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Original Paper

Factors Affecting Tomato Productivity in Western Oromia, Ethiopia: Evidence from Smallholder Farmers

Kifle Degefa[1], Getachew Biru[2], Galmesa Abebe[1]*
[1]*Bako Agricultural Research Center, Bako, Ethiopia*
[2]*Oromia Agricultural Research Institute, Finfinne, Ethiopia*
Corresponding author: kifledd3@gmail.com

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Abstract**-- Tomato is one of the most important fruit vegetable crops in Ethiopia supporting the livelihood and improving the economic life of many farmers. However, the productivity of the crop is low due to poor production management practices, limitations in the availability of pesticides and fungicides, limitations to access information, market fluctuation, and shelf life of the crop. The study was undertaken in western Oromia to understand major factors affecting the tomato productivity of smallholder farmers. It was based on the cross-sectional data collected from 135 randomly selected farmers during the 2019/20 cropping season. The data were analyzed using descriptive statistics and an econometric model. The result depicted that the productivity of tomatoes was significantly affected by inputs like labor, oxen power, fertilizer, and pesticides. From the OLS result, gender, education, family size, off/non-farm activities, farm experience, livestock holding, extension access, credit access, and market/traders information positively affected tomato productivity, while age and field distance was affected negatively. The variety and biotic factors affected the tomato productivity of smallholder farmers positively and negatively, respectively. The findings will be helpful for tomato producers, private companies, and other sectors that participated in crop production by solving the above important variables.**

Keywords- Factors, tomato productivity, smallholder farmers, western Oromia & Ethiopia

I. Introduction

Tomato (*Solanum lycopersicum L.*) is one of the most widely grown and consumed vegetable crops in the world [1]. The production system ranges from home gardening, and smallholder farming to commercial farms owned both by public and private enterprises [2]. Among horticultural crops, tomato is ranked third globally in terms of production volume after potato and sweet potato [3]. It is also the first in terms of processing volumes [4]. The crop is often called “poor people orange” because they are a good source of vitamins, particularly vitamins A and C, a rich source of natural lycopene, and a carotenoid possessing anti-oxidative activity [5, 6].

Tomato is one of the most important vegetable crops in Ethiopia supporting the livelihood and improving the economic life of smallholder farmers in the country and the most consumed fruit vegetable in Ethiopia [7-9]. Over the years' tomato production is the major horticultural crop using irrigation in the area [10,40]. According to this author, the trend of tomato production is increasing as an income generation source for smallholder farmers. However, the productivity of tomatoes in the country is constrained by many barriers like poor production management, limitation of availability of inputs (high yielder improved seed, pesticides, and fungicides), limited access to market information, traders' or market fluctuation, and shelf life of fruits (perishability of the crop) [11-18]. To solve these barriers, efforts have been done towards improving tomato productivity by utilizing improved varieties that are highly productive and resistant to pests [19] and dissemination of the varieties by research centers and other sectors for more than two decades. According to the Ethiopian government policy, the strategy to increase the horticultural crop productivity of smallholder farmers is through increasing the adoption and utilization of inputs [7]. However, the promoted inputs have not been used to their full potential and no substantial gains could be achieved by using the inputs alone [15]. This implies the need for further investigation on factors affecting tomato productivity to design an appropriate system generating reliable information.

There are limited findings on horticultural crops, especially factors affecting their productivity, as majority of studies delve into the production management and marketing systems rather than [14,19-22,41]. A missing component of studies on tomato production is understanding factors affecting tomato productivity of smallholder farmers who are widely known to grapple with low productivity of tomato. Therefore, this study aimed to understand major factors affecting tomato productivity as the basis for designing appropriate extension and research programs to boost the tomato productivity of smallholder farmers.

II. RESEARCH METHODOLOGY

A. Description of the Study Areas

The study was conducted in Bako Tibe and Guto Gida districts of western Oromia. Bako Tibe and Guto Gida are located in Western Oromia at 251 km and 328 km from Finfinnee the capital city of Ethiopia, respectively. The Bako Tibe district is divided into three agro-ecological zones involving lowland (51%), midland (37%), and highland (12%), and Goto Gida is also located at 036^0 33' E longitude, 09^0 05' N latitude. The annual rainfall of Bako Tibe district ranges from 1200-1300 mm with an annual temperature range from 13.8-27.8^{0}C, while the Goto Gida district is 1854.9 mm on average. The total population of Bako Tibe district is 136,829, consisting of 47.1% men and 52.9% women whereas the total population of Guto Gida is 89,906 which involves 45,810 men and 44,096 women. In the districts, more than 90% of the population depends on agriculture for their livelihood with maize, tef, coffee, sorghum, potato, and tomato leading crops [10].

