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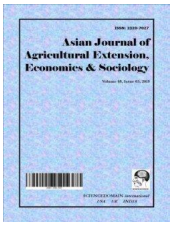

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Analysis of Resource Use Efficiency in Tomato (*Solanum lycopersicum)* Production in Kogi State, Nigeria

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Authors' contributions

This work was carried out in collaboration between all authors. Author SJI design the study, wrote the proposal, performed the data analyses and wrote the first and final draft of the manuscript. Authors UMS and BO managed the literature searches and participated in data collection and processing. All authors read and approved the final manuscript.

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ABSTRACT

The study was on resource use efficiency among tomato farmers in Kogi State, Nigeria. The data were collected from 240 tomato farmers through purposive sampling in 2014. Questionnaire design was the instrument used for data collection. Data collected were analysed through the use of simple descriptive statistics, OLS regression analysis and efficiency ratio. The result of the study showed that majority of tomato farmers in the State were married males with an average family size of 7 members. Farmers' educational status, farming experience, contact with extension workers, and farm size were positively related and significant at 1% in influencing the output of tomato produced in the State. Resources such as pesticide, labour, years spent in school, quantity of seed and farm size were positively and significantly related to tomato output in Kogi State. Quantity of pesticide, seed and fertilizer were over utilized while labour and farm size were underutilized. It is recommended that government should implement policies that will facilitate the efficient utilization of agricultural resources among tomato farmers in Kogi State.

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1. INTRODUCTION

Tomato (*Solanum lycopersicum)* is one of the most popular and widely grown fruit in the world including Africa [1,2]. It is native to South America [3], but was introduced into West Africa by Portuguese traders and freed slaves from West Indies [4]. It is the second most important vegetable worldwide, in terms of the amount of vitamins and minerals it contributes to the diet [5]. Genetic evidence shows that the progenitors of tomatoes were herbaceous green plants with small green fruit and a centre of diversity in the high lands of Peru [6]. Tomato is the edible, often red fruit/berry of the Nightshade (*Solanum lycopersicum*) commonly known as a tomato plant.

According to a press release by the Central Bank of Nigeria in 2013 [7], an annual total area of one million hectares is reportedly used for tomato cultivation in Nigeria while it makes up about 18 percent of the average daily consumption of vegetables in homes. Nigeria is ranked second largest producer of tomato in Africa and fourteenth largest in the world, producing 1.51 million metric tonnes of tomato annually valued at ₦87 billion at an average of 25-30 tonnes per hectare under rainfed production, Central Bank of Nigeria [7].

Tomato is grown and eaten all over the world. It is used in diverse ways, including raw in salads, and processed into tomato soup. Unripe green tomatoes can also be breaded and fried. Tomato juice is sold as a drink. The fruit is preserved by drying, often in the sun, and sold either in bags, baskets or in jars with oil. Tomato is rich in vitamins [8], minerals and lycopene, an excellent antioxidant [2] that helps to reduce the risk of prostate and breast cancer [9].

Tomato production requires a high level of management, large labour and capital inputs and close attention to detail. Tomato production is subject to the variations that occur in weather, which may result in severe crop damage and losses [10]. Labour requirements for production, harvesting, grading, packaging and transporting are very intense. Erdogan [11] confirms that tomato production is labour intensive and bulk of production is mostly supported by small family farm.

Major tomato producers in Kogi State are small scale farmers who could hardly produce enough to meet the demand of consumers. Tomato produced in the State is done mostly during the dry season, that is, October to May. The period between July to September is severe tomato scarce period because of high incidence of pests and disease associated with growing tomato; general crop management and shifting of tomato producers to production of grain crops [12]. These critical supply elements drive high demand for fresh tomatoes, causes inflation of fresh tomato price, opens market for unhygienic sun-dried tomato as well as clearance for imported fresh tomatoes from neighbouring States.

The failure of tomato farms to meet demand in Kogi State has raised concern over the ability of these farms to increase tomato output. In view of the growing demand for tomato in Kogi State, improving the efficiency of resource use would be the key to increased tomato production in the State. Thus, for the State to thrive in tomato production, it needs to achieve a high level of efficiency which is essential for competitiveness and profitability. It is against this background that this study intends to carry out the technical efficiency of resource use among tomato farmers as well as the factors influencing the output of tomato in Kogi State, Nigeria.

