Vol. 18(5), pp. 295-307 May, 2022
DOI: 10.5897/AJAR2022.15933
Article Number: B9692A069123
ISSN: 1991-637X

http://www.academicjournals.org/AJAR

African Journal of Agricultural Research

Full Length Research Paper

Maize production constraints at household levels: The case of Hawassa Zuria district in Sidama Region, Ethiopia

Solomon Yokamo[1,2*], Xiaoqiang Jiao[1], Fekadu Gurmu[3], Aklilu Atinafu[2], Tsadiku Alemu[2] and Rongfeng Jiang[1]

[1]College of Resources and Environmental Sciences, Key Laboratory of Plant-Soil Interactions, Ministry of Education; National Observation and Research Station of Agriculture Green Development (Quzhou, Hebei), China Agricultural University, Beijing 100193, China.
[2]Southern Agricultural Research Institute (SARI), Hawassa 06, Ethiopia.
[3]Ethiopian Agricultural Research Council Secretariat (EARCS), Addis Ababa, Ethiopia.

Received 11 January, 2022; Accepted 7 April, 2022

Maize is the most important cereal crop in Ethiopia in terms of plantation area, production volume, and economic importance for food security. Despite the relative yield increment at the national level, maize production in the study area has been hindered by a couple of factors. This study was conducted to assess and evaluate maize production constraints in the Hawassa Zuria district. Primary data was collected from 60 randomly selected maize producers. Accordingly, socioeconomic factors such as sex (β = -2.02), educational level (β = 0.18), total livestock unit (TLU) (β = 0.27), and major income source (β for agriculture = 2.75 and β for private works = 3.05) could significantly influence maize production and productivity at 1% probability level. The institutional factors such as access to agricultural inputs, extension services, credit, irrigation, and membership in rural cooperatives; and agronomic factors such as fertilizer use, planting density, weeding frequency, tillage mechanisms, and pest and disease infestation were identified as the major challenges likely influencing maize production in the study area. Based on the study outcomes, policy recommendation is made such as improving the educational level, enhancing input access and empowering farmers to adopt and apply a full package of agronomic practices that help to improve soil fertility and thus crop productivity. As a result, addressing these constraints would be critical to improving food production.

Key words: Agronomic factors, determinants, maize, multiple linear regression, production and productivity, policy recommendation.

INTRODUCTION

Global food demand is expected to rise sharply due to rising population growth, shifting dietary preferences,

*Corresponding author. E-mail: solomonyokamon@gmail.com, rfjiang@cau.edu.cn.

and increased demand for renewable energy (Yengoh, 2012). The most important policy goal is to ensure food security by producing enough high-quality food and making it accessible and affordable to consumers all over the world (Saghir and Hoogeveen, 2016). According to recent estimates, global food demand will rise by 100% to 110% between 2005 and 2050 (Tilman et al., 2011). The green revolution that transformed Asian agriculture had little impact in Africa, and food scarcity and poverty remain major issues. Ethiopia is Africa's second-most populous country, with a population of more than 110 million people. Because of the country's wide range of altitudes, the climate varies significantly. Food insecurity is a hot policy issue in Ethiopia, as it is in other SSA countries. Agriculture is the dominant sector, accounting for approximately 46.3% of total GDP and 80% of employment (Solomon, 2020). Smallholders dominate the crop production system, cultivating approximately 90% of cropland and producing more than 90% of agricultural output (Urgessa, 2014).

Cereal crops are in high demand as food crops, with maize accounting for the majority in terms of cultivation and use as food, animal feed, and a source of energy (bio-fuel) (Fan et al., 2020; Shiferaw et al., 2011). In terms of area coverage, production volume, and economic importance in Ethiopia, it is a major strategic crop (CSA, 2019; Abate et al., 2015). Although the Ethiopian government allocates about 10% of its total expenditure to the agricultural sector (which is the benchmark of a *New Partnership for Africa's Development (NEPAD)* for sub-Saharan Africa) (Abrha, 2015), the productivity of cereal crops is below the global average due to a multitude of biotic and abiotic factors (Dessie, 2018). For example, the national average cereal yield is low (about 2.45 t ha^{-1}) (Dessie, 2018) compared to the global average yield of 3.9 t ha^{-1} (Tadele, 2017). Furthermore, there was a significant difference between actual and potential maize yield (Liben et al., 2020), and the water-limited yield potential is approximately 13.9 t ha^{-1} (GYGA, 2020).

Maize productivity in farmers' fields is primarily due to soil fertility depletion. Subsistence-oriented production systems, institutional weakness, and soil fertility deterioration due to insufficient use of external inputs are among the factors mentioned as potentially influencing crop production and productivity (Urgessa, 2014). The study conducted in South Ethiopia revealed that inherent soil fertility, limited access to improved seeds, pests and diseases, erratic rainfall, soil erosion, deforestation, limited access to credit services, weak market linkages, and poor field management practices are among the major factors affecting crop production (Yokamo et al., 2018).

The fertilizer use in the country is inadequate to sustain crop production. For example, the N and P consumption in maize production increased from 16 kg ha-1 in 2004 to about 34 kg ha-1 by 2013 (Abate et al., 2015). This amount is below the *"Abuja's Declaration on Fertilizer use for the African Green Revolution"* of 2006 in which member states of the African Union adopt to increase fertilizer use to 50 kg ha^{-1} by 2015. Moreover, nutrient mining due to inadequate external input supply and straw removal, monocropping, bio-physical and institutional factors, such as limited access to relevant production inputs, infrastructural underdevelopment, and poor farm mechanization, are also mentioned for their significant contribution to low crop productivity (Anteneh and Asrat, 2020; Tamene et al., 2015). Organic fertilizer has recently received a lot of attention due to its ability to improve soil quality and thus crop productivity. Despite its significance, it is not widely adopted and promoted in the country because households use it for competing needs (Abera, 2017).

Planting density is among the most important yield determining factor. Agronomic panel survey (APS), which is conducted in the Oromia and Amhara regions, revealed that about 87.5% of farmers maintained their maize planting density below the national recommendation rate (which is 44,444-53,333 plants/ha depending on the variety) at harvest, and this contributed to lower grain production (Tesfaye et al., 2019). This is supported by the discovered positive relationship between plant density and grain yield and number of harvested cobs.

Several studies that have been conducted in Ethiopia focused on the adoption of agricultural technology, value chain analysis, and highlighted some determinant factors affecting crop production, and marketing (Abebe and Halala, 2020; Degefu et al., 2017; Mazengia, 2016; Chilot and Dawit, 2016). However, only limited information is available in this region, particularly in the study area regarding the maize production trends at household levels, and this study was conducted to assess and evaluate the major bottlenecks affecting maize production and productivity in the wider scope. Therefore, this study was conducted with the objectives of evaluating the major factors affecting maize production (socio-economic, institutional, and agronomic factors) at the smallholder farmer's level and reviewing policy implications.