B. Sampling Technique

The study was conducted in the east Wollega and west Shewa zones. A combination of purposive and simple random sampling techniques was used to select an appropriate sample of households. The two zones were selected purposively from five zones of western Oromia based on the potential of the crop. From these zones two districts namely Bako Tibe and Goto Gida district were selected purposively based on tomato production potential and the extent of production. Seven *kebeles*[1] were selected randomly from 20 *kebeles* that produced tomatoes based on proportionally to *kebeles*[1] growing tomato in the districts. Accordingly, four *kebeles* from Bako Tibe and three *kebeles* from Guto Gida were selected. Finally, from 282 tomato producer farmers, 135 sample households were selected randomly using probability proportionality size following a simplified formula provided by Yamane [23].

$n = \frac{N}{1+N(e^2)}$; Where n= sample size, N= total tomato producers & e= level of precision (0.05)

C. Data Types and Methods of Data Collection

Both primary and secondary data were used for this study purpose. The primary data was collected from 135 sample households growing tomatoes using a pre-tested semi-structured questionnaire during the 2019 cropping season. The collected data were focused on farm and farmers' characteristics, inputs used, tomato production management, tomato plot status, income sources, tomato market information, biotic factors information, extension, and credit services during the survey period. To gain more comprehensive data and establish robust discussion, secondary data were collected from the agriculture office, tomato inputs sources, CSA of Ethiopia.

D. Methods of Data Analysis

The collected data was analyzed using descriptive statistics and a multiple linear regression model. Descriptive statistics including mean, standard deviation, percentage, frequency, and independent t-test were used to describe socio-economic, institutional factors and input used. Multiple linear regression (OLS) model was used to identify factors affecting tomato productivity in the study areas. This OLS model is applicable if and only if all sample households participate in tomato production. In this study, all sampled households produced tomatoes. Some basic assumptions tests of OLS like multicollinearity and heteroscedasticity were carried out. This model is also used for its simplicity and practical applicability [24,25]. Econometrics model specification of tomato production function matrix is given as below:

$Y_i = X_i' \beta_i + U$; Where; Y_i= quantity of tomato produced, X'_i= a vector of explanatory variables, β_i= a vector of parameters to be estimated, and U= disturbance term

III. RESULTS AND DISCUSSION

A. Tomato Production and Inputs

Tomato production and inputs used by the sample households include labor, oxen, chemical fertilizers (Urea & NPS), seed, and chemical technologies are summarized in Table I. Each variable was tested for their impact on tomato productivity using an independent t-test. To produce 27.4 tons of tomato output per hectare, 130.52 man-days labor, 11.70 oxen-days oxen for land plowing, 76.50 kg of Urea, 112.63 kg of NPS, 0.55 kg of seed, and 2.57 liters of pesticides (insecticides, fungicide, etc.) have been used.

Inputs used by farmers were statistically significant at $p < 0.05$, which implies that increasing significant inputs like labor, oxen, fertilizer and pesticides increased tomato productivity. This result is similar to the findings of previous studies [26-29] reporting that increased inputs result in increased productivity.

TABLE I. TOMATO PRODUCTION AND INPUTS USED

Variables (n=135)	N	Min.	Max.	Mean	Std. Dev.	P-value
Yield (tons)	135	7.90	48.67	27.40	11.21	_
Labor (MD)	135	110.00	173.68	130.52	18.24	0.00**
Oxen OD)	135	8.00	16.00	11.70	3.30	0.00**
Urea (kg)	135	18.42	250.00	76.50	32.91	0.01**
NPS (kg)	135	26.32	375.00	112.63	48.39	0.01**
Seed (kg)	135	0.08	0.97	0.55	0.21	0.44
Pesticides (lit)	135	1.00	7.50	2.57	1.10	0.02*

B. Effect of Socio-economics and Farm Tomato Production

The impacts of socio-economics and farm characteristics of sample households, such as age, education level, family size, livestock holding, cultivated land, and tomato farm distance, are summarized in Table II, which documents descriptive statistics of these factors. The average age of sampled

[1] *Kebele* is a small unit of administration in Ethiopia that is equivalent to Ward in other Africa countries.

households in the study areas was 44.12 years with minimum age and maximum age at 25 & 88 years old, respectively. This implies that tomato farming was mainly practiced by middle-aged farmers. The survey result shows that about 18.52% of sampled household heads were illiterate. However, about 81.48% of sampled household heads attended primary schooling to secondary schooling. The average schooling of household head in the areas was 5 years with the minimum and maximum 2 & 12 years, respectively. The average family size of the household was 6.44 persons ranging from 2 to 13 persons. This number points to the availability of labor for agriculture activities which makes it easy to implement farm activities.

