

Research Article

Determinants of Adoption of Improved Sorghum Varieties by Small-Scale Farmers in Selected Districts of Western Oromia

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Abstract

Achieving national food security and diversifying export earnings from agricultural products is one of the major challenges currently facing developing countries like Ethiopia. Ethiopia is the largest producer of sorghum in Africa, contributing to ensuring food security in the country. Despite the high production potential and the economic importance of the crop, the adoption, and dissemination of improved sorghum varieties are constrained by various factors. To this end, this study aimed to identify determinants of adoption of improved sorghum varieties in selected districts of Western Oromia Region, Ethiopia with the specific objectives of identifying factors affecting adoption and assessing factors hindering the production of improved sorghum varieties. The study was based on cross-sectional data from 154 randomly selected sorghum-producing farmers. Descriptive and econometric analyses were used to analyze data. The results show that about 14.94% and 85.06% were adopters and non-adopters of the crop respectively. Probit model results showed that education and extension service affected the probability of adoption of improved sorghum varieties positively and significantly while TLU affected it negatively and significantly. Untimely availability of improved seed, Price of seed, Quality of improved seed, unavailability of credit to buy seed, Untimely availability of fertilizer, High price of fertilizer, Access to market information, Low grain price, and Pests and disease are the major constraints that affect sorghum production in the study area. This study suggests the high importance of institutional and government support in education, Extension service, and improved cows than a large number of local breeds. Therefore, policy and development interventions should give emphasis on the improvement of such institutional support systems so as to achieve the adoption practice which increases the production and productivity of small-scale farmers.

Keywords

Adoption, Constraint, Sorghum, Probit

1. Introduction

1.1. Background

Sorghum is the world's fifth-largest and most important cereal grain crop after wheat, maize, rice, and barley [9]. It is the

second most important cereal crop after maize in Sub-Saharan Africa [14]. It is used as human food, and it is a staple food for more than 100 million people in Eastern Africa [10]. It is also used as animal feed and industrial raw material [3].

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Ethiopia is the largest producer of sorghum in Africa after Nigeria and Sudan and the second after Sudan in the Common Market for Eastern and Southern Africa member countries [2, 16]. Sorghum is a major staple food crop that ranks second after maize in total production as well as the third-largest crop in productivity after wheat and maize and area coverage after tef and maize [5]. The crop is one of the most widely grown cereal crops in a wide range of agro-ecologies between 400m and 2500m altitudes [8] and a staple food crop for millions of poor Ethiopians whose food insecurity is rambling [3].

In the Oromia region, sorghum is the total production and area coverage from all regions of Ethiopia and the third most important crop in the region [5]. Since sorghum is a staple crop of subsistence farmers, increasing productivity and production is often considered a means of improving the incomes and food security of poor farmers especially, in the East Wollega and West Shewa zones of Oromia [6]. Sorghum research was conducted in the last five decades by different research centers including the Bako Agricultural Research Center with many success stories [8].

Productivity-improving crop technology can be an option for rural farmers to eliminate hunger and food insecurity by increasing production, reducing food prices, and making food more accessible to the poor. The use of high-yielding crop varieties facilitates the growth of agro-processing enterprises and non-farm sectors and stimulates the transition from low-productivity subsistence agriculture to a high-productivity agro-industrial economy [12]. Further, developing and promoting the adoption of yield-increasing crop varieties in a sustainable manner helps improve the livelihood of rural farmers [4].

Clearly, the food security of the majority of rural farmers can be improved if the performance of the agricultural sector is enhanced. Improvement and diffusion of sorghum varieties have an invaluable role in reversing food insecurity. Due to this Chemed, Lalo, and Gemedi sorghum varieties have been generated and promoted for many years in the study area by BARC. Despite such an intervention the adoption and intensity of adoption of improved sorghum varieties are not studied. Therefore, this study was proposed to identify the determinants of adoption and intensity of adoption of improved sorghum varieties to fill the existing knowledge gap.

1.2. Objectives of the Study

1. To identify factors affecting the adoption of improved sorghum varieties in the study areas.
2. To assess production constraints of improved sorghum varieties in the study areas.

2. Research Methodology

In this chapter, a brief description of the study areas, sampling methods and sample size, sources and types of data and data collection methods, methods of data analysis, and measurement & definitions of variables are presented.

