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DETERMINANTS OF TECHNICAL EFFICIENCY IN IRRIGATED TOMATO PRODUCTION UNDER KANO RIVER IRRIGATION PROJECT, PHASE I

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ABSTRACT

The present study has estimated the Determinants of Technical Efficiency in Irrigated Tomato Production under Kano River Irrigation Project, Phase I. Primary data were collected from 213 irrigated tomato farmers, using multi-stage sampling techniques in three local government areas covered by KRIP. Data were collected during the 2014/2015 irrigation farming season using structured questionnaire. Data collected were analyzed using two-stage Data Envelopment Analysis (DEA) and regression models. Findings further revealed that none of the sampled irrigated tomato farmer reached the frontier threshold. Also, factors such as age, household size, farming experience, sources of finance, sex and cooperative society were responsible for 59% total variation in technical efficiency among the three categories of irrigated tomato farms. Based on the findings of this study, it can be concluded that age, household size, farming experience, amount of credit, extension contact, cooperative societies and sex were the determinants of technical efficiency were for all the three categories of farms. It was therefore, recommended that since cooperative membership was a significantly determinant of technical efficiency, irrigated tomato farmers should join cooperative societies, so as to be able to benefit from the government and non-governmental organisations through increased credit access, input supply and farm advisory services.

Keywords: Tomato, Production, Irrigation, Technical Efficiency, Kano-River

INTRODUCTION

One of the main reasons for low productivity in agriculture all over the world, including Nigeria is the inability of the farmers to fully exploit the available technologies, resulting in lower efficiencies of production (Murthy, Sudha, Hegde and Dakshina, 2009). This fact has been emphasized in many studies, particularly on cereals and pulses (Villano and Fleming, 2006; Mehmet and Ceylon, 2007). Tomato (*Lycopersicon esculentum* Mill) is an important vegetable crop in many parts of the world. It is one of the most important vegetables grown for its edible fruits in virtually every part of Nigeria. It is also one of the most widely cultivated crops in the world. It is an important source of vitamins and an important cash crop for small - holder and medium scale commercial farmers (Shankara, Joep Van Lidt, Marja Martin and Barbara, 2005). The tomato fruit is an essential component of the diet of man and also an important industrial commodity (Jaliya, Sani, Lawal and Murtala, 2007).

Tomato fruit is a good source of many essential nutrients and vitamins. It is therefore an important source of vitamin A, Iron and Calcium which are critical to the nutrition of children and pregnant women and essential for healthy growth and protection against diseases (Anons, 2011). It also has medicinal properties as it removes disease particles and opens natural channels of the body. It is gentle natural stimulant for kidneys and helps to wash away the toxins which contaminate system and cause diseases. (Anons, 2010). Despite these great importance, tomato is faced with major problems or issues limiting agricultural productivity in Nigeria and these includes low yields due to the use of low technology inputs, poor yielding seeds and livestock, lack of or poor adoption of improved production technologies, poor infrastructure, poor access to finance and poor marketing structures. Thus, to raise productivity and stimulate the sector, these problems need to be mitigated through adequate research and provision of technologies which would lead to competitive production (CBN, 2010).

Government in its efforts to mitigate these issues or problems confronting tomato production, large scale tomato production introduced the Kano River Irrigation Project, Phase I (Olanrewaju and Swarup,1983).The bulk of tomato production lies in the Northern part of the country especially areas around Jigawa and Kano States (Abba and Shehu, 2007). As a result of tomato production under the KRIP, a 1500 tonnes per day tomato processing plant is being constructed in the area. These haves provided employment to thousands of the tomato merchants and brokers in local processing and marketing of the commodity (HJRBDA, 2013). Consequently, this study intended to examine the determinants of technical efficiency in irrigated tomato production under Kano river irrigation project, phase I.

Table 1: Irrigated Tomato Production for Three Seasons in the Study Area

Dry Season (Year)	Area Covered (Hectares)	Average Yield (Tonnes/Ha)	Production (Metric Tonnes)
2009/2010	1,200.00	15.0	18,000.00
2010/2011	7,736.00	15.0	116,040.00
2011/2012	4,798.13	17.5	83,967.28
2012/2013	300.00 15.0	4,500.00	

Source: HJRBDA (2013/CPV 2014)

METHODOLOGY

The Study was carried out in Kano State, Nigeria. The State lies between Latitudes 12^0 $37^{'}$ North to 9^0 $33^{'}$South and Longitudes 9^0 $29^{'}$ to 7^0 43'West. It shares boundary with Jigawa State to the Northeast, Katsina State to the Northwest and Kaduna State to the South. Kano State consists of two agro-ecological zones namely, Northern Guinea Savannah (NGS) and the Sudan Savannah (SS). The southern part of the State is in the NGS, which has an annual rainfall of 600-1,200mm. The central and northern parts are in the SS, with an annual rainfall of 300-600mm (Kano State Government, 2012).The state comprises of 44 local government areas with population of 9,383,682 (NPC, 2006). The projected population in 2018 with national growth rate of 3.0% is 13,745,862.84. The predominant ethnic groups are Hausa and Fulani.