TABLE II. CONTINUOUS VARIABLES OF HOUSEHOLD

Variables	N	Min.	Max.	Mean	Std. Dev.
Age of household head (year)	135	25.00	88.00	44.12	13.87
Education level of household head (year)	110	2.00	12.00	5.00	2.61
Family size of household (number)	135	2.00	13.00	6.44	2.77
Number of livestock by Tropical Livestock Unit (TLU)	135	1.13	22.93	8.45	5.90
Total cultivated farmland (ha)	135	0.50	7.50	1.56	1.19
Farm distance (minute)	135	5.00	60.00	25.04	14.99

Regarding livestock holding the sampled household owned on average 8.45 TLU of livestock for crop production (ox for land plowing) and income generation purposes. This income is used for inputs and food item purchases as needed. Additionally, using manure is also an important variable for the rural household's land productivity enhancement by improving soil fertility. Another important factor influencing crop productivity is farmland. The average total cultivated farmland of the sampled households was 1.56 hectares ranging from 0.50 to 7.50 hectares. The average distance between home and field is 25.04 minutes, ranging from 5 minutes to 60 minutes (Table 2).

The descriptive statistics on gender, off/non-farm activity, variety, extension service, credit access, market information access, and biotic factor of sampled households are summarized in Table III. Of the total households, about 84.44% and 15.56% of the sample households were male and female household heads, respectively. Out of total sampled households about 80.74% of household heads obtained income from off-farm and non-farm activities. Farmers who obtained additional off/non-farm activities like petty trade, crop trading, livestock trading, daily laborer in agriculture and non-agriculture, crafting, etc. received additional income to support their investment in tomato production. This is coherent with [30] which stated that farmers used off/non-farm activities income to purchase inputs like seed, fertilizers, and chemicals.

The result displayed that about 62.96% of sampled households used Galilea variety, and 37% of sampled households used Cochoro variety. The Galilea and Cochoro varieties produced 32.44 tons and 18.84 tons per hectare respectively. Galilea variety was high yielder than Cochoro variety which implies that a higher yielder improved seed can cause a remarkable improvement in tomato production for smallholder farmers. This is in line with [31] that reported that seeds that fulfill the quality requirements have a positive impact on the productivity of land.

Extension services, credit, and market information are the more important services in tomato production, the data of which are summarized in Table 3. The report reveals that 84.80% of sampled households received extension service on production management, disease, and insect control. This finding affirmed [32] that stated that agricultural extension was the delivery of inputs information, price of commodity forecasting information, and speeding technology adoption to farmers. The result showed that only 20.00% of sampled household heads utilized credit for increasing tomato production. In this vein, [33] argued that smallholder farmers used credit availability as the best option to diversify their economic activities and increase financial resources to purchase agricultural inputs.

Regarding market information, about 77.80% of households received market information on tomato quality and market demand seeking. This result is in line with [14] that underlined the value of market information for reducing market imperfection by enabling farmers to sell their products and share adequate technology information through prospective marketing linkage to achieve high productivity. Concerning biotic factors, such as insects (whitefly, aphids, etc.) and disease (fungi, bacteria, and viruses) as critical challenges in tomato production systems. The result has shown that about 28.10% of sampled household heads struggled with biotic factors which reduce tomato production. The result is similar to the findings of [15,34] who stated that more than 60% of the productivity of developing countries was lost due to biotic and abiotic factors.

TABLE III. THE DESCRIPTION OF HOUSEHOLD

Variables (N= 135)		N	Percentage
Male household heads (male)		114	84.44
Obtained income from off/non-farm activity (yes)		109	80.74
The Household used Galilea variety (yes)		85	62.96
Institutional variables setting	Received extension services on tomato (yes)	101	74.81
	Credit utilized (yes)	27	20.00
	Received market information (yes)	105	77.78
Existence of biotic factors (insects, disease, etc) in the field (yes)		38	28.15

C. *Factors Affecting Tomato Productivity of Smallholder Farmers*

Before using the OLS model, some assumptions were made. To test multicollinearity among explanatory variables, the Variance Inflation Factor (VIF) test was conducted. The mean of the VIF result was 8.51 which indicated no series multicollinearity problem among the explanatory variables [24]. The problem of heteroscedasticity or no-equality of error variance was tested and the *P*-value was not significant at a 5% confidence interval. This confirmed that there was no problem with heteroscedasticity [25].

According to Table IV, education level, gender, plot distance, the variety used, biotic factor, credit used, and extension service affected tomato productivity positively and negatively. The education level was positively related to farmers' efforts in increasing tomato production, which was found significant at a 10% confidence interval. The positive relationship implies that an increased education level enables access to more information on the new variety and field management. This means that the education level is very significant in enhancing tomato productivity as it allows farmers to acquire new concepts on production techniques and use new high-yielder varieties. This finding is consistent with the findings of [7, 35] who stated that the education level of a household affected strongly crop productivity.

