowering and 15 days after flowering (N<sub>4</sub>) recorded significantly more number of capsules per plant (18.14), number of seeds per capsule (90.14), seed yield per plant (5.05 g), thousand seed weight (2.90 g) and seed yield per hectare (849.43 kg) significantly more number of capsules per plant (22.42), number of seeds per capsule (101.00), seed yield per plant (3.59 g), thousand seed weight (3.32 g) and seed yield per hectare (880.08 kg) superior over (50 % N equivalent through FYM + 50% N equivalent through vermicompost)+ foliar application of cow urine spray @ 10% at flowering and 15 days after flowering (N<sub>6</sub>) (13.33, 78.50, 2.01g, 2.22g and 757.67kg, respectively). This might be due to increased yield parameters like yield per plant, number of pods per plant, number of seeds per pods, weight of 1000 seeds, due to enhanced rates of photosynthesis and biomass production (Kumar *et al.*, 2024). The better production of yield attributes and yield could be due to the supply of nutrients in balanced amount and available form. The increased growth in terms of plant height, branches per plant and expansion of leaf lamina provided greater sites for photosynthesis and diversion of photosynthates towards sinks. These results are in conformity with the findings of Darzi *et al.* (2012) in *Pimpinella anisum*. The present results are in agreement with the report of Tabasiet *al.* (2024) in *Foeniculum vulgare*, Moradi *et al.* (2010) in *Foeniculum vulgare* and Nuthana (2017) in black cumin.

## 5. CONCLUSION

The study highlights the impact of sowing dates and organic nutrient management on black cumin (*Nigella sativa* L.) seed production. Sowing during the first fortnight of November (D<sub>2</sub>) outperformed October sowing (D<sub>1</sub>), resulting in higher seed yield and improved yield components such as the number of capsules per plant, seeds per capsule, and thousand-seed weight. Among nutrient treatments, applying 125%

N equivalent via vermicompost combined with foliar cow urine spray (N<sub>4</sub>) delivered the best results, significantly enhancing seed yield and quality. These findings emphasize that optimizing sowing schedules and adopting organic fertilization strategies can substantially boost black cumin production.

UNDER PEER REVIEW

**Table 1. Effect of dates of sowing and application of nutrition on number of capsules per plant in black cumin**

Treatment	Number of capsules per plant								
	2021-22			2022-23			Pooled		
	D <sub>1</sub>	D <sub>2</sub>	Mean	D <sub>1</sub>	D <sub>2</sub>	Mean	D <sub>1</sub>	D <sub>2</sub>	Mean
N <sub>1</sub>	11.00	13.00	12.00	15.33	19.00	17.17	13.17	16.00	14.58
N <sub>2</sub>	12.33	14.67	13.50	16.00	21.67	18.83	14.17	18.17	16.17
N <sub>3</sub>	14.33	17.33	15.83	18.00	22.00	20.00	16.17	19.67	17.92
N <sub>4</sub>	16.00	19.67	17.83	24.00	30.00	27.00	20.00	24.83	22.42
N <sub>5</sub>	10.33	14.33	12.33	16.67	15.33	16.00	13.50	14.83	14.17
N <sub>6</sub>	10.00	12.67	11.33	15.67	15.00	15.33	12.83	13.83	13.33
N <sub>7</sub>	15.67	16.33	16.00	19.33	23.00	21.17	17.50	19.67	18.58
<b>Mean</b>	12.81	15.43	14.12	17.86	20.86	19.36	15.33	18.14	16.74
<b>Factors</b>	<b>S.Em±</b>		<b>CD at 5%</b>	<b>S.Em±</b>		<b>CD at 5%</b>	<b>S.Em±</b>		<b>CD at 5%</b>
<b>D</b>	0.41		2.52	0.42		2.56	0.31		1.90
<b>N</b>	0.90		2.63	1.50		4.39	0.85		2.49
<b>D×N</b>	1.27		NS	2.13		NS	1.21		NS