2. MATERIALS AND METHODS

This study was carried out in Kogi State, Nigeria which is located in the central region of Nigeria. It is popularly called the Confluence State due to the fact that the confluence of River Niger and River Benue is at it's headquarter in Lokoja. Lokoja, the State headquarter is the first administrative capital of modern day-Nigeria. The State lies between latitude $6^0 30^{'}$ N and $8^0 48^{'}$ N and longitude $5^0 23^{'}$ E and $7^0 48^{'}$ E. Kogi State has a population of about 3,278,487 people [13]. The State has land area of about 30,354.74 square kilometers. Out of this total area, the State has 2 Million hectares of cultivable land but only about 0.5 Million hectares are under cultivation, (Kogi State Economic Empowerment and Development Strategy (KOSEEDS), [14]).

A purposive sampling technique was used to select eight Local Government Areas (LGAs) from the four agricultural zones. The eight LGAs selected were: Kabba-Bunu, Ijumu, Bassa,

Omala, Ankpa, Lokoja, Ajaokuta and Olamaboro. These LGAs were purposively selected based on their level of involvement in tomato production. The survey was carried out in 2014. Two communities from each of the LGAs were randomly selected to give a total of sixteen communities used for the study. Fifteen tomato farmers were randomly selected from each of the sixteen communities to give a total of 240 respondents used for the study. Structured questionnaire was administered to the selected tomato farmers from the selected communities. The study used descriptive statistics, multiple regression analysis and efficiency ratio to analyse the data. The Multiple Regression and Efficiency Ratio models were specified as follows:

2.1 Multiple Regression Analysis

For this study, three functional forms were tested on the primary data collected, but the Cobb-Douglas function was chosen based on the R^2, value of the estimated coefficients, number of significant variables and conformity with the *a priori* expectation. The Cobb-Douglas production function investigated in this study is expressed mathematically as;

$$Y=f(X_s)$$
$$Y=f(X_1, X_2, X_3, X_4, X_5, X_6, X_7, e_i)$$
$$LnY=b_0+b_1LnX_1+b_2LnX_2+b_3LnX_3+b_4LnX_4+b_5LnX_5+b_6LnX_6+b_7LnX_7+e_i$$

Where:

Y= Output (kg), β_0= Intercept (kg), β= Marginal effect of X_S on Y, X_1= Sex (1 = Females, 0 = Males), X_2= Age of Respondents (years), X_3= Farming experience (years), X_4= Educational status (years), X_5= Household size (number), X_6= Access to extension (Number of contacts), X_7 = Farm size (hectares) and e_i= Error term.

It is expected that the value of each of the variables, that is, $b_1 – b_7$ will be positively related to the output of tomato in the area. By implication, the higher the quantity of these variables, the higher the output of tomato.

2.2 Efficiency Ratio

Efficiency ratio was used to determine the efficiency of resources used in tomato production. The estimated coefficients of the relevant independent variables were used to compute the Marginal Value Products (MVP) and their corresponding Marginal Factor Costs (MFC). The equation is

$$r = \frac{MVP}{MFC}$$

Where r = efficiency ratio

MVP = Marginal Value Product of variable input
MFC = Marginal Factor Cost

The value of MVP was computed using the regression coefficient of each input and the price of the output was expressed as stated below:

$$MVP_x = b_i \times P_y$$

Where
P_y = price per unit of output
b_i = regression coefficient of input i (i = 1, 2, ...n)
MVP_{xi} = Marginal Value Product of $input_{xi}$

The prevailing market price of inputs was used as the Marginal Factor Cost (MFC) [15].

The values of the ratios are interpreted thus:

i. If r < 1, means that the resource in question was over-utilized-therefore, if the quantity of such input is increased, profit will increase.
ii. If r > 1, means that the resource was under-utilized. If the quantity of such input is decreased, profit will increase.
iii. If r = 1, it means that the resource was being efficiently utilized.

3. RESULTS AND DISCUSSION

3.1 Socio-Economic Characteristics of Tomato Farmers in Kogi State

The distribution of respondents according to age revealed that majority (82.5%) were in the age range of 41-60 years. 9.6% of the respondents were above 60 years of age while 7.9% were within the age range of 21-40 years (Table 1). The mean age was 51 years. This implies increased productivity and technical efficiency among tomato farmers in the area since majority of the farmers are still in their active and productive age. This agrees with the findings of [16] who found that tomato production was dominated by adults who were between the age range of 40-60 years of age and attributed it to labour requirement in tomato production.

