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Research Article

# Multiple linear regressions on determinants of ginger production in yeki district, Sheka Zone, South West Ethiopia

**Alemu Bekele Eticha***

Department of Statistics, College of Natural and Computational Science, Mizan-Tepi University, Tepi, Ethiopia

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***Corresponding author:** Alemu Bekele Eticha, Department of Statistics, College of Natural and Computational Science, Mizan-Tepi University, Tepi, Ethiopia, E-mail: alemubekele1@gmail.com

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## Abstract

Ginger is an important crop that is produced worldwide for both spice and medicine. Ethiopia is one of the sub-Saharan countries which cultivate and export ginger to other countries. Even though ginger is an essential spice in the country, constraint faced during production reduces its output. Thus, this study aimed to identify the determinants of ginger production in the case of Yeki woreda. Primary data were collected using a self-administrative questionnaire administered on 110 ginger producers selected using a simple random sampling technique. Furthermore, data analysis methods descriptive statistics and multiple linear regressions were applied. The mean value of ginger yield was 51.74 quintals. The empirical result discovered that fertilizer use ($p<0.001$), bacteria disease ($p<0.0340$), education levels ($p<0.0001$, $<0.0001$, $<0.0009$, $<0.0034$), farm size ($p<0.0025$), farmer experience ($p<0.0003$), and weeds ($p<0.0018$) were significant predictor variables in determining ginger production. Moreover, the result revealed that 85.00% of the discrepancy of ginger production explained by the independent variables included in the multiple linear regression model. Generally, fertilizer use, farm size in a hectare, the experience of farmers, weeds effect, diseases like bacteria wilt, and education level of farmers were the significant factors of ginger output. Therefore, the study recommends the implementation and improvement of ginger production at the producer level by considering the use of fertilizer, farm size, herbicides, education level of farmers, and control bacterial wilt disease. Thus, developmental institutions, agricultural extensions, and governments are advisable to improve the yield of ginger production via controlling the significant determinants.

## Introduction

In developing countries like Ethiopia, the agricultural sector plays a vital role in economic growth and industrial development. The importance of agriculture in the economy of Ethiopia evidenced in percent of GDP shared in 2019 was 33.88%. Moreover, 90% of the poor gain their livelihood from the agriculture sector. However, Ethiopian agriculture is characterized by low productivity due to technical and socio-economic factors. Regularly the farmers with the same resources are producing different per hectare output because of several unknown determinants in developing countries like Ethiopia [1].

The largest ginger producer countries were India, China, Jamaica, Nigeria, Sierra Leone, Thailand, and Australia [2]. Ethiopia is also another moderate producer of ginger since the 13th century [3]. Ethiopia is the major supplier of ginger to India and international trade [4,5]. The major ginger growing areas in Ethiopia were the south nation nationality people's regional state and the Oromia state [6].

According to the Ministry of Agriculture and Rural Development, 99 % of the ginger production of Ethiopia was from the Southern Nations, Nationalities, and Peoples Regional State, while about 1 % was from the Oromia National Regional State [6]. The Southern Nations, Nationalities and Peoples Regional State of Ethiopia, is endowed with verity spices including "*Kororima*" (*Aframomumkororima*), Turmeric (*Curcuma longa*), Cardamom (*Elletariacardamomum*), Black



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pepper (*Piper nigrum*), Cinnamon (*Cinnamomum Verum*), and ginger (*Zingiber Officinale*) more than any other regions of the country [4,7].

Ginger is the most important spice that has a vital role in the agricultural economy of the country. It contributes to raise the socio-economic status of the rural people and to earn foreign exchange currency and environmental protection.