**Legend:** NS: Non-significance

**Date of sowing (D):** D<sub>1</sub>- October I fortnight

D<sub>2</sub>- November I fortnight

**Nutrition Application (N):**

N<sub>1</sub>: 100 % N equivalent through FYM + Foliar application of Panchagavya @ 3 % at flowering and 15 Day after flowering

N<sub>2</sub>: 125 % N equivalent through FYM + Foliar application of Cow urine spray @ 10 % at flowering and 15 Day after flowering

N<sub>3</sub>: 100% N equivalent through vermicompost + Foliar application of Panchagavya @ 3 % at flowering and 15 Day after flowering

N<sub>4</sub>: 125 % N equivalent through vermicompost + Foliar application of Cow urine spray @ 10 % at flowering and 15 Day after flowering

N<sub>5</sub>: (50 % N equivalent through FYM + 50 % N equivalent through vermicompost) + Foliar application of Panchagavya @ 3 % at flowering and 15 Day after flowering

N<sub>6</sub>: (50 % N equivalent through FYM + 50 % N equivalent through vermicompost) + Foliar application of Cow urine spray @ 10 % at flowering and 15 Day after flowering

N<sub>7</sub>: 100 % Recommended Dose of Fertilizers (control)

**Table 2. Effect of dates of sowing and application of nutrition on number of seeds per capsule in black cumin**

Treatment	Number of seeds per capsule								
	2021-22			2022-23			Pooled		
	D <sub>1</sub>	D <sub>2</sub>	Mean	D <sub>1</sub>	D <sub>2</sub>	Mean	D <sub>1</sub>	D <sub>2</sub>	Mean
N <sub>1</sub>	75.67	84.67	80.17	82.00	91.00	86.50	78.83	87.83	83.33
N <sub>2</sub>	78.33	86.67	82.50	84.00	93.00	88.50	81.17	89.83	85.50
N <sub>3</sub>	90.33	90.33	90.33	96.67	96.67	96.67	93.50	93.50	93.50
N <sub>4</sub>	96.00	99.67	97.83	102.33	106.00	104.17	99.17	102.83	101.00
N <sub>5</sub>	83.00	80.00	81.50	89.33	86.33	87.83	86.17	83.17	84.67
N <sub>6</sub>	74.00	76.67	75.33	80.33	83.00	81.67	77.17	79.83	78.50
N <sub>7</sub>	89.33	93.00	91.17	95.67	99.33	97.50	92.50	96.17	94.33
Mean	83.81	87.29	85.55	90.05	93.62	91.83	86.93	90.45	88.69
Factors	S.Em±		CD at 5%	S.Em±		CD at 5%	S.Em±		CD at 5%
D	0.54		3.30	0.52		3.15	0.53		3.22
N	4.03		11.77	4.04		11.79	4.04		11.78
D×N	5.70		NS	5.71		NS	5.71		NS

**Legend:** NS: Non-significance

**Date of sowing (D):** D<sub>1</sub>- October I fortnight

D<sub>2</sub>- November I fortnight

**Nutrition Application (N):**

N<sub>1</sub>: 100 % N equivalent through FYM + Foliar application of Panchagavya @ 3 % at flowering and 15 Day after flowering

N<sub>2</sub>: 125 % N equivalent through FYM + Foliar application of Cow urine spray @ 10 % at flowering and 15 Day after flowering

N<sub>3</sub>: 100% N equivalent through vermicompost + Foliar application of Panchagavya @ 3 % at flowering and 15 Day after flowering

N<sub>4</sub>: 125 % N equivalent through vermicompost + Foliar application of Cow urine spray @ 10 % at flowering and 15 Day after flowering

N<sub>5</sub>: (50 % N equivalent through FYM + 50 % N equivalent through vermicompost) + Foliar application of Panchagavya @ 3 % at flowering and 15 Day after flowering

