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Research Article

Contributing factors of maize production using multiple linear regressions in mizan-aman district, bench-shako zone, Southwest of Ethiopia

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Abstract

Agriculture is the backbone of the Ethiopian economy. Maize is one of the plants which mostly used for indigenous food like bread, injera, qolo, nifiro and soup in Ethiopia. Despite farmers of Mizan-Aman produce maize, they challenged in a low amount of the production that comes from unknown causes. Therefore, this study was conducted to access the production of smallholder farmers and to identify factors that influence production of maize. The study based on the information which collected from 105 randomly selected farmers, using self-administrative questionnaire. The multiple linear regressions were used and identified factors of maize production. In addition, data diagnostics analysis was used to determine the goodness of the regression model on the maize yield. According to the result, the mean production of maize in study was 33.72 quintal per hectare. Additionally, the regression result revealed that productions of maize were significantly influenced by the education level of producers, fertilizer use, and variety maize seeds that used since each of them have p-value 0.04, 0.000 and 0.042 respectively. Thus, the study suggested, Mizan-Aman developmental agricultural workers must help the maize producer farmers on education level, fertilizer use and seed of maize to improve their production. Furthermore, education level of the farmers will be improved by give training on farming and farming related technologies.

Introduction

The agriculture sector plays an important role in economic growth of developing countries. Agriculture is considered as a backbone of the Ethiopian economy. Agriculture contributes about 34 percent of the GDP in 2019 and 90 percent of the population is dependent directly or indirectly on agriculture in Ethiopia [1]. The crop maize (*Zea mays*) originated in Mexico, 7000 years ago from a wild grass, and Native Americans transformed maize into a better source of food [2]. Recently, maize is grown throughout the world, United States, China, and Brazil being the top three maize-producing countries in the world [2]. In addition, maize is the major common diet over 85 percent of the population in Kenya [3]. It is believed that the maize was comes from Kenya to Ethiopia. In the recent history, maize has emerged as a leading cereal crop in Ethiopia [4]. Ethiopia is the second highest maize producer in Sub-Saharan Africa next to Nigeria [5,6] Maize production of Ethiopia increased from 939 thousand tonnes in 1970 to 8500 thousand tonnes in 2019, growing at annual rate 7.64% [7]. Similarly, the Maize production increased from 8350 thousand tonnes in 2018 to 8500 thousand tonnes in 2019 with growing annul rate 1.8% [7]. It has been reported that a lot of households now grow maize than any other cereal in Ethiopia [8]. Maize is an agricultural product in most of the Ethiopia regions like the Amhara, the Oromia and the south nation and nation and national states.

The main food crop in Mizan-Aman district, Bench-Sheko zone was maize, whereas the main cash crop in the zone was coffee [9]. Therefore the maize consumed as roast, 'injera', 'nifiro' and soup in Mizan-Aman district. According to scholars, the maize contains approximately 72% starch, 10% protein, and 4% fat, supplying an energy density of 365 kilocal/100g [10,11]. Maize can be processed into a variety of food and industrial products, including starch, sweeteners, oil, beverages, glue,

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industrial alcohol, and fuel ethanol. Approximately 40% of the maize production in the United States is used for fuel ethanol [12]. As the ethanol industry absorbs a larger share of the maize crop, higher prices for maize will intensify demand competition and could affect maize prices for animal and human consumption. Low production costs, along with the high consumption of maize and micronutrient deficiencies are common public health problems, make this staple food an ideal food vehicle for reinforcement [2,13].

Different studies clear out that variety of seeds and resource management practices to achieve higher yield, income and minimize risks [8]. The identified factors that affect maize production were education of farmer [14], fertilizer use [4], land-labor ratio, use of fertilizer, use of pesticide, manure and household size [15], age of farmer [16] and farm size [17]. However in this study aimed to identify more maize production determinants. Provision of agricultural technology might not assure its success in reducing the maize yield gap unless successfully used by maize growers [5].

