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Assessment of Black Cumin (*Nigella sativa* L.) Production and Productivity Influencing Factors in North and Northeastern Ethiopia

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ABSTRACT

The aim of this study was to evaluate North and Northeastern Amhara's output of black cumin and the factors that affect its productivity. The survey was carried out in six districts and three zones in North and Northeastern Ethiopia between January and April 2024. Data were gathered through semistructured interviews, focus groups, and field observations. Using a stratified random sample technique, 199 black cumin farmers from 12 kebeles were chosen. Primary and secondary sources were used to collect the data. According to the survey results, the respondents' average age was 41 years, their landholding size was 0.32 ha, they had 22 years of producing experience, and their maturity time was 126 days. Male respondents made up 69% and female respondents made up 31%, with an average training participation rate of 1.95. Furthermore, 23% of people were illiterate and 77% of people were literate. Approximately 62% and 44% of black cumin crops were rotated and interplanted with other crops, respectively. The topography variable results showed that 54% of respondents planted black cumin in undulating farmland, while 46% planted it in a plain. Additionally, 36% of respondents' farmed black cumin using improved varieties, 42% of respondents' black cumin farms were impacted by pests, and 79% and 21% of respondents sold black cumin seed at high and low prices, respectively. Multiple linear regression analysis showed that black cumin productivity is significantly and favorably impacted by family size, crop rotation, variety type, product market price, and training variables, while household head age had a significant negative impact. According to the results, authorities should prioritize encouraging farmers to use better crop varieties, crop rotation, enhanced markets, and farmer training initiatives.

1 | Introduction

In developing countries, larger sections of the populations depend on agriculture. In Africa, there is an abundance of resources and high potential of attracting investors and producers in various agricultural productions and emerging markets [1]. Agriculture has been a significant driver of the Ethiopian

economy for many years, and it has contributed about 43% of the country's GDP while also employing almost 85% of the labor force and making up about 90% of the exports [2].

Black cumin (*Nigella sativa* L.) is a flowering plant that belongs to the family Ranunculaceae. Literature also revealed that black cumin is native to the Mediterranean region, but currently, it is

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cultivated in different parts of the world including Ethiopia [3]. The majority of the global commercial supply of these seeds is obtained from cultivation in India [4].

The estimated early world production is 600,000 tons, with 86% of the share in India, followed by Iran (4%), Syria (3%), and Turkey (2%). The remaining 5% comes from different countries such as Egypt, Pakistan, and Afghanistan [5]. In contrast, the top 10 countries that have the highest export values of black cumin in order are Malaysia, Indonesia, China, the Netherlands, Germany, Sweden, India, the United States, Russia, and Spain [6].

Ethiopia is a country with different and favorable agroecological zones for the production of various spices, vegetables, and crops [7, 8]. In Ethiopia, it is a cultivated plant mostly grown in back gardens of homesteads and also on heavier soils as a field crop, tolerating a wide range of soils, occasionally found growing wild between 1500 and 2500 m. In Ethiopia, black cumin is one of the most important spice types that are mainly produced to flavor foods, preparation of oil for perfumes and medicinal purposes, source of income, crop diversification, and export purposes [9, 10]. In addition, in Ethiopia, the seeds are important spices used in preparing hot pepper sauce and other dishes; they are also used to flavor some types of bread. They are mixed with melted butter, wrapped in a piece of cloth, and sniffed to relieve some types of headaches [11].

In the country, the annual production of black cumin was 14,730 metric tons in the 2021/2022 cropping season [12]. Even though the production and area coverage of black cumin have been increasing, its productivity is still very low in the country. The national average productivity is very low and was reported to be $0.64 \text{ t}\cdot\text{ha}^{-1}$, which is below the global average and some major producing countries including India ($2.20 \text{ t}\cdot\text{ha}^{-1}$) [13, 14]. Due to the increased demand of black cumin seed for local consumption and other importance, such as oil and oil rosin for medicinal purposes, its export market, its potentiality in crop diversification, income generation, and its importance to reduce the risk of crop failure and others made black cumin as the best alternative crop under Ethiopian smaller landholdings [9]. It is also the second important cash spice crop that is exported to an international market next to ginger [10].

Despite the country's favorable environmental conditions for its production and importance in the economy, the black cumin cropping system has been given little attention to improve its production and productivity, and hence, it remained an underutilized crop. Moreover, the production and productivity of black cumin were influenced by various socioeconomic, demographic, institutional, and environmental factors [10, 15]. Furthermore, indigenous and local knowledge is gradually being lost as the custodians die before passing on information to the younger generations. The documentation of indigenous and local knowledge through ethnobotanical studies is important in the conservation and utilization of biological resources [16].

In Ethiopia, no sufficient documented ethnobotanical data are available on black cumin, whereas this information remains a prerequisite for effective implementation of conservation strategies and for the development of new varieties. Therefore, standard collection and documentation of data through an ethnobotanical survey will provide information or strategies to

overcome constraints affecting black cumin production in Ethiopia. Besides, the generation of information and documentation on black cumin production and the factors that influence its productivity are crucial for future interventions. Hence, this study was designed to assess black cumin production patterns and investigate the factors influencing its productivity in Ethiopia.

