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Factors Affecting Sorghum Production in Tanzania

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Sorghum Production, Tanzania , Agricultural Inputs , Farmer Education , Multiple Regression Analysis

ABSTRACT

Sorghum, a staple crop critical to food security in Tanzania's semi-arid regions, faces significant productivity challenges. This study examines the factors influencing sorghum production in Tanzania, using cross-sectional data from the National Sample Census of Agriculture (NSCA) 2019–2020. The research analyzes demographic characteristics, such as age, gender, and education of household heads, as well as agricultural inputs like seeds, fertilizers, and agrochemicals to determine their impact on sorghum production. Employing multiple regression analysis, the results reveal that education positively influences productivity, while fertilizers show a negative correlation, likely due to improper application. Seed quantity, herbicides, and insecticides significantly enhance production. Conversely, larger plot sizes are associated with lower productivity, suggesting inefficiencies in resource management. The study emphasizes the need for targeted policy interventions to improve access to high-quality seeds, provide farmer education on input management, and promote better resource allocation for smallholder farmers. These findings offer valuable insights for policymakers aiming to boost sorghum productivity, strengthen food security, and support rural livelihoods in Tanzania.

1. Introduction

Sorghum is a critical cereal crop globally, valued for its drought tolerance and versatility in various climatic conditions. Globally, sorghum is cultivated in over 100 countries, with major producers including the United States, India, Nigeria, and Sudan. As a staple food crop in many regions, sorghum contributes to global food security and is a key ingredient in livestock feed and industrial applications (FAO, 2020).

In Africa, sorghum is a fundamental food crop, particularly in semi-arid regions where its resilience to harsh climatic conditions makes it a primary staple. Countries such as Nigeria, Sudan, Ethiopia, and Burkina Faso are among the top producers on the continent. Studies (e.g., Tesfaye et al., 2019) have shown that sorghum is not only a source of food but also a significant income source for smallholder farmers. However, despite its importance, average yields in Sub-Saharan Africa remain below global averages due to challenges such as poor access to quality seeds, inadequate fertilizer use, and limited farmer knowledge of improved practices.

In East Africa, sorghum is widely cultivated in countries such as Kenya, Uganda, Ethiopia, and Tanzania. The region benefits from sorghum's ability to thrive in dry conditions where other crops fail. However, similar to other African regions, production is constrained by limited access to agricultural inputs and insufficient farmer training (Mamo et al., 2019).

Sorghum is an essential cereal crop in Tanzania, particularly in semi-arid regions where its drought tolerance makes it a vital component of food security strategies. Despite its significant role in the livelihoods of rural communities and in addressing food security, sorghum productivity remains far below its potential in Tanzania. The average production per hectare is approximately 1.2 tons, considerably lower than the estimated potential of 3 tons per hectare. These low production rates are concerning, especially given the increasing challenges posed by climate variability, land degradation, and limited access to agricultural inputs. The need to better understand the factors affecting sorghum production is critical for improving yields, ensuring food security, and supporting smallholder farmers.

Several factors have been identified as affecting agricultural productivity, including the demographic characteristics of farmers and the availability of essential agricultural inputs. Studies have suggested that education level plays a key role in improving productivity, as better-educated farmers are more likely to adopt modern farming techniques that lead to increased yields. Previous research in Sub-Saharan Africa, such as work by Tesfaye et al. (2019) and Mamo et al. (2019), has emphasized the importance of education and access to inputs such as seeds, fertilizers, and agrochemicals. However, in the context of Tanzanian sorghum production, there is limited data on how these factors interact to affect production,

and whether the trends observed in other crops apply similarly to sorghum.

The use of improved seeds and fertilizers has often been linked to higher yields in various crops, including sorghum. However, as noted by Degefa et al. (2022), improper use of fertilizers, particularly over-application or misuse, can result in negative outcomes for crop productivity, a trend that has been noted in other parts of East Africa. Similarly, the availability and use of agrochemicals, such as herbicides and insecticides, play a significant role in improving yields by reducing pest damage and weed density. Nonetheless, farmers in Tanzania often face challenges accessing these inputs due to cost and logistical constraints, and there is limited research exploring how such inputs affect sorghum production specifically.

The gap in the literature regarding the impact of demographic characteristics, such as education and gender, alongside agricultural inputs on sorghum production in Tanzania, presents a need for further investigation. This study seeks to fill that gap by examining how these factors affect sorghum production, to provide data-driven recommendations for improving productivity. By focusing on data from the 2019–2020 National Sample Census of Agriculture (NSCA), this research seeks to understand the correlations between farmer characteristics and the use of inputs, such as seeds, fertilizers, and agrochemicals, and their effect on sorghum production.