It is known that Ethiopia has sufficient input resources of agriculture but the majority of the populations are still under severe risk of poverty. Thus the country still imports different cereal crops for food purpose. Then the best optimal solution for the country may be to identify determinants of the production and productivity in the country. The cropping system in former Bench-Maji and Bench-Shako zone is predominantly undertaken by the use of traditional farming system. The farmers believed that large quantity of yield is obtained expanding land seize and the farming is characterized by the low production per hector [14,16]. Consequently, the annual income from farming, especially maize is too low which is not sufficient for households to change their live standard. The study in Mizan-Aman only identified a single significant factor education level of the farmers while education is multilateral [14]. However, this study aimed to identify more factors that influence maize yield in Mizan-Aman. Accordingly, variety of seed was added to the predetermine variables in this study. The multiple linear regressions method applied to identify several independent variables these depend on maize production, since multiple linear regressions were used to identify more independent variables [17,18].

Methods

Study area

This study conducted in Mizan-Aman district farmers which are found in Bench-Shako zone, south nation and national people's regional state, south west Ethiopia. It is located 562 km away from Addis Ababa. The major economic activities of the people in this area are producing crops such as maize *(Zea Mays)*, wheat, coffee, banana, Enset /false banana (*Ensete ventricosum*) and ginger *(Zingiber officinale)*. From these wheat and maize are mostly used for food consumption, while coffee and ginger are for cash. Mizan-Aman district has well suitable climate and rich in natural resources [14]. The maize produced in the area used for food consumption and supplied to local merchants.

Data collection

The primary data was directly collected from randomly selected farmers by administrative questionnaire. In general, out of total 589 farmers, 105 sample farmers were selected in the study area. The sample selected by simple random technique because it is simple and honest method.

Study variable

The interest variable of the finding was yield of maize production in quintal per hectar in Mizan-Aman district. The predictor variables were: education status of farmer, age of farmer, working hours per day, fertilizer use, farm size (in hectare), seed type, soil fertility, weeding effect, and use of irrigation.

Multiple linear regressions

Multiple linear regression model (MLRM) is a statistical techniques used to identify the linear relationship of dependent and independent variable [18]. The general linear model for MLRM in which response is related to a set of independent variable (Xi) is given:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + + \beta_k X_k + \varepsilon_i$$

Where Y = Maize produced in quintal; β_0 is the intercept and $\beta_1, \beta_2, ..., \beta_k$ are coefficients of the variable $X_1, X_2, ..., X_k$ are k^th^ independent variables and ε_i error term. The Maximum Likelihood is used to estimate parameters of regression model and a general linear regressions model is tested by analysis of Variance (ANOVA).

Model adequacy checking

The model checked whether the typical assumptions of multiple linear regression method are fulfilled. Analysis of residual is an effective way to discover several type of model adequacy. Also, normal probability plot is used to test linearity and normality assumptions. Thus, multicollinearity, linearity, normality and others are tested in the study. Test of presence of multicollinarity refers to the existence of high (perfect) linear relationship among regressors. Therefore the variance inflation factor (VIF) was applied in this study. The general rule of thumb indicates multicollinarity problem for corresponding variable if the value of VIF greater than 10.

Results

Descriptive of socio-demographic

The descriptive statistics of socio-demographic factors displayed in Table 1. Out of the total 105 farmers, 70 (66.7%) used fertilizer and 35 (33.3%) not used fertilizer on maize growing. Similarly, 59 (56.2%) of farmers used modified seeds and 46 (43.8%) do used modified seeds on corn farm. None users of modified seed were used local seeds of maize. Also, 29 (27.6%), 72 (68.6%), and 4 (3.8%) are illiterates, primary, secondary and above education levels of farmers respectively. In the same way, 75 (71.4%) of farmers have naturally fertile soil and 30 (28.6%) of farmers have infertile soil type. In case

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of farming practice, 66 (62.9%) used traditional farming mechanism and 39 (37.1%) are used extension farming system. Lastly, 70 (66.5%) of farmers produced maize in irrigation, and 35 (33.3%) do not used irrigation farm.