2 | Materials and Methods

2.1 | Description of the Study Area

The ethnobotanical survey was carried out in black cumin-growing areas of Northeastern Amhara in Kalu and Ambassel Woredas of South Wollo; Habru and Gubalafeto Woredas of North Wollo; and Alefa and Takusa Woredas of North Gonder Zone (Figure 1).

2.2 | Sampling Method and Sample Size Estimation

A multistage sampling approach was used in this investigation. The three administrative zones of the study areas were chosen in the first stage using a purposive selection technique. Experts from the Amhara Region's Agricultural and Natural Resources Bureau assisted in the selection of the three zones. The selection of the research zones was based on a long history of black cumin production, farmers' traditional knowledge, and a high production potential. Six woredas from the three zones were sampled in the second stage using a purposeful random sampling technique. Twelve kebeles (PA) from each of the six woredas were sampled in the third stage using a systematic random sampling process. Lastly, using stratified random sampling techniques based on a probability proportionate to the size sampling procedure from the sampled kebeles and the Yamane [17] formula at a 95% confidence interval, 5% variability, and 7% precision, 199 black cumin producer farmers' households were chosen (Table 1, Equation (1))

$$n = \frac{N}{1 + N(e)^2}, \quad (1)$$

where n is the size of the sample, N is the total household size (the population size), and e is the level of precision ($e = 0.07$).

2.3 | Sources, Methods, and Tools of Data Collection

Data were gathered using a mix of primary and secondary sources. Through individual farmer interviews, farm field observations, and 10 key informants (five males and five females) for six focus group discussions (one FGD for each woreda) led by open-ended or unstructured questions, primary data were collected from the sampled farm families in 12 rural kebeles using a pretested semistructured interview survey [18]. Additionally, during the fieldwork, six woredas' Agricultural and Natural Resources offices as well as the Zonal Agricultural and Natural Resources Department in each zone were visited to gather secondary data.

2.4 | Data Analysis

SAS software and descriptive statistics were used to evaluate the gathered data [19]. Socioeconomic characteristics were described

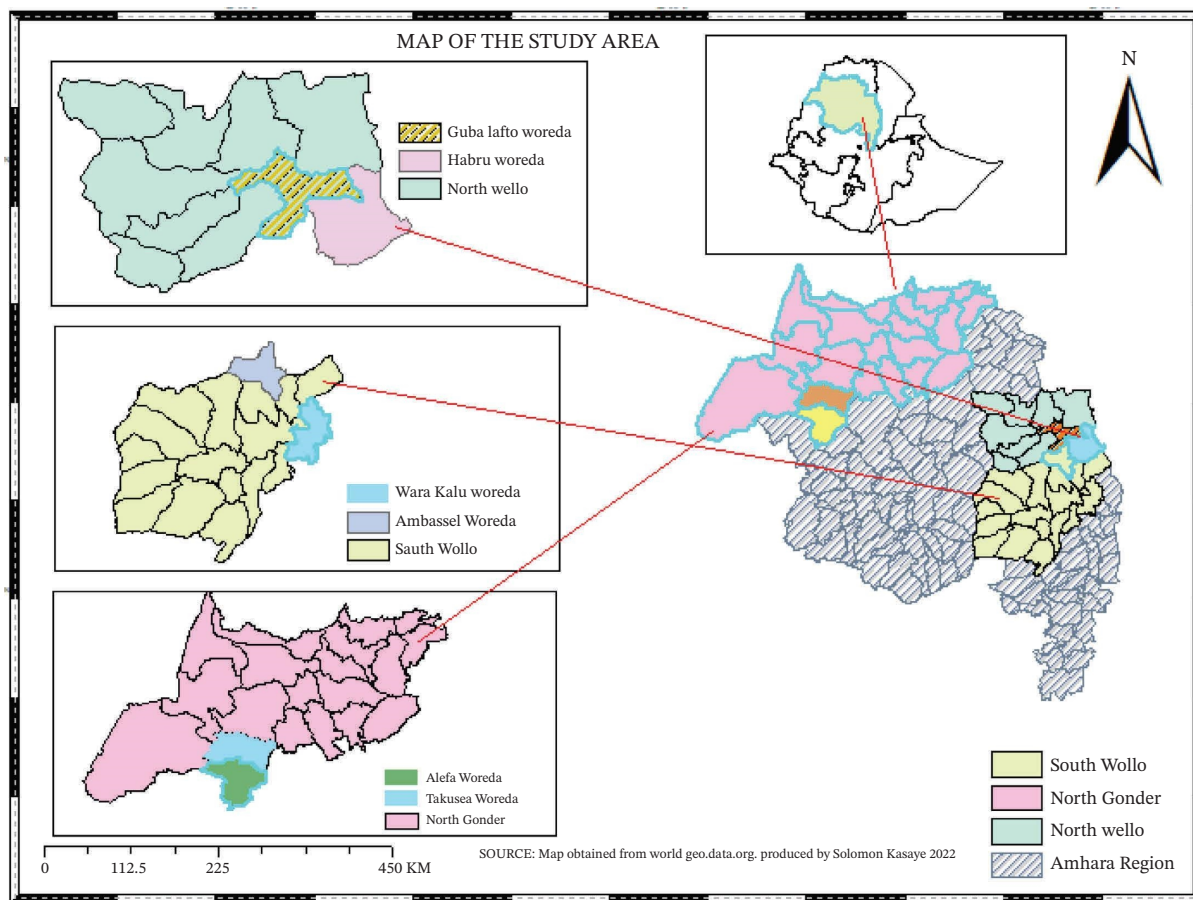


FIGURE 1 | Map of Ethiopia showing the Amhara Region and the study woredas.

