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ECONOMIC VIABILITY OF ONION PRODUCTION IN THE COMMUNE OF GRAND-POPO, REPUBLIC OF BENIN

Olubunmi Abayomi Omotesho[1], Clemencio Parfait Douvi[1], Ivie Loretta Olaghere[1]✉

[1]University of Ilorin, Nigeria

Abstract. This study estimated the profitability and the level of technical efficiency of onion farms. It also identified factors that contribute to technical efficiency in onion production. Data were collected from 180 randomly selected onion farms using a pretested interview schedule. The farm budgetary technique and the stochastic production frontier were modelled for data analysis. The profitability indices revealed a value of 0.771 and 0.280 for operating ratio and return on capital invested, respectively. The mean technical efficiency score for the farms was 88.35%. Quantities of water and onion seedlings, farm size, household size, and farming experience significantly affected the technical efficiency of the farms. The study concluded that onion production was profitable in the studied area. The government should look into the possibility of providing an alternative source of irrigation for the farmers to conserve water and lower the cost of irrigation.

Keywords: onion farms, operating ratio, random sampling, stochastic production frontier, south of Benin

INTRODUCTION

Agriculture has always been recognised as the basis for advancement in developing countries. The Republic of Benin, like other countries in Africa, experiences an evolution of the urban and out-of-town agricultural sector (Dayou et al., 2020). This is primarily due to the increased food needs that arose as a result of the high population growth which has been observed in the country since 1990 (Houndjo et al., 2018). Thus, the attainment of food security status became a crucial quest for the decision/policy makers. Onion (*Allium cepa* L.) represents 10 to 25% of vegetables consumed in the Republic of Benin. Although onion is well spread and has excellent potential for export due to favourable agro-climatic conditions, its production often does not meet the demand in Benin (Cathala et al., 2003; Vieri et al., 2013). In the last decade, the country has experienced a steady increase in the need for onion, as a consequence of the population growth (Dayou et al., 2020). This situation has, therefore, led to the dependency of Benin on other countries of the sub-region such as Nigeria and Niger for the supply of onions, especially during the off-peak season, even though the country ranks as one of the largest producers of onions in the region (FAO, 2012). In 2009, policymakers of the Agricultural Development Programme inaugurated the Strategic Plan for Agricultural Sector Revival (PSRSA). It plan was designed to promote the agricultural sector. In particular, the products significant in terms of consumption and those that couldbe substantial import products in Benin such as onions. The new policy was aimed at ensuring food self-sufficiency first, and then opening up the potential for export of the agricultural commodities. This

✉Ivie Loretta Olaghere, Department of Agricultural Economics and Farm Management, Faculty of Agriculture, University of Ilorin, P.M.B. 1515, Ilorin, Kwara State, Nigeria, e-mail: olaghere.il@unilorin.edu.ng; https://orcid.org/orcid-search/search?searchQuery=0000-0002-5026-0316

step is expected to increase the national production of onion and reduce the country's dependence on neighbouring countries for the availability of onions (Vieri et al., 2013).

Hence, to achieve a real progress in the agricultural sector, it is necessary to create some strategies to boost agricultural productivity. In developing plans, individual factors and indices must be measured. The insufficiency of land (which is the basis for all agricultural production) appears today as a threat to the sustainability of agriculture. This phenomenon of the inadequacy of land is accentuated by the intense urbanisation currently observed in many developing countries which prevents the development of urban agriculture (Jama and Pizarro, 2008; Satterthwaite et al., 2010, Jayne et al., 2014; Ergen 2016; Lasisi et al., 2017; Peerzado et al., 2019). Efficiency is an imperative factor in productivity growth. The inability of the Benin onion sub-sector to meet the domestic needs is probably attributable to low production and inefficiencies in the use of resources, especially among small-scale farmers who use traditional technology. Information on the costs and returns associated with onion production in the south of Benin will guide policymakers in terms of the steps required to encourage more people, especially the youth, to go into onion production. In an economy where opportunities for new technologies are lacking and resources are scarce, inefficiency studies could indicate that it is possible to raise productivity by improving the existing efficiency without necessarily increasing the resource base. To adequately assess ways by which productivity can be increased, this study sought to estimate the profitability of onion production, examine the level of technical efficiency of the onion farms and identify possible factors that determine the technical efficiency of said farms.