The cropping system is mostly undertaken under rain-fed condition and majority of the farmers are small scale holders with less than 2.5 hectares per farming household and either resources are meager (KNARDA, 2002). The upland crops commonly grown are millets, sorghum, cowpea and maize, while the low land/Fadama crops grown in the state includes tomato, onion, and pepper with rice and wheat grown in the flood plains and irrigated areas. The Research was specifically conducted under Kano River Irrigation Project (KRIP), Phase I because of large scale cultivation and highest number of tomato farmers in the state.

The KRIP is one of the largest and successful projects, not only in Nigeria, but in West African sub-region. It is unique in its design in that the entire water distribution network operates on gravity. Water is conveyed from Tiga Dam to the project site through 18km long main canal, which splits into East (Bunkure) and West (Garun Mallam and Kura) Branches. Crops cultivated include tomato, wheat, onion, maize, rice, garlic, cucumber, potatoes, millet, guinea corn and melon (HJRBDA, 2013). The KRIP Phase I is currently providing all year-round direct employment to about 41,250 farmers and their families. Over 5.0 million man-days of employment are being generated as indirect employment to communities within and outside the project area annually. Farmers produce an average of 200,000 metric tonnes of food and cash crops valued at over ₦2.7 billion annually, thereby contributing significantly toward enhancing national food security (HJRBDA, 2013).

Figure 1: Map of Kano State showing the study area.

Sampling Procedure and Sample Size

Kano state comprises of three agricultural zones, namely Danbatta, Rano and Gaya zones. Rano zone was purposively selected because of its highest number of irrigated tomato farmers. The major irrigated tomato producing local government areas in the zone are Bunkure, Garun-Mallam and Kura which are covered by (KRIP) Phase I, (HJRBDA, 2013).Two villages with the highest number of large scale irrigated tomato farmers from each of the three local government areas were purposively selected. Finally, random number sampling was employed to select 10%, the three categories of scale are homogeneous having similar characteristics in terms of age, location or employment (Nielsen, 1998; Procter and Meullenet,1998), of the total population (2122) making a sample size of 213. According to Haruna (2004), Usman and Bakari (2013), the three categories of irrigated tomato farmers were:

i. all farmers with farm size of less than a hectare are small scale farmers(<1.0ha)

ii.all farmers with one hectare to less than three hectares are medium scale farmers(1.0ha to 2.9ha)

iii. all farmers with three hectares and above are large scale farmers (3.0ha and above)

Table 2: Summary of Sampling Procedure (n=213)

Local govt.	Village	Sampling frame			Sample size (10%)		
		S	M	L	S	M	L
Bunkure	Gafan	342	68	32	34	7	3
	Dorayi	129	50	18	132	5	2
Garun Mallam	Bangaza	62	27	35	6	3	4
	Agalawa	133	38	20	134	2	
Kura:	Bugau	466	44	118	474	12	
	Dakasoye	392	133	15	3913	2	

Source: KRIP-WUCS (2014)

Note: 1. The villages were purposively selected based on high number of large size irrigated tomato farmers for the sampling.

2. S, M and L stand for Small, Medium, and Large sizes respectively.

Data collection

Primary data were used for this study. The data collected was based on 2014/2015 irrigation farming season with the aid of structured questionnaire through the assistant of field enumerators in a manner that allows the collection of relevant data on specific variables that were investigated. Information was collected on the following variables among others: age, sex, marital status, educational status, household size, access to extension contacts, farming experience, farm size, sources of finance, cooperative membership, type and cost of labour (both family and non-family), access to market, type and cost of inputs used per hectare, revenue, water rate, produce prices, and problem faced by the farmers.

