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Technical efficiency of watermelon (*Citrullus lanatus*) production in Ogun State, Nigeria

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Abstract

This study was designed to measure the level of technical efficiency, its determinants in watermelon (Citrullus lanatus) production and the constraints in the production system in Yewa North Local Government of Ogun State using a stochastic frontier production function. A combination of purposive and random sampling technique was used to select 80 watermelon farmers for the study. The socio-economic characteristics show that the farmers are predominantly males, mostly (78.8%) married with majority (87.6%) having at least primary school education. The cost and return analysis shows a high net farm income per hectare of ₦25, 574.24. The estimated farm level mean technical efficiency was found to be 65 percent. This result indicates that great opportunities exist for the farmers to increase their productivity and income through improvement in technical efficiency. Age and off-farm income were found to be positively and significantly related to the technical efficiency while education was negatively signed, as expected, but significant. Policies aimed at improving farmers' access to education through aggressive awareness campaigns and mass mobilizations are recommended by the study.

Keywords: Watermelon, Technical efficiency, Frontier production function, Ogun State.

Introduction

The origin of watermelon has been traced to Africa and the Middle East where it was cultivated for thousands of years, and in China since at least 900 AD. Watermelon was brought to the New World in the 1500s. Watermelon is the fruit of a plant originally from a vine of southern Africa. It is a member of the *cucurbitaceae* family. The crop is grown commercially in areas with long frost-free warm periods (Majid, 2011). China, Turkey, Iran, Brazil, United States, Egypt and Russian Federation are the major watermelon producers (FAO, 2010). In 2009, Iran produced about 3,070,000 tonnes of watermelon on 130,718 hectares of land. Hamadan province is one of most important watermelon producers in Iran. In 2008, for example, the crop was planted in 13,717 ha in this province (Majid, 2011).

The watermelon fruit, loosely considered a type of melon (although not in the genus *Cucumis*), has a smooth exterior rind and a juicy, sweet, usually red interior

flesh. The species descriptor *Citrullus vulgaris* is sometimes, synonymously, used to refer to this plant (*vulgaris)* meaning "common" (Fehner, 1993). Watermelon (*Citrullus lanatus*) is a warm season crop in the Cucurbit family. As with other vine crops in this family, watermelon can require considerable space, depending on the production method (Rhodes and Zhang, 1999).

Costs of production of watermelon would vary depending on location. Costs such as water and land least vary by the production location, but the amounts of inputs such as fertilizer, pesticide, etc. depend on weather and soil (Rhodes and Zhang. 1999). Generally, watermelon production is labour intensive, especially in harvesting and postharvest handling (Baameur, 2009). Several reasons have been the basis for the need of improving the production of watermelon; one of which is that it can survive even in a water logged area (Robinson, 2000). This shows the employment opportunity that watermelon production could provide to the teeming unemployed youth in Nigeria. In addition, watermelon can serve the purpose of both a fruit and a vegetable; therefore, having a higher market demand.

Watermelon is popularly used as a fruit, to be a sweet enhancer or fun accompaniment to our everyday meals. The watermelon is often cut into bite-sized squares or balled, or very often simply sliced and enjoyed. It's also used in the types of recipes that are created using fruit. The whole watermelon is edible, even the rind. In places like China, the watermelon is stir-fried, stewed and often pickled. In this case, the watermelon is being used as a vegetable. Pickled watermelon rind is also widespread in Russia (Wehner, 1999).

Despite the economic importance of watermelon, studies in economic analysis of the crop in Nigeria are scarce, though there are a number of studies carried out on its agronomy. It is important therefore, to ask the following question, for which this study aims at providing answers; first, is watermelon production profitable? Second, what are the causes of low production and supply of watermelon?

Information on the costs and returns as well as technical efficiency of watermelon production will be very useful. Technical efficiency here refers to the ability to produce the highest level of output with a given bundle of resources (Onyenweaku and Nwaru, 2005). According to Dung *et al*. (2010), the estimation of the technical efficiency using stochastic frontier production function makes it possible to find out whether the deviation in technical efficiency from the frontier output is due to farm specific factors or external random factors. The broad objective of this study is to provide information that will optimize watermelon output within the limits of farmers' scarce resources. The specific objectives of the study are to describe the socio-economic characteristics of producers, examine the cost and return structure of watermelon production, analyze the technical efficiency of the system and determine the sources of inefficiency in watermelon production. The study provides a policy solution aimed at improving watermelon production in the study area.