MATERIALS AND METHODS

A survey was carried out in the commune of Grand-Popo in the south of Benin. It is majorly an urban region. The commune has about 1,185 ha on which food crops are cultivated. It has approximately 13,730 households, including 5,494 rural families with a mean household size of 4.2 individuals. More than 40% of households are actively involved in agriculture. Crops grown include maize, rice, beans, peanuts, cassava, onions, carrots, peppers, and some leafy vegetables.

Onion farmers were the target population for the purposes of this study. A three-stage sampling technique was adopted for the study. The first stage included the purposive selection of three districts, namely Grand-Popo, Gbehoue, and Agoue, due to the high onion production activities. This was followed by the random selection of eight communities in Grand-Popo and six communities each in Gbehoue and Agoue based on the proportion of communities in the districts. A list of farmers producing onion within these communities was obtained from the CeCPA (Communal Centre for Agricultural Promotion). From that list, the proportional/random sampling was used to select onion producers based on the total number of farmers in each community. In total, data from 180 farmers were used for the study. Data were collected using a structured pretested interview schedule. Data collection was conducted from January to March of 2016 and covered the production period between November andMarch (the dry season). The costs and returns of onion production were estimated using the gross margin and net farm income analysis.

Following the study by Olaghere et al. (2017), this was specified as:

$$\text{Gross Margin (GM)} = \text{GVO} - \text{TVC} \quad (1)$$

$$\text{GVO} = \text{P x Q} \quad (2)$$

$$\text{Net Farm Income (NFI)} = \text{GM} - \text{TFC} \quad (3)$$

where:

GVO – gross value of output
TVC – total variable cost
P – unit price of onions
Q – quantity of onion output
TFC – total fixed cost

The straight-line method of depreciation was used and computed as follows:

$$\text{Cost of item} - \text{salvage value / useful life} \quad (4)$$

Useful life

The profitability indices were specified as:

$$\text{Operating ratio (OR)} = \text{TVC/GVO} \quad (5)$$

$$\text{Returns on capital invested (RCI)} = \text{NFI/TC} \quad (6)$$

where:

$$\text{TC} = \text{TFC} + \text{TVC} \quad (7)$$

The stochastic frontier model by Battese and Coelli (1998) was used to measure the technical efficiency of farmers in the studied area. The stochastic parametric method has been widely used in the estimation of technical efficiency in agriculture, especially in developing countries.

It is specified in the implicit form as follows:

$$Y_i = f(x_i\beta) + v_i - \quad (8)$$

where:

Y_i – is the output of the i^{th} farmer (kg)
X_i – is the vector of input quantities of the i^{th} farmer
β – is a vector of unknown parameters to be estimated
v_i – is the random error term which accounts for measurement error and other factors beyond the control of the farmer
while, μ_i – is the negative random error variable, which accounts for inefficiency in production, and is assumed to be half-normally distributed.

Following the work by Tegegne et al. (2014), this study adopted the Cobb Douglas functional form due to its simplicity in terms of analysis and interpretation. Explicitly, the functional form was specified as:

$$InY = \beta_o + \beta_1 InX_1 + \beta_2 InX_2 + \beta_3 InX_3 + + \beta_4 InX_4 + \beta_5 InX_5 + (v_i - u_i) \quad (9)$$

Thus, to estimate a Cobb-Douglas Production function, we logged all the input and output data before the data analysis.

Where:

Y – onion output (kg)
X_1 – quantity of fertiliser (kg)
X_2 – land size (ha)
X_3 – quantity of hired labour (person/day)
X_4 – quantity of seeds (kg)
X_5 – quantity of irrigation water used (cm^3/ha)
β_1–β_5 – production function parameters to be estimated
B_0 – intercept
u_i – negative random error
v_i – stochastic error term.

The inefficiency of a production process is assumed to be influenced by some socio-economic parameters. For the study, the model was defined as:

$$\mu_i = d_0 + d_1Z_1 + d_2Z_2 + d_3Z_3 + d_4Z_4 + d_5Z_5 + d_6Z_6 \quad (10)$$

where:

Z_1 – access to extension (1 = yes; 0 = otherwise)
Z_2 – household size (adult equivalent)
Z_3 – educational level (number of years of successful schooling)
Z_4 – experience of the farmer (years)
Z_5 – specific training (1 = yes; 0 = otherwise)
Z_6 – quantity of credit obtained (FCFA XOF)
μ_i – technical inefficiency effect
$d_0, d_1, d_2, d_3, d_4, d_5, d_6$ – parameters to be estimated.

Given that the dependent variable of the inefficiency model represents the mode of inefficiency, a positive sign of an estimated parameter means that the associated variables have a negative effect on efficiency but a positive effect on inefficiency and vice versa.