METHODOLOGY

Description of the study area

The study was conducted in the Hawassa Zuria district of Sidama region, Ethiopia (Figure 1). Hawassa Zuria district borders Lake Hawassa in the north, Oromia region in the west, Boricha district in the south, and Tula town in the east. It is located at latitude and longitude 07° 01′ 54″ N and 38° 15′ 39″ E, respectively, and an altitude of 1700-1850 m.a.s.l. The agro-climatic condition of the district is warm sub-humid lowlands (85%) and sub-humid (15%), with mean annual rainfall and temperature of 1015 mm and 23.6°C, respectively. The livelihood of the people is mainly based on mixed subsistence farming and crop production involved in the intensively managed small farms. Enset (*Ensete ventricosum*),

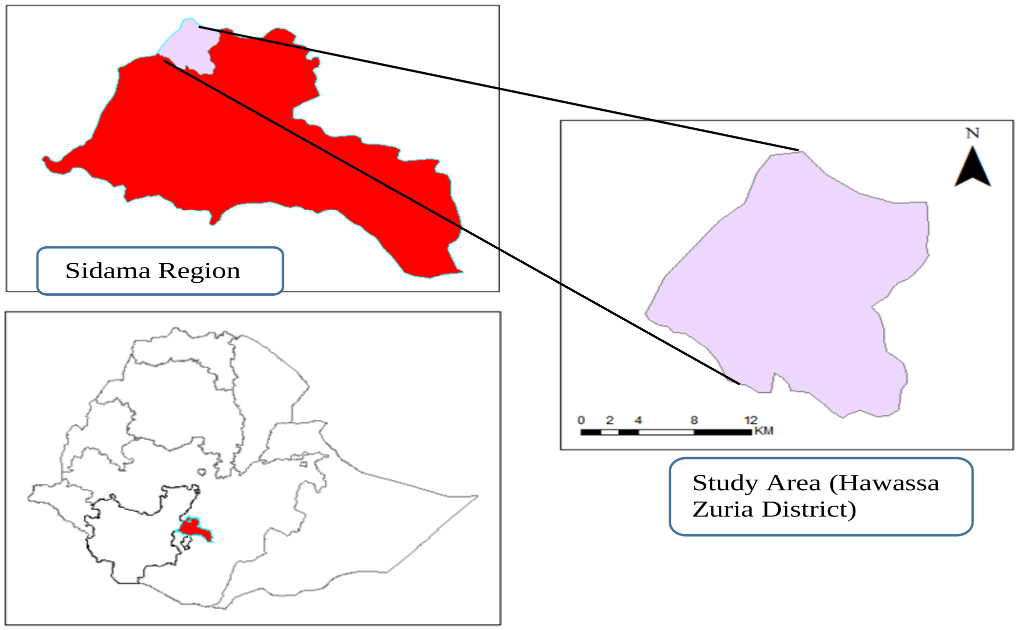

Figure 1. Map of the study area.

maize, teff, haricot bean, sweet potato, and sugarcane are among the dominant crops grown in the study area.

Sampling procedure and sample size

A two-stage sampling technique was employed in the present study. The study district (Hawassa Zuria district) and two villages (Guye Bole and Amol Faja) were selected using the purposive sampling technique based primarily on their maize production potential. A total of 60 household heads involved in maize production were randomly selected from the two villages.

Data source and collection methods

The current study used both primary and secondary data. Primary data was collected through pre-tested and semi-structured questionnaires that comprise information related to socio-economic characteristics, institutional, and agronomic variables. The questionnaires were designed in a way that enables the collection of relevant information capable of answering the research objectives. The primary data was gathered in July 2021 by experienced enumerators who are fluent in the local language and culture. The secondary data were collected from different published sources and reports. Several articles were reviewed and relevant information was extracted. Data from the Central Statistical Agency of Ethiopia (CSA), as well as FAOSTAT database were used in the present study.

Statistical analysis

Descriptive statistics such as mean, percentage, frequency, minimum, and maximum were used to analyze the household-level characteristics and other relevant institutional and agronomic factors. Different data analysis tools such as Microsoft Excel, SPSS V.22, and STATA V.12 were used for statistical analysis; while Sigma Plot V. 12.5 was used to draw figures.

Model specification

Multiple linear regression (MLR) model was employed to identify the linear relationship between independent and dependent variables for socio-economic factors affecting maize production. This model was selected because all the sampled respondents are maize producers and also due to its simplicity and practical applicability (Wondim et al., 2020). The general form of a multiple linear regression model is given under Equation 1:

$$Y = \beta_o + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_k X_k + \varepsilon_i \quad (1)$$

where Y= maize production (t ha^{-1}), β_o is the intercept, $\beta_1, \beta_2, \ldots, \beta_k$ are a vector of parameters to be estimated, $X_1, X_2 \ldots, X_k$ are a vector of explanatory variables and ε_i is a disturbance term.

The post estimation diagnostic tests (linearity, normality, and multicollinearity) were conducted to check the validity and robustness of the estimated model.

Linearity: The normal probability plot (*p-p* plot) was drawn to check the relationship between maize production and the independent (socio-economic) variables. Figure 2 (left) shows that all the observations are laid near the fitted straight line, implying a nearly linear relationship between maize crop production and independent variables.

Normality: It was checked through a graphical method using a histogram of residual. Figure 2 (right) reveals that the normality assumption is approximately fitted because the histogram of the residuals of the maize production has a bell shape and is unimodal.

Multicollinearity: It was detected by a Variance Inflation Factor (VIF) approach. A VIF having a value less than 10 is usually considered as no multicollinearity, while a VIF having a value more than 10 is considered as highly collinear. Table 1 shows that the

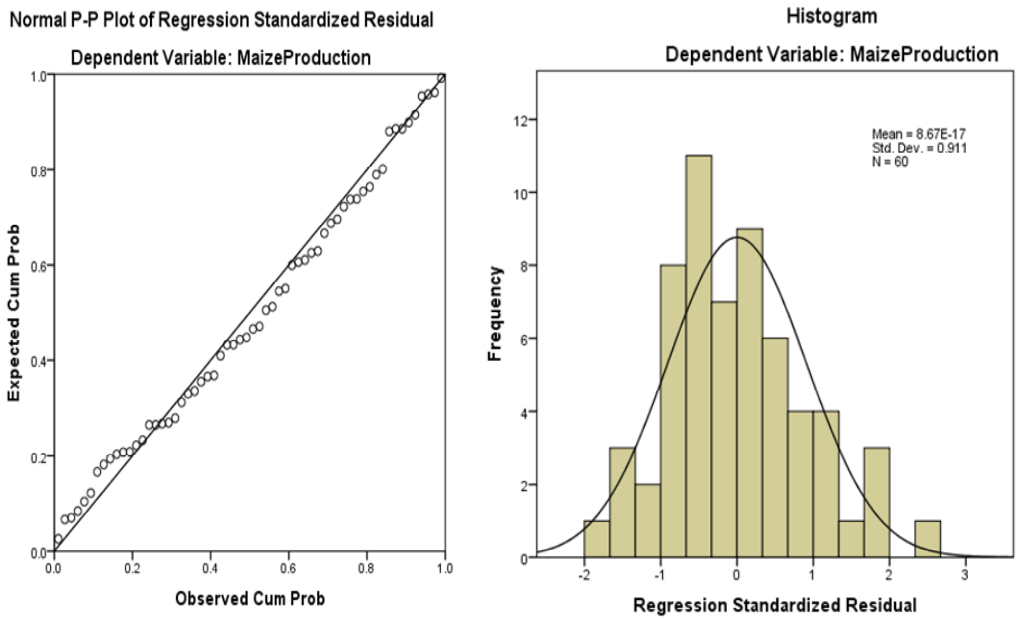

Figure 2. Probability plot of the regression model (left) and histogram of the standardized residual of the regression model of maize production (right) in the study area.

