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Economic and Extension Drivers of Technical Efficiency in Sesame (*Sesamum Indicum* L.) Production in Takum and Ussa Local Government Areas of Taraba State, Nigeria

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Abstract

This study analyzed the drivers of technical efficiency in sesame production. Multistage sampling procedure was used to select 150 sesame farmers for the study. Data obtained were analyzed using farm budgeting techniques, stochastic frontier production function, and constraint index analysis. The results revealed that sesame production was profitable, with a net farm income of ₦143,007.63 per hectare and a return on investment of ₦1.60, indicating that farmers gained ₦1.60 for every naira invested in production. The stochastic frontier analysis showed an average technical efficiency level of 87%. Seeds, fertilizer, agrochemicals, and labour were found to have positive effects on sesame output. However, 34% of farmers had contact with extension agents within the previous year, with an average of 1.8 extension visits. The major sources of production information were fellow farmers (62%) and radio (48%), while extension agents accounted for 28%. Major constraints affecting extension access included inadequate extension personnel (86.7%), high cost of accessing extension services (79.2%), and untimely dissemination of information (72.5%). The study concludes that although sesame production is technically efficient, weak extension delivery systems limit further productivity improvement. It recommends strengthening extension staffing, and promoting timely, farmer-oriented information delivery channels to enhance sesame productivity.

Keywords: Technical efficiency, extension services, sesame production, constraints, Taraba State

Introduction

Sesame (Sesamum indicum L.) ranks among the earliest domesticated oilseed crops and is often called the “queen of oilseeds” because of its high oil concentration, pleasant taste, and excellent nutritional qualities (Yadav et al., 2022). This crop serves many purposes across food processing, pharmaceutical manufacturing, and industrial production including cosmetics, lubricants, and animal feed formulations. Sesame seeds contain substantial amounts of protein, essential amino acids such as methionine and tryptophan, B and E vitamins, and several bioactive substances like lignans, flavonoids, and phenolic compounds. Its oil is especially valued for resistance to oxidation, owing to natural antioxidants including sesamin, sesamolin, and sesamol, which makes it useful for both culinary and industrial applications (Yadav et al., 2022).

Worldwide, sesame cultivation occupies roughly 11.7 million hectares, producing an average yield near 512 kg per hectare (Yadav et al., 2022). Asia and Africa together supply more than 95% of global output. Nigeria is among the world's leading producers and the foremost producer in Africa, a reflection of the crop's suitability for tropical agro-ecological zones, especially the Guinea savanna belt (Afolabi et al., 2025). Sesame also represents a major non-petroleum export commodity for Nigeria, with large shares of production going to international buyers in Asia and the Middle East. Consequently, the crop offers considerable potential for generating foreign exchange and diversifying the agricultural sector.

In spite of this economic significance and rising global demand, sesame farming in Nigeria remains largely smallholder-driven, marked by modest input applications and limited uptake of modern technologies. Research evidence consistently shows a wide gap between attainable and realized yields, pointing to inefficiencies within production systems. Current yields across Nigeria stay well below what is possible, chiefly because of restricted access to quality inputs, weak extension advisory services, and poor allocation of resources. Raising sesame productivity therefore demands attention to technical efficiency—farmers' ability to produce maximum output from given inputs—and also to agricultural extension, which functions as the main channel for disseminating knowledge, recommendations, and practical support to farmers.

Analyses of efficiency reveal critical information about production performance, highlight areas where resources can be used more effectively, and guide economic policy measures. Yet economic efficiency alone cannot be achieved unless extension delivery is effective. Extension services shape farmers' access to timely information, their adoption of improved practices (such as correct fertilizer and seed rates), and ultimately their technical efficiency. Conversely, poor extension outreach—characterized by rare agent visits, untimely advice, and high costs of obtaining information—reinforces inefficiency. Understanding how economic factors (costs, revenues, credit, cooperative membership) interact with extension factors (access to agents, information sources, delivery constraints) is essential for designing integrated interventions that enhance both productivity and farmer welfare.