Ginger is an incredibly important crop produced in different countries for both spice and medicine. Mostly ginger plant needs infertile sandy soil and a warmly humid warm climate [8]. The substance analysis of ginger shows that it contains over 400 different compounds that give many functions [9]. Ginger has an indispensable ingredient used for food processing throughout the world because of pleasant aroma biter taste and carminative property. Ginger has been used as species and medicine in countries like India, China, and England since ancient times. Ginger widely hunted for culinary purposes in gingerbread, biscuits, cakes, puddings, soups, and pickles. Also, it has been in the production of ginger oil and some alcoholic drinks like Ginger brandy, Ginger wine, Ginger beer, and Ginger ales. Anti-inflammatory, anti-oxidant, anti-platelet, hypotensive, and hypolipidemic were among animal drugs made from ginger. Traditionally infections like high cholesterol levels, inflammation, asthma, migraine, morning sickness, cancer, and vomiting in humans are treated by ginger ingredients [9-13]. Ginger is the most imperative spice crop in Ethiopia. Pregnant women use herbal remedies like garlic, ginger, and eucalyptus to treat pregnancy-related problems during pregnancy in Ethiopia [10].

Thus, Ethiopian ginger must compete with other countries in terms of quality, quantity, and price.

The farmers of Yeki district produce ginger traditionally did not change their living standards because of earning low yield of ginger due to many factors, of which ginger bacterial wilt disease was reported [6]. Despite this, there are so many factors that influence ginger production. The study from Tanzania that fitted a regression analysis and point out that farmer's education level, the use of fertilizer, land size under ginger production and frequency of contacting extension services had a significant contribution to ginger farming [2]. The study from Nigeria reported that age, income, seed, fertilizer, and agrochemicals were significant variables [14]. Another study from Nigeria indicated that, if all farmers efficiently use the available resources, the resulting increase in ginger output offset, increasing the farmers' income [15]. Thus, this finding has the main objective in identifying factors of ginger production in Yeki woreda by using multiple linear regression method.

## Materials and methods

### Study area

The study takes place on farmers of Yeki Woreda, Sheka zone, SNNPR, southwest of Ethiopia. Based on the 2007 Census conducted by the CSA, this woreda has a total population of 134,519, of whom 68,895 are men and 65,624 women. Based on geographical location, Latitude: 7° 14' 60.00" and Longitude: 35° 24' 59.99" E. It is situated at the altitude of 1200 meters above sea level representing a low land altitude and characterized by hot humid with an average annual rainfall of 1559 mm and a mean maximum and minimum temperature of 30.23 ºC and 16.09 ºC, respectively [15]. The main economic activities of the people in this area are producing crops and fruits such as maize, wheat, coffee, banana, inset, ginger, avocado, mango, papaya, sugarcane, tomatoes, khat, potato, turmeric, and cabbage. From these ginger and coffee are used as a cash crop; wheat, maize, inset, and others used for financials as well as household consumption purposes. The farmers in the woreda produce ginger for financial income. They supplied it to local merchants. The local merchants also buy the total quantity of output from farmers and further send it to those merchants that found in Addis Ababa (Figure 1).

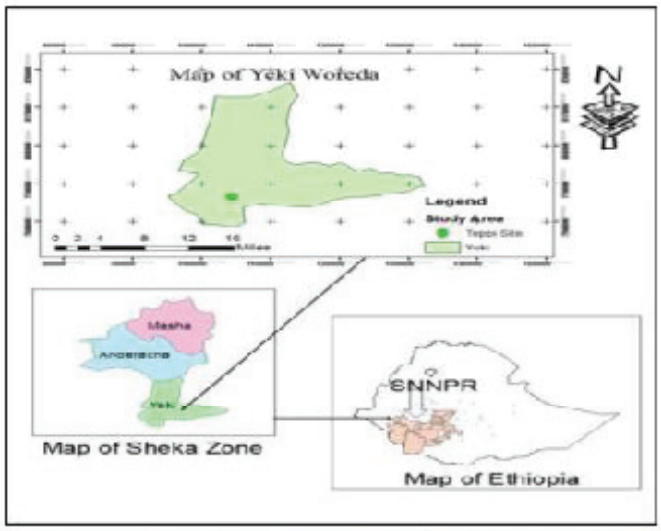


**Figure 1:** Administrative map of the study area (Source: Regional statistics office of SNNPR)

### Study design and study population

A cross-sectional study design applied to ginger producer farmers who found in Yeki woreda. The study populations are all ginger farmers who produce it in 2018.