2.1. Description of the Study Areas

This study was conducted in West Shewa, East Wollega, and Bonno Bedelle zones. From the West Shewa zone, Ilu Gelan and Dano districts are located at 200 km and 233 km, respectively to the west of Finfinne, the capital city of Ethiopia. The location of the Ilu Gelan district is 8°59'51"N latitude, 37°19'49" E longitude, and 1812 meters above sea level altitude whereas the Dano location is 8°40' N latitude, 37°20' E longitude, and 1400 - 2500 m a.s.l. The annual rainfall of those districts is 1351 and 1400 - 1900 mm, respectively. In both districts, more than 90% of the population depends on agriculture for their livelihood with maize, tef, and sorghum leading crops. Agro-ecologically, both districts are characterized by highland (5%), midland (25%), and lowland (70%). In both districts, a mixed crop-livestock production system is the main agricultural practice performed by the majority of the farmers.

From the East Wollega zone, Bonaya Boshe and Wayu Tuka districts which are located at 307 and 323 km, respectively to the west of Finfinne are used. The location of Bonaya Boshe district is 8°54'45"N latitude, 37°02'16" E longitude, and 1613-1641 meters above sea level altitude whereas Wayu Tuka location is 8°56'N and 9°07'N latitude, 36°32' E and 36°48' E longitude and 1300-3140 m a.s.l. altitude. The annual rainfall of those districts is 1000-1200 and 99.9 - 4026 mm, respectively. In both districts, more than 90% of the population depends on agriculture for their livelihood with maize, tef, and sorghum leading crops. In both districts, a mixed crop-livestock production system is the main agricultural practice performed by the majority of the farmers.

From Bunno Bedelle zone, Chewaqa district which is located 390 km to the west of Finfinne is used. The area lies within altitude ranges of 900 - 1400 m a.s.l. The annual rainfall of this district ranges from 1000 - 1200 mm. In the Chewaqa district, again more than 90% of the population depends on agriculture for their livelihood with maize, rice, sorghum, and sesame leading crops.

2.2. Sampling Methods and Sample Size

A three-stage sampling technique was employed to select sample respondents. In the first stage, districts were purposively selected for this study, due to the fact that improved sorghum technology is widely popularized by Bako Agricultural Research Center (BARC). In the second stage, Kebeles were randomly selected. Households in districts were stratified into producers and non-producers and representative samples were selected from each producer of sorghum.

The sample size was determined by using a formula developed by Cochran's [7] sample size formula for categorical data.

$$n = \frac{Z_{\alpha/2}^2 pq}{e^2}$$

Where n is the sample size for the study, $Z_{\frac{\alpha}{2}}$ is for the selected alpha level of 0.025 in each trial =1.96, p is the number of adopters q is the number of non-adopters and e is the precision level.

2.3. Sources and Types of Data and Data Collection Methods

Both primary and secondary data were used. For this study, primary data were collected on a one-to-one interview basis using a structured survey questionnaire pre-tested and administered by well-trained and experienced enumerators who have knowledge of the farming system and the local language. During the personal interview information on sorghum varieties grown, key socio-economic elements (including age, gender, education level, family size, membership in farmers' organizations, consumption expenditures, distance of a residence from input and output markets, and extension offices, and institutional and other relevant) factors were collected. The secondary data source includes books, journals, and other published and unpublished documents from Bako Agricultural Research Center, Zonal and District Agricultural offices, the internet, and other related sources to supplement primary data.

2.4. Methods of Data Analysis

In this study, both descriptive statistics and econometric models were used to analyze the data.

2.4.1. Descriptive Statistics

Descriptive statistics such as mean, standard deviation, frequency distribution, and percentages were used to clearly show sample unit characteristics. A chi-square test and an independent sample t-test were also used to compare adopters and non-adopters in terms of explanatory variables.

2.4.2. Econometric Model

The Probit econometric model was applied to analyze explanatory variables of as shown in equation (1).

The probit model can be specified as shown below:

$$Y_i = F(X_i\beta) + \epsilon_i \quad (1)$$

$$Y_i = \begin{cases} 1, & \text{if adopted} \\ 0, & \text{otherwise} \end{cases} \quad (2)$$

where, $\epsilon \sim N(0,1)$; β = maximum likelihood; ϵ = error term; X = set of independent variables included in the model. Since estimates of the probit model provide only the direction of effects, the marginal effects are usually calculated to interpret the actual change in the probability of independent variables.

$$\text{Marginal effects} = \beta_i \phi(z) \quad (3)$$

where, β_i = coefficients of the variables; $\phi(z)$ = cumulative normal distribution value associated with the mean dependent variable from the probit estimation.

2.5. Measurement and Definitions of Variables for Adoption

2.5.1. Dependent Variables

Adoption Decision

The dependent variable for the probit model takes a dichotomous value depending on the farmers' decision either to adopt (one) or not to adopt (zero) the improved Sorghum varieties production.

Adopters are farmers who use the Lalo, Chemedda, and Gemedi Sorghum varieties. Non-adopters are farmers who didn't use at least one variety.

Table 1. Summary of independent variables, their definitions, and expected effect.