Despite the strategic importance of sesame, little empirical evidence exists on the combined economic and extension determinants of technical efficiency at the farm level, especially in emerging production zones like Takum and Ussa Local Government Areas of Taraba State. This study aims to fill that gap by investigating the economics and extension drivers of technical efficiency in sesame production in these two LGAs. Specifically, the study sets out to: (1) analyze the costs and returns of sesame production; (2) evaluate farmers' technical efficiency levels in sesame production; (3) assess farmers' access to extension services for sesame production; and (4) identify extension-related constraints that limit technical efficiency.

Methodology

Primary data were used for this study. It was collected with the use of a structured questionnaire. Data were collected on the socio-economic characteristics of farmers, access to credit and membership of cooperative. Information on production inputs (such as farm size, labour use, planting materials, fertilizer, agrochemicals, and other variable inputs) and output variables (quantity of sesame produced and corresponding sales value) was collected to facilitate the estimation of production costs, returns, and technical

efficiency among sesame farmers. The input data that were collected include: labour, fertilizer, seed, and agro-chemical and farm size. The sesame farmers in the study area constitute the study population. A multistage sampling procedure was employed to select the respondents for the study. At the first stage, purposive sampling was used to select Takum and Ussa Local Government Areas for their predominance of sesame production. In the second stage, simple random sampling was used to select five farming communities from each of the selected Local Government Areas. In the third stage, snowball sampling technique was used to identify 435 sesame farmers to serve as the sample frame. Finally, 150 sesame farmers were randomly selected from the sample frame to form the sample size for the study.

Stochastic frontier production function and budgeting technique were used to analyze the data. Budgeting technique was used to estimate the cost and return of sesame production. Net Farm Income (Budgeting Technique) was used to estimate cost and returns per hectare. Values were assigned to family labour by obtaining the product of prevailing wage rate and man-days of family labour. Besides, depreciation values on farm tools and implements (hoe, sprayer, cutlasses, etc.), rent on land and cost of purchase of land were computed to get net farm income per hectare.
It is assumed that the technical inefficiency effects are independently distributed and U_i arises by truncation (at zero) of the normal distribution with mean $U_{ij,}$ and variance σ^2. Where U_{ij} is defined by:

$U_i = \delta_0 - \delta_1 Z_{1ij} + \delta_2 Z_{2ij} + \delta_3 Z_{3ij} + \delta_4 Z_{4ij} + \delta_5 Z_{5ij} + \delta_6 Z_{6ij} + \delta_7 Z_{7ij} + \delta_8 Z_{8ij}$
U_i = Technical inefficiency of the i^{th} farmer
Z_1= Age of the farmer (Years)
Z_2= Household size
Z_3= Education level
Z_4= Farming experience
Z_5= Farm size
Z_6= Cooperative Membership (Yes=1, No=0)
Z_7= Access to credit (Yes=1, No=0)
Z_8 = Extension Contact

Results and Discussion

Cost and Returns of Sesame Production

The cost and return analysis (Table 2) indicates that sesame production was profitable in the study area. The average total variable cost was ₦72,422.37/ha, with labour accounting for the largest proportion of production costs (₦25,126.50/ha), confirming that sesame production is labour-intensive. This finding agrees with Tahir et al. (2021), who similarly reported labour as the dominant cost component in sesame production in Adamawa State, Nigeria.

The average fertilizer application rate (61.3 kg/ha) was below the recommended 100 kg/ha, suggesting that financial constraints may have limited fertilizer use. In contrast, the average seed rate (5.39 kg/ha) slightly exceeded the recommended 5 kg/ha (Yadav et al., 2022), indicating a tendency towards over-seeding. Similarly, herbicide use (9.45 L/ha) was considerably higher than the recommended 2–2.5 L/ha, which may reflect farmers' heavy reliance on chemical weed control due to high labour requirements for manual weeding.
The average total production cost was ₦88,872.37/ha, while the average gross revenue and net farm income were ₦231,880.00/ha and ₦143,007.63/ha, respectively. Although

the average yield (421.6 kg/ha) was below the potential yield of 1,000 kg/ha reported by Yadav et al. (2022) under improved management practices, sesame farming remained economically rewarding. The lower yield may be attributed to pest and disease incidence, inadequate input use, and reliance on local seed varieties.