### Sampling methods

A simple random sampling was in data collection within self-administers questionnaires on selected farmers in Yeki woreda. Accordingly, 110 ginger producer farmers were selected randomly in the district. Additionally, the secondary data on backgrounds gathered from Yeki Woreda agricultural office.

### The study variables

The dependent variable was the amount of ginger produced in the study area before June 2018. The independent variables were: sex, age, number of labor, work time, Family member, price in birr, Fertilizer applied in quintal, Farm size in a hectare, weeds, experience of farmer and diseases like bacteria Table 1.



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Table1: Description and code of independent variables in the ginger data.

| No | Variable | Description | Code |
|---|---|---|---|
| 1 | Sex | Sex family head farmer | 0=female , 1=male |
| 2 | Age | Age of family head farmer | Quantitative (in years) |
| 3 | Labour | Number of labours participated in ginger production | Quantitative(count) |
| 4 | Work time | Working time per day | Quantitative(in hour) |
| 5 | Farm size | Farm area in hectare | Quantitative (in hectare) |
| 6 | Experience | Farmer experience | Quantitative (in year) |
| 7 | Education | Education level of farmers | 0=Illiterate, 1=Primary, 2=High school 3=Preparatory , 4= more than preparatory |
| 8 | Disease | Disease effect on ginger | 0=Yes, 1=No |
| 9 | Weed | Weeds effect on ginger | 0=Yes, 1=No |
| 10 | Fertilizer | Fertilizer used o for ginger | Quantities(Kilogrma) |
| 11 | Family | Family members | Quantitative(count) |
| 12 | Price | Price of ginger | Quantitative(in birr) |

## Multiple linear regression

Linear regression analysis is a statistical method used to estimate the relationship between one or more independent variables and a single dependent variable. A Multiple Linear Regression method was applied to determine significant factors from potential explanatory variables. The general form of a multiple linear regression model is given by:

$$Y = \beta_o + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_k X_k + \varepsilon_i$$

Where Y = Ginger produced in quintal; $\beta_o$ is the intercept and $\beta_1, \beta_{2\ldots}, \beta_k$ are coefficients of the variable $X_1, X_{2,\ldots,} X_k$ are independent variables and $\varepsilon_i$ error term [15].

## Estimation of model parameters

The Maximum Likelihood was to estimate the parameters of the regression model. Analysis of variance used to test the general significance of the model. The model was significant when at least one predictor variable is significant to the dependent variable.

## Model adequacy checking

The model adequacy diagnostics checked via residual analysis or residual plots. These include:

**Linearity:** Linearity indicates that the relationship between the dependent and independent variables should be linear in the parameter.

**Normality:** Normality of random error tested with a plot of residual against the cumulative probability or quantile-quantile plot.

**Homoscedasticity:** Plotting the standardized residuals against time order is to examine the variance of the error term is constant.

**Multi collinearity:** The decision on multicollinearity based on variance inflection factor (VIF). If the value of VIF is less than ten, the collinearity was tolerable, but if it is more than 10, VIF is a risk.

# Results

## Descriptive results

This section represents the results and characteristics of the farmers. Of the total of 110, 75(68.2%) of them were males and 35(31.8%) of the respondents were females. Similarly, percentages 34.0%, 38.2%, 7.8%, 2.7%, and 17.3% were education levels of illiterates, primary, High school, preparatory school, and above the preparatory school. In the case of the use of fertilizer, 66.4% of farmers used fertilizer on ginger, and 36.4% of respondents not used fertilizer on ginger. Also, 75.5 percent of farmers reported that ginger production was affected by the bacterial disease, while 88.2% stated that ginger was affected by a variety of weeds.