using descriptive statistics like mean, percent, and frequency. The parameters affecting the productivity of black cumin in the research area were then determined using multiple linear regression models. Multiple linear regression models and their estimate using ordinary least squares (OLSs) are without a doubt the most widely used econometrics tool. When every family in

the sample produces black cumin, OLSs are employed. The following formula, used by [20], can be used to estimate a continuous dependent variable and its association with a set of dummy, categorical, or continuous explanatory factors. The multiple linear regression models are specified as follows (Equation (2)):

TABLE 1 | Description of the sampled zones, woredas and kebeles, and their sample size.

Zones	Zone's black cumin producers HHs	Woreda	Woreda's black cumin producers HHs	Kebeles (PA)	Black cumin producer HHs	Sample sizes
N. Gonder	3500	Alefa	360	1	190	20
				2	170	20
		Takusa	300	1	150	20
				2	150	20
South Wollo	2500	Kalu	250	1	140	20
				2	110	20
		Ambassel	200	1	100	20
				2	100	20
North Wollo	1000	Habru	150	1	75	10
				2	75	10
		Gubalafeto	100	1	50	10
				2	50	8
Total	7010		1360	12	1360	199

Note: HHs: household.

Abbreviation: PA: peasant association.

$$Y = \beta_0 + \beta_1x_1 + \beta_2x_2 + \dots + \beta_{14}x_{14} + \varepsilon, \quad (2)$$

where the following are the explanatory variables and the dependent variable (Y) is the amount of black cumin productivity expressed in tons: The household head's education level is represented by X_1 , which is 1 if they attended formal school and can read and write at any grade level and 0 otherwise. X_2 is the household head's sex, with 1 denoting a male and 0 denoting a female. X_3 is the household head's age in years; X_4 is the number of family members; X_5 is the size of the household head's landholding in hectares; X_6 is the household head's cropping system (1 if intercropped and 0 otherwise); X_7 is the household head's crop rotation (1 if rotated and 0 otherwise); X_8 is the number of years that the household head has produced black cumin; X_9 is the number of days that the black cumin variety matures; and X_{10} is the topography of the household head's black cumin farm; 1 is undulating and 0 is not. X_{11} denotes the presence of pests on the household head's black cumin farm (1 if pests appeared and 0 otherwise); X_{12} denotes the variety the household head uses (1 if improved and 0 otherwise); X_{13} denotes the household head's black cumin product market price (1 if low price and 0 otherwise); and X_{14} denotes the household head's participation in training, in number. Table 2 lists the many kinds of variables, their meanings, how they are measured, and their expected impact on production.

3 | Results and Discussion

3.1 | Socioeconomic Characteristics of the Respondents

Table 3 displays the descriptive statistics for the continuous and dummy variable outcomes. The findings indicated that the 199 household head respondents ranged in age from 21.00 to 75.00 years, with a mean age of 41.08 years. This suggests that those who are young and economically active dominate the production of black cumin in the studied locations. This outcome is consistent with research by Dessie et al. [7, 8] and Wassihun et al. [21], which found that the average age of potato and red pepper growers in Northwest Ethiopia was 46.69 and 48.31 years, respectively. Dessie et al. [4], Teshome and Anshiso [10], Ngolle and Salehe [22], and Bayeta [23] reported similar findings. In a similar vein, the household head's average family size was 6.91, ranging from 3 to 11. Comparable findings also showed that the average home family size was 6.2 [4, 20, 24]. The results highlighted the importance of bigger families engaging in agricultural production, particularly when every member of the household boosts productivity and provides services to support the family's economy [23, 25]. The household head's average landholding size was 0.32 ha, while the lowest and largest landholding sizes were 0.06 and 1.25 ha, respectively, according to the results. Similar findings were reported by Dessie et al. [4], who found that the average area of land used for black cumin was 0.4 ha. Land is the most valuable natural resource in nations like Ethiopia, where agriculture is the main economic sector [23, 26]. This suggests that if there was an adequate supply of family labor, farmers with greater landholdings would make more money, which would raise the demand for kids who could help on the farm [27]. Black cumin production experience ranged widely, with a minimum of 10.00 years and a maximum of 42.00 years, with an average of 22.04 years. The likelihood that farmers would see the significance of producing black cumin increased by 1.68%