The profitability index of 1.6 indicates that farmers realized a return of ₦1.60 for every ₦1.00 invested, equivalent to a net gain of ₦0.60 per naira invested. Likewise, the gross ratio of 0.40 implies that only 40% of gross revenue was expended on production costs, reflecting efficient resource utilization and strong financial viability. These findings corroborate those of Oniah and Edem (2021), who likewise reported that sesame production generated positive returns in Northern Cross River State, Nigeria. Overall, the results demonstrate that sesame farming is a viable and economically sustainable enterprise in the study area, despite its relatively low productivity.

Table 1: Costs and returns of sesame farmers

Variables	Average quantity/ha	Unit price (₦)	Value (₦)
1. Gross Returns			
Average yield (kg)	421.6	550	231,880
2. Inputs			
i. Variable costs			
a) Seeds (kg)	5.39	620.00	3,341.8
b) Fertilizer (kg)	61.3	10,780.67	14,014.87
c) Herbicides (ltr)	9.45	1,900	17,955
d) pesticides (ltr)	3.60	2,200.00	7,920
e) Labour (man/day)	23.93	1,050	25,126.5
f) Transportation (₦)		300	2,100
g) Bags (₦)	7	280.6	1,964.2
Total Variable Cost			**72,422.37**
ii. Fixed inputs			
a) Cutlass			2,000
b) Hoe			1,600
c) Sprayer			12,500
d) Sickle			350
Total Fixed Cost			**16,450**
3**. Total Costs (i)+(ii)**			**88,872.37**
4. Net Farm Income NFI			**143,007.63**
5. Rate of Return			**1.6**
6. Gross Ratio (TC/GR)			**0.4**

Source: Field Survey, 2025

Technical Efficiency of Sesame Production

The maximum likelihood estimates (MLE) of the stochastic production function for sesame farmers are presented in Table 2. The coefficients of variance parameter σ2 (sigma squared) and Gamma (γ) were significantly different from zero. Consistent with Oladele et al. (2025), the statistical significance of the variance parameter (σ2) and Gamma (γ) is an indication of a good fit of the model and confirmation of distribution assumption of the composite error term. The Gamma (γ) value estimated was 0.83 which implies that 83% of the difference between the observed and the actual output were basically due to technical inefficiency of farms.

Table 2: Technical efficiency of sesame production (Stochastic Frontier Production Function (SFPF) output

Variable	Parameter	Coefficient	Std. Error	t-value	p-value
Constant	β_0	3.915735	0.0877295	44.63	0.0001***
Seed	β_1	0.058737	0.0244727	2.40	0.0164**
Fertilizer	β_2	0.2377171	0.0424739	5.60	0.0001***
Agro-chemical	β_3	0.0460335	0.0222292	2.07	0.0384**
Labour	β_4	0.0670246	0.0308532	2.17	0.0298***
Variance Parameters					
Variance of Inefficiency Term (σ^2u)		0.0644505	0.0083061		
Variance of Random Error Term (σ^2v)		0.0283318	0.0047611		
Total variance ($\sigma^2 = \sigma^2_u + \sigma^2_v$)		0.0927823	0.0009105		
Lambda ($\lambda = \sigma_u/\sigma_v$)		2.274848	0.0120442		
Gamma $\gamma = \sigma^2_u / (\sigma^2_u + \sigma^2_v)$		0.6946			

Source: Field Survey, 2025. *** and ** significant at 1 % and 5% levels of significance respectively