Methodology

The study was conducted in Yewa North Local Government Area of Ogun state. It is one of the few areas where watermelon is produced in Ogun state; with its headquarters in Ayetoro. It is divided into

four zones which are Isokan, Iju, Ketu central and Ketu south. The area is essentially derived Forest vegetation endowed with good climate condition for agricultural production throughout the year. Its tropical nature enables bi-modal rain peak per annum in July and September with dry season in November. The main occupation in this study area is farming, trading, and other agro-business. The target populations were the watermelon farmers in Yewa North, Ogun State. These farmers could only be found in few selected places in the area.

Four towns/villages were purposively sampled, for large production of watermelon in the study area, namely; Egua, Ijoun, Ibese and Ayetoro. Thereafter, twenty (20) watermelon farmers were randomly selected in each of the town/village; this procedure gave a sample size of eighty (80) farmers used in the study. Data was collected from the watermelon farmers by scheduled interview; through the use of a structural questionnaire.

Descriptive analysis was used to examine the socio-economic characteristics of the farmers in the study area. Budgetary analysis was used to examine the cost and return structure of watermelon production in the study area, it is measured as:

Gross Farm Income (GFI) = Total Revenue (TR) – Total Variable Cost (TVC)…. (1)
Net Farm Income (NFI) = Total Revenue – Total Cost of Watermelon production …(2)
Return on Investment: $\frac{\text{Net Income}}{\text{Total Cost}}$ X 100 ……..(3)

Quantitative technique was used to estimate the technical efficiency of watermelon farmers in the study area. Following Aigner, Lovell and Schmidt (1977), Meeusen and Vanden Broeck (1977) and Coelli (1995) a Cobb-Douglas form of Stochastic Frontier Production Function (SFPF) was specified and estimated as follows:

$$\ln Q_i = \alpha_0 + \sum_{j=1}^{6} \beta_j \ln(X_{ji}) + \sum_{j=1}^{6}\sum_{k=1}^{6} \psi_{jk} \ln(X_{ji}) \ln(X_{ki}) + V_i - U_i \quad \text{.....(4)}$$

Where:
Q_i = Quantity of watermelon produced by the i-th cultivator;
X_1 = Quantity of inorganic fertilizer (per bag)
X_2 = Quantity of seed(s) (Kg)
X_3 = Number of labour (manday)
X_4 = Total land area (hectare)
X_5 = Herbicides (liters)
X_6 = Other Intermediate Cost (₦)

The inefficiency model base on Battese and Coelli (1995) was specificied as:

$$\mu_i = \delta_0 + \sum_{i=1}^{5} \delta_i Z_i + \omega_i \quad \text{.....(5)}$$

Where;
Z_1 = age of the farmer (years)
Z_2 = sex of the farmer (years)
Z_3 = marital status
Z_4 = off-farm income (₦)
Z_5 = number of farmers having membership orientation on borrowing
Z_6 = experience of the farmer (years)
Z_7 = educational level of farmer (years)

Results and discussion

Socio-economic characteristics of the respondents

The socio-economic characteristics of the respondents described in this study include the age of the respondents, sex, marital status, educational qualification, household size and major occupation.

Table 1 shows that a good number of the watermelon farmers in the study area are adults, they are within the age bracket of 31-60 years. This age group constituted 87% of the total respondents. Only 40% of the respondents are above 50years of age. The sex distribution of the sampled farmers revealed that 76.3% of the sampled watermelon farmers are male while only Table 1 further reveals that about 78.8% of the farmers are married while 21.3 are either single, widow or divorced. It is also noteworthy that majority of the farmers' attained (82.6%) either a primary school education or secondary school education. Only about 5% attended higher institution while the remaining 12.5% did not have any form of formal education. On an average, watermelon farmers in the study area can be considered to be literates; as majority of them can read and write.