for every year. This is conceivable since senior farmers may possess greater knowledge and experience regarding the production and significance of agricultural crops compared to younger farmers [10]. Research conducted in Ethiopia has demonstrated a significant correlation between farmers' perceptions of crop expansion and the number of years they have worked in agriculture [23, 28]. The average maturity period in the research region was 126.15 days. This finding is in line with that of Dessie et al. [4], Anshiso & Teshome [9], and Teshome & Anshiso [10]. Male respondents had an average training participation rate of 1.95, while female respondents had an average of 69.35% and 30.65%, respectively (Table 3). Dessie et al. [4] and Ngolle and Salehe [22] found similar results regarding the predominance of men: roughly 96.28% and 3.72% of sample homes were headed by men and women, respectively. Table 3 shows that of the respondents, 76.88% were literate and 23.12% were illiterate. According to research findings, approximately 57.45% and 42.55% of sample homes were illiterate and literate, respectively [4]. The outcome is in line with research by Asfaw and Admassie [29], who found that agricultural productivity and income are significantly influenced by education. To achieve agricultural development, investments in technology and production methods should be matched by equivalent investments in human resources. This is due to the fact that farmers require knowledge and information in order to use technology, get feedback, change their methods, and sell their goods [23, 30]. This result is consistent with the findings of Oluwasola [31] and Ngolle and Salehe [22], who proposed a strong correlation between education levels and information availability and the adoption of technical improvements in agriculture. Farmers' ability to increase production and adjust to new farming methods may be hampered by inadequate knowledge. Similarly, approximately 44.22% and 62.31% of black cumin crops had been rotated and interplanted with other crops, respectively (Table 3). This finding demonstrated that a large number of households used crop rotation and intercropping techniques to produce black cumin. This suggests that smallholder farmers have employed intercropping and rotation techniques to enhance soil fertility and boost black cumin yield. The topography variable results showed that 54.27% of respondents grew black cumin in undulating cropland, while 45.73% of respondents grew it in plain or level terrain (Table 3). The topography variable results show that 54.27% of respondents planted black cumin in undulating farmland, whereas 45.73% planted it in a plain. Given its high susceptibility to soil erosion, challenges with tillage, and low soil nutrient content, this suggests that undulating terrain is one of the main variables affecting black cumin output. Therefore, the topography element has a significant impact on black cumin productivity. According to Bakker et al. [32], farming on steep terrain may result in soil erosion, which would lower agricultural output. Pests impacted about 42.21% of respondents' black cumin farms, while 36.18% of respondents used improved types to grow black cumin (Table 3). According to the results, 64% of the participants cultivated black cumin using regional cultivars. The respondents cited the inaccessibility of better varieties as the main justification for using native types. Table 3 shows that 79.40% and 20.60% of the respondents sold black cumin seed at high and cheap prices, respectively. According to this study, 79.40% and 20.60% of respondents sold black cumin seed at high (800 birr per kilogram) and low (400 birr per kilogram) market prices, respectively. Dessie et al. reported a similar outcome [4].

TABLE 2 | Definition, measurement, and the predicted effect of the variables affecting black cumin productivity in the survey area.

Variables	Types of variable	Measurements and definitions	Anticipated effects on productivity
Productivity	Continuous	Dependent variable black cumin productivity in tons	
Education level of the HH head	Dummy	Independent variables 1 if learned formal school and 0 otherwise	+
Sex of the household head	Dummy	1 if male and 0 otherwise	±
Age of the household head	Continuous	Year	-
Family size	Continuous	Number	±
Landholding size	Continuous	Hectare	+
Cropping system	Dummy	1 if intercropped and 0 otherwise	+
Crop rotation	Dummy	1 if rotated and 0 otherwise	+
Black cumin production experience	Continuous	Year	+
Maturity period	Continuous	Month	+
Topography	Dummy	1 if undulating and 0 otherwise	-
Pests	Dummy	1 if pests appeared and 0 otherwise	-
Variety type	Dummy	1 if improved and 0 otherwise	+
Product market price	Dummy	1 if low price and 0 otherwise	±
Participation in training	Continuous	Number	+

Note: -: negative effect; +: positive effect; ±: positive or negative effect on productivity of black cumin.

3.2 | Analysis of Influencing Factors

Multiple linear regression models were used to determine the factors affecting black cumin productivity (Table 4). The pre-suppositions of the traditional linear regression model must be upheld for parameter estimation to be successful. Therefore, using the proper test statistics, the proposed explanatory factors were examined for multicollinearity. The average VIF value was determined to be 2.05, indicating a moderate, and generally acceptable, amount of multicollinearity between predictor variables in regression model. The explanatory variables are uncorrelated with the error term, which is a core assumption of OLS regression (often referred to as the exogeneity assumption or the condition of no endogeneity). Additionally, the study of the coefficient of determination (R^2) result revealed that 95.28% of the fitted data in a regression model described the dependent variable. This suggests that around 95.28% of the variation in black cumin productivity can be explained by explanatory factors. Consequently, a better fit for the model is suggested by the R^2 value. Moreover, high R^2 indicates a strong relationship between the variables and a very good fit of the model to the data. The high value of R^2 indicated that there was a strong linear association between the predictor(s) that are family size, crop rotation, variety type, product market price, and training and productivity; that is why they were significantly correlated. In addition, the model includes key, relevant predictors or variables that strongly influence the dependent variable productivity, making a high reflection of a well-specified model. This finding is in line with that of Dessie et al. [4], Anshiso & Teshome [9], and Teshome & Anshiso [10], who reported that the coefficient of determination was used to assess the regression model's goodness of fit in the black cumin production determinant study. In order to determine the factors impacting black cumin productivity on smallholder farmers' acreage, 14 explanatory variables were employed. Eight of these factors were determined to be nonsignificant at the 5% level of significance, while six were found to be statistically significant. Furthermore, out of all the independent factors, nine were shown to have a positive correlation with black cumin productivity, whereas five had a negative correlation.