The descriptive statistics of qualitative variables including mean, standard deviation, minimum and maximum values of the continuous variable displayed in Table 2. The age of maize producer farmer was estimated at an average of 42 years and 8 months. The highest age of the maize producer is 65 years, while the minimum age is 26 years. The average number of weeding of maize was estimated on average 1.59. The highest number of weeding of maize is 3, while the minimum number of weeding is 1. The amount of maize production was estimated an average of 33.72 quintal per hectare. The highest amount of maize production per year is 67 quintal per hectare and the minimum amount of maize production per year is 8 quintal per hectare. The land size covered in hectare was estimated at an average 6.8476 hectare per household. The highest land size is 8 hectare and the minimum land size is 3 hectare was used for maize production.

Multiple linear regression analysis

Overall regression model analysis: The analysis of variance result displayed on Table 3 revealed that the overall regression model is significant since p-value of regression model is 0.000 which is less than significance value α value =0.05. Therefore, at least one of the independent variable has a significant impact on the linear regression of maize production. Thus, the general multiple linear regression models are statistically significant for the maize production data since it has p-value=0.000.

Individual regressors coefficient estimation: From Table 4, the estimated parameters for multiple linear regression models were displayed. It can be observed that education level was statistically significant effect on the production of maize (p-value=0.048) at 95% confidence interval. In addition modified seeds use was statistically significant effect to the production of maize (p-value=0.00) and fertilizer use on maize production was statistically significant to production of maize (p-value=0.042).

Table 1: Frequency and percentages of categorical variables in Maze production in Mizan-Aman, Bench-Sheko zone, SNNPR region, Ethiopia.

Name of Variables	Category of the variables	Frequency of category (Count)	Percentage of category (%)
Education level	Illiterate	29	27.6
	Primary school	72	68.6
	Secondary school and above	4	3.8
Fertilizer use	Used	70	66.7
	Not Used	35	33.3
Modified seed use	Used	59	56.2
	Not Used	46	43.8
Soil fertility	Fertile	75	71.4
	Infertile	30	28.6
Farming system	Modern	39	37.1
	Traditional	66	62.9
Irrigation	Used	70	66.7
	Not Used	35	33.3

Table 2: The descriptive of continuous variable in maize production in Mizan-Aman, Bench-Sheko zone, SNNPR region, Ethiopia

Quantitative Variables	Minimum	Maximum	Mean	Std. Deviation
Maize yield quintal/hectare	8	67	33.72	13.97
Age in years	26	65	42.83	8.84
Working time/day(in hour)	4.00	9.00	6.85	1.37
Land size in hectare/ household	3	8	5.06	1.108
Weeding time (count)	1	3	1.59	0.549

Table 3: Analysis of Variance table of multiple linear regressions of maize production data.

Source	Sum of Squares	df	Mean Square	F	Sig.
Regression	8279.535	11	752.685	5.830	.000
Residual	12007.456	93	129.112		
Total	20286.990	104			

Table 4: Multiple linear regression analysis and parameter estimation of maize production data in Mizan-Aman, Bench-Sheko zone, SNNPR region, Ethiopia.

Parameters	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	28.324	12.018		2.357	.021
Education level	.271	.135	.172	2.003	.048
Age	4.278	2.292	.156	1.867	.065
Working time	-.504	.848	-.050	-.595	.553
Land size	.525	1.093	.042	.480	.632
Farming type	-.539	2.719	-.019	-.198	.843
Type of soil	-.148	2.808	-.005	-.053	.958
Weeding times	2.585	2.204	.102	1.173	.244
Seeds	14.967	2.496	.534	5.997	.000
Price	1.182	2.427	.040	.487	.627
Fertilizer use	5.695	2.759	.197	2.064	.042
Irrigation use	4.517	2.561	.153	1.764	.081

Furthermore, intercept (β_0) = 28.324 is the estimated average maize produced per hectare when any independent variable is not considered in the model. In case of education level coefficient β_1 = 0.271, implies that when education level of farmer is increased by one step, then maize production is increased by 0.271 quintal per hectare when all other predictors kept constant. The slope of fertilizer use is $\beta 2$ =5.69, indicates that when the fertilizer is used, then the maize yield is increased by 5.69 quintal per hectare, with fix of all other variables in the model. Lastly, seeds are strongly associated with maize production. The coefficient of seeds $\beta 2$ =14.967, point out that if improved seeds used on maize farm the production of maize increased 14.967 quintal per hectare.