Table 1: Socio-Economic Characteristics of Farmers

Age Range	**Frequency**	**Percentage**
21 – 30	10	12.5
31 – 40	20	25.0
41 – 50	18	22.5
51 – 60	32	40.0
Sex		
Male	61	76.3
Female	19	23.8
Marital Status		
Married	63	78.8
Single	3	3.8
Widowed & Divorced	14	17.5
Education		
No formal education	10	12.5
Primary	37	46.3
Secondary	29	36.3
Tertiary	4	5.0
Household Size		
2 – 4	21	26.3
5 – 7	49	61.3
8 – 10	8	10.0
11 and above	2	2.5
Major Occupation		
Farming	61	76.3
Trading	4	5.0
Artisan	11	13.8
Civil Servant	4	5.0
Total	**80**	**100.0**

The distribution of the farmers' household size shows that most of them (61.3%) have relatively large household of 5-7 members. The distribution further shows that about 12.5% of the farmers have eight or more members in their households. Only about a quarter of the farmers (26.3%) have four or less household size. Table 1 also shows that 76.3% of the watermelon farmers in the study area are full-time farmers. Only about 23.8% are part-time farmers who engage in off-farm activities such as trading, artisan and civil service.

Other farms/farmers Characteristics

The study examines other socio-economic characteristics of the watermelon farms and farmers in the study area. The results are presented in Table 2 below.

The results indicate that more than half of the watermelon farms (about 55%) were never subscribed to a cooperative society. Also about 80 percent of the watermelon farmland was inherited. This result indicates that farmers rarely buy farmland (about 3.8%) for the purpose of watermelon production. Most of the respondents in the study area (55%) were found to acquire watermelon production skill through friends. Farmers' cooperatives trained about 23.8 percent. While farmers that attended institutional training or contacted extension agents on the know-how of watermelon production are 6.3 percent and 15 percent respectively. Table 2 further reveals that about 67.5 percent of the sampled farms purchased their seed from local market while 23.8 % and 8.8% purchased seed from farmers' cooperative society and Agro-service centre respectively.

Table 2 also shows that most farms in the study area (about 88.8 percent) have cultivated watermelon for at least four years. This period is long enough for the farms to acquire necessary experience to maximize output and optimize their productivity. The distribution of farms' method of disposing their output shows that bulk of the farm outputs (about 6.3percent and 65 percent) are sold directly by the farmers either at farm gate or at local market respectively. Marketing intermediaries, marketing cooperative and middlemen, play very little role in watermelon marketing.

Table 2: Distribution of Farm Characteristics

Coop Membership	Frequency	Percentage
Yes	36	45.0
No	44	55.0
Land Acquisition		
Inheritance	64	80.0
Leasing	13	16.3
Purchased	3	3.8
Production Skill Source		
Institutional training	5	6.3
Friends	44	55.0
Extension	12	15.0
Farmers' Cooperative	19	23.8
Sources of Seed		
Local market	54	67.5
Farmers' cooperative	19	23.8
Agro-service	7	8.8
Experience		
1 – 3	9	11.3
4 – 6	34	42.5
7 – 9	16	20.0
> 10	21	26.3
Sales Method		
On-farm (Farm gate)	5	6.3
Local markets	52	65.0
Marketing cooperative	2	11.3
Middle men	2	17.5
Total	**80**	**100.0**

Budgetary Analysis of Watermelon Production

Table presents the results of budgetary analysis of watermelon in the study area. It shows the analysis of costs and returns of the farms as well as the level of profitability in watermelon farming.

Table 3: Cost and Return Analysis of Watermelon Production

Characteristics of Watermelon	Mean(₦)/Ha	Std. Deviation	Percentage of TC
Total Revenue	104,187.50	39932.25077	
Variable Cost			
Seed Cost	7,054.38	4171.82528	8.97
Fertilizer Cost	3,005.63	1083.12703	3.83
Labour Cost	20,660.00	8761.93725	26.28
Transportation Cost	8,275.00	2715.28724	10.53
Marketing Cost	5,901.25	1759.13484	7.51
Total Variable Cost	44,896.26	-	57.12
Fixed Cost			
Land Cost	4,750.00	13584.47550	6.04
Price of Cultivating Tools	4,661.25	1333.45404	5.93
Cost of Machinery	23,217.50	28262.86993	29.53
Storage Cost	1,088.25	2791.57583	1.38
Total Fixed Cost	33,717.00	-	42.88
Total Cost	78,613.26		
Gross Margin	59,291.24		
Net Farm Income	25,574.24		
Benefit Cost Ratio	1.57		
Profitability Index	0.11		
Rate of return on investment	57.23		
Rate of return on variable cost	156.96		
Operating Ratio	0.57		