3.2.1 | Age of the Household Head

Black cumin productivity was found to be negatively impacted by the age of the household head at a 1% level of significance. This indicates that black cumin productivity decreased by $0.004 \text{ t} \cdot \text{ha}^{-1}$ as responders get older. In a similar vein, Bayeta [23] found that the decision to produce black cumin was strongly and favorably influenced by the age of the household head.

3.2.2 | Family Size

Black cumin productivity was positively connected with the number of families attending production, which was statistically significant at a 1% probability level. The coefficient indicates that a one-person increase in family size would result in a $0.019 \text{ t} \cdot \text{ha}^{-1}$ improvement in the black cumin output. This suggests that households with a variety of family sizes that participate in black cumin cultivation provide a sizable labor force to the farm activity, which raises the crop's yield. This result is in line with that of Inoni [33], who found that family size can increase production by supplying labor for farming. Additionally, research by Gebre

TABLE 3 | Results of descriptive statistics of sampled black cumin producers in the study area.

Variables	Mean	Standard deviation	Minimum	Maximum
Age of the household head in years	41.08	11.41	21.00	75.00
Family size in number	6.91	1.80	3.00	11.00
Landholding size (ha)	0.32	0.25	0.06	1.25
Black cumin production experience in years	22.04	5.67	10.00	42.00
Maturity period in days	126.15	8.94	111.00	155.00
Training participation in number	1.95	0.71	1.00	3.00
Education level of the household head			Frequency	Percent
Learned formal school		1	153	76.88
Not learned formal school		0	46	23.12
Sex of the household head				
Male		1	138	69.35
Female		0	61	30.65
Cropping system				
Intercropped		1	88	44.22
Pure stand		0	111	55.78
Crop rotation				
Rotated		1	124	62.31
Not rotated		0	75	37.69
Topography				
Undulating		1	108	54.27
Not undulating (level/plain)		0	91	45.73
Pests				
Pest appeared		1	84	42.21
Pest not appeared		0	115	57.79
Variety type/input				
Improved		1	72	36.18
Not improved		0	127	63.82
Product market price				
Low price		1	41	20.60
Not low price		0	158	79.40

Note: Source: own computation result, 2024.

et al. [34] found that a 10% increase in family size would result in a 7.5% increase in maize output. According to research by Asfaw et al. [35], Bayeta [23], and Bilgili et al. [36], the size of the entire family has a substantial impact.

3.2.3 | Crop Rotation

It was shown to be statistically significant at 5% level of significance with the expected positive association, as shown in Table 4. According to the coefficient, if all other factors stay the same, rotating black cumin with other crops could boost productivity by 0.099 t · ha⁻¹. In comparison to farmers who do not engage in crop rotation on their farmland, farmers who rotate their crops could improve soil fertility, reduce soil erosion, maintain soil health, break the life cycle of disease pests, and enhance nutrients available for black cumin crops, all of which would increase black cumin productivity. This result is consistent with earlier research by Bowles et al. [37], who found that smallholder farmers benefited economically from diverse crop

rotation, which raised crop yields. Han et al. [38] conducted a crop rotation experiment in the Loess Plateau of China using different combinations of alfalfa after cultivation and found that the mean yield increased by 44.40% compared to continuous cropping of rapeseed and by 42.90% compared to continuous cropping of wheat when rapeseed was sown during the winter. Another study by Wang et al. [39] found that over a 3-year period, maize–potato rotation increased maize production by 15.5%–23.40% and decreased soil water consumption rates by 16.81%–24.83% as compared to continuous maize farming.

3.2.4 | Variety Type

At a 1% significance level, productivity was positively impacted by selecting and utilizing better black cumin planting material kinds. According to the results, black cumin productivity might rise by 0.083 t · ha⁻¹ if farmers cultivate better kinds as opposed to those who employ local varieties, which are characterized by low yield, less stable yield, and susceptibility to biotic and abiotic factors;

TABLE 4 | Result of multiple linear regression analysis for variables predicting the productivity of black cummin.

Variable	Coefficient	Standard error	t-stat	Significance	Tolerance	Variance inflation factor
Intercept	0.445***	0.06522	6.83	< 0.0001		0
Education level of the HH head	0.002	0.00745	0.27	0.7841	0.863	1.16
Sex of the household head	−0.011	0.00648	−1.74	0.084	0.953	1.05
Age of the household head in year	−0.004***	0.00055	−6.88	< 0.0001	0.217	4.61
Family size in number	0.019***	0.00292	6.48	< 0.0001	0.312	3.20
Landholding size in a hectare	0.008	0.01309	0.65	0.519	0.840	1.19
Cropping system	−0.002	0.00612	−0.35	0.723	0.920	1.09
Crop rotation	0.099***	0.01013	9.79	< 0.0001	0.353	2.83
Black cummin production experience in years	−0.001	0.00075	−1.59	0.113	0.479	2.09
Variety maturity period in days	0.0002	0.00035	0.63	0.527	0.862	1.16
Farm topography	0.001	0.00616	0.08	0.939	0.903	1.11
Pests	−0.006	0.00607	−1.04	0.300	0.947	1.06
Variety type	0.083***	0.01077	7.72	< 0.0001	0.318	3.14
Product market price	0.055***	0.01210	4.56	< 0.0001	0.356	2.81
Training participation rate	0.027***	0.00613	4.43	< 0.0001	0.455	2.20
F (14, 184) at 5%	40.14					
Prob > F	0.0000					
R-squared	0.9528					
Adj R-squared	0.9492					
Mean VIF						2.05