From Table 2, the average ginger produced in the area was 14.8 quintal per hectare on average land size cultivated by ginger, 0.28 hectares. In similar way average age, an average number of labors, average birr paid to workers, average work time per day, the average experience of farmers and an average number of family member participated on the production were 51.7 years 1.8, 609.74 birrs, 8.2 hours, 11.46 years, 621.98 kg, and 2.0 respectively.

## Results on regression analysis

The regression analysis result shows that the general regression model was significant to study ginger as indicated by analysis of variance (Table 3) at the significance of F-value ($p < 0.05$). Thus the overall regression model is significant to study ginger. The coefficient of determination)= 0.852, indicated that 85% of the variation in the ginger production explained by the predictor variables included in the regression model such as fertilizer applied in kg, farm size in a hectare, weeds, experience of farmer and diseases.

Table 2: Results of descriptive statistics on ginger production in Yeki woreda, 2018.

| Variable | Mean | Std Dev | Sum | Minimum | Maximum |
|---|---|---|---|---|---|
| Production (quintal ) | 14.81 | 6.43 | 1629 | 4.00 | 38.00 |
| Age(years) | 51.74 | 9.96 | 5691 | 29.00 | 72.00 |
| Labor(count) | 1.82 | 0.903 | 122.00 | 1.00 | 5.00 |
| Labor payment(birr) | 609.74 | 412.34 | 42072 | 0 | 2000 |
| Farm size(hectare) | 0.28 | 0.18 | 31.10 | 0.06 | 1.00 |
| Work time (hr) | 8.15 | 1.86 | 897.00 | 3.00 | 11.00 |
| Experience(yrs) | 11.46 | 5.33 | 1261 | 5.00 | 28.00 |
| Fertilizer used(kg) | 621.99 | 293.53 | 46027 | 200.00 | 2000 |
| Family members | 2.027 | 0.89 | 223.00 | 0 | 6.00 |

Table 3: Results of Analysis of variance on ginger production in Yeki woreda, 2018.

| Source | DF | Sum Squares | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| Regression | 7 | 918.812 | 131.258 | 13.469 | <.0001 |
| Error | 102 | 993.980 | 9.745 | | |
| Total | 109 | 1912.792 | | | |



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The regression analysis on specific predictor variables was given in Table 4 and show that ginger production is influenced by farm size, fertilizer use, farmer experience, education level of the farmer, diseases like bacteria and weeds because each of them has p-value less than 0.05. In the next part the interpretations of each coefficient of the regression model. An intercept =16.35 was the average ginger produced while the model was not considered any variable. Land area is one of the most important and scarce in agricultural production. The farm size has a positive impact on ginger production. Thus, the land area coefficient = 8.78 is the change in the ginger yield in quintal for a one-hectare increase of land size by fixed all other variables constant. It implies that when the farm area increased by one hectare, then the ginger yield is improved by 8.77quital.

The experience of the farmer coefficient = 0.4953 is the change in ginger production when all other factors constant. This indicates that when the experience of a farmer improved by one year, the ginger production is increased by 0.495 quintals.

The education level dummy is significant to ginger production. The educational literature of the farmer is confirmed that important feature that determines the readiness of the producer to accept new ideas and innovations. More educated farmers more expected to adopt new technologies to increase their ginger production. The coefficient of illiterate = 6.539 implies that the ginger production was decreased by 6.539 quintals when the farmer was illiterate than the above preparatory education level. Similarly, the coefficient of primary school = 8.735 indicates that the ginger production was decreased by 8.735 quintals when the farmer education level was primary school than that education level above the preparatory school when every other predictor variables were kept constant. In the same way, the coefficient of high school =6.429 points out that ginger production decreased by 6.429 quintals for a primary school than above preparatory school when all other variables keep constant. The estimator of preparatory school =7.541 indicates that the ginger production decreases by 7.51 quintal for the preparatory school education level than that of above the preparatory school when all other variables kept constant.