Majority (72.1%) of the respondents were male while 27.9% were female. This implies that tomato production in the study area was

dominated by men. 27.9% involvement of females in tomato production indicated that women were also in the business but to a smaller extent. This is in line with studies by [16] and [17] who reported that males dominated tomato production in Adamawa and Niger States respectively.

Distribution of respondents according to marital status revealed that majority (76.7%) of the respondents was married, 11.7% were single, 7.1% were widowed, and 4.6% of the respondents were divorced. This implies that apart from been a major source of income to the family, majority of the tomato farmers produce tomato most likely to cater for their family needs.

The table further revealed that half (50%) of the respondents had no formal education. 28.3% of the respondents attended primary school. 15.4% attended secondary school at both junior and senior secondary level, while 6.3% of the respondents attended tertiary institutions. This implies that about half (50%) of the sampled farmers do not know how to read and write while another 50% can read and write. The low level of education of the farmers could affect their adoption of appropriate technology. This agrees with the findings of [18] and [19] who reported relatively high level of illiteracy among small scale farmers in Rivers and Ogun States respectively.

Result on major occupation of the respondents showed that most (61.7%) of the tomato farmers were into full-time farming on an average farm size of 1.3 hectares. 19.5% combined civil service work with tomato production, while 11.7% and 7.1% of the respondents combined tomato production with artisan and trading respectively. This implies that the agricultural sector serves as source of employment and income to many households in the area. This finding is consistent with [20] who posited that the agricultural sector of Nigeria economy contributes significantly to rural employment, food security, provision of industrial and raw materials.

About 73.3% of the respondents had above 30 years of tomato farming experience. 13.8% had 21-30 years of experience, 8.7% had 1-10 years of tomato farming experience, while 4.2% of the sampled respondents had between 11-20 years of farming experience. The average farming experience was 37 years. The high level of experience among tomato farmers in the area may increase their level of efficiency, because the more experienced a farmer is, the more efficient he is supposed to become and vice versa. The finding supports the findings of [21], who reported a positive and significant relationship between farming experience and technical efficiency among Fadama farmers in Adamawa State.

About 95.8% of tomato farmers in the area cultivated tomato on an area of 3 hectares and below. Only 4.2% of the respondents had a farm land of above 3 hectares for tomato production. The mean farm size was 1.5 hectares. This implies that tomato production in the study area is still at the subsistence level. The small area of farm land may also be attributed to the perishable nature of tomato. This confirms the result of separate studies carried out by [22] and [23] who reported that the average number of hectares cultivated per farmer was found to be about 1.5 hectares.

Household size of most respondents ranged from 7-12 members (37.5 percent), above 12 members (32.5 percent) and to those with less than 6 members (30 percent). The mean household size was about 7 members per household. It is expected that members of the household will serve as source of labour on the farm. The range of household size is lower when compared with what is obtainable in the Northern part of the country, which recorded an average size of 13 members per household [24]. The average household size of 7 is the same with the national average of 7 and slightly lower than the findings of [25] who found a higher level of labour availability with an average of 8 members per household. Orebiyi et al. [26] have also reported that large family size may mean more family expenses and fewer funds for agricultural activities. The mean household size also could characterize moderate dependency ratio in Nigeria (Udo, 1999 in [27]).

About 51.3% of tomato farmers in the study area had annual income of ₦ 50 000 - ₦ 100 000 from tomato production, 22.5% of the respondents had below ₦ 50 000, 13.3% had above ₦ 150 000 annually from tomato production, while 12.9% of the sampled respondents had between ₦ 100 000 – ₦ 150 000 from tomato production. The average income of the respondents from tomato production was ₦ 74 590. This implies that tomato production in the study area is still at the subsistence level. Mikloda [28] associated low income with poverty. Also, according to [29], over 90% of the country's food supply comes from the agricultural population who are smallholder farmers.