Note: Source: own computation result, 2024.

improved varieties offer higher and more stable yields as well as greater tolerance or resistance to diseases, insect pests, drought, heat, cold, parasitic weeds, and other stress factors (Table 4). The modified wheat seeds yielded 33% more than the indigenous seed in the Kugbei [40] research conducted in Afghanistan. Additionally, Gebre et al. [34] found a favorable and substantial association between enhanced seeds and productivity, which is consistent with our findings. Therefore, a 10% increase in the use of enhanced maize seeds would lead to a 5.33% increase in output. According to Meseret [41], Bayeta [23], and Kondo et al. [42], the choice to produce malt barley was greatly and favorably influenced by the type of seed used (local or enhanced variety).

3.2.5 | Product Market Price

At the 1% significance level, the product market price variable was significant and had a positive coefficient. According to the findings, black cumin productivity might rise by 0.055 t·ha⁻¹ depending on the product market price (Table 4). This result is consistent with research by Dessie et al. [4].

3.2.6 | Training Participation Rate

Additionally, training and productivity were found to be positively and significantly correlated (Table 4). According to the model's findings, black cumin productivity would rise by 0.027 t·ha⁻¹ if farmers received one more training. This suggests that farmers who receive hands-on training might boost black cumin productivity because the training enhances their knowledge and proficiency in managing it, including applying various inputs. Mariyono et al. [43] claim that agricultural training gives farmers practical knowledge and technical expertise. According to studies by Schreinemachers et al. [44] and Bayeta [23] in Bangladesh, trained farmers would boost the net family income by 48%, and 31% of them initially accepted the technology compared to nontrained farm households.

4 | Conclusion and Policy Implications

Multiple linear regression analysis showed that black cumin productivity is significantly and favorably impacted by family size, crop rotation, variety type, market price, and training, while household head age had a significant negative correlation with black cumin productivity. In light of the results, governments ought to concentrate on motivating farmers to embrace completely packaged new technology, like enhanced crop varieties. In order to increase soil fertility and sustain productivity, agricultural policy must support and expand crop rotation, enhance markets, and provide farmer training programs.

Nomenclature

CBI	Center for the Promotion of Imports from developing countries
CSA	Central Statistical Agency
EIA	Ethiopian Investment Agency
FAO	Food and Agriculture Organization
FGD	Focus group discussion
GDP	Growth domestic product

ha	Hectare
HH	Household
OLS	Ordinary least squares
ORCID	Open Researchers and Contributors Identity Document
PA	Peasant association
SAS	Statistical Analysis System
t	Ton
Tridge	Three-way bridge
VIF	Variance inflation factor.

Author Contributions

The field survey, statistical analysis, and manuscript drafting were all completed by Solomon Kassaye Ejigu. The remaining writers oversaw the field survey, organized the study, and helped write the report.

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Disclosure

The final text has been read and approved for submission by all authors.

Consent

The authors have nothing to report.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

References

1. D. D. Fiergbor, "An Empirical Studies into Mutual Funds in Emerging Markets; Prospects for Personal Financial Planning," *Global Economics Science* 1, no. 1 (2020): 31–37, <https://doi.org/10.37256/ges.11202070.31-37>.
2. Central Statistical Agency (CSA), "Agricultural Sample Survey: Statistical Agency Report on Area and Production of Major Crops (Private Peasant Holdings, Mean Season), Statistical Bulletin, CSA, Addis Ababa, Ethiopia," *Journal of Food Quality* (2023).
3. K. C. Bhutia, S. Bhandari, R. Chatterjee, S. O. Bhutia, and N. Gurung, "Integrated Micronutrient Spray on Yield Assessment of Black Cumin (*Nigella sativa*) in Nadia District of West Bengal," *Journal of Crop and Weed* 11 (2015): 205–209.
4. A. B. Dessie, T. M. Abate, B. T. Adane, T. Tesfa, and S. Getu, "Estimation of Technical Efficiency of Black Cumin (*Nigella sativa* L.) Farming in Northwest Ethiopia: A Stochastic Frontier Approach," *Journal of Economic Structures* 9, no. 1 (2020): 1–14, <https://doi.org/10.1186/s40008-020-00198-1>.
5. Cbi, "The European Market Potential for Cumin Seeds," (2023), <https://www.cbi.eu/market-information/spices-herbs/cumin/market-potential>.
6. Tridge, "Black Cumin Oil," (2023), <https://www.tridge.com/intelligence/ncs/black-cumin-seed-oil/export>.