N<sub>6</sub>: (50 % N equivalent through FYM + 50 % N equivalent through vermicompost) + Foliar application of Cow urine spray @ 10 % at flowering and 15 Day after flowering

N<sub>7</sub>: 100 % Recommended Dose of Fertilizers (control)

**Table 3. Effect of dates of sowing and application of nutrition on seed yield per plant in black cumin**

Treatment	Seed yield per plant (g)								
	2021-22			2022-23			Pooled		
	D <sub>1</sub>	D <sub>2</sub>	Mean	D <sub>1</sub>	D <sub>2</sub>	Mean	D <sub>1</sub>	D <sub>2</sub>	Mean
N <sub>1</sub>	1.94	2.60	2.27	1.99	3.16	2.58	2.09	2.92	2.50
N <sub>2</sub>	2.13	2.72	2.42	2.28	3.37	2.83	2.24	3.08	2.66
N <sub>3</sub>	2.16	2.78	2.47	2.62	2.74	2.68	2.43	2.80	2.62
N <sub>4</sub>	2.86	3.90	3.38	3.31	4.15	3.73	3.12	4.07	3.59
N <sub>5</sub>	1.92	2.60	2.26	2.20	3.07	2.63	2.10	2.87	2.49
N <sub>6</sub>	1.41	2.19	1.80	1.64	2.64	2.14	1.57	2.45	2.01
N <sub>7</sub>	2.50	2.87	2.69	3.02	3.54	3.28	2.80	3.23	3.02
<b>Mean</b>	2.13	2.81	2.47	2.44	3.24	2.84	2.34	3.06	2.70
<b>Factors</b>	<b>S.Em±</b>		<b>CD at 5%</b>	<b>S.Em±</b>		<b>CD at 5%</b>	<b>S.Em±</b>		<b>CD at 5%</b>
<b>D</b>	0.09		0.56	0.10		0.58	0.11		0.64
<b>N</b>	0.27		0.77	0.22		0.65	0.21		0.60
<b>D×N</b>	0.38		NS	0.32		NS	0.29		NS

**Legend:** NS: Non-significance

**Date of sowing (D):** D<sub>1</sub>- October I fortnight

D<sub>2</sub>- November I fortnight

**Nutrition Application (N):**

N<sub>1</sub>: 100 % N equivalent through FYM + Foliar application of Panchagavya @ 3 % at flowering and 15 Day after flowering

N<sub>2</sub>: 125 % N equivalent through FYM + Foliar application of Cow urine spray @ 10 % at flowering and 15 Day after flowering

N<sub>3</sub>: 100% N equivalent through vermicompost + Foliar application of Panchagavya @ 3 % at flowering and 15 Day after flowering

N<sub>4</sub>: 125 % N equivalent through vermicompost + Foliar application of Cow urine spray @ 10 % at flowering and 15 Day after flowering

N<sub>5</sub>: (50 % N equivalent through FYM + 50 % N equivalent through vermicompost) + Foliar application of Panchagavya @ 3 % at flowering and 15 Day after flowering

N<sub>6</sub>: (50 % N equivalent through FYM + 50 % N equivalent through vermicompost) + Foliar application of Cow urine spray @ 10 % at flowering and 15 Day after flowering

N<sub>7</sub>: 100 % Recommended Dose of Fertilizers (control)