Dependent variables 1. Adoption of improved sorghum variety		Dummy (1. Yes 0. No)	
Independent Variables	Definitions of variables	Unit of measurement	Expected sign
Age	Age of household head	Years	+/-
Sex	Sex of the household head	1. Male 0. Female	+
Family size	Number of persons per household	No	+
Marital statues	Marital status of household heads	0. Married; 2. Widowed; 1. Divorced; 3. Single	+/-
Education	Formal education level of household head	Grade attended	+
Non-farm	Income from non-farm activities	1. Yes 0. No	+
Farming experience	Sorghum farming experience of the household head	Years	+

Dependent variables 1. Adoption of improved sorghum variety		Dummy (1. Yes 0. No)	
Independent Variables	Definitions of variables	Unit of measurement	Expected sign
Off-farm	Income from off-farm activities	1. Yes 0. No	+
Livestock	Number of livestock owned	TLU	+
Distance to a market center	Distance of farmers' house from a nearby market	Hour	-
Credit	Use of credit for framing	1= Yes 0=No	+
Farm size	Total land holding size of the household head	Hectares	+
Extension	Participation of extension service	1=Yes 0=No	+

3. Results and Discussion

3.1. Descriptive Results

The sample size handled during the survey was 154. Out of the total interviewed sorghum producers 129 (83.77%) were

male-headed and the remaining 25 (16.23%) were female-headed. The chi-square test of sex distribution, marital status, and credit access between the adopters and non-adopters was found to be insignificant while the chi-square test of access to extension between the adopters and non-adopters was found to be significant at a 5% level of significance.

Table 2. χ^2 -test for binary independent variables.

Variable		Non-Adopters (N=131)		Adopters (N=23)		χ^2 -test	Total (N=154)	
		No	%	No	%		No	(%)
Sex	Male	110	83.97	19	82.61	0.0266	129	83.77
	Female	21	16.03	4	16.39		25	16.23
Marital status	Married	124	94.66	22	95.65	0.6297	146	94.80
	Widowed	4	3.05	1	4.35		5	3.25
	Single	3	2.29	0	0.00		3	1.95
Credit	Yes	113	86.26	18	78.26	0.9853	131	85.07
	No	18	13.74	5	21.74		23	14.93
Extension	Yes	96	73.28	20	86.96	30.9682**	116	75.32
	No	35	26.72	3	13.04		38	24.68

The adopters' average age, Sorghum production experience, and education level were 42.52 years, 15.35 years, and 4.05 grades respectively, and it is about 42.88 years, 17.92 years, and 2.54 grades respectively for non-adopters. The t-test of age, sorghum production experience, TLU, Off-farm income, non-farm income, family size, and distance to market between adopters and non-adopters was found to be insignificant. That

means there is no statistical mean difference between adopters and non-adopters in terms of the variables. The t-test of education level between adopters and non-adopters was found to be significant at a 1% level of significance. That means there is a statistical mean difference between adopters and non-adopters in terms of education level.

Table 3. *t-test for continuous independent variables.*

Variable	Non-Adopter (N=131)		Adopters (N=23)		t-test
	mean	Std	Mean	Std	
Age	42.88	1.07	42.52	1.78	0.1337
Sorghum Production experience	17.92	0.88	15.35	1.89	1.1508
Education level	4.05	2.78	2.54	2.86	-2.95***
TLU	6.535802	.388999	5.46913	.9541606	1.0554
Off-farm income	1915.73	536.06	2336.96	1576.88	-0.2929
Non-farm income	745.04	227.61	739.13	486.85	0.0102
Family size	6.56	0.26	6.43	0.46	0.1882
Distance to market	30.21	1.48	26.96	4.70	0.8060

3.2. Econometric Results

In this sub-section, the results of the Probit regression model are presented and discussed and the major constraints of sorghum production are explained.

Table 4. *Determinants of adoption of improved sorghum varieties.*

Variables	Probit regression		
	Coef.	Std. Err.	Marginal Effect
Sex	0.121	0.076	0.026
Age	0.013	0.003	0.003
Education	0.157***	0.013	0.0270
Sorghum production Experience	-0.024	0.004	-0.005
Family size	0.053	0.012	0.011
Distance market	-0.004	0.002	-0.001
Marital Status	-0.037	0.056	-0.008
TLU	-0.058*	0.007	-0.012
Off-farm income	-6.29e-06	.000	-1.34e-06
Non-farm income	-0.001	.0001	-3.46e-06
Credit	-0.471	0.101	-0.119
Extension	0.693*	0.050	0.120
constant	-1.526*		
sigma			
Number of obs =154 Prob > chi2 = 0.06064			
LR chi2(12) =10.11 Log likelihood = -57.98			
Pseudo R2 =0.0780			

The adoption decision of farm households is influenced by different socioeconomic, technical, and institutional factors. Different variables are important across different spaces and over time in explaining the adoption of technologies by farmers. Based on theoretical models and empirical evidence, many factors are hypothesized to influence the adoption of improved sorghum varieties.

