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Adoption of improved potato varieties in Ezha District Southern, Ethiopia

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Abstract

The improvement of potato yield and overall production is significantly dependent on the integration of advanced technologies, particularly the use of enhanced potato varieties. Nevertheless, the uptake of these improved varieties in developing nations, such as Ethiopia, is constrained by a range of factors, including socio-economic, demographic, and institutional challenges. To investigate this matter, the study was conducted in the Ezha District, located in southern Ethiopia. This research used a three-stage sampling technique and gathered primary data through interviews, focus group discussions, and key informant interviews, as well as secondary data from various references. The analysis of the data indicated that the adoption rate of improved potato varieties was 48.4%, while the intensity of adoption was 55.01%. Based on the probit regression model, it was found that factors such as level of education, size of land and livestock, frequency of extension contact, and membership in a cooperative had a positive impact on farmers' decisions to adopt improved potato varieties. Conversely, the distances to the farmer's training centre and the nearest market had a negative influence. As a result, it was suggested that stakeholders, including the local community, District Agriculture Office, and research institutes, should promote improved potato varieties in the study area to enhance potato yield and production.

Keywords: improved potato varieties, determinants, probit model

1. INTRODUCTION

Potato (Solanum tuberosum L.) is a crucial root and tuber crop precisely grown in more than 125 countries worldwide. It is a short-cycle crop that is well-suited for double cropping, making it a popular choice for farmers (Yigezu, Y. A., C. Y. Tizale and A. Aw-Hassan, 2015). In terms of production, it is the fourth-most important food crop globally (FAO, 2019) and the most important of the vegetable crops. Over the past two decades, potato production and harvested areas have more than doubled in Africa, making it a vital food security crop in the high altitude and variable rainfall of Sub-Saharan Africa. For over 150 years, potatoes have been cultivated in Ethiopia; they provide food and income to over 2.3 million households across the country (Seifu F. and E. Betewulign, 2017).

Potatoes are a multifunctional crop that can be grown in a different agroecology (Burke, J. J., 2017). It is used to address seasonal food shortages during other food crops being depleted through storage (Singh, B. P. and Rana, R. K., 2015). So far, the importance of potatoes is increasing due to urbanisation and the introduction of potato-processed products such as French fries (crisps) and potato crisps and their impact on demand; as a food source, it also plays a major role in the national economy (Ketema, M., D., Kebede, N. Dechassa, and F. Hundessa, 2016).

Ezha is one of the districts that grow potatoes extensively for economic and social benefits in the southern part of Ethiopia. In fact, the productivity of the crop is low due to multidimensional factors such as

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inadequate supply of disease-resistant and high-yielding varieties, limited knowledge of agronomic and crop protection management technologies, and poor postharvest handling (Nigussie, D., K. Mengistu, D. Haile, K. Wole, A. Tamiru, B. Olkaba, A. Solomon, and T. Samuel, 2012). As a matter of fact, implementation of agricultural technology like improved varieties plays a crucial role in enhancing agricultural productivity, attaining food self-sufficiency, alleviating poverty, and mitigating land degradation (Solomon and T. Samuel, 2012). In addition to increasing farmers' income, maintaining food security, contributing to economic development, and improving their capacities to maximise their benefits (Anis, G., H. Hassa, and A. El-Sherif), H. Saneoka and A. EL Sabagh, 2019).

Improved varieties (IVs) produce more crops and are better at fighting late blight virus and bacterial wilt. As a matter of fact, research centres, universities, and private enterprises in Ethiopia have introduced more than 36 improved potato varieties (Woldegiorgis, G. 2013). However, many Ethiopian farmers remain hesitant to adopt these improved potato varieties for cultivation. As a matter of fact, the productivity of potatoes in Ethiopia is considerably lower than that of other nations, attributed to several challenges, including the prevalence of diseases, lack of access to improved seed varieties, insufficient storage infrastructure, and an antiquated production system (Gebru, H., A., Mohammed, N. Dechassa, and D. Belew, 2017). Moreover, farmers are not adopting advanced technologies as anticipated, primarily due to the prohibitive costs of seeds, the inadequate availability of fertilisers and pesticides, a lack of credit facilities, and limited awareness. Still, the integration of enhanced agricultural technology is essential for improving the living conditions of the rural poor. In fact, improved potato varieties currently grown in the study area include Belete, Jalene, and Gudene. Notably, there has been no prior research conducted in this region concerning the acceptance of new potato varieties or the barriers that impede the adoption of improved potato varieties. Therefore, this study was initiated to investigate the determinant factors that affect the adoption of enhanced potato varieties and analyse the rate and extent of their implementation within the study area.