The specific objectives of this study are threefold: first, to determine the effect of the household head's demographic characteristics on sorghum produced; second, to investigate the relationship between agricultural inputs, such as seed quantity, fertilizers, and agrochemical use, and sorghum produced; and third, to assess the effect of these agricultural inputs such as seed quantity, fertilizers, herbicides, fungicides, and plot size on overall sorghum production. By understanding the dynamics between these factors, the study aims to contribute to broader efforts to improve agricultural efficiency, increase sorghum production, and promote food security in Tanzania.

This study is significant for several reasons. Improving sorghum production has the potential to strengthen food security and enhance the livelihoods of smallholder farmers who depend on this crop. By identifying key demographic and input-related factors affecting productivity, this research offers valuable insights for policymakers and development practitioners focused on increasing agricultural efficiency. The results can help in formulating better-targeted agricultural policies and programs that enhance access to critical inputs, provide tailored training, and support the most vulnerable farming communities, including female-headed households. Through these interventions, there is potential to increase production and contribute to rural economic development and poverty alleviation.

2. Methods and Materials

2.1 Data Collection

This study utilizes cross-sectional data from the National Sample Census of Agriculture (NSCA) 2019/2020, which provides a comprehensive dataset on agricultural practices across Tanzania. The dataset includes detailed information from approximately 122,780 households engaged in sorghum production, capturing demographic characteristics (age, gender, education level) and agricultural input usage (seeds, fertilizers, agrochemicals). The census also records data on plot size, production techniques, and output in terms of production.

2.2 Analytical Framework

The study employs a multiple regression analysis model to assess the effect of various demographic and agricultural inputs on sorghum productivity. The dependent variable is sorghum production per hectare, while the independent variables include:

- Demographic characteristics: Age, gender, and education level of household heads.
- Agricultural inputs: Seed quantity, fertilizer usage, herbicide, fungicide, and insecticide application.
- Environmental factors: Plot size and seasonal rainfall data.

2.3 Data Analysis Module

The study uses STATA for statistical computations and SPSS for descriptive statistics to perform the analysis. These modules are suitable for handling large datasets like NSCA, allowing for regression analysis, significance testing, and interpretation of key variables affecting sorghum production.

2.4 Model Specification

The multiple regression model is specified as follows:

$Y = \beta0 + \beta1*X1 + \beta2*X2 + \beta3*X3 + ... + \varepsilon$

Where:

- Y is the dependent variable.
- $\beta0$ is the intercept (constant term).
- $\beta1$, $\beta2$, $\beta3$, ... are the coefficients of the independent variables.
- X1, X2, X3, ... are the independent variables.
- ε is the error term, representing unexplained variability.

3. Results

3.1 Demographic Characteristics and Sorghum Production

Table 1: Distribution of Household Heads by Gender

Gender	Frequency	Percentage
Male	27,456	76.96%
Female	8,218	23.04%
Total	**35,674**	**100%**

The analysis shows that the majority of sorghum-producing households are male-headed. However, the gender of the household head does not significantly affect sorghum yields.

3.2 Education and Sorghum Production

Households headed by individuals with higher education levels report significantly higher yields, indicating that education plays a key role in adopting improved farming techniques.

3.3 Agricultural Inputs and Sorghum Production

Table 2: Seed Type Used by Farmers

Seed Type	Frequency	Percentage
Local Seeds	34,464	96.61%
Improved Seeds	1,040	2.92%
Both Local & Improved	170	0.48%

Results in Table 2 indicate that most farmers (96.61%) use local seeds for sorghum production, 2.92% use improved seeds, and only 0.48% use both.

The use of improved seeds is positively correlated with higher yields, though only a small percentage of farmers use them. Fertilizer usage, which is reported by 8.29% of farmers, shows a negative impact on yield, likely due to improper application or poor-quality inputs.

3.4 Inferential Analysis

Table 3: Multiple Regression Results

Variable	Coefficient	Standard Error	t-value	P-value
Gender	**3.097**	**2.559**	**1.21**	**0.226**
Age of Household Head	**0.021**	**0.065**	**0.32**	**0.753**
Education Level	**3.775**	**1.845**	**2.05**	**0.041***
Plot Size	**-8.726**	**0.854**	**-10.21**	**0.000*****

Improved Seed Used	**1.127**	**0.057**	**19.87**	**0.000*** **
Fertilizer Used	**-0.008**	**0.001**	**-8.34**	**0.000*** **
Herbicide Used	**37.268**	**6.760**	**5.51**	**0.000*** **
Fungicide Used	**-16.891**	**2.532**	**-6.67**	**0.000*** **
Insecticide Use	**3.803**	**1.192**	**3.19**	**0.001** **
Rainy Season	**33.312**	**1.175**	**28.35**	**0.000*** **

The multiple regression analysis indicates that education has a positive and significant impact on sorghum yield ($\beta = 3.775$, $p = 0.041$), while fertilizer usage negatively affects yield ($\beta = -0.008$, $p < 0.001$). Improved seed usage significantly increases yield ($\beta = 1.127$, $p < 0.001$), whereas larger plot sizes show diminishing returns ($\beta = -8.726$, $p < 0.001$). These findings emphasize the importance of farmer education and proper input use for improving productivity**.**

4. Discussion

4.1 Impact of Education on Sorghum Production

The results show that education significantly influences sorghum production, with a positive coefficient of 3.775 ($p = 0.041$). This suggests that as farmers' education levels increase, their sorghum yields also improve.

