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Black Cumin (*Nigella sativa* L.) Variety Adaptation Trial at Bule Hora, West Guji zone, Ethiopia

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ABSTRACT

Black cumin (*Nigella sativa* L.) is one of the most important spices and cash crops in Ethiopia. Despite its significance, the national average black cumin yield is low due to many constraints, including the unavailability of improved varieties for each growing and potential area. This research was conducted to evaluate the adaptability and yield potential of the released black cumin varieties. It was conducted at Bule Hora during the 2020–2022 cropping season, and six black cumin varieties were evaluated using a CRBD with three replications. The results of the analysis of variance showed the presence of significant variations among years for all traits and among varieties for traits like the number of primary branches, the number of pods per plant, and grain yield. However, no significant difference was observed for traits like days to flowering, days to maturity, plant height, and thousand seed weights among varieties and their interaction with the year. The highest seed yield was recorded for Kena (875.26 kg ha1), followed by Silingo (692.1 kg ha1), whereas the lowest grain yield was recorded for Darbera (570.4 kg ha1), followed by Kenani (628.14 kg ha1). Accordingly, Kena and Silingo black cumin varieties were selected based on their yield performance. The two selected varieties should be demonstrated and promoted in order to create demand among the farmers so as to produce black cumin in the area.

Keywords

Adaptability, black cumin, improved variety, commercial purposes

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Introduction

Black cumin (*Nigella sativa* L.) is a member of Apiaceae (Umbelliferae), which is believed to be originated in Eastern Mediterranean, Southern Europe, West Asia, and Egypt, but is widely cultivated in Iran, Japan, China and Turkey (Cheikh-Rouhou *et al.,* 2007). Ethiopia is a country with different and favorable agroecological zones for production of various spices, particularly of black cumin, white cumin, pepper, paprika, turmeric, fenugreek, garlic, coriander, ginger, cardamom, and basil are grown in Ethiopia for consumption and commercial purposes (Tesfa *et al.,* 2017), making it one of the top spice producer and consumer countries and ranking first and seventh in Africa and global stages, respectively (Anonymous, 2019). Black cumin is grown in Ethiopia's highlands (1500–2500 m.a.s.l.), mostly in the regions of Amhara, Oromia, and the Southern Nations and

Nationalities People's (SNNP) region. It is frequently grown together with cereals as an intercrop (Birhanu, 2015; Herms *et al.,* 2015). Its ecological needs are comparable to those of tef, chickpeas, and lentils, which are typically grown with residual moisture after the major rainy season (Girma *et al.,* 2015).

According to Merga *et al.,* (2018), Ethiopian black cumin variants have up to 50% thymol in their seeds, a monocyclic phenolic component that makes cumin an important source for the health care sector. With more than 100 distinct chemical components, its seed contents have special chemical qualities (Bardideh *et al.,* 2013). In Ethiopia, black cumin is one of the most important spice types, which is mainly produced to flavor foods, prepare oil for perfumes and medicinal purposes, source of income, crop diversification, and export purposes. It is also the second most important cash crop exported to international markets, next to ginger (Teshome and Anshiso, 2019).

The national average productivity of black cumin was reported to be 0.64 t ha-1 Zigyalew (2020), which is well below the global average and some major producing countries, including India (2.2 t ha-1). Lack of improved variety, improper fertilizer rate, postharvest handling issues, inadequate agricultural practices and extension systems, and marketing issues were the primary factors affecting black cumin production and productivity. Furthermore, no research has been done to evaluate the adaptability of improved black cumin varieties, despite their use and the suitable midlands of agroecology in the in the west Guji zone.

Evaluating the adaptability of improved black cumin varieties to the midland regions of the Guji zone is crucial for diversifying its production, availability, and farmers' income. Thus, the goal of this study was to evaluate the yield and growth traits of the black cumin varieties that had been released in order to select and recommend a higher-yielding variety for the midlands of the western Guji zone.

Materials and Methods

Description of the experimental site

The experiment was conducted at Bule Hora during the 2020–2022 cropping season. Bule Hora is located at 465 km along the Addis Ababa-Moyale main road in southern Ethiopia. The site is situated at 05° 75879" N latitude and 03802845.8" E longitude, with an elevation of 2371 meters above sea level vel (m.a.s.l.). The area has bimodal rainfall patterns, and there are two separate crop-growing seasons locally called *Gana* and *Hagaya*.

The main season, *Gana*, extends from mid-March to July, and *Hagaya* from September to October. The area receives a minimum of 748.7mm and a maximum 1353.5mm of annual rainfall, with annual mean maximum and minimum temperatures of 10.70 °C and 25.3 °C, respectively.