Controlling other factors, the regression result shows a stark difference between female and male heads in tomato productivity, in that both significantly influenced the productivity positively at a 5% level. According to this result, males are more likely to attend training and visit demonstrations, yet they tend to struggle with poor field management due to their workload at home. In general, female household heads used fewer improved technologies and used fewer amounts of inputs which result in lower productivity than male household heads. The result in line with [36] result stated that male households produced high output than female households from the same plot.

The distance to the tomato field significantly and negatively influenced tomato productivity in the study areas. This result illustrates that with the longer distance to the tomato field, it is presumed that productivity tends to decline, which is in line with [11] result. According to (Lu *et al*. [37] distance to the field is an indicator of travel time, which decreases working time and results in poor supervision.

Households who used Galilea variety seed positively affected tomato productivity. This implies that policy interventions that make improved Gelilea variety seed available to more farmers could enhance productivity. The result is in line with [29,31,38] who stated that the choices accessible to farmers' new high yielder variety at a reasonable price, and at the right place and time contribute to increased crop productivity.

Regarding biotic factors that negatively influenced tomato productivity, which was found significant at a 1% level. The negative relationships between biotic factors and tomato productivity. The number of biotic factors increased the tomato productivity, while it might also decrease productivity. In this direction, [15, 31,34] demonstrate that biotic factors reduced crop productivity by up to 60% of productivity in developing countries.

TABLE IV. FACTORS AFFECTING TOMATO PRODUCTIVITY

Independent Variables	**Coefficient**	**Std. Err**	**t**	**P>|t|**
Household Variables				
Age of household head (years)	0 .0266983	0.0555438	0.48	0.632
Education level of household head (years)	0.5563477*	.29483	1.89	0.062
Family size of household (number)	0.302019	0.3143128	0.96	0.339
Sex of household head	4.844826**	2.018598	2.40	0.018
Farm and Income Variables				
Total cultivated plot (ha)	-0.0009159	0.4078868	-0.00	0.998
Plot distance from home (minute)	-0.1612717**	0.0662343	-2.43	0.016
Number of livestock in TLU (number)	0.0321777	0.1398744	0.23	0.8181
The variety of incomes used by the household	5.831817***	1.096034	5.32	0.000
Income of off/non-farming activity	0.7011712	1.907968	0.37	0.714
Biotic factors (disease, insect, etc)	-3.802788***	1.423387	-2.67	0.009
Institutional Variables				
Credit utilization of household member	3.876844***	1.344427	2.88	0.0051
Extension services on tomato production and marketing	3.635859**	1.546135	2.35	0.020
Tomato market information	2.710428	1.185762	2.29	0.024
Constant	14.32968***	5.024361	2.85	0.005

Number of obs. = 135; F (13, 121) = 44.02; Prob > F = 0.0000; R-squared = 0.8255 and Adj.= 0.8067

According to the result, agricultural credit positively affected tomato productivity, which has been acknowledged by statistical analysis at a 1% level. The positive relationship implies that the importance of credit in agricultural production allows producers to satisfy the cash needs caused by the production cycle of land preparation, planting, cultivation, and harvesting. The result is similar to [33,39] results which stated that access to credit potentially ensures the adoption of new varieties and other inputs which increased crop productivity.

The access to extension service positively influenced tomato productivity, which has been confirmed statistically with a 5% confidence interval. This result demonstrates that better technologies and support for services in endorsing new varieties, the chemical used, and market information enhance farmers' knowledge of crop production and increases productivity. The result is in line with [7,12] results who stated that extension services provide input information used, market, and other technologies that increase crop productivity.

IV. CONCUSSION AND RECOMMENDATIONS

The data analyzed by the OLS model result indicate that education level (10%), gender (5%), the variety used (1%), credit utilized (1%), and extension service (5%) positively affected tomato productivity. Tomato farm distance and biotic factor have an inverse relationship, which has been confirmed significant at 5% and 1% confidence intervals, respectively. The income received from credit was used for purchase inputs and rent labor for tomato land preparation, planting, cultivation, and harvesting which affected the crop productivity positively. Farmers' financial resources, especially females, are also used to help improve their output. An extension is the main information source for the rural community by improving farmers' skills and knowledge of agricultural technologies which affect crop productivity. Strategies for strengthening the existing agricultural extension service through improving farming techniques with technological innovation are deemed very important. Biotic factors, such as insects and fungus which loss of tomato production. Providing adequate high yielder variety with biotic factors resistance will be suggested.

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