Analytical techniques

The factors influencing the producer level of technical efficiency was determined by regressing the efficiency indices from model against some socio-economic characteristics of the farmer. The technical efficiency indices were used as proxy for technical efficiency. The technical efficiency model is implicitly expressed as:

$$Y = f\ (X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8, X_9, U_i), \quad (1)$$

Where:

Y_i = technical efficiency (technical efficiency indices)
X_1= age of farmer (years)
X_2 = farming experience (years)
X_3 = level of education of farmer (years of formal education)
X_4 = household size (numbers)
X_5= sex of the farmer (male or female)
X_6 = number of extension contact
X_7 = group membership (years of membership)
X_8 = source of finance (value in Naira)
X_9 = marital status (married=1, unmarried=0)
$\alpha_1 - \alpha_9$ = parameters to be estimated.
U_i is expected to be negatively related to the level of inefficiency in irrigated tomato production under small, medium and large sizes.
Subscript i indicate ith farmer in the sample

The functional forms (Linear, Semi-Log, double-log, and Exponential) were tried and the lead equation (semi-log, one with the highest coefficient of determination R^{-2} value) was selected.

RESULTS AND DISCUSSION

Estimate of technical efficiency based on the three sizes of production in the study area

The frequency distribution of the technical efficiency estimates for irrigated tomato farmers in the study area as obtained from the Data Envelopment Analysis model is presented in Table 3. Result revealed that 49%, 56% and 64% of the small, medium and large farms respectively operated within a technical efficiency range of 0.61 and less than 1.00. While, approximately 39%for all farms operated within a technical efficiency range of 0.20-0.40. The implication of this result is that majority of the irrigated tomato farmers are not technically efficient in the use of production resources. This maximum possible level attainable may be due to inefficiency and hence results to low productivity. The study also reveals that technical efficiency among the irrigated tomato farmers varied substantially ranging between 0.316 and 1.00 for small farms, 0.474 and 1.00 for medium farms and 0.656 and 1.00 for large farms with a mean technical efficiency of 0.763, 0.826 and 0.854 for small, medium and large farms respectively. This result suggests that the farmers are not utilizing their production resources efficiently, indicating that they are not obtaining maximal output from their given inputs. In other words, technical efficiency among the irrigated tomato farmers can be increased by 23.7%, 17.4% and 14.6% for small, medium and large farms respectively through better use of available production resources such as fertilizers and pesticide given the current state of technology. This finding agrees with (Asogwa, Ihemeje and Ezihe, 2011) that Nigerian rural farmers did not obtain maximum output from their given quantum of inputs.

Table3: Frequency distribution of technical efficiency estimates based on size of operation in the study area

Technical Efficiency	Small Farms	Medium Farms	Large Farms
<0.20	2	0	0
	(1)	(0)	(0)
0.20-0.40	49	4	0
	(32)	(11)	(0)
0.41-0.60	26	12	9
	(17)	(33)	(36)
0.61-0.80	75	20	16
	(49)	(56)	(64)
0.81-1.00	0	0	0
	(0)	(0)	(0)
Mean	0.763	0.826	0.854
Min	0.316	0.474	0.656
Max	1	1	1

Determinants of technical efficiency of irrigated tomato producing farms

In assessing the determinants of technical efficiency of irrigated tomato production in the study area as shown in Table 4, four functional forms (linear, semi-log, double-log and exponential) were estimated. The semi-log model was chosen as the lead equation due to the higher coefficient of determination (R^{-2}) value, the significance number of explanatory variables and the conformity of estimates to a priori expectations.

It was revealed that the determinants of technical efficiency were age, household size, farming experience, amount of credit, extension contact, cooperative societies and sexfor all the three categories of farms.

The coefficient of age was significant for all the three categories of farms. It implies that 1% increase in their age could influence the efficiency to the extent of 0.69% increase in small farms, 0.90% increase in medium farms and -0.33% decrease in large farms. Coefficient for age was found to be positive for age among small and medium scale farms. It implies that as the age of farmers increases their experience in acquiring and handling inputs increases thereby making them more efficient. On the other hand, coefficient for age was negative among the large-scale farm but significant at 10%. It implies that older farmers have acquired more human capital through their experiences, but they also may be less willing to adopt new ideas to tomato productions which could reduce efficiency. Abdullahi and Huffman (1998) found that older rice farmers in Northern Ghana were less efficient than younger farmers while Coelli *et al., (*2002) found that younger rice farmers in Bangladesh were more efficient than older rice farmers.