Table 1. Results obtained from variance inflation factor (VIF) using variables influencing maize production data in the study area.

Variable	VIF	Tolerance (1/VIF)
Sex	1.53	0.655
Age	6.715	0.149
Education	2.575	0.388
Family size	1.95	0.515
Dependency ratio	1.07	0.935
Total farm size	5.63	0.178
Farm size allocated for maize	4.5	0.223
Farming experience	8.01	0.164
Major income sources	1.097	0.912
TLU	1.664	0.601
Mean	3.47	0.472

variables used for identifying socio-economic factors affecting maize production in the study area have a VIF value of less than 10. The mean VIF value is 3.47 and while the mean tolerance value calculated was 0.472, which means that there is no evidence of multicollinearity in the variables of the estimated model.

RESULTS AND DISCUSSION

Household characteristics of the respondents

The household characteristics of the continuous and categorical variables are presented in Tables 2 and 3. The average age of the sample households is 41.65 ± 15.32 years (ranging from 25 to 88 years). The average educational level of the sample respondents is 5.86 years. The average family size is 5.58 ± 1.9 members; whereas the dependency ratio ranges from 0 to 5, with an average of 1.05 ± 1.01. The average farm size, farm size allocated for maize, and farming experiences in the study area were 0.77 ± 0.55 ha, 0.68 ± 0.72 ha, and 25.4 ± 13.84 years, respectively (Table 2). The descriptive result on categorical variables revealed that 88.3% of the total sample respondents are male-headed households, while 11.7% are women-headed households. On average, about 91.7% of the sample respondents depend on agriculture. Among the total sample respondents, 96.7%

Table 2. Results obtained from descriptive statistics on continuous/quantitative variables.

Variable	Observation	Min	Max	Mean	St dev.
Age	60	25	88	41.65	15.32
Education level (in years)	60	0	15	5.86	4.57
Family size	60	2	10	5.58	1.9
Dependency ratio	60	0	5	1.05	1.01
Total farm size (Ha)	60	0.15	2.5	0.77	0.55
Farm size allocated for maize (Ha)	60	0.11	5	0.68	0.72
Farming experience (years)	60	2	65	25.4	13.84

Source: Survey Result (2021).

Table 3. Results obtained from descriptive statistics on categorical variables.

Variable	Category	Observation	%
Sex	Male	53	88.3
	Female	7	11.7
Income sources	Agriculture	55	91.7
	Salary	2	3.3
	Private works	3	5
Pieces of cultivated land	1	38	63.3
	2	20	33.3
	3	2	3.3
Hired labor	Yes	28	46.7
	No	32	53.3
Livestock ownership	Yes	58	96.7
	No	2	3.3
Oxen ownership	Yes	32	53.3
	No	28	46.7

Source: Survey Result (2021).

are livestock owners, whereas 53.3% of the respondents have an ox that is used for land preparation (Table 3).

Status of maize production

Maize is the most important strategic crop in the food security of Ethiopia. It accounts first in total production and productivity and second to teff (*Eragrostis tef)* in area coverage. The data showed that the area coverage and total production of maize exceeded 2.2 million hectares and 9.6 million tons, respectively, while the productivity is about 4.2 t ha^{-1} by 2019 (Figure 3) (FAOSTAT, 2020). Also, the reported regional (Sidama region) maize productivity is about 4.38 t ha^{-1} (CSA, 2020). The increase of maize productivity from the 1990s is due to the wide adoption of improved seeds, increased investment in extension systems and seeds, and improved access to markets, to mention a few (Abate et al., 2015). Despite such a yield increase, there was a huge yield gap between actual and potential yields.

The result of the current study showed that the yield of maize during the 2019/2020 growing season ranged from 0.5 to 6.5 t ha^{-1} among the sample respondents, and the average yield was 2.05 t ha^{-1}, which is about 104.8 and 113.6% lower than the national and regional average yields, respectively (Figure 4). Moreover, only 8.3% of sample respondents achieved a higher grain yield above the national average. This result revealed the lower yield performance in the study area and thus alarming for

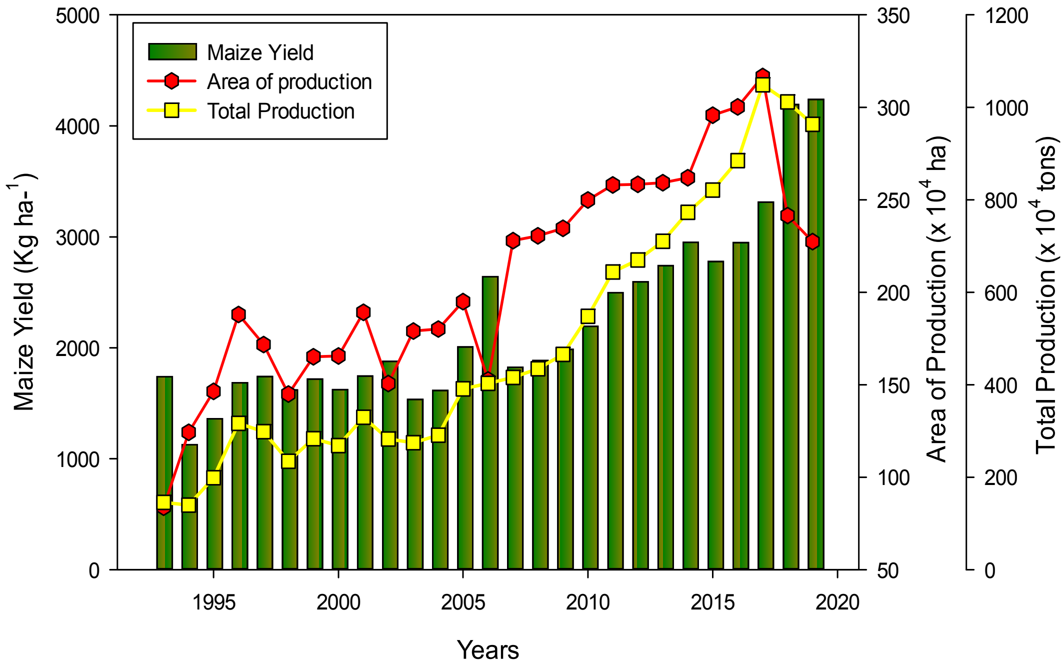

Figure 3. Maize yield (kg ha^{-1}), total production (×10^4 tons), and area coverage (×10^4 ha) in Ethiopia from 1993-2019.
Source: FAOSTAT database.