2. Materials and Methods

2.1. The study area

The research was carried out in the Ezha District, which is in the Gurage Zone of the Southern Ethiopia Regional State of Ethiopia. Ezha is one of the sixteen districts in the Guraghe zone. It is positioned 180 km from Addis Ababa, in the southwest route along the main road to Wolkite. The district's geographical coordinates are from 8°50' to 9°15' N and from 38°25' to 38°45' E. According to the 2007 census report by the CSA, the population of Ezha District was 84,905, with 40,261 males and 44,644 females. The district altitude ranges from 1895 to 3200 m.a.s.l. The area experiences a bimodal distribution of rainfall, with short rains occurring from February to May and heavy rains from June to September. The average annual rainfall is approximately 950to1100 mm. The minimum and maximum temperatures range from 7.5°C to 28°C, respectively.

2.2. Data Types, Source and Method of Data Collection

A cross-sectional study design was used in the research. The data collection techniques employed for this study encompassed household surveys, focus group discussions, and key informant interviews in the Ezha District during the production year of 2022/23. For this study, data were collected in both qualitative and quantitative forms. Qualitative data was obtained through focus group discussions and key informant interviews. Conversely, primary quantitative data was gathered using an arranged questionnaire format through 7.5 CSPRO software and a computer-assisted personal interview (CAPI). This data includes factors related to demographics, socioeconomics, and institutions, as well as the farmers' responses to the adoption of improved potato varieties and their rate and extent. Additionally, field observations were conducted to gather information about potato production on a farm station. Secondary data was obtained from the District Finance and Economic Development Office and the Central Statistical Agency of Ethiopia.

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2.3. Sampling and sample size determination techniques

The sample household was selected using a three-stage sampling technique. In the initial stage, Ezha District was purposefully chosen out of the 16 districts in Guraghe Zone due to its high potential for potato production. Ezha District consists of 29 rural kebeles, out of which six were identified as potential potato producers. In order to be included in the study, three Kebeles were selected at random from this group in the second stage. Thirdly, from three kebeles, choose farmers randomly using a probability proportionate to size sampling approach, taking into account the size of each selected kebele. These steps resulted in a total sample household of 250. The sample size for the three Kebeles was determined at a 0.05 (5%) level of precision using a simplified formula provided by Yemane (1967).

$$n = \frac{N}{1+N(e^2)} = 250 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 1$$

Where n is required sample, N the total number of households for the three Kebeles and
e is degree of confidence.

$$ni = \frac{Ni(n)}{\sum Ni} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 2$$

Where ni = sample from the i^{th} kebele, Ni is total population in the i^{th} kebele.,ΣNi is the summation of population in three selected kebeles and n is sample size of the study.

2.4. Method of data analysis

Both descriptive and econometric methods are used to analyse the collected data. Descriptive statistics such as percentages, means, and standard deviations were utilised to analyse the explanatory variables. Inferential statistics, specifically t-tests and χ2 tests, were employed to determine if there were significant differences among households that adopted improved potato varieties in terms of continuous and categorical variables. Narrative and interpretation analyses were used to analyse qualitative data gathered from FGDs and KIIs. The collected data was analysed using Excel 2010 and Stata V15 software.