The coefficient=-2.879 indicates that the change in ginger production when the farmer report any bacteria disease. This coefficient implies that the ginger yield was averagely decreased by 2.879 quintals when the ginger was influenced by any bacterial and when all other variables kept constant. The estimator =-3.88 indicates that the change in ginger production when the ginger is affected by weed. Also, this means that the average ginger production decreased by 3.88 quintals compared with unaffected with weeds when all other variables kept constant. The coefficient of fertilizer =20.45039 was the change in ginger production when fertilizer used increased by one kg. The ginger production increased by 20.45039 quintals, compared with none fertilizer users, and when all other predictor variables were constant in the regression model. Lastly, all influenced factors are very significant in the production of ginger in the study area.

The fitted regression model is given:

$$\hat{Y}i = 16.3524 + 8.7759X_1 + 0.4953X_2 + 6.5391X_3 + 8.7350X_4 + 6.4299X_5 + 7.5413X_6 - 2.8797X_7 - 3.8808X_8 + 20.45039X_9$$

Where $\hat{Y}$ = the ginger production in quintal, $X_1$ = farm area in hectare, $X_2$ = Farmer experience in year, $X_3$ =education(Illiterate), $X_4$= education(primary) $X_5$= education(secondary), $X_6$ = education level(preparatory), $X_7$= disease(Yes), $X_8$ = weeds(Yes) and $X_9$ = fertilizer(kg).

## Model diagnostics

The Normal Probability plot checks the relationship between ginger production and predictor variables. Figure 2, demonstrates that the p-p plot graph indicates that all observations are lie approach to the straight line fitted and approximately confirm linearity and normality postulate.

**Table 4:** Results on forwarding variable selection and parameter estimation on ginger production data.

| Variable | Parameter | Est.(S .E) | 95% Confidence Limits | | P-value |
|---|---|---|---|---|---|
| Intercept | Intercept | 16.35(4.14) | 8.2391 | 24.657 | 0.0001* |
| Farm size | Land size | 8.77(2.90) | 3.0807 | 14.4711 | 0.0025* |
| Experience | Experience | 0.49(0.13) | 0.2262 | 0.7644 | 0.0003* |
| Education | Illiterate | -6.53(1.60) | -9.6823 | -3.3959 | 0.0001* |
| | Primary | -8.73(1.76) | -12.1985 | -5.2715 | 0.0001* |
| | High school | -6.43(1.945) | -10.2430 | -2.6167 | 0.0009* |
| | Preparatory | -7.54(2.57) | -12.5933 | -2.4893 | 0.0034* |
| | Above prep (Ref.) | | | | . |
| Disease | Disease(Yes) | -2.87(1.36) | -5.5519 | -0.2075 | 0.0347* |
| | No(Ref.) | | | | . |
| Weeds | Weeds | -3.88(1.243) | -6.3170 | -1.4445 | 0.0018* |
| | No(Ref.) | | | | . |
| Fertilizer | Fertilizer(Kg) | 20.45(4.93) | 30.1289 | 10.7718 | 0.0001* |

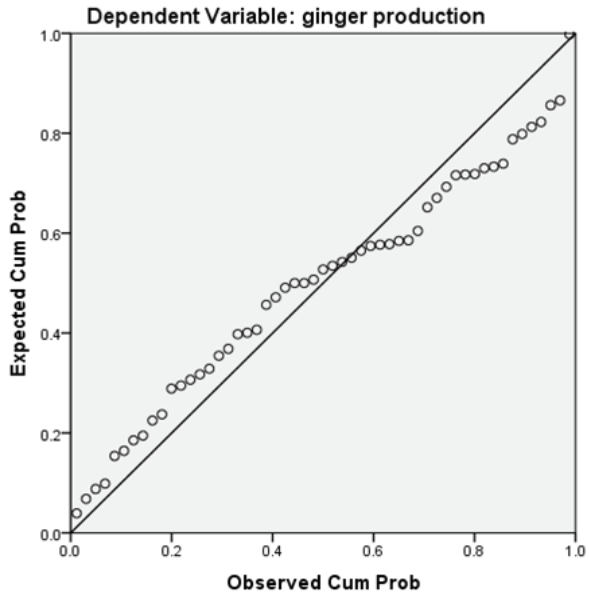


**Figure 2:** Normal Probability plot residuals of ginger data.



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As the rule of thumb, if the VIF of a variable exceeds 10, that variable is said to be highly collinear. The VIF value for age, labor, Land size, work time, experience, Price were; 1.53, 1.66, 1.60, 1.05, 1.15, 1.51, 1.27 respectively and indicates that multicollinearity was not a problem of the model (Table 5).

