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Evaluation of black cumin (*Nigella sativa* L.) varieties for seed yield potential under semi-arid conditions of northern Telangana

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ABSTRACT

Black cumin (*Nigella sativa L.*) is a valuable spice and medicinal crop however, in the semi-arid Northern Telangana Zone, there is a lack of comprehensive evaluation of improved black cumin varieties under dryland conditions. This study aimed to assess the performance of five varieties AN-1, AN-20, NS-32, NS-44, and a local check during the Rabi season of 2024-25 at the Horticultural Research Station, Adilabad. Significant variation was observed among the varieties for plant height, number of branches, capsules per plant, seeds per capsule, 1000-seed weight, and seed yield. AN-20 recorded the highest seed yield (1258.33 kg/ha), followed by AN-1 and NS-32, while the local check showed the lowest performance. These findings suggest that AN-20 and AN-1 are well-adapted to semi-arid dryland conditions and hold promise for commercial cultivation in the Northern Telangana region.

Introduction

Black cumin (*Nigella sativa* L.), a flowering plant of the Ranunculaceae family, is an ancient medicinal and culinary herb native to the Mediterranean region and widely cultivated across Asia, the Middle East, and parts of Africa (Xue *et al.*, 2016). The crop has gained global prominence for its diverse uses in culinary applications, cosmetics, pharmaceuticals, and traditional medicine systems. It thrives predominantly in arid and semi-arid environments owing to its low input requirements and adaptability to marginal soils (Sahin *et al.*, 2003). The seeds are small, angular, and black with a characteristic pungent aroma and flavor, making them popular ingredients in bread, pastries, pickles, and spice blends (Rasulloh *et al.*, 2018).

India is the leading global producer of black cumin, with an estimated cultivation area of approximately 9,000 hectares and annual production ranging between 7,000 and 8,000 tonnes (FAOSTAT, 2019; Pathak *et al.*, 2021). Major producing states include Rajasthan, Gujarat, Uttar Pradesh, Punjab, Bihar, Himachal Pradesh, Jammu and Kashmir, West Bengal, Assam, and Tamil Nadu. Despite this extensive cultivation, yield levels vary significantly across regions. For instance, experimental trials in Prayagraj, Uttar Pradesh, reported yields of up to 2.48 t/ha for improved genotypes such as Azad Kalonji (Singh *et al.*, 2023), compared to the national average of 0.8–1.0 t/ha, highlighting the potential for improvement through varietal selection and agronomic optimization.

Yield disparities among global producers are largely attributed to suboptimal agronomic practices, limited adoption of improved varieties, and poor post-harvest management

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(Anshiso and Teshome, 2019; Pathak *et al*., 2021). Numerous studies have documented considerable genetic variability in black cumin for yield and related traits. Singh *et al*. (2010) reported strong positive correlations between seed yield and traits such as plant height, number of capsules per plant, and 1000-seed weight, identifying them as key selection criteria in breeding programs. Bakhsh *et al*. (2015) also noted that genotypes with early flowering and high capsule density performed better under dryland conditions. Varietal evaluation studies in Rajasthan and Madhya Pradesh under rainfed conditions demonstrated that improved varieties out yielded local checks by 20–30% (Patel *et al*., 2018).

However, research on varietal performance under the semi-arid agro-climatic conditions of Telangana, particularly in the Northern Telangana Zone, remains limited. With increasing emphasis on dryland horticulture, black cumin presents a promising high-value crop option for these regions. Therefore, the present study aims to evaluate the performance of selected *Nigella sativa* varieties under the dryland conditions of Adilabad district in Northern Telangana.

Material and Methods

The field experiment was conducted during the Rabi season of 2024–25 at the Horticultural Research Station, Adilabad, located in the Northern Telangana Zone (Latitude 19.6480'N, Longitude 78.5321'E, at an elevation of 257 meters above MSL). The site falls under a semi-arid agro-climatic zone characterized by an average annual rainfall of approximately 850 mm. The average annual temperature is 30.08°C, and July is the wettest month. The predominant soil type is sandy loam in texture, neutral in reaction. Nutrient analysis indicated Organic Carbon 0.4%, and low in available nitrogen 200.6 kg/ha, medium in available phosphorus and potassium contents 18.2 and 206.4 kg/ ha respectively.