2.4.1 Probit Regression Model

The decision of a farmer to participate in the cultivation of improved potato varieties is a dependent variable that can be represented as a binary variable with a value of either one or zero, indicating whether the household is an adopter or not. According to Greene, W. (2004), the participation decisions of households can be determined using either logit or probit models, as the results of both models are similar. A probit regression model was used for this study to evaluate the factors influencing farmers' decisions to adopt improved potato varieties, following the estimation procedures of Long (Williams, R. 2016). The probit model considers the error term distribution and realistic probabilities (Agwu, N. M., E.E. Nwankwo and C.I. Anyanwu, 2014). But according to the probit model, there is an unobserved continuous variable Y* that influences the value of the response variable Y, whereas the response variable Y assumes values of 0 and 1 for non-adopters and adopters, respectively (Sebopetji, T.O., and A. Belete, 2009). Therefore, Y* is expressed as:

$$Y^* = \beta Xi + \varepsilon \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Where: ε~N(0, 1). Then, Y can be viewed as an indicator of whether this latent variable is

Positive, such that Y = 1 (Y* > 0), that is, 1 if Y* > 0, i.e., (ε <βXi), and 0 otherwise, * that determines the value of Y.

3. RESULTS AND DISCUSSIONS

3.1. Descriptive analysis

The male-headed respondents were about 90.8%, while the remaining 9.20% were female-headed. About 92.56% of adopters of improved potato varieties were male-headed households, and the remaining households were non-adopters. Out of the female-headed households, 7.44 % were adopters, and the rest were non-adopters. The result indicates that there is not a statistically significant association between the adoption of IPVS and the sex of the household head. The variables

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that significantly correlated with participation in improved potato varieties were access to credit, cooperative membership, and participation in demonstration and off-farm activities.

Many farmers obtain additional income by participating in off-farm activities. The result of the study revealed that 51.60% of sample households participated in off-farm activities. There was a significant association between off-farm activities and the adoption of improved potato varieties at the 10 % probability level (p = 0.05) (Table 1). In addition to this, the assertion is supported by FGD and KII. From the adopters, about 78.51% were members of the cooperative. The results of chi-square analysis indicated that members of cooperatives had a significant relationship with the adoption of improved potato varieties at a 1% significance level (p = 0.000). These households' participants in the cooperative have access to improved seed, credit, training, information, and experience sharing among them. Thus, these households are encouraged to adopt improved potato varieties. Concerning credit access, only 32.8% of households got credit access; similarly, 38.84% and 27.13% of the improved potato varieties adopters and non-adopters, respectively, got credit access. The result of the chi-square test (p = 0.049) showed that there was a significant association between credit access and adoption of improved potatoes at the 5% significance level. The study found that improved potato variety adopters were higher among participants in demonstrations (27.27%) than non-participants (16.27%). The results revealed that there was a significant relationship between the adoption of improved potato varieties and participation in demonstrations at a 5% significance level (p = 0.035).

Table.1 Descriptive results of dummy independent variable

Variables	Total HH		Adopter		Non-adopter		χ^2 test	**P value**
	N	(%)	N	(%)	N	(%)		
Sex HHH							0.87	0.351
Female	23	9.20	9	7.44	14	10.85		
Male	227	90.8	112	92.56	115	89.15.		
Participation of demonstration							4.45	0.035**
Yes	54	21.60	33	27.27	21	16.28		
No	196	78.40	88	72.73	108	83.72		
Credit access							3.88	0.049**
Yes	82	32.8	47	38.84	35	42.68		
No	168	67.20	74	61.11	94	55.05		
Cooperative membership							29.59	0.000***
Yes	153	61.21	95	78.51	58	44.96		
No	97	38.80	26	21.49	80	55.03		
Off-farm Participation							3.66	0.05*
Yes	129	51.60	70	57.85	59	45.74		
No	121	48.40	51	42.15	70	54.26		

Based on the survey findings, it was observed that the average educational attainment of individuals who adopted improved potato varieties was 6.61 years of schooling, whereas for non-adopters, it was 4.82 years. The t-test analysis revealed a statistically significant mean difference at a 1% level of significance (p = 0.000). These results suggest that adopters tend to have a higher level of education compared to households with lower

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educational backgrounds. Consequently, it can be concluded that farmers who embrace improved potato varieties generally possess a higher educational level than those with a lower educational level. It was hypothesised that farmers who have more experience in potato production would possess better knowledge.