Treatments and experimental design

The treatments consist of six released black cumin varieties (Silingo, Kena, Gemechis, Darbera, Soressaa, and Keneni), which were obtained from the Sinana and Kulumsa Agricultural Research Center. The varieties were evaluated for three consecutive cropping seasons (2020–2022). The individual plot size was 2m x 2.4 m, consisting of eight rows with 0.3 m spacing between rows.

The spacing between plots and adjacent blocks was 1m and 1.5m, respectively. Seed rates of 15kg ha-1 and fertilizer rates of 55 kg ha-1 of urea (during planting and top dressing), as well as 40kg ha-1 of blended NPS, were calculated for the plots and uniformly applied to the plots. All agronomic and other management practices, such as land preparation and weeding, were done uniformly for all treatments. The experiment was set up in a randomized complete block design (RCBD) with three replications.

Data collected

Growth parameters

Days to 50% flowering: The number of days elapsed between date of sowing and date of 50% flowering was computed and expressed as average number of days to flowering.

Days to 90% maturity: the duration between planting and the date at which the plant's morphological observations attain 90% of maturity level was calculated.

Plant height (cm): Plant height was measured in centimeters at physiological maturity from the ground level to the tip of plant from five randomly selected plants in each plot. The values are expressed as mean values.

Number of branches per plant: Number of primary and secondary branches per stem was randomly counted from selected five middle row plants at final harvest.

Number of pods per plant: On individual plant basis, number of pods in the tagged plants counted manually. The mean pods per plant taken for each treatment.

1000 seed weight (gm): The seeds obtained from each of the five-tagged plants were dried in the sun to around 8.0% moisture content, weighed and counted with a seed counter. Their weight measured by an Analytical balance and the average weight was expressed in grams.

Seed yield per hectare (kg): Grain yield was determined by harvesting plants from the net middle plot area to avoid border effects. Seeds, which were obtained from the corresponding net plot were cleaned manually. After drying to around 8.0% moisture, weighed using sensitive balance and recorded as mean values of seed yield per hectare in kilograms.

Data analysis

The SASGLM (General Linear Model) procedure (SAS Institute Inc. 2002) was employed for the analysis of variance. Duncan Multiple Range test (DMRT) at 5% level of significance were used for mean comparisons, whenever genotype differences were significant.

Results and Discussion

Phenology and growth traits

Phenology and growth traits of the six black cumin varieties planted at Bule Hora on-farm showed statistically significant differences ($p<0.01$) among years for all traits, while interaction of variety within year showed statistically significant difference for traits like number of primary branches, number of pods per plant, and grain yield.

Days to flowering and maturity of varieties ranged from 84.44 to 87 and 151.77 to 157, respectively, with a mean of 83.83 days to flowering and 153.83 days to maturity. Among varieties, the Gemechis variety was late to attain 50% flowering (87 days) and maturity (157 days). Early flowering variety have great importance for producing more yields within a year by reducing the days to maturity of the crops. The Gemechis variety exhibited late flowering and late maturity.

Based on the results of the analysis, there was a non-significant difference between the varieties for plant height. The varieties had a mean plant height of 48.63 cm, which ranged from 45.22 to 50.35 cm. The tallest and shortest of the plants were measured for the varieties Kena and Gemechis, respectively.

Arega *et al.,* (2021) also reported a mean plant height of 48.25 cm for six released black cumin varieties, which ranged from 43.5 cm to 51.67 cm in the midlands of the Western Giji zone. The result of the current finding is in line with that of Bozdemir *et al.,* (2022).

The number of primary branches for six varieties ranged from 2.7 to 7.7, with an overall mean of 6.5. The lowest number of primary branches was registered for the Gemechis variety, while the highest number of primary branches was recorded for the Kena variety.

The varieties with a higher number of primary branches are expected to produce a higher number of secondary branches and pods per plant, which will increase the yield.

Yield and Yield Components

The analysis of variance result showed that there was a significant difference among varieties in the number of pods per plant. The number of pods per plant for six varieties ranged from 15.48 to 23.42, with an overall mean of 19.0 pods per plant recorded among six black cumin varieties. Two varieties, Darbera and Soresa, had mean numbers of pods per plant greater than 19, whereas three varieties had a lower mean number of pods per plant than the overall mean of variety.

The number of pods per plant is a significant selection criterion for obtaining high-yielding varieties. Accordingly, Kena and Darbera varieties had the maximum number of pods per plant with a mean of 23.42 and 21.91, respectively (Table 2), whereas Gemechis variety gave the least mean pods per plant (15.48). The results of the current research are also in line with those reported by Gezahegn and Sintayehu (2016). On the other hand, the varsities had not much difference for thousand seed weight ranged from 1.75 (Kena) to 1.86 (Gemechis) with an overall mean of 1.76 (Table 2).

The overall grain yield was significantly influenced by year ($p<0.01$) among varieties (Table 2). The interaction effects of varieties by year on grain yield were significant.