The weather conditions during the black cumin cropping period are presented in Table 1. October 2024 to April 2025 exhibited typical Rabi season weather patterns, with lower minimum temperatures in the winter months and rising temperatures toward the end of the cropping cycle. Relative humidity declined gradually after December 2024, while rainfall was negligible except in October and sporadically in March and April 2025

Table 1. Weather data during the black cumin cropping period (2024-25)

Month	Minimum temp. (°C)	Maximum temp. (°C)	Relative humidity (%)	Rainfall (mm)	Rainy days
Oct-24	23.1	34.0	84.9	35.6	3
Nov-24	14.6	30.9	82.9	0.0	0
Dec-24	14.0	29.9	79.5	5.6	1
Jan-25	12.8	31.3	74.9	0.0	0
Feb-25	15.3	34.1	55.7	0.0	0
Mar-25	23.8	37.6	67.0	6.0	4
Apr-25	28.0	41.0	69.9	13.78	3

Source: Automatic Weather Station (AWS), Agricultural Research Station, Adilabad

The experiment was laid out in a randomized complete block design (RCBD) with four replications. The treatments comprised five black cumin genotypes, including four improved varieties are AN-1, AN-20, NS-32, and NS-44 along with a local check. Varietal details such as maturity period, plant height, seed characteristics, average yield potential, and specific traits are presented in Table 2.

All experimental plots were managed using uniform cultural practices throughout the cropping cycle. During the Rabi season of 2024–25, land preparation for black cumin was completed on 14 October 2024, followed by sowing on 16 October 2024. Thinning operations were carried out on 18 November 2024. Manual weeding was done three times: the first on 6 November 2024, the second on 11 December 2024, and the third on 29 January 2025. The crop was harvested on 28 February 2025, and post-harvest drying was completed by 3 March 2025. A pre-emergence application of pendimethalin 30 EC @ 1 L/ha was used for weed control. The crop was raised in plots of 3.0 m × 2.0 m with a spacing of 30 cm × 10 cm, using a seed rate of 7 kg/ha, which resulted in an approximate plant population of 3,33,333 plants per hectare. For nutrient management, 10 t/ha of FYM was incorporated along with 40:20:20 kg/ha of NPK. The full dose of phosphorus and potassium, along with one-third of nitrogen, was applied as basal, while the remaining nitrogen was top-dressed in two equal splits at 30 DAS and at the flowering stage. Light irrigation was given immediately after sowing, followed by flood irrigation every 15–25 days. For pest management, 2% neem oil was sprayed to control sucking pests. The crop attained maturity within 125–135 days, after which harvesting was carried out.

Table 2. Varietal characters of black cumin included in the study

Variety	Source	Days to maturity	Seed colour	Average yield (kg/ha)	Special traits	Reference
AN-1	ICAR- NRCSS, Ajmer	135	Jet black	1129	Resistant to root rot	Meena *et al*., 2023; Kant *et al*. 2009
AN-20	ICAR-NRCSS, Ajmer	145–150	Black	1025	28.08% higher yield over other released varieties	Meena *et al*., 2023; Kant *et al*. 2009
NS-32	JNKVV, Jabalpur	170–175	Dark brown	1120	High oil content (36–38%)	Singh *et al*., 2024; Kant *et al*. 2009
NS-44	JNKVV, Jabalpur	150–155	Dark brown	850	Resistant to powdery mildew	Singh *et al*., 2024; Kant *et al*. 2009
Local	Adilabad (Farmer selection)	140–145	Black	-	-	-

During the course of the experiment, data were recorded on a range of growth and yield attributes. These included plant height at maturity (cm), number of primary and secondary branches per plant, days to first flowering, and days to maturity. Yield components such as number of capsules per plant, number of seeds per capsule, 1000-seed weight (g), and seed yield per hectare (kg/ha) were also measured. These parameters were selected to comprehensively evaluate the performance of black cumin genotypes under semi-arid dryland conditions.