Elasticity of Production and Return to Scale

The estimate of elasticity of output with respect to inputs of production is presented in Table 3. The parameters of the stochastic frontier model showed that all the outputs elasticity is positive. The positive sign implies that as the input variable increased, the output increased, and vice versa. The output elasticity for seed, fertilizer, agrochemicals and labour are 0.05874 percent, 0.23772 percent, 0.04603 percent and 0.06702 percent respectively. This means that, one percent increase in the quantity of seed used per hectare will result in an increase in output by 0.05874 percent. Similarly, a percentage increase in fertilizer employed per hectare will increase yield by 0.23772 percent. Also, a percentage increase in agrochemicals utilized will increase yield by 0.04603 percent. Table 4 further shows that a percentage increase in labour used will increase output by 0.06702 percent. The estimated return to scale value is 0.40951 and is less than one, indicating decreasing returns to scale, which indicates some of the inputs are excessively used.

Table 3: Output of Elasticity for input

Variable	Elasticity
Seed	0.05874
Fertilizer	0.23772
Agro-chemical	0.04603
Labour	0.06702
Return to scale (RTS)	**0.40951**

Source: Field Survey, 2025.

Inefficiency Production Model Estimates

The inefficiency component of the model was also estimated and presented in table 4. The negative sign of the estimated parameters indicates that the variable reduces total output inefficiency (increases efficiency). The positive signs of the estimated coefficients increase inefficiency (decreases technical efficiency). The results revealed that the Age, Access to credit, cooperative membership of sesame farmers and extension contact were the only significant variables, and therefore reduces technical inefficiency (or increase technical efficiency). The coefficient of the age of the sesame farmer was negative and statistically significant at ($P<0.01$). The negative sign of the age of farmer reduces technical

inefficiency (increases efficiency). The coefficient of the age of farmer (-6.353527) implies that a unit increase in the age of farmers will result in the increase in technical efficiency in sesame production by (63%) in the study area this could be as the result of the fact that as age increases, farmers experience in sesame production and risk management increase. This finding is comparable with recent sesame-efficiency evidence showing that farmers' socioeconomic and institutional characteristics are important determinants of production efficiency (Oladele et al., 2025). On the other hand, access to credit, cooperative membership and extension contact were found to be -1.027983, -0.3946657 and -0.2175, respectively, and also significant but at $p<0.05$. Also, implying that a unit increase in the access to credit, cooperative membership and extension contact will increase their technical efficiencies by 102 %, 39.5% and 21.75 %, respectively.

Table 4: Inefficiency of production estimates

Variable	Parameter	Coefficient	Std. Error	z-value	p-value
Age	Z_1	-6.353527	0.9610458	-6.61	0.0001***
Household size	Z_2	0.0156552	0.0173237	0.90	0.3662
Education level	Z_3	0.147174	0.1990495	0.74	0.4597
Farming experience	Z_4	0.0391367	0.0556153	0.70	0.4817
Farm size	Z_5	0.022349	0.026744	0.84	0.4036
Cooperative Membership	Z_6	-0.3946657	0.4151671	-0.95	0.3416
Access to credit	Z_7	-1.027983	0486893	-2.11	0.0348**
Extension Contact	Z_8	-2.748555	1.486654	-1.85	0.0643*

Source: Field Survey, 2025.

Technical Efficiency Indices

The frequency distribution of technical efficiency among sesame farmers is presented in Table 5. The individual technical efficiency indices range between 53% and 98%, with a mean technical efficiency of 87%. The mean technical efficiency implies that, on average, farmers achieved 87% of the potential output obtainable from the existing set of inputs and technology. Thus, sesame output could be increased by about 13% through more efficient use of existing resources. This finding is consistent with Mezgebo et al. (2021), who identified considerable scope for efficiency improvement among smallholder sesame producers, and with Oladele et al. (2025), who reported significant differences in production efficiency among sesame farmers in North-West Nigeria.

Table 5: Technical efficiency of sesame farmers

Class		Percentage
0.10-0.19		0.00
0.20-0.29		0.00
0.30-0.39		0.00
0.40-0.49		0.00
0.50-0.59		2.00
0.60-0.69	3	2.00
0.70-0.79	10	6.7
0.80-0.89	32	21.3
0.90-0.99	102	68.0
Total	**150**	**100**
Maximum	0.98	
Minimum	0.53	
Mean	0.87	

Source: Field survey, 2025.