Results in Table 3 show that though the cost of machinery (29.53 %) is the highest cost incurred by watermelon farmers, Variable cost (57.12 %) is observed to be more important in watermelon production. Labour cost accounted for 26.28 percent of the total cost of producing watermelon per hectare followed by the transportation cost and seed cost (10.53 and 8.97 % respectively). Fertilizer cost is only 3.83 % of the total cost; showing that farmers do not generally apply fertilizer to watermelon farms. It is also evident from the result that farmers do market their output by themselves, thereby, minimizing the cost of marketing (7.51 %). Table 3, further reveals the level of profitability in watermelon production. A high net farm income per hectare of ₦25,574.24 is reported. This result is further confirmed by the results of profitability ratio conducted. The Benefit-Cost ratio of 1.57 implies that for every **₦1** incurred as a cost in watermelon production in the study area, the farmers tends to make a marginal return of ₦0.57k.

Technical Efficiency analysis for Watermelon production

One of the main aims of this study was to empirically analyze the technical efficiency of watermelon farmers in the study area with a few to identifying factors affecting their production performance. This was undertaken by specification and joint

estimation of a function (Equation 4) and an inefficiency model (Equation 5) using the parametric stochastic frontier approach of Coelli (1995). The result is presented in Table 4. This table presents results of joint Maximum Likelihood Estimation (MLE) of the output frontier and inefficiency equation as well as the Ordinary Least Squares (OLS) version of the output frontier.

Table 4: Technical Efficiency analysis of watermelon

Watermelon variables	**Parameter**	**OLS**	**MLE**
Constant	β_0	0.1351	0.1284
		(0.3867)	(0.9754)
Quantity of Inorganic fertilizer	β_1	-0.1635	-1.7182
		(-0.1056)	(-0.6709)
Quantity of seed (kg)	β_2	3.5549	-2.3587*
		(2.1710)	(-1.9888)
Manday of hired labour	β_3	2.7586 *	3.2056***
		(1.9718)	(2.9858)
Total land area (hectare)	β_4	-0.1921	2.1806*
		(-0.1196)	(1.9667)
Herbicide (liters)	β_5	-0.1894	0.2374
		(-0.1352)	(0.9783)
Other Intermediate cost (₦)	β_6	-0.4573	0.2277
		(-0.2799)	(0.4827)
sigma-squared		3.1599	
Constant	δ_0	-2.6131	(-1.969)
Age of the farmers (yr)	δ_1	-2.2421**	(-2.1285)
Sex of the farmers	δ_2	-0.9815	(-0.4161)
Marital status	δ_3	0.47555	(0.6148)
Off-farm income	δ_4	2.3184*	(2.0759)
Number of farmers having	δ_5	0.3640	
Membership orientation on borrowing		(0.3156)	
Farmers' experience in watermelon	δ_6	-0.2751	(-0.2589)
Education level of farmers	δ_7	3.3394**	(2.6941)
sigma-squared		2.1064	(3.7432)
Log Likelihood Function	L/F	-1.3652	2.3524
Mean Efficiency		0.6508	

Figures in parenthesis are t values (,** and*** denote significant level at10%, 5% and1%)*

From the Maximum Likelihood Estimate (MLE), the coefficient of quantity of seed and number of hired labour and total land area cropped are significant. The coefficient for the variable X_2 representing the quantity of seed planted is negatively signed but significant at 10 percent level. The result implies that as the additional kilogramme of seed is planted per hectare, the output will decrease by 2.35kg. Farmers are therefore, expected to use optimum seed rate. The number of hired labour (Variable X_3) and the total land area cropped (variable X_4) are positively signed and significant at 1 percent and 10 percent level. By implication, increase in manday of hired labour and hectarage of land allocated for watermelon will increase output of watermelon by 3.21kg and 2.18kg respectively.