The data recorded for various growth and yield parameters were subjected to analysis of variance (ANOVA) appropriate for a randomized complete block design (RCBD), using the GRAPES online statistical software developed by Gopinath *et al.* (2020). Treatment means were compared using the Least Significant Difference (LSD) test at the 5% level of significance to determine the presence of statistically meaningful differences among the genotypes.

Results and Discussion

The results revealed significant differences among the five black cumin genotypes for all the agronomic and yield-related parameters evaluated under the semi-arid conditions of Adilabad (Table 3).

Among the tested genotypes, significant variation was observed in plant height. AN-20 recorded the highest plant height (64.5 cm), followed by AN-1 (53.25 cm) and NS-44 (47.72 cm). The observed variation in plant height can be attributed to genotypic differences and inherent growth characteristics, along with favorable cool temperatures during early vegetative growth, which promote elongation (Kant *et al*., 2009). Similarly, *Singh et al*. (2024) in black cumin reported that among all the tested genotypes Azad Kalonji had highest plant height followed by AN-20. According to Shweta *et al*. (2023) reported that high heritability (broad sense) for the total plant height in AN-1 and AN-20 varieties. A significantly highest number of primary (7.25) were recorded in AN-20 followed by AN-1 (6.20) and NS-44 (5.35) which was on par with NS-42 and significant highest secondary branches (9.85) was also recorded in AN-20, followed by NS-32. Branching habit is influenced by genetic potential and is also responsive to environmental conditions, sowing time, and crop management practices. These results are in agreement with the findings of Singh *et al.* (2024) reported that number of primary branches per plant and secondary branches highest in Azad Kalonji followed by local-2 and NS-44.

The highest number of flowers per plant was significantly observed in AN-20 (76.50), followed by AN-1 (69.50) and NS-44. The earliest flowering was recorded in AN-20 (47.57 days), followed by AN-1 (52.55 days) and a greater number of days to flowering was noticed in local check (76.75 days). In black cumin, flowering generally occurs on terminal branches, and early flowering is often associated with early germination and robust vegetative growth. An increase in branching also contributes to flower production, ultimately enhancing seed yield. Similar observations were reported by Singh *et al*. (2024) results indicated that earlier flowering in Azad Kalonji and number of flowers per plant found in Azad Kalonji followed by AN-20 and minimum number of flowers per plant recorded in NS-44.

With respect to reproductive traits, AN-20 recorded significantly highest number of capsules per plant (19.50), followed by NS-32 (17.00) which was on par with AN-1 (16.50). Singh *et al*. (2024), who also observed significant varietal differences for capsule formation. Significantly earliest days to maturity was observed in AN-20 (121.40 days), followed by AN-1 (134.05 days) which was on par with NS-32 and NS-44. These differences may be attributed to genetic variability among the genotypes. Comparable trends were reported by Singh *et al.* (2024) results showed that Azad Kalonji followed by AN-1.

Seed quality traits such as number of seeds per capsule and 1000-seed weight were also significantly influenced by genotype. AN-20 recorded the highest values (84.50 seeds per capsule) followed by NS-32 (78.50) which was on par with AN-1 (76.25). 1000-seed weight was significantly highest recorded in AN-20 (2.69 g) followed AN-1 (2.38 g) which was on par with NS-44 (2.26 g). NS-44 was on par with NS-32 (2.06 g). This improvement may be attributed to optimal climatic conditions during seed formation, particularly warm and sunny weather that favors seed development (Kant *et al*., 2009). Similar results were Singh *et al.* (2024) reported that Azad Kalonji had highest number of seeds per capsule followed by AN-20 and 1000-seed weight was highest recorded in Azad Kalonji followed by local variety-2 and AN-20.