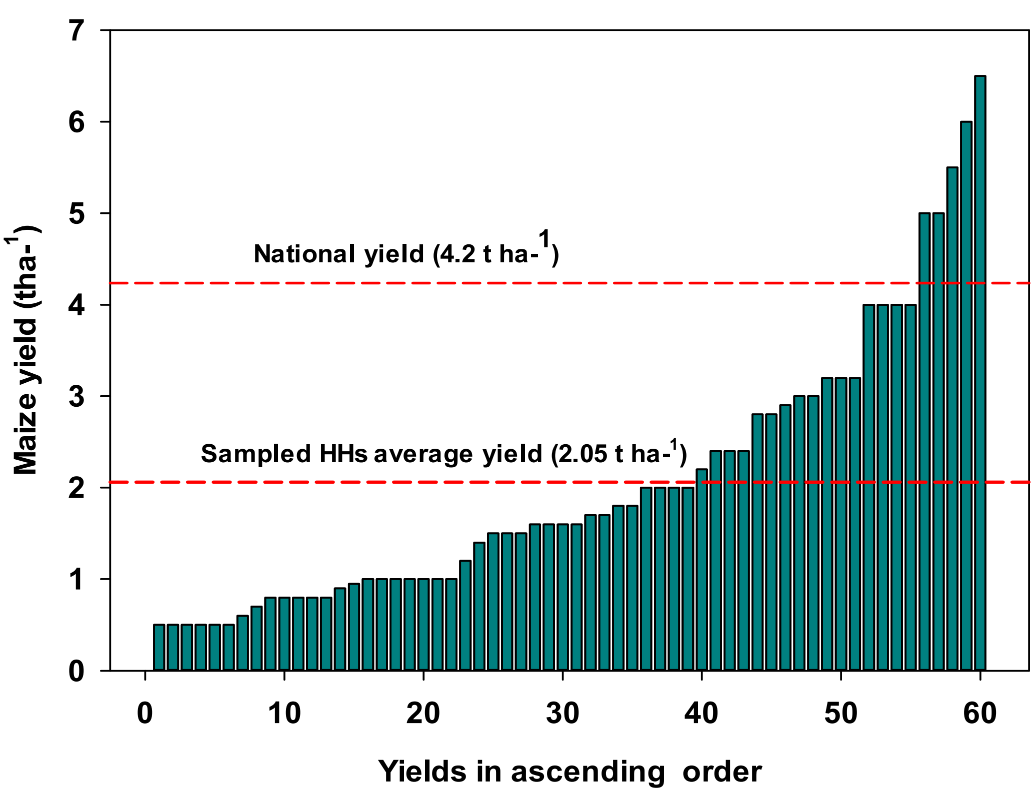

Figure 4. Maize grain yield (t ha^{-1}) of the 2019/2020 growing season in the study area. This yield data is obtained through structured questionnaires by interviewing respondents how much they produced in last season.

Table 4. Estimates of regression analysis.

Variable	Coefficients	Std. error	t-ratio	p-value
Constant	-0.93	1.52	-0.61	0.54
Sex (Male=1)	-2.02	0.56	-3.58	0.001***
Age	0.006	0.025	0.25	0.806
Education level (years of schooling)	0.18	0.056	3.25	0.002***
Family Size	-0.06	0.109	-0.57	0.572
Dependency Ratio	-0.16	0.14	-1.13	0.26
Total farm size	-0.91	0.596	-1.54	0.13
Farm size allocated for maize	0.604	0.66	0.92	0.36
Farming experience	0.02	0.027	0.74	0.461
Total livestock unit (TLU)	0.27	0.074	3.61	0.001***
Major income source				
Agriculture	2.78	0.97	2.85	0.006***
Private work	3.05	1.11	2.73	0.009***
Number of observations	60			
F (11, 48)	4.58			
R-squared	0.5122			
Prob > F	0.0001			

***Indicates a significance level at 1% probability.
Source: Survey Result (2021).

exploring solutions to improve productivity.

Major determinant factors affecting maize production in the study area

Socio-economic factors

Among the regressed ten variables, four variables could significantly (at 1% of probability level) influence maize production (Table 4). The coefficient of sex (β= -2.02) indicates that when the household head is male, the maize production is decreased by 2.02 t ha^{-1}, ceteris paribus. This finding is in agreement with Asfaw et al. (2012). On the contrary, Gishu et al. (2018) reported that male has relatively better access to the information and thereby adopt the maize variety more than their female counterparts, while Bekele and Guadie (2020) reported a non-significant effect of sex on coffee production.

The coefficient of educational level (β= 0.18) reveals that a unit increase in the education level of a household increases the maize production by 0.18 t ha^{-1}, ceteris paribus. This study is in line with Mazengia (2016). Education is one of the most important variables which likely influence crop production. The study revealed that educated households have a better understanding of accessing useful agricultural technology, formulation, and execution of farm plans and have relatively better access to market information than non-educated households (Gishu et al., 2018; Mazengia, 2016). Moreover, Atinafu et al. (2022) reported that a one-year increase in education attainment significantly (at a 10% significant level) increased the probability of the adoption and intensity of improved wheat production technology by 0.07 and 1.029%, respectively.

The coefficient of total livestock unit (TLU) (β=0.27) reveals that a unit increase of TLU increases maize production by 0.27 t ha^{-1}, ceteris paribus. The presence of TLU is an important factor for households to easily exchange the livestock into cash and buy different agricultural inputs, produce more manure, and also it serves as compensation at the time of risks such as crop failure. Previous studies reported that households with TLU are more likely than their counterparts to adopt modern agricultural technologies (Gishu et al., 2018; Berihun et al., 2014). The coefficient of the major income source (β for agriculture= 2.75 and β for private works= 3.05) reveals that the households who rely on agriculture and private works produce 2.75 and 3.05 t ha^{-1} more yield than the households who majorly depend on salary, respectively. This is because the households who mainly depend on agriculture can thoroughly manage their field to achieve a high yield. Also, a household with a private job can be able to buy improved seeds such as high-yielding variety (HYV) and fertilizers, manage their fields, and hire external labor than full-time salaried HHs. This result is in agreement with Berihun et al. (2014).