Model adequacy diagnostics

The model goodness of test is proved with R square. Hence, the value of R^2 = 0.6895 shows that 68.95% of the variability of the maize yield is explained by regressors included in the model.

Mullticolinearity: If VIF statistic greater than 10 it is severe to muticollinerity. Accordingly, each of the independent variable has variance inflation factor (VIF) value less than 10, which indicates that there is no co-linearity severe multicollinearity (see Table 5).

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Normality: The normality assumption of multiple linear regressions was checked using probability plot or histogram of residuals. The results of Figures 1,2 showed that approximately the assumption of normality of the interest variable is sufficient since the residual plot is normal.

Linearity: The linearity assumptions are checked by p-p plot of standardized residual. Thus, normal P-P plot of regression standardized residual show that normal probability plot for the residual is appropriately straight line. The Figure 2 indicated that the regression model is approximately linear since almost all points of residual are approximately on the straight line and it indicates the dependent variables (yield of maize) and independents variables are linear relationship.

Homoscedasticity: Homoscedasticity checked using plot between the standard predictor values and standard residuals. As displayed using Figure 3, the scatter plot of standardized predicted residual versus the response variable we can see that the residual shows there is no systematic random pattern. It indicates that the error term has constant variance. Therefore, it satisfies constant variance assumption approximately.

Table 5: Variance inflation factor results of each independent variable of maize yield data.

Variables	Colinearity Statistics	
	Tolerance	VIF
Educational level	.867	1.154
Age	.909	1.101
Working time	.919	1.088
Land size	.847	1.181
Farming type	.713	1.403
Type of soil	.764	1.309
Weeding times	.847	1.181
Seeds use	.802	1.247
Price of maize	.940	1.064
Fertilizer use	.699	1.430
Irrigation	.844	1.185

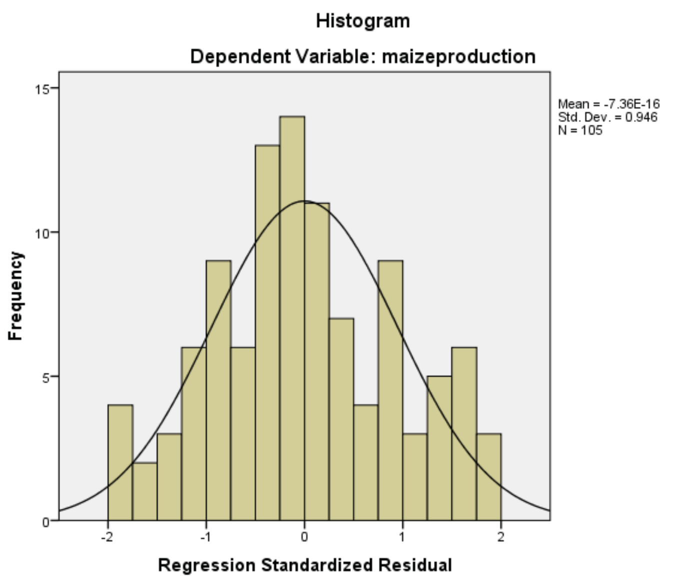

Figure 1: Histogram of standardized residual of regression model of maize production in Mizan- Aman, Ethiopia

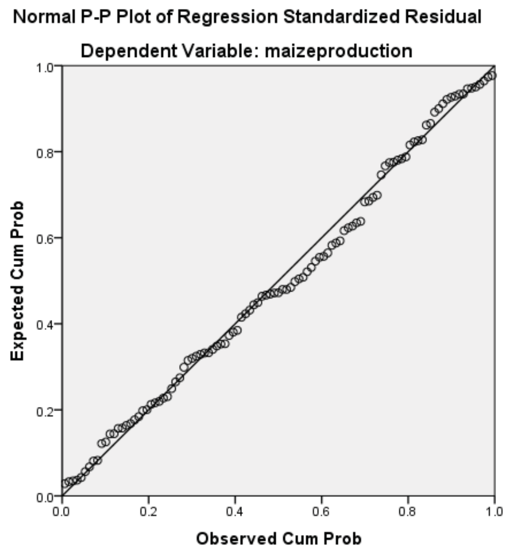

Figure 2: Probability plot of regression model of maize production in Mizan-Aman, Ethiopia.