Educated farmers are more likely to adopt improved farming techniques, access agricultural information, and make informed decisions. This aligns with the findings of Smith et al. (2020), who reported that education enhances farmers' capacity to utilize modern inputs effectively. Similarly, Mghenyi and Jayne (2021) found that educated farmers in East Africa were more likely to diversify crops and adopt climate-smart practices.

These findings indicate that education empowers farmers with knowledge and skills, leading to better management of agricultural practices. To enhance sorghum production in Tanzania, policymakers should prioritize farmer education through targeted training and extension services.

4.2 Impact of Fertilizer Usage on Sorghum Production

The study reveals a negative relationship between fertilizer usage and sorghum production, with a

coefficient of -0.008 ($p < 0.001$). This indicates that increasing fertilizer use leads to reduced sorghum yields.

This negative effect may be due to improper fertilizer application, such as incorrect dosage or timing, which can harm crops. In line with this, Tadele and Beshir (2019) found that excessive fertilizer use reduced yields in Ethiopian sorghum farms. Similarly, Mutuku et al. (2022) highlighted that balanced fertilizer use improved yield outcomes in East African cereals.

These findings underscore the importance of proper fertilizer management. Agricultural training programs should emphasize the correct use of fertilizers to optimize sorghum production.

4.3 Impact of Plot Size on Sorghum Production

The analysis indicates a negative relationship between plot size and sorghum yield, with a coefficient of -8.726 ($p < 0.001$). This suggests that larger plots are associated with lower yields.

This may be attributed to inefficient resource management on larger farms. Gebre and Rahmeto (2020) similarly reported that smallholder farms in Ethiopia achieved higher productivity per hectare than larger farms, due to better input management.

The findings imply that effective resource management is critical for optimizing production. Extension services should focus on teaching efficient resource management techniques, particularly for farmers with larger plots.

4.1 Policy Recommendations

To effectively enhance sorghum production in Tanzania, a comprehensive set of policy recommendations is essential. These recommendations are based on empirical findings from the study and are supported by insights from relevant literature, ensuring a balanced approach that aligns with existing policies, such as the National Agricultural Policy and the Sustainable Development Goals (SDGs).

Enhancing Access to Agricultural Inputs;

Access to quality agricultural inputs, including improved sorghum seeds and fertilizers, remains a critical factor in increasing productivity. Studies (e.g., Msuya et al., 2020; Kweka & Moshi, 2019) emphasize that improved seed varieties adapted to local soil and climate conditions can significantly enhance yield. This aligns with the Tanzanian Agricultural Policy, which advocates for the promotion of improved seed varieties and sustainable input use. Policymakers should ensure that these inputs are available at affordable prices, particularly for smallholder farmers.

Strengthening Farmer Education and Training;

Farmers' knowledge of modern agricultural practices, including proper input application, pest

management, and soil conservation, is vital. Research (e.g., Chacha et al., 2021) indicates that farmer training significantly improves crop management practices and productivity. The Tanzanian Agricultural Extension Policy underscores the need for continuous farmer education. Implementing tailored training programs, with a focus on local farming challenges, can enhance productivity.

Promoting Gender-Inclusive Agricultural Practices;

Female farmers, especially those heading households, are currently underrepresented in sorghum production. Studies (e.g., Mbowe & Juma, 2022) show that gender disparities in access to resources and training reduce overall productivity. Policies should include targeted support for female farmers through access to credit, training, and land ownership rights, aligning with SDG 5 (Gender Equality) and SDG 2 (Zero Hunger).

Facilitating Access to Agricultural Finance;

Access to affordable agricultural credit is essential for smallholder farmers to invest in improved seeds, fertilizers, and modern farming equipment. According to Kileo (2020), lack of financing is a major barrier to agricultural productivity in Tanzania. Policies should promote microfinance initiatives and low-interest loans specifically for smallholder sorghum farmers.

Enhancing Agricultural Research and Development (R&D);

Continuous research on sorghum varieties, soil management, and pest control is essential. Strengthening the link between research institutions and farmers can ensure that innovative solutions reach the grassroots level. This recommendation aligns with the Agricultural Sector Development Program (ASDP II), which prioritizes agricultural R&D.

5. Conclusion

This study highlights the critical role of education and access to agricultural inputs in improving sorghum yields in Tanzania. Policy interventions aimed at improving access to quality inputs and farmer education are necessary to support smallholder farmers and increase productivity. Further research is needed to explore the long-term impact of climate change and the effectiveness of targeted interventions on sorghum production.

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