Contact with Extension Agents

Table 6 shows that only 34.0% of sesame farmers had any contact with an extension agent in the 12 months preceding the survey. The majority (66.0%) had no contact at all. Among those contacted, most (23.3%) received only 1–2 visits annually, with a mean contact frequency of 1.8 visits per year. The very low contact frequency (34%) is consistent with findings by Aderinto & Adebayo (2019) in northern Nigeria, where extension agent-to-farmer ratios can exceed 1:3,000. Such limited contact leaves most farmers without technical backstopping on input rates, pest control, or post-harvest handling, thereby perpetuating suboptimal practices and low technical efficiency.

Table 6: Distribution of farmers by contact with extension agents

Contact indicator	Percentage (%)
Had contact in past 12 months	34.0
1–2 visits	23.3
3–4 visits	8.0
≥5 visits	2.7
No contact in past 12 months	66.0
Total	**100**

Source: Field survey, 2025

Mean contact frequency (among those contacted) = 1.8 visits/year

Sources of Agricultural Information

Farmers were asked to identify their primary sources of information on sesame production. Multiple responses were allowed. Results in Table 7 reveal that other farmers (62.0%) and radio (48.0%) are the dominant sources of information, while extension agents were cited by only 28.0% of respondents. Cooperatives and input dealers played minor roles. The heavy reliance on other farmers (62%) suggests that informal, peer-to-peer knowledge transfer dominates the study area. While this can be cost-effective, it often perpetuates inaccurate or incomplete recommendations (for instance, under-dosing of fertilizer, over-seeding among others). Radio remains a promising medium, but its messages are often generic and untimely. The low extension agent reach (28%) explains why many farmers are unaware of recommended practices such as the optimal fertilizer rate of 100 kg/ha (actual use was only 61.3 kg/ha, as shown in Table 1 above).

Table 7: Distribution of farmers by sources of agricultural information

Information source	Percentage (%)
Other farmers (neighbors, relatives)	62.0
Radio	48.0
Extension agents	28.0
Farmer cooperatives	20.7
Input dealers (agro-chemical shops)	12.0
Television	6.0
Mobile phone/voice messages	4.7

Source: Field survey, 2025

*Multiple responses allowed; percentages exceed 100%.

Type of Extension Messages Received

Table 8 reveals that among the 51 farmers who had contact with extension agents, the most frequently received messages were land preparation (84.3%) and weeding/herbicide application (76.5%). Technical recommendations on fertilizer rate (19.6%) and seed

rate (31.4%) were rarely communicated, despite their significant impact on technical efficiency (see earlier stochastic frontier results).

Table 8: Type of extension messages received

Message type	Percentage (%)
Land preparation	84.3
Weeding / herbicide use	76.5
Pests and disease control	54.9
Harvesting techniques	43.1
Recommended seed rate	31.4
Recommended fertilizer rate	19.6
Post-harvest handling / storage	15.7

Source: Field survey, 2025

The neglect of fertilizer and seed rate recommendations is particularly problematic, given that these two inputs had the highest elasticities in the production function (fertilizer elasticity = 0.2377; seed elasticity = 0.0587). Without extension reinforcement, farmers continue to under-apply fertilizer and over-apply seed, contributing to the decreasing returns to scale (RTS = 0.41) observed earlier.

Satisfaction with Extension Services

Table 9 reveals that farmers who had contact were asked to rate their satisfaction using a 3-point scale (Satisfied, Indifferent, Dissatisfied). Only 33.3% expressed satisfaction, while 47.1% were dissatisfied, citing untimely visits, lack of follow-up, and inadequate technical depth. Low satisfaction likely reduces farmers' willingness to adopt recommended practices, even when contact occurs. This finding aligns with the inefficiency model result that extension contact significantly improves efficiency (coefficient = -2.7486, $p<0.05$) – but only when contact is meaningful and timely.