Also, it was found that the coefficient of household size was significant for all the three categories of farms. It implies that 1% increase in their household size could influence the efficiency to the extent of 0.25% increase in small farms, 0.10% increase in medium farms and -0.16% decrease in large farms. It implies that larger the household size the more available labour help in farm work. The size of the household in a society usually influences the rate of population growth of that society, which in turn can determine the labour force. It is assumed that the larger the size of the household of a farming community, the greater the availability of hands to offer help in farm work (Okafor *et al*., 1994).

Farming experience was also found to significantly influence the technical efficiency in the two categories of farms (small and large scale farms).It implies that 1% increase in their farming experience could influence the efficiency to the extent of 0.35% increase in large farms and 0.00002% increase in small farms. Most experienced farmers know cropping practices to employ for optimum yield which is likely to have higher productivity. Oluyole *et al.,* (2009) also reiterated that an experienced farmer is likely to have higher productivity and hence be able to provide more food for his household members.

It was found that source of finance significantly influences the technical efficiency in the two categories of farms (small and medium scale farms). It implies that 1% increase in their amount of credit received could influence the efficiency to the extent of -0.02% decrease in small farms and 0.001% increase in medium farms. Suggesting that households with access to credit facilities would be economically empowered to divert incomes and access food in adequate quantity and quality. However, the result indicated negative coefficient for small scale farms. This may likely be attributed to the bureaucratic process(s) involved in credit acquisition, nature and type of collateral etc.

Extension contact and sex were found to significantly influence the technical efficiency in large scale farms. It implies that 1% increase in their contact with the extension agent and sex could influence the efficiency to the extent of 0.001% increase and in -0.62% decrease in large farms, respectively. The regression produced a negative coefficient for sex indicating the tendency for female headed households to have lower efficiency scores. This could be because women are more aware or concerned with the food requirements of the family (Thomas 1990).They may therefore be more likely than men to recognize the advantages of cost saving technologies and are hence able to produce at lower costs. In addition, female household heads are normally members of farmer groups and are more likely to regularly attend meetings organized by extension workers. This makes them more knowledgeable and certain to adopt new technologies. Frequent extension contacts expose the farmer to new and improved farming practice, enhances the level of adoption

and general farm output. This implies that the higher the number of extension contacts per cropping season, the higher the probability of increased productivity.

It was found that cooperative society was also found to significantly influence the technical efficiency in the two categories of farms (small and medium scale farms). It implies that 1% increase in their membership in cooperative society could influence the efficiency to the extent of 0.00003% increase in small farms and -0.004% decrease in medium farms. Active participation in cooperative activities tend to attract benefits in terms of helping members in mobilizing resources within society for agricultural operations and marketing, access to inputs (essential manufactured goods) at cheaper rates, enables members take advantage of economies of scale in production, processing and marketing of agricultural produce. Also, it assists in the training and education of members in modern agricultural practices and use of agricultural inputs

Table 4: Estimate of the Determinants of Technical Efficiency of Irrigated Tomato Production

Variable	Small Farms		Medium Farms		Large Farms	
	coefficient	t-value	B	t-value	B	t-value
Constant	0.996	16.306	0.477	0.700	1.878	3.970
Age	0.688***	93.024	0.902***	5.838	-0.328*	-1.931
Household size	0.246***	13.630	0.100*	1.748	-0.163***	-2.487
Education	0.00001	0.431	0.0001	0.413	-0.000005	-0.046
Farming experience	0.00002*	1.884	-0.010	-0.168	0.348***	2.714
Amount of credit	-0.019***	-2.688	0.001***	3.656	-0.0002	-1.413
Extension contact	0.000004	0.396	-0.0001	-0.532	0.001***	4.972
Cooperative societies	0.00003**	2.438	-0.004***	-27.001	0.0001	0.930
Sex	-0.000003	-0.402	0.038	0.173	-0.621***	-3.133
Marital status	0.006	0.296	0.191	0.613	-0.118	-1.249
R^2	0.686		0.489		0.743	
Adjusted R^2	0.585		0.423		0.689	

Note: *** P < 0.01,** P < 0.05 and * P < 0.10

CONCLUSION AND RECOMMENDATIONS

Based on the findings of this study, it can be concluded that irrigated tomato farming being an essential component of the diet of man and also an important industrial commodity, any attempt to increase its production would be a right step in the right direction for economic development. It was revealed that age, household size, farming experience, amount of credit, extension contact, cooperative societies and sex were the determinants of technical efficiency were for all the three categories of farms. It was therefore, recommended that since cooperative membership was a significantly determinant of technical efficiency, irrigated tomato farmers should join cooperative societies, so as to be able to benefit from the government and non-governmental organisations through increased credit access, input supply and farm advisory services.

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