The lower section of Table 4 presents the coefficients of variables in the inefficiency equation and their associated t-ratios. It shows that coefficients for Age, Off-farm income and Education were significant. Specifically, the coefficient of Age is negative and significant ($P<0.05$); which means that as the farmer aged the level of inefficiency in the production of water melon will decrease in the study area. Contrarily, the coefficient for variables Z_4 representing the off-farm income generated by the farmer is positively signed and significant at 10 percent. This implies that increase in off-farm income increases inefficiency. Examining the variable Z_7 in the inefficiency model of the pooled regression, results in table 4 show that educational level coefficient was negative but significant at the 5% level. Similar result was reported by Okoruwa and Ogundele (2004). This shows that increase in the years of schooling among the food crop farmers can reduce inefficiency in the production performance.

The mean of technical efficiency distribution of watermelon producers, as shown in Table 4, in the study area was 0.6508. The result shows that the farmers are about 65.08% technically efficient. This implies that there is need for improvement in the production performance of the farmers.

Conclusions and recommendation

The results from this study show that technical efficiency in watermelon production in Yewa North Local Government of Ogun State is at the average of 65 percent, indicating that there are still opportunities to increase productivity and income in the study area through more efficient use of production resources.

Important factors directly related to technical efficiency are age, off-farm income and education. Policies aimed at improving farmers' access to education through aggressive awareness campaigns and mass mobilizations are needed. Agricultural shows, on-farm demonstration and other informal education could be organized to sensitize the farmers on improving their productivity.

The study found that increase in age increase inefficiency; it is therefore, become imperative to encourage youth to invest in watermelon production. Off-farm income was also found to reduce efficiency; policies on alleviation of rural poverty should be intensified along provisions of low cost farm inputs in the rural areas will encourage full time farming among the farmers.

References

Aigner, D.J., C. A. Kn. Lovell and P. Schmidt (1977). Formation and

Estimation of Stochastic Frontier Production Function. *J. Agric Economics*. 41:61-74

Baameur. (2009). Tomato Fruit Quality in Response to Reduced water Application. Retrived from http:// www.ashs.org/db/horttalks/detail.lasso?id=727.

Battese, G. E. and T. J. Coelli (1995). A Model for Technical Inefficiency Effects on a Stochastic Frontier production Function for panel Data. *Empirical Economics,* 20, 325—332

Coelli, T. J. (1995). Recent developments in frontier modelling and efficiency measurements. *Australian Journal of Agriculture,* 39, 219-245.

Dung, E. A, Akinpelu, O. A., Olojede, A. O., Asumugha, G. N., Ibrahim, H. Y., Lenka, D. M.and Amadi, C. O. (2010). Technical Efficiency of Hausa Potato Production in Southern Kaduna State, Nigeria. *Nigerian Agric. Journal* 41(1):52-56.

FAO (2010). FAOSTAT. Retrieved from http//www. faostat.fao.org/site/339/default.aspx

Fehner, T. (1993). Watermelon, *Citrullus lanatus* (Thunb.) Matsum. & Nakai. p. 295-314. In: G. Kalloo and B. O. Bergh (eds.). Genetic Improvement of Vegetable Crops. Oxford, Pergamon Press. New York.

Majid, N. (2011). Energy use and Cost Analysis of Watermelon Production under Different arming Technologies in Iran. *International Journal of Environmental Sciences*. (6):1144-1153

Meeusen, W. and J. van den Broeck. (1977). Efficiency Estimation from Cobb-Douglas Production Functions with Composed Error. *International. Economic. Review,* 18, 435- 44.

Onyenweaku, C. E and Nwaru J. C (2005). Application of a stochastic Frontier production Function to the Measurement of Technical Efficiency in Food Crop Production in Imo State, Nigeria. *Nigeria Agricultural Journal*, 36, 1-9.

Rhodes, B. and X. Zhang. (1999). Hybrid seed production in watermelon. p.69-88 In: A. S. Basra (ed.). Food Products Press, New York.

Robinson, R. W. (2000). Rationale and methods for producing hybrid cucurbit seed. p. 1-47. In: A. S. Basra (ed.). Food Products Press, New York.

Wehner, T. C. (1999). Heterosis in vegetable crops. p. 387-397. In: J. G. Coors and S. Pandey (eds.). Genetics and exploitation of heterosis in crops. Amer. Soc. Agron., Madison, Wis.