Institutional factors

The survey results revealed that all the sample

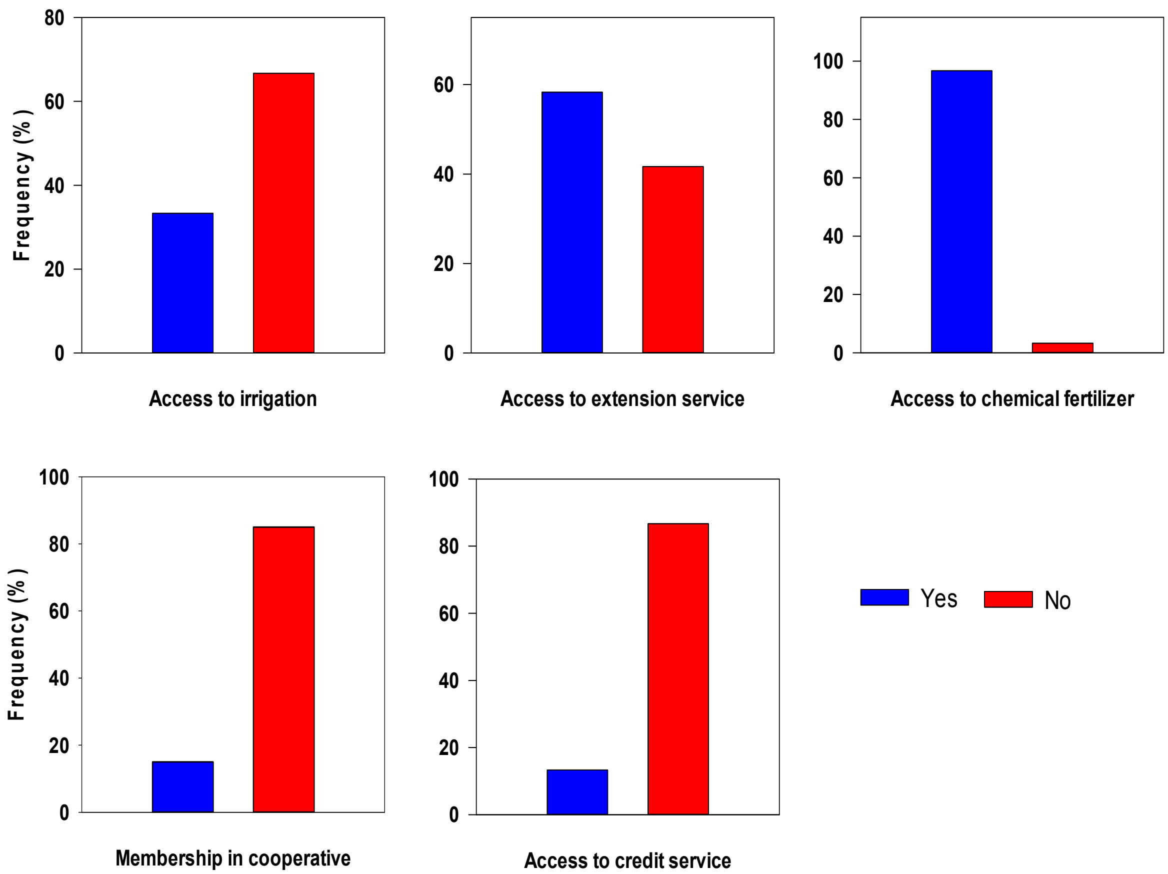

Figure 5. Major institutional factors affecting maize production in the study area.

respondents in the study area uses improved maize varieties. Also, about 96.7% of the sample respondents applied chemical fertilizer in the previous growing season (Figure 5). This figure does not depict the intensity of fertilizer use but rather its utilization/adoption by respondents. Irrigation is a major factor that is likely to influence agricultural production. It is an unsurpassed strategy in the region where there are erratic rain and frequent drought. In the present study, about 66.7% of the sample respondents do not have access to irrigation and only 33.7% use traditional irrigation systems. The lack of irrigation access is due to financial constraints in building irrigation canals, the high cost of motor pumps, a lack of awareness, land disintegration, and other factors. According to the study, farmers with irrigable land and who use irrigation water have a 9.8 and 23.6% higher probability of using chemical fertilizer and HYV, respectively, than their counterparts (Berihun et al., 2014). Access to extension service is an important variable to disseminate agricultural information to farmers, which helps them to get awaked about the existence and benefits of improved agricultural technologies. It has been reported that a producer who works closely with extension agents has a higher maize yield (Wondim et al., 2020). Despite the government's significant investment in public extension services, approximately 41.7 percent of the sample respondents do not use extension services in the study area (Figure 5).

Credit is an important variable that enables producers to purchase agricultural inputs and influence long-term farm investments. It has a significant impact on household decisions regarding the use of chemical fertilizer and improved varieties (Berihun et al., 2014). In the present study, about 86.7% of sample respondents have no access to credit services. This profoundly influences maize production due to the limitation of cash to buy agricultural inputs. The study demonstrated that credit access significantly influences the probability of adoption and intensity of improved wheat production technology by 0.47 and 6.95%, respectively, ceteris paribus (Atinafu et al., 2022). Rural cooperatives play a vital role in enhancing farmers' access to different services such as extension and market information. Regarding membership in a rural cooperative, about 85% of the sampled respondents are not a member of any farmers' organization. Farmers who participate in social activity have better access to agricultural information than their counterparts. A Tobit model result revealed that

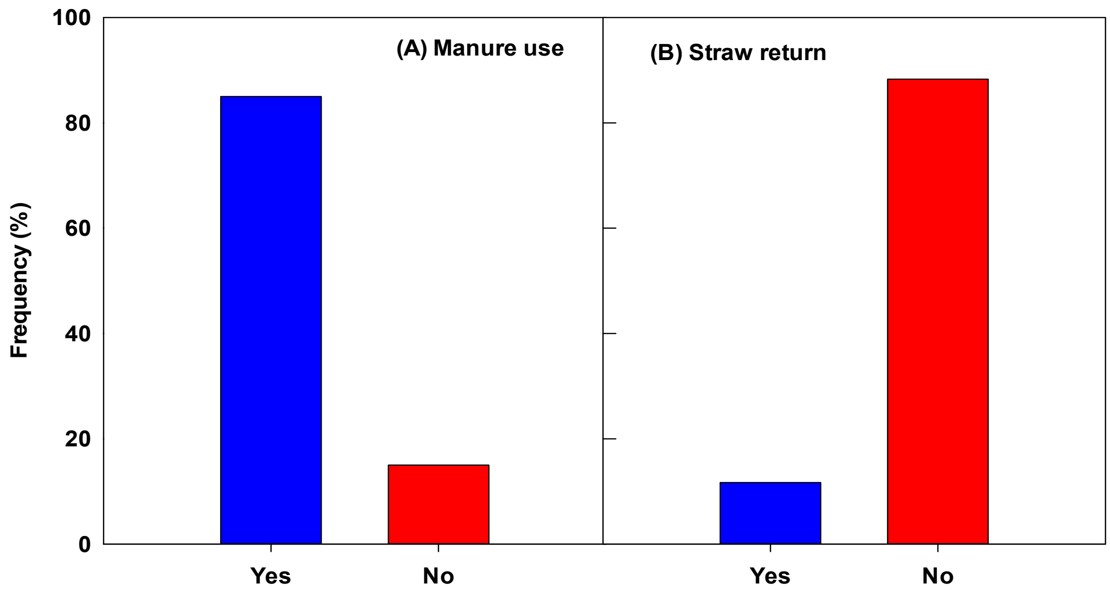

Figure 6. Frequency distribution of organic manure use and crop straw return among sample respondents.