7. A. B. Dessie, T. D. Koye, A. D. Koye, and A. A. Abitew, "Analysis of Red Pepper Marketing: Evidence From Northwest Ethiopia," *Journal of Economic Structures* 8, no. 1 (2019): 24–34, <https://doi.org/10.1186/s40008-019-0156-0>.
8. A. B. Dessie, A. A. Abitew, and A. D. Koye, "Analysis of Smallholder Farmers' Cooperation in Eucalyptus Woodlot Production in Wegera District, Northern Ethiopia," *Small-Scale* 18, no. 3 (2019): 291–308, <https://doi.org/10.1007/s11842-019-09418-4>.
9. D. Anshiso and W. Teshome, "Economic Value of Black Cumin (*Nigella sativa* L.) Conservation at Bale Zone of Oromia Region, Ethiopia," *American Journal of Business* 6, no. 4 (2018): 104–109.
10. W. Teshome and D. Anshiso, "Assessment of Production and Utilization of Black Cumin (*Nigella sativa*) at the Oromia Regional State, Ethiopia," *Asian Journal of Agricultural Extension, Economics and Sociology* 31, no. 3 (2019): 1–12, <https://doi.org/10.9734/ajaees/2019/v31i330132>.
11. S. Edwards, S. Nemomissa, and I. Hedberg, *Flora of Ethiopia and Eritrea* (Addis Ababa University, the National Herbarium, 2000).
12. Eia (Ethiopian Investment Agency), "Spice Industry Strategic Plan (2015–2025)," *Spices Industry Strategic Plan, Ethiopia* (2022).
13. G. Zigayalew, G. Wosene, and H. Girma, "Correlation and Path Coefficient Analysis in Yield and Yield-Related Components of Black Cumin (*Nigella sativa* L.) Accessions, at Jimma, Southwest Ethiopia," *International Journal of Agronomy* 3 (2020): 1–9.
14. Food and Agriculture Organization (FAO), "World Food and Agriculture-Statistical Year Book" (2023).
15. A. R. Nejad and I. Khorramabad, "Productivity of Cumin (*Cuminum cyminum* L.) as Affected by Irrigation Levels and Rows Pacing," *Australian Journal of Basic and Applied Sciences* 5, no. 3 (2011): 151–157.
16. C. Munthu, M. Ayyapar, N. Raja, and S. Ignacimuthu, "Medicinal Plants Used by Traditional Healers in Kancheepuran District of Tamil Nadu," *India Journal of Ethnobiology and Ethnomedicine* 2 (2006): 43.
17. T. Yamane, *Statistics: An Introductory Analysis Harper and Row* (Evanston and London and John Weather Hill. Inc, 1967).
18. G. J. Martin, *Ethnobotany: A Method Manual* (Chapman and Hall, 1995).
19. SAS (Statistical Analysis System) Institute, *Statistical Analysis System User's Guide* (SAS Institute Int, 2019).
20. A. W. Belayneh, E. G. Yeshe, and K. H. Gemeyida, "Determinants of Sesame Market Supply in West Omo and Bench Sheko Zones, Southwest Ethiopia," *International Journal of Agronomy* 2022 (2022): 5134478.
21. A. N. Wassihun, T. D. Koye, and A. D. Koye, "Analysis of Technical Efficiency of Potato (*Solanum tuberosum* L.) Production in Chilga District, Amhara National Regional State, Ethiopia," *Journal of Economic Structures* 8, no. 1 (2019): 1–18, <https://doi.org/10.1186/s40008-019-0166-y>.
22. A. Ngolle and F. S. Salehe, "Economic Contribution of Spice Farming to Household Income on the Slopes of the Uluguru Mountains, Morogoro Region, Tanzania," *Tanzania Journal of Agricultural Sciences* 23, no. 2 (2024): 351–365.
23. G. G. Bayeta, "Determinants of Spice Crops Production Decision and Commercialization Among Smallholder Farmers: Evidence From Goro District of Bale Zone, Southeastern Oromiya, Ethiopia," (Dire Dawa, Ethiopia: Haramaya University, 2023), MSc. thesis.
24. S. A. Shah, S. Ali, A. Ali, and A. Baig, "Economic Analysis of Maize Production in Central Khyberpaktunkhwa, Pakistan," *Sarhad Journal of Agriculture* 36, no. 3 (2020): 966–973.
25. B. Msongaleli, S. Tumbo, F. Rwehumbiza, and N. Kihupi, "Determinants of Farm-Level Decisions Regarding Cereal Crops and Varieties in Semi-Arid Central Tanzania," *African Journal of Agricultural Research* 10, no. 30 (2015): 968–978.
26. A. Amsalu, L. Stroosnijder, and J. D. Graa, "Long-Term Dynamics in Land Resource Use and the Driving Forces in the Beressa Watershed, Highlands of Ethiopia," *Journal of Environmental Management* 83, no. 4 (2007): 448–459, <https://doi.org/10.1016/j.jenvman.2006.04.010>.
27. K. Kim and H. Park, "Landholding and Fertility in Korea: 1914–1925," *Journal of Family History* 34, no. 3 (2009): 275–291, <https://doi.org/10.1177/0363199009337998>.