The 3 explanatory variables that have been found to significantly influence the decision by the sample farm households with regard to whether or not to adopt improved Sorghum varieties are interpreted and discussed below.

Education: The education level of the household head, which is one of the important indicators of human capital, has a positive and significant effect on the adoption of improved sorghum varieties at a 1% level of significance, implying that the likelihood of adoption increases with farmer's formal education level. On average, each additional year of education of the household head increases the probability that a farmer adopts improved sorghum varieties by 2.7%. This is consistent with the research results of [1, 13, 15, 11].

Livestock (TLU): Livestock holding negatively and significantly related to the adoption of improved sorghum varieties at a 10% level of significance, implying that farmers with more livestock holding are more unlikely to devote a signif-

icant amount of land to improved sorghum varieties than those households with less livestock holding. A household with large livestock holdings allocates more land for grazing than for sorghum production. A one-unit increase in livestock holding (TLU) decreases the adoption of improved sorghum varieties by 1.2%.

Extension: Extension was positively related to the adoption of improved sorghum varieties at a 10% level of significance. The result of probit regression indicates that as compared to farmers who got extension service on improved sorghum varieties, those farmers who did not get an extension on sorghum their probability of adoption of improved sorghum varieties decreased by 12%.

3.3. Major Sorghum Production Constraints

Major sorghum production constraints are presented in Table 5 below. The first major constraint of sorghum production was the high price of fertilizers (86.36%). This implies that the government should give due attention to the availability and price of the sorghum. Pests and disease, Low grain prices, and Access to market information are Constraints ranked high in importance by the farmers.

Table 5. Major sorghum production constraints of sample households.

Constraints (n=154)	N	%	Rank
1. Untimely availability of improved seed	106	68.83	5
2. Price of seed	66	42.86	8
3. Quality of improved seed	80	51.95	7
4. Unavailability of credit to buy seed	57	37.03	9
5. Untimely availability of fertilizer	94	61.04	6
6. High price of fertilizer	133	86.36	1
7. Access to market information	117	75.97	4
8. Low grain price	125	81.17	3
9. Pests and disease	129	83.77	2

4. Conclusion and Recommendations

4.1. Conclusion

The activity was initiated with the objective of identifying factors affecting the adoption and assessing production constraints of improved sorghum varieties in the selected districts of western Oromia.

A three-stage sampling technique was employed to select

sample respondents using Cochran's (1977) sample size formula for categorical data. Both descriptive statistics and econometric (probit) models were employed to identify factors affecting the adoption of improved sorghum varieties.

The sample size handled during the survey was 154. Out of the total interviewed sorghum producers, 129 (83.77%) were male-headed and 825 (16.23%) were female-headed households.

Descriptive statistics such as mean, standard deviation, and percentages were used. The chi-square test and t-test were

also used to compare adopters and non-adopters regarding explanatory variables.

The econometric results showed that education level, TLU, and Extension services affected the probability of adoption of the improved sorghum varieties at 1%, 10%, and 10% levels respectively. In contrast, Untimely availability of improved seed, Price of seed, Quality of enhanced seed, unavailability of credit to buy seed, Untimely availability of fertilizer, High price of fertilizer, Access to market information, Low grain price, and Pests and disease are the major constraints that affect sorghum production in the study area.

4.2. Recommendations

On the basis of the results of this study, the following recommendations are suggested to be considered in the future intervention strategies which are aimed at promotion of improved sorghum varieties.

Education has a significant positive impact on the adoption of improved sorghum varieties. Hence, strengthening adequate and effective basic educational opportunities for rural farming households in general and to the study areas in particular is required. In this regard, the federal and regional governments need to strengthen the existing provision of formal and informal education by facilitating all necessary materials.

The size of livestock owned has a significant negative impact on the adoption of improved sorghum varieties. The government should Strengthen the farmers by providing high-yielding crossbreeds over a large number of local breeds, improving health services, better livestock feed (forage), and disseminating artificial insemination in the areas to improve the adoption of improved sorghum varieties.

Extension Service was found to be positively and significantly influencing the adoption of the improved sorghum varieties. So, Development agents should give intensive extension services and education that improve the adoption of improved sorghum varieties by farm households.

The government should give attention to the major constraints of sorghum production in the study area.

Author Contributions

Galmesa Abebe is the sole author. The author read and approved the final manuscript.

Conflicts of Interest

The authors declare no conflicts of interest.

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