Table 5. Influence of different organic fertilization on maize yield (averaged yield) over the control plots in Ethiopia.

Input type	Application rate ($t\ ha^{-1}$)	Average grain yield ($kg\ ha^{-1}$)	Yield increases over the control (%)	References
Compost	5-10	3722.5	21	Laekemariam and Gidago (2013)
	5	6132	54.5	Negassa et al. (2001)
Farmyard manure (FYM)	12	6204	20.1	Gemechu (2020)
	3-5	6192	14.7	Berhanu (2019)
	4-12	6088	61.4	Negassa et al. (2005)
Wheat straw (WS)	3-5	7386.5	36.86	Jelde and Shimelis (2019)
WS+FYM	6-10	9894	83.3	

Source: Different published sources

being a member of any social organization enhances the probability of adoption and intensity of improved wheat production technology by 0.156 and 2.273%, respectively (Atinafu et al., 2022).

Agronomic factors

Use of organic fertilizer: The blanket recommendation of nitrogen and phosphorous fertilizer at the national level is among the major challenges affecting soil and crop productivity. The use of organic fertilizer in farmland becomes the most important practice to enhance soil quality and thereby crop productivity. In the present study, about 85% of the total sampled respondents use organic manure in their fields (Figure 6). Regarding straw use, about 88.3% of the sample respondents do not use/return straw into fields (Figure 6); rather they use it for other competing values such as animal feed, fuel for cooking, and so on. Furthermore, the survey results showed that farmers who use organic manure and return straw into the fields have obtained a higher yield (45.3 and 16.5%, respectively) than their counterparts as indicated in Table 6. Yengoh (2012) reported that the use of animal droppings and compost improves the soil structure, enhances soil aeration, and increases grain yields.

The application of organic fertilizer is crucial to augment the low nutrient supply status, particularly in low-input and low-output areas including the Hawassa Zuria district. It enhances soil fertility to form a conducive environment for sustainable production (Andong et al., 2019; Liu et al., 2014). Table 5 reveals the positive influence of organic fertilizers on maize yield in different

Table 6. Average maize yield under a different category of agronomic variables in the study area.

Variable	Category	Maize yield (t ha^{-1})
Manure	User	2.15
	Non-user	1.48
Straw return	User	2.3
	Non-user	2
Planting density	Low	2.57
	Medium	1.33
	High	1.32
Weed frequency	Twice	1.43
	Thrice	2.37

Source: Survey Result (2021).

regions of Ethiopia. However, it is very substantial to intensify research on improving soil fertility and crop yield through organic amendments. Nevertheless, respondents in the study area do not have sufficient know-how regarding the application rate, type, quality, and nutrient content in the organic inputs. Therefore, it is necessary to create awareness to farmers on the selection, preparation, processing, and application methods of organic inputs.

Plant density: Plant density is among the major yield determining factors that affect crop production and productivity. It affects crop yield by influencing yield components. The majority of maize growers in the study area use the low planting density, that is, below the national recommendation rate. The survey results show that 58.33, 16.7 and 25% of the sampled respondents use planting density of <44,444 (low), 44,444-60,000 (medium) and >60,000 (high) plants/ha, respectively, for planting (Figure 7A). Some respondents perceive that planting densely results in weak crop growth and thereby lower yields. Maize is planted during the rainy season and which increases the probability of lodging at a higher density. In Ethiopia, the optimum plant spacing and density recommended for maize are 75 cm × 30 cm(which is 44,444 plants/ha) (Temesgen, 2019), but it may reach up to 53,333 plants/ha depending on the variety. However, this spacing recommendation has been used for a long time without taking into consideration the various morphological differences that exist among maize varieties as well as edaphic and climatic variations (Tasew, 2021; Temesgen, 2019).

The results showed that planting at lower density gives about 93.2 and 94.7% higher yield than planting at medium and higher density, respectively (Table 6). The reason might be increasing the plant density with inadequate/limited soil nutrients results in yield reduction. As the plant density increases, the available resources to the individual plants decrease. Contrary to this finding, Tesfaye et al. (2019) found a positive and linear relationship between maize grain yield and plant density. However, it is advisable to determine the optimum plant density depending on the environmental factors (soil status and moisture supply) and agronomic management practices of the locality to get maximum yields (Temesgen, 2019; Lakew and Berhanu, 2019).

Weeding frequency: Weeds are a permanent constraint to crop productivity in agriculture. The survey result revealed that 66.7% of the sampled respondents weed their maize field three times while the remaining 33.3% weeds only two times in a growing season (Figure 7B). Weeding three times results in a higher yield advantage (65.7%) over weeding twice (Table 6). The decline of yield with poor weed management is due to the increased inter-competition for soil nutrients, moisture, and sunlight, which resultantly reduces resources use efficiency and affects crop productivity. This finding is in agreement with (Tamene et al., 2015). Therefore, improved field management and on-time weeding are important to enhance crop productivity.

Tillage mechanisms: Among the total sampled respondents, about 70% plough their land by oxen (using their own and hired oxen), while the remaining 28.3% prepare through hand hoe using labour force (including hired labour), and only 1.7% use a tractor (Table 7). The results demonstrated that the use of modern farm mechanization practices is extremely low in the study area. However, the low farm mechanization in Ethiopia, and particularly in the study area, is due to cost, land fragmentation, issues related to cost-benefit (utility), to mention a few. As suggested by Guush et al. (2016), having policies that actively assure widespread availability

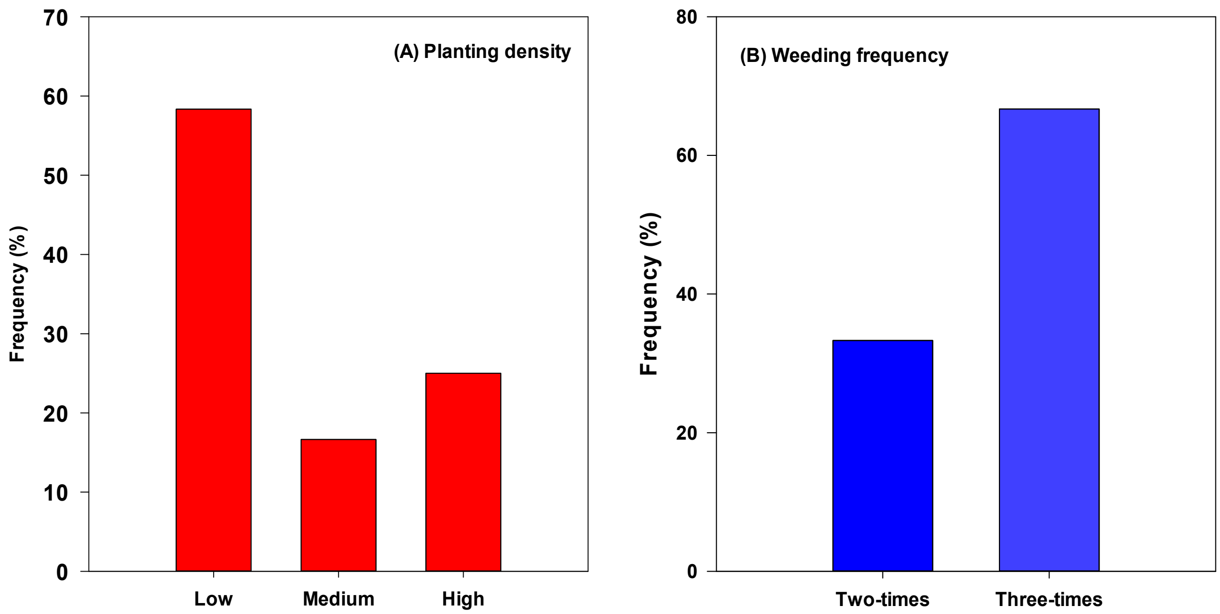

Figure 7. Frequency distribution of planting density (A) and weeding frequency (B) among sample respondents.