A maximum efficiency in production has a value of one and a lower value represents less than maximum efficiency. From the individual farm's technical efficiency, the mean technical efficiency for the sample is obtained (Awoyinka and Ikpi, 2005). The parameter Gamma (γ) has the value between zero and one, i.e., $0 < \gamma < 1$. According to Battese and Tessama (1993), γ is the total output attained at the frontier, which is attributed to technical efficiency. Similarly, $1 - \gamma$ measures the technical inefficiency of the onion farms.

RESULTS AND DISCUSSION

This section presents and discusses the data analysed in the study.

Socio-economic characteristics of onion farmers

These are presented in Table 1.

The results suggest that onion production in the studied area was male-dominated. The distribution of the onion farmers by age shows that the modal age group was between 40–49 years with the mean age being about 43 years. This means that many of the farmers were middle-aged. Almost 75% of the onion farmers were married, while the rest were single, separated, or widowed. A high percentage of married farmers could imply large household sizes. Table 1 showed that half of the respondents had a household that ranged between 1–3 persons (adult equivalent), while the other half had 4–7 persons. The average household size was about four persons. Almost 81% of respondents attained some

Table 1. Socio-economic characteristics of onion farmers

Variables	Category	Frequency (n = 180)	Percentage	Mean
1	2	3	4	5
Sex	male	128	70.83	
	female	52	29.17	
Age (years)	≤29	20	11.11	43.58
	30–39	43	23.89	
	40–49	65	36.11	
	50–59	42	23.33	
	≥60	10	5.56	
Marital status	single	18	9.72	
	married	132	73.61	
	widowed	20	11.11	
	separated	10	5.56	
Household size (number of adult equivalent)	1–3	90	50.00	3.63
	4–6	90	50.00	
Education level	no formal	35	19.44	
	primary	63	35.00	
	secondary	72	40.00	
	tertiary	10	5.56	
Main occupation	farming	148	82.22	
	fishing	20	11.11	
	trading	12	6.67	
Farming experience (years)	1–5	60	33.33	7.75
	6–10	68	37.78	
	11–15	47	26.11	
	>15	5	2.78	
Access to extension	yes	110	61.11	
	no	70	38.89	
Farm size (hectares)	0.05–1.99	155	86.11	0.85
	2.00–3.00	25	13.89	
Access to credit	yes	75	41.67	
	no	105	58.33	
Special training	yes	93	51.67	
	no	87	48.33	
Land ownership	inherited	85	47.22	
	purchased	45	25.00	
	rented	50	27.78	
Quantity of irrigation water (cm^3/ha)	≤80	3	1.67	632.66
	81–556	90	50.00	
	557–1033	72	40.00	
	>1033	15	8.33	
Source of irrigation water	open well	57	31.94	
	tube well	123	68.06	

Source: field survey, 2016.

level of formal education. About 82% of respondents were primarily onion farmers. Others indicated fishing as their primary occupation or some kind of trading or another. Also, the majority of farmers owned their farmlands, which were either purchased or inherited. The analysis of years of experience shows that there were more new entrants into the farming activities in the studied area. Seventy-one percent of the farmers had less than 11 years of experience in onion production, while the mean farming experience in the studied area was about eight years. The majority of onion farmers interviewed (61.11%) had contact with extension agents. It was found out that the onion farmers had various sizes of land under cultivation.

The land area cultivated ranged 0.05–3 ha. The mean farm size recorded in the study was 0.85 ha. This confirms that the majority of farmers were small-scale producers. It was noted during the field survey that like other vegetables, onion is produced on plots, and their dimensions vary among farmers in the studied area. Plot sizes of 6 m^2 (2 m × 3 m) and 18 m^2 (6 m × 3 m) were commonly found. In the studied area, more than half (58.33%) of onion farmers used personal savings to finance their farm activities. The analysis showed that 51.39% of farmers had received specialised training during a specific time in their farming career. The majority (72.22%) of onion farmers in the studied area had a secure land arrangement because they owned their land which was either inherited or purchased. In the studied area, underground water from open and tube wells was used for irrigation. Irrigation was done mostly by flooding the fields with motorised pumps. The onion farms were irrigated twice a day throughout the cycle of production (three months).

Profitability analysis of onion farms

This subsection estimated the costs and returns of onion production. The results per hectare for a cycle of production for the onion farms are presented in Table 2.