28. Z. Adimassu and A. Kessler, "Factors Affecting Farmers' Coping and Adaptation Strategies to Perceived Trends of Declining Rainfall and Crop Productivity in the Central Rift Valley of Ethiopia," *Journal of Environmental Systems Research* 5 (2016): 1–16, <https://doi.org/10.1186/s40068-016-0065-2>.
29. A. Asfaw and A. Admassie, "The Role of Education on the Adoption of Chemical Fertiliser Under Different Socioeconomic Environments in Ethiopia," *Agricultural Economics* 30, no. 3 (2004): 215–228, [https://doi.org/10.1016/s0169-5150\(04\)00023-4](https://doi.org/10.1016/s0169-5150(04)00023-4).
30. C. Chowa, C. Garforth, and S. Cardey, "Farmer Experience of Pluralistic Agricultural Extension, Malawi," *Journal of Agricultural Education and Extension* 19, no. 2 (2013): 147–166, <https://doi.org/10.1080/1389224x.2012.735620>.
31. O. Oluwasola, "Stimulating Rural Employment and Income for Cassava Processing Households in Oyo State, Nigeria Through Policy Initiatives," *Journal of Development and Agricultural Economics* 2, no. 2 (2010): 18–25.
32. M. M. Bakker, G. Govers, C. Kosmas, V. Vanacker, K. V. Oost, and M. Rounsevell, "Soil Erosion as a Driver of Land-Use Change," *Agriculture, Ecosystems & Environment* 105, no. 3 (2005): 467–481, <https://doi.org/10.1016/j.agee.2004.07.009>.
33. O. E. Inoni, "Impact of Rural Roads and Marketing Infrastructure on Output and Income of Farming Households in Ughelli South Local Government Area, Delta State," in *Proceedings of the 10th Annual National Conference of the Nigerian Association of Agricultural Economists Held at University of Abuja* (New York, October 2021).
34. G. G. Gebre, H. Isoda, D. B. Rahut, Y. Amekawa, and H. Nomura, "Gender Differences in Agricultural Productivity: Evidence From Maize Farm Households in Southern Ethiopia," *GeoJournal* 86, no. 2 (2021): 843–864, <https://doi.org/10.1007/s10708-019-10098-y>.
35. N. S. Asfaw, H. Jema, and T. Bosena, "Determinants of Smallholder Farmers Commercialization of Potato in Kofale District, West Arsi Zone, Oromia Regional State, Ethiopia," *Journal of Investment and Management* 9, no. 2 (2020): 56–62.
36. M. E. Bilgili, H. Yilmaz, S. Akkoyun, Y. Vurarak, and M. Gül, "Factors Affecting Cotton Production Decisions of Farmers: Eastern Mediterranean Region, Turkey," *Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development* 8, no. 2 (2015): 41–49.
37. T. M. Bowles, M. Mooshammer, Y. Socolar, et al., "Long-Term Evidence Shows That Crop-Rotation Diversification Increases Agricultural Resilience to Adverse Growing Conditions in North America," *One Earth* 2, no. 3 (2020): 284–293, <https://doi.org/10.1016/j.oneear.2020.02.007>.
38. L. Han, J. Ding, and Q. Han, "Effects of Alfalfa-Grain (Oil) Crop Plowing Rotation on Soil Moisture and Crop Yield in Loess Plateau," *Transactions of the Chinese Society of Agricultural Engineering* 28, no. 24 (2012): 129–137.
39. H. Wang, X. Zhang, X. Yu, H. Hou, and Y. Fang, "Maize-Potato Rotation Maintains Soil Water Balance and Improves Productivity," *Agronomy Journal* 113, no. 1 (2021): 645–656, <https://doi.org/10.1002/agi2.20434>.
40. S. Kugbei, "Efficiency of Wheat Seed Production and Crop Diversification in Afghanistan," *Journal of Crop Improvement* 25, no. 3 (2011): 191–201, <https://doi.org/10.1080/15427528.2011.547751>.
41. S. U. Meseret, "Determinants of Smallholder Farmers Production and Commercialization of Malt Barley in Digalu Tijo Woreda, Arsi Zone,

Oromia Region, Ethiopia,” (San Antonio: St. Mary’s University, 2015), MSc Thesis.

42. E. Kondo, D. B. Sarpong, and I. S. Egyir, “Production and Market Participation Decisions of Smallholder Cowpea Producers in the Northern Region of Ghana: A Triple Hurdle Model Approach,” in *Paper Presented at the 6th African Conference of Agricultural Economists* (Abuja, Nigeria, September 2019).

43. J. Mariyono, J. Waskito, A. Kuntariningsih, G. Gunistiyo, and S. Sumarno, “Distribution Channels of Vegetable Industry in Indonesia: Impact on Business Performance,” *International Journal of Productivity and Performance Management* 69, no. 5 (2019): 963–987, <https://doi.org/10.1108/ijppm-11-2018-0382>.

44. P. Schreinemachers, M. H. Wu, M. N. Uddin, S. Ahmad, and P. Hanson, “Farmer Training in Off-Season Vegetables: Effects on Income and Pesticide Use in Bangladesh,” *Food Policy* 61 (2016): 132–140, <https://doi.org/10.1016/j.foodpol.2016.03.002>.