**Table 4. Effect of dates of sowing and application of nutrition on 1000 seed weight in black cumin**

Treatment	1000 seed weight (g)								
	2021-22			2022-23			Pooled		
	D <sub>1</sub>	D <sub>2</sub>	Mean	D <sub>1</sub>	D <sub>2</sub>	Mean	D <sub>1</sub>	D <sub>2</sub>	Mean
N <sub>1</sub>	2.16	2.62	2.39	2.11	2.84	2.48	2.14	2.73	2.43
N <sub>2</sub>	2.01	2.79	2.40	2.20	3.00	2.60	2.10	2.90	2.50
N <sub>3</sub>	2.45	2.78	2.61	2.75	2.90	2.83	2.60	2.84	2.72
N <sub>4</sub>	2.96	3.89	3.42	2.75	3.70	3.23	2.85	3.80	3.32
N <sub>5</sub>	1.92	2.52	2.22	2.03	2.74	2.39	1.98	2.63	2.30
N <sub>6</sub>	1.98	2.31	2.14	2.23	2.35	2.29	2.10	2.33	2.22
N <sub>7</sub>	2.56	2.94	2.75	2.78	3.18	2.98	2.67	3.06	2.86
<b>Mean</b>	2.29	2.84	2.56	2.41	2.96	2.68	2.35	2.90	2.62
<b>Factors</b>	<b>S.Em±</b>		<b>CD at 5%</b>	<b>S.Em±</b>		<b>CD at 5%</b>	<b>S.Em±</b>		<b>CD at 5%</b>
<b>D</b>	0.06		0.39	0.08		0.51	0.07		0.42
<b>N</b>	0.13		0.38	0.14		0.41	0.10		0.30
<b>D×N</b>	0.18		NS	0.20		NS	0.14		NS

**Legend:** NS: Non-significance

**Date of sowing (D):** D<sub>1</sub>- October I fortnight

D<sub>2</sub>- November I fortnight

**Nutrition Application (N):**

N<sub>1</sub>: 100 % N equivalent through FYM + Foliar application of Panchagavya @ 3 % at flowering and 15 Day after flowering

N<sub>2</sub>: 125 % N equivalent through FYM + Foliar application of Cow urine spray @ 10 % at flowering and 15 Day after flowering

N<sub>3</sub>: 100 % N equivalent through vermicompost + Foliar application of Panchagavya @ 3 % at flowering and 15 Day after flowering

N<sub>4</sub>: 125 % N equivalent through vermicompost + Foliar application of Cow urine spray @ 10 % at flowering and 15 Day after flowering

N<sub>5</sub>: (50 % N equivalent through FYM + 50 % N equivalent through vermicompost) + Foliar application of Panchagavya @ 3 % at flowering and 15 Day after flowering

N<sub>6</sub>: (50 % N equivalent through FYM + 50 % N equivalent through vermicompost) + Foliar application of Cow urine spray @ 10 % at flowering and 15 Day after flowering

N<sub>7</sub>: 100 % Recommended Dose of Fertilizers (control)

**Table 5. Effect of dates of sowing and application of nutrition on Seedyield in black cumin**

Treatment	Seedyield(kgha <sup>-1</sup> )								
	2021-22			2022-23			Pooled		
	D <sub>1</sub>	D <sub>2</sub>	Mean	D <sub>1</sub>	D <sub>2</sub>	Mean	D <sub>1</sub>	D <sub>2</sub>	Mean
N <sub>1</sub>	723.33	801.67	762.50	751.00	826.00	788.50	737.17	813.83	775.50
N <sub>2</sub>	769.33	806.33	787.83	797.00	834.00	815.50	783.17	820.17	801.67
N <sub>3</sub>	786.33	810.67	798.50	814.00	838.33	826.17	800.17	824.50	812.33
N <sub>4</sub>	808.33	921.00	864.67	836.00	955.00	895.50	822.17	938.00	880.08
N <sub>5</sub>	701.00	800.33	750.67	728.67	829.33	779.00	714.83	814.83	764.83
N <sub>6</sub>	688.33	798.33	743.33	716.00	828.00	772.00	702.17	813.17	757.67
N <sub>7</sub>	803.67	907.67	855.67	831.33	935.33	883.33	817.50	921.50	869.50
Mean	754.33	835.14	794.74	782.00	863.71	822.86	768.17	849.43	808.80
Factors	S.Em±		CD at 5%	S.Em±		CD at 5%	S.Em±		CD at 5%
D	8.45		51.43	8.34		50.74	8.39		51.08
N	14.32		41.78	14.27		41.67	14.24		41.57
D×N	20.24		NS	20.19		NS	20.14		NS