Table 2. Costs and returns of onion production in the studied area

Variables	XOF /ha	Percentage of total cost
Gross value of output (GVO)	1 763 240	
Variable costs		
Seeds	26 889	1.95
Water	1 007 619.23	73.14
Labour	140 000	10.16
Fertiliser	111 913	8.12
Herbicide	72 997	0.53
Fuel	65 438.77	4.75
Total variable cost (TVC)	1 359 157	98.65
Fixed costs		
Rental value of land	5 653	0.42
Depreciation costs	12 750	0.93
Total fixed cost (TFC)	18 403	1.35
Total cost (TFC + TVC)	1 377 560	100
Gross margin (GVO -TVC)	404 084	
Net farm income (GM – TFC)	385 680	
Operating ratio (TVC/GVO	0.77	
Returns on capital invested	0.28	

XOF 475.00 = USD 1.00
Source: own estimation based on field survey.

The positive value of the net farm income shows that the farmers can cover both variable and fixed costs. The total variable cost accounted for almost 99% of the total cost. However, the value of the operating ratio suggests that 77% of their gross revenue from onion production is spent as operating expenses. This value is much higher than that reported by Baloch et al. (2014) and Grema and Gashua (2014). This was a result of the high total variable cost recorded in the study, which was primarily due to the imputed cost of water used for irrigation. Irrigation was done by flooding the onion fields. This was done with the use of water pumps which were either owned by the farmers or rented. Apart from the massive volume of water that was used to irrigate the farms (633 cm^3/ha), the farmers paid high levies for water in the studied area. On the other hand, fuel cost accounted for 4.8% of the total variable costs while fertiliser and labour costs accounted for about 8 and 10% of total costs respectively. The value of the return on capital invested suggests that for every XOF 100 spent on a one hectare farm size for onion production, the farmer would make a return of about XOF 28. This means that after all fixed and variable expenses have been met; the onion farmer has almost 30% returnof the initial amount invested. This shows that onion production in the studied area is a profitable enterprise.

Analysis of technical efficiency of onion producers

This subsection presents the technical efficiency indices of onion farms.

Table 3. Technical efficiency distribution of onion farms

Technical efficiency	Frequency	Percentage
30–59.99%	5	6.94
60.00–79.99%	6	8.33
80.00–95.00%	34	47.22
>95.00%	27	37.50
Total	72	100
Maximum		98.90
Minimum		30.29
Mean		88.35

Source: own estimation based on field survey.

The results revealed that technical efficiency ranged between 30.29% and 98.9% in the studied area. This is shown in Table 3. The technical efficiency distribution between 80–98.9% was achieved on about 85% of farmsof farms . This implies that the majority of farmers were able to combine their inputs in such a manner to attain maximum output level. The minimum technical efficiency score recorded in the study indicates that if a farm were to increase efficiency by 69.71%, it would be operating on the frontier. The mean efficiency of the farms was 88.35%. This compares favourably with other efficiency studies conducted such as that by Savi (2006), who analysed the level of technical efficiency among okra farms in the Valley of Mono, and found the mean technical efficiency to be 71.2%. Similarly, Arouna et al. (2010) found a 73% mean technical efficiency score among cashew farms in Benin. Less than one technical efficiency indices of all the sampled onion farms indicates that opportunity still exists for increasing the output of onion farms using available inputs and existing technology.

Determinants of technical efficiency

The expected parameters obtained from the analysis of the Maximum Likelihood Estimates (MLE) of the Cobb-Douglas based on the Stochastic Production Function for onion farmers are presented in Table 4. The value of Gamma (ɤ) was estimated to be 0.824. This implies that the onion farms had about 82.4% technical efficiency level in terms of production. This means that about 17.6% of them represent the most significant proportional reduction in random factors such as unfavorable weather and disruption in input supplies that could be achieved in the production of onions without the decrease in output.

As revealed in Table 4, the positive and significant coefficient for the farm size shows that if a farm size is increased by one percent, the yield per hectare of onion will increase by 0.507%. This finding corroborates studies by Baree (2012), Bhatt and Bhat (2014), and Singh et al. (2019). They reported that farmers with larger farms were more technically efficient than those with smaller farms. Furthermore, the coefficient of farm size, which is also its elasticity of output is the highest amongst the inputs used in production. This is an attestation to the prominent role of land in agriculture. The negative sign for the amount of water used for irrigation suggests a situation of excessive use of the resource by the onion farmers in the studied area. Similar findings were recorded by Tegegne et al. (2014). This may have been due to irrigation that was majorly done in the studied area by flooding the fields, resulting in water wastage. This method of farm irrigation has been reported to be the least efficient since the plants need