Table 7. Frequency distribution of tillage/producing methods among sample households in the study area.

Tillage methods	Observation	Percentage
Hand hoe	17	28.3
Oxen	42	70.0
Tractor	1	1.7
Total	60	100

Source: Survey Result (2021).

Table 8. Frequency distribution of sample respondents on the pest and disease incidence and pesticide use.

Parameter	Category	Observation	Percentage
	Yes	46	76.3
Pest and disease incidence	No	14	23.3
	Total	60	100
	Yes	11	18.3
Pesticide application	No	49	81.6
	Total	60	100

Source: Survey Result (2021).

of appropriate mechanized services to producers at affordable prices, likely impacts Ethiopia's agricultural transformation.

Pests and diseases: Several biotic and abiotic factors contribute to the low maize productivity in the study area. In this study, about 76.3% of sampled respondents' fields were infested by some pests and diseases in the last growing season (Table 8). Regarding agro-pesticide use, only 18.3% of sample respondents have applied it (Table

8). The reason is that households may not afford the agrochemicals due to high costs. Fall armyworm (FAW) (*Spodoptera frugiperda*) has recently become an economically important pest among maize producers in Ethiopia, including the study district. It contributed to low crop production more than any pests from its introduction in 2017 in the country (Assefa, 2018; Keno et al., 2018). The increasing distribution and influence of crop pests and diseases exacerbate future food insecurity and stability of food supplies. Therefore, the development of appropriate strategies such as disease-resistant varieties, adapting and optimizing efficient farming methods, sustainable and integrated pest management, and other crop protection strategies are needed to ensure future food production and security (Keno et al., 2018; Yengoh, 2012).

CONCLUSION AND POLICY RECOMMENDATION

Maize is a strategic crop for Ethiopian food security, and there is a significant margin for fully capturing the expanding domestic market. In this study, the major determinants affecting maize crop production and productivity were evaluated in the Hawassa Zuria district of Sidama region, Ethiopia. As a result, socioeconomic, institutional, and agronomic factors were identified as the most significant factors influencing maize production in the study area. Furthermore, a larger knowledge gap regarding the application of suggested agronomic practices was identified among farmers. The following policy recommendation has been made based on the study findings: (i) improving the educational level of households that facilitates better acceptance of agricultural technologies and access to marketing information; (ii) improving accessibility of agricultural inputs such as fertilizer, improved seeds, and credit services to farmers and building irrigation schemes to increase crop productivity; and (iii) empowering farmers to adopt and apply a full package of agronomic practices that help to improve soil fertility and thereby crop productivity. However, additional research of this type across the entire region is required to provide basic information about crop production factors and to investigate different strategies for closing the yield gap at the household level.

CONFLICT OF INTERESTS

The authors declare that they have no known competing financial interests.

ACKNOWLEDGEMENTS

The authors greatly acknowledge China Agricultural University (CAU) and Sino-Africa STB project for the invaluable support to conduct the study. They also acknowledge the extension agents for their invaluable support during data collection.

REFERENCES

Abate T, Shiferaw B, Menkir A, Wegary D, Kebede Y, Kindie T, Menale K, Gezahegn B, Berhanu T, Tolera K (2015). Factors that transformed maize productivity in Ethiopia. Food Security 7:965-981. Available at: https://doi.org/10.1007/s12571-015-0488-z

Abebe A, Halala H (2020). Factors Affect Maize Production and Marketing in Wolaita and Dawuro Zones, SNNPR State, Ethiopia. International Journal of Science and Research 9(2):771-783. Available at: https://doi.org/10.21275/28121901

Abera G (2017). Determination of organic materials quality based on nutrient recovery, mineral fertilizer equivalency, and maize (*Zea mays* L.) allometry. Archives of Agronomy and Soil Science 63(1):48-59. Available at: https://doi.org/10.1080/03650340.2016.1192281

Abrha BK (2015). Factors Affecting Agricultural Production in Tigray Region, Northern Ethiopia. Doctoral Dissertation, University of South Africa.

Andong C, Xu M, Wang B, Zhang W, Liang G, Hou E, Luo Y (2019). Manure acts as a better fertilizer for increasing crop yields than synthetic fertilizer does by improving soil fertility. Soil and Tillage Research 189:168-175. Available at: https://doi.org/10.1016/j.still.2018.12.022

Anteneh A, Asrat D (2020). Wheat production and marketing in Ethiopia : Review study. Cogent Food and Agriculture 6(1). Available at: https://doi.org/10.1080/23311932.2020.1778893

Asfaw S, Shiferaw B, Simtowe F, Lipper L (2012). Impact of modern agricultural technologies on smallholder welfare: Evidence from Tanzania and Ethiopia. Food Policy 37(3):283-295. Available at: https://doi.org/10.1016/j.foodpol.2012.02.013

Assefa F (2018). Status of Fall Armyworm (Spodoptera Frugiperda), Biology and Control Measures on Maize Crop in Ethiopia: A Review 06(02). Available at: https://doi.org/10.33687/entomol.006.02.2498

Atinafu A, Lejebo M, Alemu A (2022). Adoption of improved wheat production technology in Gorche district, Ethiopia. Agriculture and Food Security 11(1):1-8. Available at: https://doi.org/10.1186/s40066-021-00343-4

Bekele A, Guadie T (2020). Multiple Linear Regression Analysis on Factors Affecting Coffee Production in Bench-Shako Zone: In Case of Mizan-Aman District, Southwest Ethiopia. Advances in Bioscience and Bioengineering 8(2):24. Available at: https://doi.org/10.11648/j.abb.20200802.13

Berihun K, Bihon K, Kibrom A (2014). Adoption and Impact of Agricultural Technologies on Farm Income: Evidence From Southern Tigray, Northern Ethiopia. International Journal of Food and Agricultural Economics 2(4):91-106. Available at: https://doi.org/10.22004/ag.econ.190816

Chilot Y, Dawit A (2016). Adoption of Crop Technologies among Smallholder Farmers in Ethiopia: Implications for Research and Development. Ethiopian Journal of Agricultural Sciences pp. 1-16.