The size of a family is a crucial factor in determining the labour force available for a household, which in turn affects the likelihood of adopting improved potato varieties (as shown in Table 2). The t-test result indicated that there is a significant mean difference in household size between adopters and non-adopters of improved potato varieties, with a significance level of 1% (p = 0.0001). For farmers who adopted improved potato varieties, the distance to the nearest market was 28.52 minutes, which is less than the average of 35.03 minutes for non-adopters. Therefore, the distance to the nearest market had a significant mean difference between adopters and non-adopters of improved potato varieties at the 1% significance level (p = 0.0004), as shown in Table 2. This discovery is advantageous as it facilitates more convenient access to the nearest input market, which is essential for the adoption and effective use of enhanced agricultural inputs. The insights obtained from focus group discussions (FGD) and key informant interviews (KI) further corroborate this assertion, indicating that households located closer to the market benefit from greater utilisation of farm inputs and advanced agricultural techniques.

Households that have adopted improved potato varieties had an average walking distance of 28.04 minutes to a farmer's training centre, while non-adopters had to walk for 39.14 minutes on average. This data indicates that non-adopters had to travel a longer distance to access the farm training centre compared to adopters. The t-test revealed a statistically significant disparity in the average walking time between adopters and non-adopters, with a significance level of 1% (p = 0.000).

Land is a vital resource for economic activities, particularly in rural and agricultural sectors. The size of farms plays a significant role in households' decisions to adopt new technologies. Those who adopted improved practices averaged 1.71 hectares, while non-adopters averaged 1.19 hectares of land owned. The results of the t-test revealed a statistically significant difference in landholding sizes between adopters and non-adopters at a 1% significance level (p = 0.000). Table 2. In the study area, the mean livestock holdings among the farmers were recorded at 3.20 Tropical Livestock Units (TLU). In this group, farmers who adopted new practices had an average of 3.39 TLU, while those who did not adopt had a lower average of 2.83 TLU, as shown in Table 2, which is a significant difference at the 1% level (p = 0.000). Furthermore, farmers who maintained more frequent interactions with extension agents demonstrated a greater propensity to adopt new technologies compared to their counterparts with less frequent contact. Specifically, adopters experienced an average of 14.32 interactions with extension agents annually, in contrast to non-adopters, who averaged 8.08 interactions per year. The t-test analysis showed a significant difference in how often the two groups interacted with extension agents, with a probability level of 1% (p = 0.000)..

Table 2. Descriptive results of continuous independent variable

Variable	Total HH (N = 250)		Adopter (n=121)		Non-adopter (n=129)		T-test	p-value
	Mean	SD	Mean	SD	Mean	SD		
Educat leve of hhh	5.69	3.14	6.61	3.19	4.82	2.83	4.71	0.000***
Experience of hhh	25.35	11.83	25.53	11.3	25.17	12.36	0.23	0.811
Family size	4.05	1.59	4.54	1.72	3.60	1.31	4.38	0.000***
Distance to FTC	33.77	16.79	28.04	13.73	39.14	17.65	-5.52	0.000***
Dis.tonearest market	31.88	14.69	28.52	10.55	35.03	17.17	-3.61	0.000***
Land owned	1.44	0.58	1.71	0.57	1.19	0.47	7.81	0.000***
Livestock holding	3.20	1.31	3.39	1.29	2.83	1.22	4.75	0.000***
Frequency of extension. Contact	10.86	11.97	14.32	10.70	7.62	8.08	5.59	0.000***

*** Represents statistically significant difference at 1 % significant level.
Source: survey data, 2023

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3.1.1. Adoption status of improved potato varieties

The farmers grow different types of both local and improved varieties in the study area. Farmers have been growing improved varieties since the 2022 production year, as revealed by focus group discussions and key formats. The sampled households were almost producing potatoes through rain-fed methods. The smallholders in the study area have adopted three officially released varieties by the Ethiopian Institute of Agricultural Research (EIAR). These improved potato varieties were: Belete, Jalene, and Gudene. Whereas in local varieties, Cercher, Asefo, Embamashe, and Eroga were grown. From the respondents (250) farmers, 121 (48.4%) used improved varieties, whereas 129 (51.6%) did not use improved varieties, as shown in the survey results. The outcome revealed that of the total adopters, 65 (53.72%) planted Gudene, which was the most widely adopted and marketable variety compared to other varieties; about 37 (30.58%) planted Belete, and 19 (15.70%) planted Jalene varieties (Table 3).