Table 4. Maximum likelihood estimates of the stochastic production frontier function of onion farmers

Variables	Coefficient	Standard error	t-values
Production model			
Constant	0.379	0.279	1.362
Qty of fertiliser	0.512	0.999	0.513
Farm size	0.570*	0.954	2.690
Qty of labour	0.559	0.420	1.337
Qty of seedling	–0.150*	0.060	–2.533
Qty of water for irrigation	–0.003*	0.001	–3.548
Inefficiency model			
Constant	4.293	1.081	3.970
Access to extension	–0.148	0.096	–1.54
Household size	0.021*	0.009	2.33
Education level	–0.832	0.994	–0.837
Farming experience	–0.586*	0.126	–4.65
Specific training	–0.635	0.995	–0.638
Amount of credit	0.190	0.430	0.441
Variance parameters			
Sigma squared δ^2	0.273	0.078	3.49
Gamma ɤ	0.824	0.061	10.67

*Significant at 5% level of probability.
Source: own estimation based on field survey.

only 20% of the water used to flood the fields (Molden, 2007). The implication of the negative value of onion seeds used for planting is that the quantity of seeds used by the farmers was also excessive. Farmers in the studied area mostly used a local variety of seeds due to their affordability and availability. It was also observed during the field survey that these farmers sowed more than the recommended rate. This most likely explains the negative coefficient sign. They explained that sowing more than the recommended rate will guarantee a high germination /emergence rate. This finding is consistent with those of Tsoho (2008), Baree (2012) and Etwire et al. (2013), who found an inverse relationship between the quantity of seeds used in production and output. The finding, however, contradicts that of Kebede and Adenew (2011).

For the determinants of technical efficiency, as seen in Table 4, the coefficients of farmers' household size and farming experience were significant at 5%. The farming experience was negatively related to technical inefficiency. This most likely means that the longer the farmers have cultivated onions, the more skills and knowledge they have gathered over time so that they can combine available inputs with the existing technology to maximise the output. This finding is in line with that of Mbanasor and Kalu (2008) and Abdulsalam and Oladimeji (2012). On the other hand, the household size was positively related to their technical inefficiency, meaning that the farmers become less technically efficient when the household size increased and vice versa. In the studied area, a larger household size usually implies the availability of family labour which was the primary source of labour. However, family members, especially children, may not be skilled enough in terms of production techniques; hence more training is required to acquire technical skills needed to increase efficiency. Findings of Idiong (2007) and Cheick (2014) corroborate the results obtained by arguing that larger household may enhance the availability of labour. However, these larger households may not guarantee efficiency since family labour, which comprises mostly of school-age children , could be in school when the labour is needed.

CONCLUSION AND POLICY RECOMMENDATIONS

This paper examines the economic viability of onion production in the Republic of Benin. The study reveals that most of the respondents are small-scale farmers who cultivate onion on farmland with an area of three hectares or smaller. Also, the cost of obtaining water for irrigation accounted for about 73% of the total cost. Notwithstanding, the profitability indices show that onion production is a viable venture in the studied area. The technical efficiency results show a mean of about 88%. Also, the farm sizes were inadequate in the studied area, while onion seedlings and water for irrigation were overutilised. Furthermore, both household size and farming experience were significant determinants of the technical efficiency status of farms. Overall, the study concludes that there is a considerable potential for onion production in the studied area, even though there is still room for increased output and, consequently, income, by efficiently combining the available resources with the existing technology for onion production. Based on these findings, we recommend a prompt dissemination of this information to youths in the commune and in the country as a whole. Access to such information could encourage them to engage in onion production, which would contribute to the reduction in the level of unemployment and poverty. Since farmers with relatively larger farms were more technically efficient than those with smaller farms, the study also recommends that government policies on land tenure systems should be reviewed in such a way to give the onion farmers better access to farmland. Although there is a high demand for land for urbanisation, a better urban planning could lead to reducing the competition for land for agriculture and urbanisation. Also, the onion farmers should be trained by the government/Extension agents on efficient water utilisation for irrigation to reduce their costs of farm irrigati. Furthermore, the provision of an improved irrigation system like the drip and sprinkler technology for the farmers will go a long way in conserving water resources and ensuring the sustainability of onion production. Improved and affordable onion seedlings should be made available to the farmers. The pretesting of seedlings before planting should also be encouraged among the farmers. This could be achieved by means of organising training programmes and workshops. This would enhance efficiency in the long term by enabling farmers to make better decisions and allocate inputs more efficiently.

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