Table 1. Distribution of respondents according to socio-economic characteristics

Socio-economic indicators	Frequency	Percentage	Mean/Mode
A. Age (years)			
20-40	19	7.9	
41-60	198	82.5	
Above 60	23	9.6	
Total	**240**	**100**	51 years
B. Sex			
Male	173	72.1	
Female	67	27.9	
Total	**240**	**100**	Male
C. Marital status			
Single	28	11.7	
Married	184	76.6	
Widowed	17	7.1	
Divorced	11	4.6	
Total	**240**	**100**	Married
D. Educational status			
No formal education	120	50.0	
Primary education	68	28.3	
Secondary education	37	15.4	
Tertiary education	15	6.3	
Total	**240**	**100**	No formal education
E. Major occupation			
Farming	148	61.7	
Civil service	47	19.5	
Trading	17	7.1	
Artisan	28	11.7	
Total	**240**	**100**	Farming
F. Farming experience (years)			
1-10	21	8.7	
11-20	10	4.2	
21-30	33	13.8	
Above 30	176	73.3	
Total	**240**	**100**	31 years
G. Farm size (hectares)			
Less than 1	96	40.0	
1-1-2.0	121	50.4	
2.1-3.0	13	5.4	
Above 3	10	4.2	1.3 hectares
Total	**240**		
H. Family size (Number)			
1-6	72	30.0	
7-12	90	37.5	
Above 12	78	32.5	
Total	**240**	**100**	7 members
I. Level of Income (Naira)			
Below 50 000	54	22.5	
50 000 – 100 000	123	51.3	
100 001 – 150 000	31	12.9	
Above 150 000	32	13.3	
Total	**240**	**100**	89, 000

Source: Field survey, 2014

3.2 Effect of Socio-Economic Characteristics on Tomato Output in Kogi State

The regression analysis on the effect of socio-economic variables on the output of tomato in the study area is presented in Table 2.

Ordinary Least Square (OLS) estimation technique was used to determine the effect of socio-economic characteristics on tomato output in the study area. Three functional forms such as linear, semi-log and double-log were fitted into the model.

After some econometric considerations such as number of significant variables, F – ratio and R^2 value, the double-log functional form was selected as the lead equation.

The regression result indicated an R^2 value of 0.740 meaning that 74 percent of the variability in the model was explained while the remaining 26 percent could be attributed to error terms and omitted variables. The F-ratio was 132.38 at 1 percent significance which means that the independent variables jointly explained the dependent variable.

Table 2 indicated that years spent in school, extension contact, and farm size were significant socio-economic variables influencing the output of tomato production in the study area. Number of years spent in school (X_4) was found to be positively related to the output of tomato and significant at 1 percent. This implies that an increase in the number of years spent in school increases the output of tomato. The higher the level of education, the more enlightened a farmer becomes in adopting new innovation with its multiplier effect on increased output. Education is believed to increase the ability to perceive, interpret and react to new events and improves farmers' managerial skills. This agrees with [30] who reported that formal education has helped farmers to obtain useful information from bulletins, agricultural newsletters and other print media sources of information. Sani et al. [31] underscore the importance of the individual farmer to know how to seek for and apply information on improved farm practices.

The coefficient of extension contact (X_6) was found to be positive and significant at 1 percent. This implies that an increase in extension contact increases the output from tomato production. Otunaiya and Akinleye [32] confirmed that contact with extension workers will increase the likelihood that a farmer will adopt improved maize technologies and this will lead to increased maize output. Also, [17] found a positive relationship between extension contact and the output of irrigated tomato in Niger State.

Table 2. Regression results for effect of socio-economic variables on tomato output

Variables	Linear	Semi-Log	Double-Log
Constant	8.075	7.076	7.623
	(0.025)	(35.242)**	(24.656)**
Sex	279.587	-0.048	0.0056
	(2.314)*	(-0.629)	(1.41)
Age	0.269	0.004	-0.070
	(0.50)	(1.055)	(-0.863)
Farming Experience	4.204	0.003	0.021
	(0.861)	(1.133)	(0.596)
Years Spent in School	26.266	-0.0196	0.089
	(3.63)**	(-4.01)**	(3.657)**
Household size	5.380	-0.016	0.001
	(0.267)	(-1.226)	(0.026)
No. of Extension contacts	171.511	-0.037	2.952
	(1.350)	(-0.467)	(69.12)**
Farm size	1537.874	0.288	0.851
	(22.418)**	(6.868)**	(25.492)**
F-value	74.505**	68.105**	132.38**
R^2	0.692	0.57	0.740

Source: Computed from field survey, 2014

*Note: Figures in parentheses are t–values. * and ** denote 5 and 1 percent level of significance respectively*

The regression result also shows that the coefficient of farm size (X_7) was positive and significant at 1 percent. This implies that a unit increase in the hectares of farm land for tomato will lead to an increase in the output of tomato, *ceteris paribus*. This corroborates [17] who reported a positive relationship between farm size and irrigated tomato output at 1 percent level of significance.