In the Ezha District, participant farmers allocated 0.083 ha to 1 ha of land for improved potato varieties. Participants assigned varying land sizes for improved varieties according to their perceptions. Accordingly, Gudene has occupied about 38.46 ha, Belete 17.18 ha, and Jalne 6.68 ha of land, on average. Gudene was the first and most widely adopted variety, occupying more land on average (Table 3). This is due to its high demand, premium pricing, and longer shelf life compared to other improved varieties. Because of this situation in the area, the farmers used it as food security for a longer time than other varieties. The proportion of areas assigned for enhanced potato varieties (intensity) among adopters' households was 55.01%, whereas an average of 44.99% was allocated for local varieties

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Table 3: Adoption status of improved potato variety in the study area

Name of varieties	**Number of farmers**	**Prcent**	**Area in hectare**	**Percent**
Gudene	65	53.72	38.46	61.71
Belete	37	30.58	17.18	27.57
Jalene	19	15.7	6.68	10.71
Total	121	100	62.32	100

Source: Survey, 2023

3.2. Econometric Model Results

3.2.1. Factors affecting utilization of improved potato varieties

The study used a probit regression model to analyse the factors that influence households' adoption of improved potato varieties. The findings, which are presented in Table 4, reveal the results of the model. The dependent variable in the probit model is the probability of adopting improved potato varieties. The model includes a total of thirteen variables. Out of all the independent variables, seven variables were found to significantly affect the adoption decisions of improved potato varieties. These variables include livestock owned, land ownership, education status of the household head, membership in a cooperative for producing potato seeds, frequency of extension contact, distance to the nearest market, and distance to the nearest farmer training centre.

The educational status of the household head has a significant and positive impact on the adoption of improved potato varieties, with a significance level of 10% (0.069). This advantage could be attributed to the fact that more educated farmers have better access to information and are more aware of new technologies, leading to a higher likelihood of adopting improved potato varieties. These results are consistent with the studies conducted by Zeru, M. (2018), Bati, B., M. Aman (2017) and Bagheri, A. (2015). However, the results of the study contradict the study findings, which also demonstrate a strong and statistically significant correlation between the size of land holdings and the likelihood of farmers adopting improved potato varieties. This association is significant at the 1% level (0.008). This result suggests that farmers with higher

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land holdings are more inclined to adopt improved potato varieties compared to those with smaller land holdings. These findings are consistent with earlier studies conducted by Tesfaye, A., G. et al. (2013) and Yigezu, Y. A., C. Y. Tizale and A. Aw-Hassan (2015).

The outcome suggests that with each additional tropical livestock unit, households are 5.2% more inclined to embrace enhanced potato varieties, which could be recognised due to the fact that households with a larger number of livestock experience a reduced capital constraint when it comes to purchasing agricultural inputs, and they also exhibit a more risk-taking behaviour when utilising technologies such as improved varieties. Additionally, organic fertiliser obtained from livestock is utilised for crop cultivation; this practice practice is leading to minimising the cost of inorganic fertiliser. These findings align with the research conducted by Yirga, C. and D. Alemu (2016), Teshome, B. (2018) and Tsion, T. E. (2022). The extension agent plays a vital role in promoting innovation by facilitating the exchange of ideas, experiences, resource information, skills, and knowledge among farmersand thereby aiding in their livelihood improvement. The presence of this variable had a positive and significant impact on the adoption of improved potato varieties with a probability level of 10% (0.079). The result suggests that farmers who have more contact with extension agents are more likely to adopt this technology compared to those with limited contact. Furthermore, farmers who maintain frequent communication with extension agents exhibit a higher likelihood of embracing improved potato varieties. These findings are consistent with the studies conducted by Teklemariam, T. M. (2014) and Wabwile, V. K., Ingasia, O. A. and Langat, J. K. (2016).