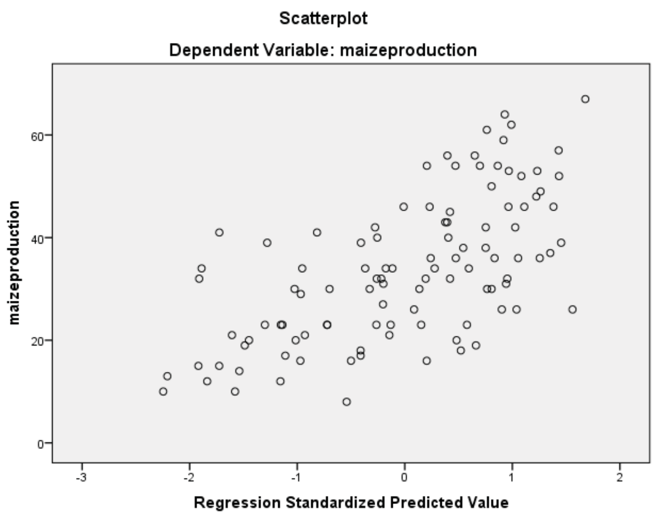

Figure 3: Scatter plot of regression standardized residual value maize production in Mizan-Aman.

Discussion

The main objective of this study is to identify the influential factors of maize production in Mizan-Aman district, Southwest Ethiopia, since the improvement of maize production must start at the farmer level. A Multiple Linear Regression is used to analysis the maize data because the maize yield per hectare is quantitative variable and there are several independent variables. Moreover, the assumption in multiple linear regressions was satisfied with the data [17]. The simple linear regression method is applied on maize production in Bench-Maji zone [14].

The multiple linear regression identified factors of maize production in Sheka zone. The results of that study revealed that fertilizer, farm size and labor were significant variables [17]. Similarly, in this study fertilizer and education level were major determinants of maize production in Mizan-

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Aman district, southwest Ethiopia. However, seed effect was identified in this study only.

The fertilizer had a significant effect on maize plant height, lodging percentage and grain yield [19]. Similarly, several scholars suggested that fertilizer has vital role in corn production [4,15,17]. In line with other scholars this paper confirmed the importance of fertilizer on maize production in Mizan-Aman district. The yield of maize and fertilizer has strong positive association since it increases the fertility of the soil. According to CSA report, about 23% of fertilizer used for maize production. Infrastructures such as transportation like road and financial constraints were reported related to commercial fertilizer use problem on maize farm [4]. Traditionally, Ethiopian farmers have used organic fertilizers for agricultural production [8].

Additionally, the education level of the farmers is another important factor of maize production. In line, the education issue was reported by several scholars [14,20]. The education level was also reported in coffee production factor in Mizan-Aman district [9]. It is suggested that education is used to selected adopted technologies [20,21].

Lastly, seeds are another factor of maize production which identified in this study result. The improved seeds used for maize production significantly increased. Similar to this result, it suggested that many farm households are aware of the complementary nature of improved maize seed and chemical [21]. The common varieties of seed are local seed and hybrid seed. Lastly, if the farmers used modified seed, improved their knowledge on farming and apply either biological or chemical fertilizer, they improve their crop production including maize.

Conclusions

This study revealed that, education level, fertilizers and seeds are factors that influence the grain yield of maize. At the producer level, the important determinants which can improve maize production are use of modified maize seed, use of fertilizer, and education level of farmers. It is usual that, identification of the important determinants of maize may not improve the maize production unless the producers incorporate it in their productivity. Thus the agricultural sectors in Mizan-Aman, and developmental agricultural workers in each district should help the farmers regarding identified factors. Additionally, the farmers have to incorporate all identified factors to improve the maize production.

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