Table 9: Satisfaction level with extension services

Satisfaction level	Percentage (%)
Satisfied	33.3
Indifferent	19.6
Dissatisfied	47.1
Total	**100**

Source: Field survey, 2025

Ranking of Extension-Related Constraints

Table 10 presents the ranked constraints. The most severe constraint was "Too few extension agents" (CI = 86.7%), followed by "High cost of accessing agents" (CI = 79.2%) and "Information arrives too late" (CI = 72.5%).

The most severe constraint identified by farmers was the scarcity of extension agents in the area, with a constraint index of 86.7%. This reflects the national problem of low extension agent-to-farmer ratios, estimated between 1:3,000 and 1:5,000 in Nigeria. With so few agents, regular farm visits are impossible, leaving the majority of farmers without technical support, and this directly contributes to the 13% technical inefficiency gap identified in Chapter Three. The second most severe constraint was the high cost of accessing extension services (CI = 79.2%). Many farmers must travel long distances to extension offices or contact agents via mobile phone, which requires credit. Poor rural road networks further inflate transport costs, thereby discouraging farmers from seeking advice. Ranked third was the problem of untimely information (CI = 72.5%). Even when information is available, it often arrives after critical decision windows – such as the optimal

timing for fertilizer application or pest scouting. This results in misapplication of inputs, reducing marginal productivity, a finding consistent with the decreasing returns to scale observed in the stochastic frontier analysis.

All of the top constraints directly impair a farmer's ability to adopt recommended practices. For example, untimely advice on fertilizer rate leads to under-application – observed at 61.3 kg/ha against the recommended 100 kg/ha – which reduces output. The inefficiency model already confirmed that extension contact significantly improves efficiency; however, these constraints explain why mere contact is insufficient without quality, timeliness, and affordability. Addressing these barriers is therefore essential to translating extension access into measurable gains in technical efficiency.

Table 10: Farmers' ranking of extension-related constraints limiting technical efficiency

Constraint	Mean score	Constraint Index (CI%)
Too few extension agents in the area	3.47	86.7
High cost of transport to reach agents	3.17	79.2
Information arrives too late (e.g., after planting)	2.90	72.5
Language/dialect barriers between farmer and agent	2.63	65.8
No follow-up after initial extension contact	2.48	62.0
Extension messages too general, not sesame-specific	2.25	56.3
Lack of demonstration plots in the community	2.10	52.5
Mistrust of extension agents (past negative experiences)	1.86	46.5

Source: Field survey, 2025

Table 11: Number of severe extension constraints per farmer

Number of severe constraints	Percentage (%)
0–1	8.0
2–3	17.3
4–5	38.7
6–8	36.0
Total	**100**

Source: Field survey, 2025

Conclusion and Recommendations

Sesame production is a profitable venture in the study area. This profitability has positive implications for investment opportunities for individuals and corporate organizations and similarly, adjustments in the production inputs such as farm size, increase and efficient utilization of fertilizers and herbicides and their cost of acquisition could lead to increased production of sesame. In the same vein, sex, age, Farming experience, membership of cooperative societies, accessibility to credit, and extension visits were significant variables that influenced efficiency. Noticeable gaps in technical efficiencies could be drastically improved upon if perceived constraints such as of high cost of input, poor access to credit, pest and disease, incessant farmers/herders clashes, poor market information and inadequate extension services when addressed would contribute to disposable income of the farmer and earn the country more foreign exchange.

Based on the findings of the study, the following recommendations were made:

i. The farmers should be encouraged to use improved seeds to increase their yield.

ii. Relevant agencies of government and NGOs should provide soft loans to sesame farmers. This would not only boost productivity but also encourage

enterprise expansion for greater output, employment generation and ultimately bridging the gap between demand and supply of sesame products in the country.

iii. The government should recruit more extension agents in order to assist the farmers in providing adequate information on the new production techniques of Sesame.

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