Furthermore, the coefficient of sex, farming experience, and household size were positive. However, the relationships were statistically not significant at the levels tested in this study. This implies that an increase in these socio-economic variables will lead to increased tomato output.

The result on farmers' age shows a negative relationship with a coefficient of -0.070. This implies that the older a farmer, the less energetic he becomes in carrying out farming operations leading to decreased tomato output.

3.3 Effects of Resources Used on Tomato Output

The effect of resources used on tomato output in Kogi State is presented in Table 3.

The efficiency indictor in Table 4 revealed that pesticide, quantity of seed, and kg of fertilizer has ratios that are less than unity. This means that these variable inputs in tomato production were over-utilized and increase in the supply of these resources will increase tomato output. The finding of this study on seed corroborates with [17] who reported an efficiency ratio of -19.3 for quantity of seed used in irrigated tomato production in Niger State. Also, [33] found an over-utilization of fertilizer, pesticide, and seed with efficiency ratio of 0.08, -0.04, and 0.16 respectively for tomato production in Benue State.

Table 4 also shows that inputs such as labour and farm size have an efficiency ratio of 1.2 and 15.2 respectively. This means that these inputs were under-utilized in tomato production in the area and a decrease in the supply of these resources will increase the output of tomato produced in the State. The result on farm size agrees with [33] who found an efficiency ratio of 1.24 for farm size. The finding on labour agrees with [17] who reported an efficiency ratio of 9.584 for labour. All the inputs were not utilized to optimum economic advantage. A resource is said to be optimally allocated if there is no significant difference between the MVP and MFC, that is, if the ratio of MVP to MFC = 1.

Table 3. Linear regression for the estimation of resource use efficiency in tomato production

Variables	Coefficients	Std. error	t-value	p-value
Pesticide	64.580	37.893	1.704	0.090*
Labour	123.652	44.964	2.745	0.003**
Quantity of seed	55.934	39.478	1.852	0.068*
Years in school	19.999	11.088	1.804	0.073*
Farm size	1519.891	86.621	17.546	0.000***
Fertilizer	0.974	1.193	0.816	0.415
Farming experience	7.005	4.786	1.464	0.145
Household size	11.398	20.316	0.561	0.575
F value = 65.471				
Prob >F = 0.000				
R^2 = 0.694				
Adjusted R^2 = 0.683				

Source: Computed from field survey, 2014.

Table 4. Estimated resource use efficiency in tomato production in Kogi State

Farm inputs	Coefficient	P_y	MVP	MFC	r= MVP/MFC	Remarks
Pesticide	64.580	5	322.9	1850	0.2	Over-utilized
Labour	123.652	5	618.26	500	1.2	Underutilized
Seed	55.932	5	279.66	925	0.3	Over-utilized
Farm size	1519.891	5	7599.46	500	15.2	Underutilized
Fertilizer	0.974	5	4.87	100	0.05	Over-utilized

Source: Computed from field survey, 2014

4. CONCLUSION

The study analysed resource use efficiency in tomato production in Kogi State, Nigeria. The OLS regression result revealed that pesticide, labour, years spent in school, quantity of seed and farm size were positively and significantly related to tomato output in Kogi State. The efficiency ratio result showed that quantity of pesticide, seed and fertilizer were over utilized while labour and farm size were underutilized. The study further showed that all the inputs were not utilized to optimum economic advantage. The profit level of farmers can be increased if these resources are efficiently allocated and utilized. Also, farmers' educational experience, contact with extension workers, and farm size increased tomato output in the State.

5. RECOMMENDATIONS

Based on the findings the following recommendations were made:

1. Prices of inputs such as fertilizer, seed and pesticide should be subsidized by government. This will enable farmers increase the use of these resources as they were over-utilized in tomato production in the study area.
2. There should be extension services that will facilitate the efficient utilization of agricultural resources among tomato farmers in Kogi State. This will enhance the output of tomato produced in the area and achievement of optimum resource allocation.
3. Educational status had positive relationship with tomato farmers' output. Therefore, policies that will enable the farmers to improve on their education and grant them increased access to credit should be vigorously pursued for increasing the farmers' efficiency and income.
4. Tomato farmers in the area should be encouraged to form cooperative societies so as to enable them obtain loans from commercial banks, agricultural banks, and other financial institutions. This will enable them purchase the needed inputs that will increase tomato output in the area.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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