**Legend:** NS: Non-significance

**Date of sowing (D):** D<sub>1</sub>- October I fortnight

D<sub>2</sub>- November I fortnight

**Nutrition Application (N):**

N<sub>1</sub>: 100 % N equivalent through FYM + Foliar application of Panchagavya @ 3 % at flowering and 15 Day after flowering

N<sub>2</sub>: 125 % N equivalent through FYM + Foliar application of Cow urine spray @ 10 % at flowering and 15 Day after flowering

N<sub>3</sub>: 100% N equivalent through vermicompost + Foliar application of Panchagavya @ 3 % at flowering and 15 Day after flowering

N<sub>4</sub>: 125 % N equivalent through vermicompost + Foliar application of Cow urine spray @ 10 % at flowering and 15 Day after flowering

N<sub>5</sub>: (50 % N equivalent through FYM + 50 % N equivalent through vermicompost) + Foliar application of Panchagavya @ 3 % at flowering and 15 Day after flowering

N<sub>6</sub>: (50 % N equivalent through FYM + 50 % N equivalent through vermicompost) + Foliar application of Cow urine spray @ 10 % at flowering and 15 Day after flowering

N<sub>7</sub>: 100 % Recommended Dose of Fertilizers (control)

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## REFERENCE

Anonymous, 2023, Agriculture Statistics at a Glance 2023, Agriculture statistics division, department of agriculture and farmers' welfare, Ministry of Agriculture and Farmers Welfare, Government of India, New Delhi.

Tabasi, H.G., Darzi, M.T. and Hadi, M.R., 2024. The Effect of Utilizing Different Types of Organic and Bio-Fertilizers on Growth, Elements Concentration, Seed Yield and Essential Oil of *Coriandrum sativum* L. *Legume Research*, 47(9), pp.1497-1505.

Kadhum M H, 2009, Evaluation yield of some varieties of *Nigella sativa* L. under different climatic conditions. *Anbar Journal of Agricultural Sciences*, 7(1): 255-261.

Kausar H, Bhoomika H R and Ibaad M H, 2016, Effect of sowing dates and stage of pinching on growth, seed yield and quality of Fenugreek (*Trigonella foenum-graecum* L.). *Environmental Research*, 9(9): 1076-1078.

Khan MR, Mostarin T, Khatun K, Sumon MM, Imtiaz AA, Samad MA, Khanom A, Sumi MA. Influence of Phosphorus Fertilization and Seed Rates on Yield Components

and Yield of Black Cumin (*Nigella sativa* L.). Asian J. Adv. Agric. Res. 2022 18(1):38-50.

Moradi R, Rezvani M P, Nasiri M M And Lakzian A, 2010, The effect of application of organic and biological fertilizers on yield, yield components and essential oil of *Foeniculum vulgare* (Fennel). *Iran Journal of Agronomy Research*, 7(2): 625-635.

Paarakh P M, 2010, *Nigella sativa* Linn. A comprehensive review. *Indian Journal of Natural Products and Resources*, 1: 409–429.

Kumar, M., Shivran, A. and Jat, R.D., 2024. Effects of Different Nutrient Management Methods on Growth and Yield of Barley (*Hordeum vulgare* L.). *International Journal of Plant & Soil Science*, 36(6), pp.687-694.

Singh B and Solanki R K, 2015, Status of seed spices research and development in India. *Indian Journal of Agricultural Sciences*, 85 (2): 151–156.

Vaseghi A, Ghanbari A, Heydari M and Davazdahemami S, 2013, Effect of sowing date and growing season on agronomical characters of Isfahanian and Indian black cumin. In: *Proceedings of 2<sup>nd</sup> National Congress on Medicinal Plants*, 15-16 May 2013, Tehran, Iran. 494.

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