Membership in a cooperative has been found to have a positive and significant impact on the adoption of improved potato varieties, with a significance level of 10% ($p = 0.08$). The involvement of farmers in a cooperative is crucial for accessing and disseminating new information and technologies. This is likely because membership in social organisations increases farmers' awareness of technologies, as they have easy access to information and can establish strong networks that facilitate access to credit and essential agricultural inputs, such as improved seeds. Interestingly, this finding contradicts the results of previous studies conducted by Ahmed, M. H. (2015), Tufa, A. and T. Tefera (2016) and Ketema, M. and D. Kebede (2017). Furthermore, the distance to a farmer's training centre was found to negatively affect the adoption of improved potato varieties when measured in minutes of walking. This variable was statistically significant at a 5% level ($P = 0.022$). The training centre serves as a vital source of information and a platform for demonstrating and disseminating technologies among farmers. This finding aligns with the study conducted by Sileshi M., R. Kadigi, K. Mutabazi, and S. Sieber (2019).

Moreover, the distance to the closest market and the adoption of enhanced potato varieties have a negative relationship at a probability level of 5% (0.02). This result suggests that when markets are located far from farmers' destinations, the probability of using improved potato varieties decreases. When farmers are closer to the market, they can take advantage of potato technology by accessing market information, purchasing agricultural inputs, and selling their products with lower transaction costs. The result was inconsistent with the findings of Abreham, G. and Y. Sete, 2019, and Feleke, A., Regasa, G. and Muche, M., 2019.

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Table 4. Determinates of adoption improved potato varieties probit model result

Variable	Coefficient	Std. error	Marginal effect(dy/dx)
Sex of household head	-0.471	0.343	-0.184
Education status of HHH	0.056*	0.034	0.022
Experience	0.005	0.008	0.002
Family size	0.069	0.065	0.027
Distance to FTC	-0.014**	0.006	-0.005
Distance to nearest market	-0.015**	0.006	-0.006
Land size	0.547***	0.206	0.218
Tropical livestock	0.131*	0.073	0.052
Extension contact	0.021*	0.012	0.008
Credit .access	-0.234	0.258	-0.092
Off far participation	-0.085	0.224	-0.034
Cooperative member	0.384*	0.219	0.151
Demonstration participation	-0.096	0.237	-0.038
Constant	-0.943	0.553	
LR ch^2	92.58		
Prob > chi2	0.0000		
Pseudo R2	0.2673		

4. CONCLUSIONS AND RECOMMENDATION

The adoption of agricultural technology plays a crucial role in enhancing agricultural productivity, attaining food self-sufficiency, alleviating poverty, and mitigating land degradation. This research aims to investigate the factors that influence the decision-making process and the extent to which farmer households adopt improved potato varieties, based on a sample of 250 households. The Probit model was employed to analyse the factors influencing farmers' decisions to adopt these improved potato varieties. The study's findings indicate that the rate and intensity of adoption of enhanced potato varieties were 48.4% and 55.01%, respectively, in the research area. The probit model results reveal that educational attainment, ownership of livestock, possession of land, cooperative membership, and frequency of extension contacts play positive and crucial roles in potato production, greatly influencing farmers' decision to adopt improved potato varieties. Nevertheless, the distance between the market and the farmer's training centre decreased the degree of adoption. This decline can be attributed to limited knowledge about potato technology and exposure to input market participation and skills to implement new agricultural technologies, such as improved potato varieties. Thus, it is imperative for the relevant organisation to focus on incentivising individuals who have already adopted improved potato varieties to continue doing so while ensuring that non-adopters have access to these improved varieties to encourage their adoption.

Conflict of interest

The author has identified no conflict of interest. The author acknowledged the Ethiopian Institute of Agricultural Research (EIAR) for supporting the project in terms of money. Furthermore, the author declared the Chiro National Sorghum Training and Research Centre for providing all necessary input.

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