Table.1 Lists of black cumin varieties used in the study

Variety	Releasing Research Center	Year of release	Altitude ranges (masl)
Keneni	SARC	2009	1800-2500
Kena	SARC	2009	1800-2500
Darbera	SARC	2006	1650-2400
Soressaa	SARC	2016	1650-2400
Silingo	KARC	2017	1800-2500
Gemechis	SARC	2016	1650-2400

Source: Minster of Agriculture and Natural Resource 2017 and from the Research Center; SARC = Sinana Agricultural Research Centers, KARC= Kulumsa Agricultural Research Center, masl = meters above sea level.

Table.2 Mean squares from combined analyses of variance over three years for six traits of Black Cumin varieties grown at Bule Hora in 2020, 2021, and 2022 (ANOVA).

SV	DF	DF	DM	PH	NB	GY	PPP	TSW
year	2	694.06**	694.06**	5949.1**	68.136**	477634**	251.912**	3.2267**
Block(yr)	6	15.26Ns	15.26Ns	58.9Ns	2.270Ns	2623Ns	3.139Ns	0.2356Ns
Varieties	5	32.79Ns	32.79Ns	29.5NS	4.930 **	154786**	95.991**	0.0476Ns
Y*V	10	23.21Ns	23.21Ns	33.2NS	2.887 *	11393**	21.603**	0.1102NS
Error	30	39.99	39.99	36.1	1.171	2649	2.637	0.1378
CV (%)		7.5	4.1	12.35	16.5	7.83	8.54	21.01

*Means with the different letters indicate significant differences. ***Significance at p<0.001;**significance at p<0.01;*significance at p<0.05 ns=not significant; PH=plant height, CV=coefficient of variation, NB= Branch number, PPP=number of pod per plant, DF= days to 50% flowering, MD=days to 90% maturity, GY=grain yield kg per hector and TSW=Thousand seed weight, Var=Variety and Yr=Year.*

Table.3 Mean value of yield and yield-related traits of six traits of black cumin varieties tested at Bule Hora in the 2020, 2021, and 2022 cropping seasons

Varieties	DF	DM	PH	NB	GY	PPP	TSW
Darbera	81.7	151.7	49.11	6.7[b]	570.4[d]	21.91[a]	1.71
Kena	84.2	154.2	50.3	7.7[a]	875.26[a]	23.42[a]	1.75
Gamachis	87.0	157.0	45.2	2.7[bc]	684.17[b]	15.48[d]	1.86
Kenani	83.5	153.5	48.22	2.7[bc]	628.14[c]	16.06[cd]	1.82
Soresa	82.0	152.0	49.57	3.0[ab]	489.5[e]	19.96[b]	1.77
Silingo	84.4	154.4	49.33	6.5[a]	692.10[b]	17.17[c]	1.66
Mean	83.8	153.8	48.6	6.5	656.5	19.0	1.76
LSD(0.05)	**Ns**	**Ns**	**Ns**	**1.04**	**49.5**	**1.56**	**Ns**
CV	7.5	4.1	12.35	16.5	7.83	8.54	21.01

*Means with the different letters indicate significant differences. ***Significance at p<0.001;**significance at p<0.01;*significance at p<0.05 ns=not significant; PH=plant height, NB= Branch number, CV=coefficient of variation, DF=days to 50% flowering,* GY (kg/ha) =*Yield kg per hector, DM= days to 90% maturity, PPP=number of pod per plant and TSW=Thousand seed weight.*

The overall means revealed that the highest seed yield was obtained from the Kena variety (875.26 kg ha1), followed by the Silingo variety (692.1 kg ha1), whereas the lowest seed yield corresponded to the Darbera variety (570.4 kg ha1), followed by the Kenani varieties (628.14 kg ha1). Arega *et al.,* (2021) also reported significant variation among six released black cumin varieties for grain yield in the midlands of the Western Giji zone.

Gezahegn and Sintayehu (2016) also reported significant variation among black cumin varieties for grain yield in the mid-highland of the West Hararghe Zone.

Recommendations

Evaluation of the adaptation and performance of black cumin varieties is an effective tool in facilitating the selection of improved cultivars for the highlands of the western Guji zone. Higher grain yields were recorded for Kena (875.26 kg ha-1) and Silingo (692.1 kg ha-1) black cumin varieties, making them selected and recommended for the highland areas of the western Guji zone.

Author Contribution

Taera Itana: Investigation, formal analysis, writing—original draft. Dejene Temesgen: Validation, methodology, writing—reviewing. Ejigu Ijara:—Formal analysis, writing—review and editing. Gutema Idosa: Investigation, writing—reviewing.

Data Availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethical Approval Not applicable.

Consent to Participate Not applicable.

Consent to Publish Not applicable.

Conflict of Interest The authors declare no competing interests.

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