CSA (2019). Agricultural Sample Survey 2018/19 (2011 E.C.), Volume 1, Report on Area and Production of Major Crops (Private Peasant Holdings, Meher Season), FDRE Statistical Bulletin 589, June 2019, Addis Ababa, Ethiopia.

CSA (2020). Agricultural Sample Survey 2019/20 (2012 E.C.), Volume 1, Report on Area and Production of Major Crops (Private Peasant Holdings, Meher Season), FDRE Statistical Bulletin 587, April 2020, Addis Ababa, Ethiopia.

Degefu K, Mengistu K, Nigussie D, Feyisa H (2017). Determinants of Adoption of Potato Production Technology Package By Smallholder Farmers: Evidence From Eastern Ethiopia. Turkish Journal of Agriculture - Food Science and Technology 5(3):26-274.

Dessie A (2018). Cereal Crops Research Achievements and Challenges in Ethiopia. International Journal of Research Studies in Agricultural Sciences 4(6):23-29. Available at: https://doi.org/10.1107/s0108768109011057

Fan F, Zhang H, Alandia G, Luo L, Cui Z, Niu X, Liu R, Zhang X, Zhang

Y, Zhang F (2020). Long-term effect of manure and mineral fertilizer application rate on maize yield and accumulated nutrients use efficiencies in north china plain. Agronomy 10(9)1329-2020. Available at: https://doi.org/10.3390/agronomy10091329

FAOSTAT (2020). Food and Agriculture Organization of the United Nations. FAOSTAT.

Gemechu B (2020). Effect of Integrated Farmyard Manure and NP Fertilizers Use on Hybrid Maize Yield and Soil Properties in Western Ethiopia. Malaysian Journal of Medical and Biological Research 7(1):7-16. Available at: https://doi.org/10.18034/mjmbr.v7i1.489

Gishu N, Yohannes M, Agidew A (2018). Determinants of Adoption of Improved (BH-140) Maize Variety and Management Practice, in the Case of South Ari, Woreda, South Omo Zone, SNNPRS, Ethiopia. International Journal of Research Studies in Biosciences 6(9):35-43.

Guush B, Kalle H, Bart M (2016). Synopsis, Agricultural mechanization in Ethiopia: Evidence from the 2015 Feed the Future survey (ESSP II Research Note 48). Available at: http://ebrary.ifpri.org/cdm/ref/collection/p15738coll2/id/130142

GYGA (2020). Global Yield Gap Analysis. Available at: Https://www.yieldgap.org/web/guest/download_data

Jelde A, Shimelis B (2019). Effects of Straw Mulch and Manure on Moisture Conservation, Yield and Yield Components of Maize (*Zea mays* L.). International Journal of Agriculture and Agribusiness 6(2):42-55.

Keno T, Azmach G, Wegary D, Worku M, Tadesse B, Wolde L, Deressa T, Abebe B, Chibsa T, Suresh LM (2018). Major biotic maize production stresses in Ethiopia and their management through host resistance. African Journal of Agricultural Research 13(21):1042-1052.

Laekemariam F, Gidago G (2013). Growth and yield performance of maize (*Zea mays* L.) to Variable rates of compost and Inorganic Fertilizer Integration in Wolaita, Southern Ethiopia. American Journal of Plant Nutrition and Fertilization Technology 3(2).

Lakew A, Berhanu T (2019). Determination of intra and inter-row spacing on the yield of pearl millet (*Pennisetum glaucum* L.) in the dryland areas of Wag Himra, eastern Amhara, Ethiopia. Archives of Agriculture and Environmental Science 4(1):45-49.

Liben FM, Adisu, T, Atnafu O, Bekele I, Berhe H, Wortmann CS (2020). Maize and sorghum nutrient response functions for Ethiopia. Nutrient Cycling in Agroecosystems 117(3):401-410.

Mazengia Y (2016). Smallholders Commercialization of Maize Production in Guangua District, Northwestern Ethiopia. World Scientific News 58:65-83.

Negassa W, Abera T, Friesen DK, Deressa A, Dinsa B (2001). Evaluation of compost for maize production under farmers' conditions. Seventh Eastern and South Africa Regional Mazie Conference, May 2015, pp. 382-386.

Negassa W, Gebrekidan H, Friesen DK (2005). Integrated use of farmyard manure and NP fertilizers for maize on farmers' fields. Journal of Agriculture and Rural Development in the Tropics and Subtropics 106(2):131-141.

Saghir J, Hoogeveen H (2016). Research to Practice Policy Briefs: Transforming Sub Saharan Africa Agriculture. Research to Practice Policy.

Solomon Y (2020). Historical Perspectives of Agricultural Extension and Research- Extension-Farmers Linkage in Ethiopia. Acta Scientific Agriculture 4(5):28-33.

Tadele Z (2017). Raising crop productivity in Africa through intensification. Agronomy 7:22. Available at: https://doi.org/10.3390/agronomy7010022

Tamene L, Mponela P, Ndengu G, Kihara J (2015). Assessment of maize yield gap and major determinant factors between smallholder farmers in the Dedza district of Malawi. Nutrient Cycling in Agroecosystems. Available at: https://doi.org/10.1007/s10705-015-9692-7

Tasew W (2021). Response of Maize (*Zea Mays* L.) Varieties to Row Spacing at Boloso Sore District, Southern Ethiopia. GRIN Verlag. Available at: https://doi.org/https://www.grin.com/document/983483

Temesgen T (2019). Effects of Varieties and Intra Row Spacing on Yield of Maize (*Zea mays* L.) under Supplementary Irrigation at Guliso, Western Ethiopia. International Journal of Environmental Sciences and Natural Resources 19(5):144-151. Available at: https://doi.org/10.19080/ijesnr.2019.19.556024

Tesfaye B, Mesfin K, Tolera A, Gebresilasie H, Gebreyes G, Fite G (2019). Some maize agronomic practices in Ethiopia: A review of research experiences and lessons from agronomic panel survey in Oromia and Amhara regions. African Journal of Agricultural Research 14(33):1749-1763.

Tilman D, Balzer C, Hill J, Befort BL (2011). Global food demand and the sustainable intensification of agriculture. Proceedings of the National Academy of Sciences 108(50):20260-20264.

Urgessa TB (2014). Review of challenges and prospects of agricultural production and productivity in Ethiopia. Journal of Natural Sciences Research 4(18):70-77.

Wondim D, Tefera T, Tesfaye Y (2020). Determinants of Maize Market Supply, Production and Marketing Constraints: The Case of Dembecha District, West Gojjam Zone, Ethiopia. International Journal of Economy, Energy, and Environment 5(5):83.

Yengoh GT (2012). Determinants of yield differences in small-scale food crop farming systems in Cameroon. Agriculture and Food Security 1(1):1-17.

Yokamo S, Endrias O, Tsebaye T, Walelegn W (2018). Identification and Prioritization of Major Agricultural Production and Productivity Constraints in the Case of Basketo Special District of Southern Ethiopia. Food Science and Quality Management 73:16-22. Available at: https://doi.org/10.4172/2329-8863.1000353