**Table 5:** Results on Variance Inflation factor of ginger production in Yeki woreda, 2018.

| Variable | Parameter Estimate | Standard Error | t Value | Pr > \|t\| | Variance Inflation |
|---|---|---|---|---|---|
| Age | -0.05278 | 0.07847 | -0.67 | 0.5046 | 1.52789 |
| Labor | 0.65434 | 0.97197 | 0.67 | 0.5043 | 1.65754 |
| Payment | -0.00068133 | 0.00197 | -0.35 | 0.7312 | 1.60079 |
| Land size | 4.82219 | 3.25605 | 1.48 | 0.1456 | 1.05245 |
| Work time | 0.42792 | 0.32538 | 1.32 | 0.1951 | 1.15089 |
| Experience | 0.66333 | 0.14877 | 4.46 | <.0001 | 1.51288 |
| Price | 0.00260 | 0.00229 | 1.13 | 0.2635 | 1.27762 |

## Decision

The main objective of this study is to identify the main factors influencing ginger production in Yeki woreda, Koricha kebele. The multiple linear regression results revealed that fertilizer use, disease status bacteria, education level, farm area in a hectare, farmer experience, and weeds are significant predictor variables of ginger production.

According to [2], the result from regression analysis showed that farmer's education level, the use of fertilizer, land size under ginger production, and frequency of contacting extension services had a significant contribution to ginger farming. In line with this study confirmed the education level of farmers, the use of fertilizer, and farm area of ginger were statistically significant. It revealed that ginger yield no influenced by social-economic factors such as age and sex [2]. However, the experience of farmers on producing ginger, a bacterial disease of ginger, and weeds effect were the additionally identified factors of ginger output under this paper. The study from Tepi agricultural research center reported that bacterial disease wilt was a problem on ginger production in the area [6]. The effect of weed was confirmed offset, decreasing the yield of ginger [18,19]. Another scholar from Nigeria examined the socio-economic factors that affect ginger production (Zingier Officinale) farming technologies using multiple linear regressions point out that educational level and credit capital influenced the ginger production farming innovation [20]. In that finding, education is related to the ability to produce and how to improve the production of ginger [20]. In contrast an education was not factor according to the study from Nepal but it stated as it has positive correlation with production [21]. The study from Nigeria based on the sample size of 100 farmers, by using the stochastic frontier production function showed that fertilizer was a significant determinant of farm output [19]. In the same way fertilizer was significant variable ginger production while labor had no enough evidence to support. Thus, fertilizer was confirmed with others. Also farm size was also a very significant variable in ginger production similar with [21]. This means there was a strong positive relationship between farm size and ginger production. Even though different scholars reported different results for their study, this study identified more variables in ginger production.

## Conclusion

Ginger is an important spice crop which is mainly produced by Ethiopian smallholder farmers for medicinal value, commercial purpose, and flavorings of food items. However, information on production, productivity, and factors of levels of ginger is limited in the country. Therefore the main objective of this study is to identify the influential factors of ginger production. The main factors that influence the ginger production were fertilizer, farm area in a hectare, diseases like bacteria, weed effect, the experience of the farmer, and education level of farmers. Thus, the improvement of ginger production is strongly influenced by all these factors in the production stage. Extension workers and other development practitioners have joined hands with the farmers in addressing helping factors by providing inputs such as fertilizer, herbicides, and training farmers on ginger farming methods. The farmers also suggested farming all available farmland and sharing their experience on ginger farming.

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