In terms of yield performance, AN-20 produced significantly highest seed yield (1258.33 kg/ha), followed by AN-1 (1124.99 kg/ha) and NS-32 (1024.99 kg/ha). The local check recorded the lowest yield (534.16 kg/ha), indicating its inferior performance under semi-arid conditions. Higher yields in AN-20, AN-1 and NS-32 were associated with early flowering, higher capsule numbers, and better seed weight. All varieties had an overlapped vegetative and reproductive phases. According to Kant *et al.* (2009), the advanced production technology of Nigella highlighted key features of different varieties. The average seed yield was reported as 800 kg/ha for variety AN-1 and 1000–1200 kg/ha for variety AN-20. Singh *et al.* (2024) reported that highest seed yield (t/ha) recorded in Azad Kalonji followed by AN-20. Hence, crop was harvested when 70 per cent capsules turned to brown. According to Shweta *et al.* (2023), the results indicated high heritability (broad sense) for growth and reproductive traits such as number of capsules, number of flowers, seed yield per capsule, and seed yield per plant, suggesting that AN-1 and AN-20 are high-yielding varieties. Moreover, high heritability coupled with high genetic advance for reproductive traits provides significant scope for the improvement of these traits to achieve higher yield. These findings are consistent with the reports of Meena *et al.* (2023) reported that AN-20 is recommended for cultivation in all nigella growing areas of Rajasthan.

Table 3. Performance of black cumin varieties under semi-arid conditions at Horticultural Research Station, Adilabad

Variety	Plant height (cm)	Primary branches/plant	Secondary branches/plant	Number of flowers/plant	Days to 1st flowering	Number of capsules/plant	Days to maturity	Number of seeds/capsule	1000-seed weight (g)	Seed yield (kg/ha)
AN-20	64.50^{a}	7.25^{a}	9.85^{a}	76.50^{a}	47.57^{d}	19.50^{a}	121.40^{c}	84.50^{a}	2.69^{a}	1258.33^{a}
AN-1	53.25^{b}	6.20^{b}	8.30^{cd}	69.50^{b}	52.55^{c}	16.50^{b}	134.05^{b}	76.25^{b}	2.38^{b}	1124.99^{ab}
NS-32	46.45^{c}	5.35^{c}	9.20^{b}	62.25^{c}	57.25^{b}	17.00^{b}	136.77^{b}	78.50^{b}	2.06^{c}	1024.99^{bc}
NS-44	47.72^{c}	5.42^{c}	8.57^{c}	68.25^{b}	60.00^{b}	13.50^{c}	138.80^{b}	71.95^{c}	2.26^{bc}	866.66^{c}
Local	43.00^{d}	5.60^{c}	7.95^{d}	61.50^{c}	76.75^{a}	12.25^{c}	150.00^{a}	70.50^{c}	1.82^{d}	534.16^{d}
SE(m)±	0.75	0.13	0.12	1.55	1.15	0.72	1.93	1.21	0.06	58.34
LSD (p=0.05)	2.31	0.39	0.38	4.78	3.58	2.22	6.03	3.74	0.19	181.71
CV (%)	2.94	4.25	2.81	4.59	3.91	9.13	2.84	3.18	5.56	12.12

Means followed by same letter in a column do not differ significantly at 5% LSD

Conclusion

The study revealed substantial genetic variability among black cumin varieties under semi-arid conditions of Northern Telangana. Improved varieties AN-20, AN-1, and NS-32 outperformed the local check and other genotypes in growth, phenological traits, and seed yield. AN-20 recorded the highest yield (1258.33 kg/ha), followed by AN-1 and NS-32, showcasing superior adaptability. These varieties exhibited desirable agronomic traits contributing to higher yield potential. Based on their performance, AN-20, AN-1, and NS-32 are recommended for commercial cultivation in the Adilabad region and similar agro-climatic zones. Further multi-location trials and participatory evaluations may help in validating these results for large-scale adoption by farmers.

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Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this manuscript.

Data Sharing

All relevant data are within the manuscript.

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