ORIGINAL RESEARCH ARTICLE

# Determinants of finger millet adoption, non-adoption and dis-adoption among smallholder farmers in Nakuru, Kenya

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## Abstract

Previous studies on technology adoption have treated smallholder farmers' decisions as being binary. In this article, we assess the adoption, non-adoption and dis-adoptions decisions among smallholder finger millet producers in Nakuru, Kenya. The crop has potential to enhance food security and nutrition in the context of climate change. Data for the study were collected from a household survey of 326 households selected through a multi-stage sampling process. Descriptive and logistic regression analysis was used to analyze the data. The study findings reveal that knowledge levels were higher among the adopters (81.4%), compared to the dis-adopters (45.6%) and non-adopters (58.2%). While attitudes towards finger millet production were generally negative, a large proportion of adopters had positive attitudes towards the economic value of the crop and its contribution to human health. Regression results show that higher levels of knowledge were positively associated with finger millet adoption. As expected, positive attitudes had a positive influence on adoption while concurrently negatively influencing dis-adoption. Further the results suggest that changing attitudes on economic value and the role finger millet plays on human health could improve adoption decisions. The other factors that had a positive influence on adoption were education, income, farming experience, while gender (being female), education (higher), and income had negative influence on dis-adoption. Overall, our results suggest the importance of psychosocial factors (knowledge and attitude), the importance of finger millet to female household heads and resource endowment factors (such as education and income) in sustaining adoption decisions while concurrently dissuading dis-adoption.

Keywords: adoption, dis-adoption, non-adoption, attitude, knowledge

## 1.0 Introduction

The global food system is facing a number of unprecedented challenges. The number of people facing food insecurity and malnutrition has continued to increase in developing countries, with the highest prevalence (22.3%) being in Sub-Saharan Africa (SSA). The food provisioning challenges in SSA are likely to intensify in the face of changing food consumption patterns, rising population, climate change and a diminishing natural resource base, especially land and water (FAO *et al*, 2022).

The production and consumption of orphaned crops such as finger millet (*Eleusine coracana* L.) is a promising strategy for enhancing food security, adaptation to climate change and restoring ecosystem resilience. The crop has a short cropping cycle (three to four months) and its production requires minimal use of external inputs (Yvonne *et al*., 2016; Tadele & Bartels, 2019). Additionally, finger millet is considered a nutri-grain with higher amounts of Iron and Zinc compared to other common staples such as rice, maize, and cassava and sorghum (Table 1).

*Table 1: Nutritional constituents of finger millet and other common staples*

| Cereals | Minerals, Vitamins and Nutrients (**%**) | | | | |
|---|---|---|---|---|---|
| | Finger millet | Rice | Maize | Cassava | Sorghum |
| Calcium | 0.33 | 0.02 | 0.03 | 33.0 | 0.04 |
| Phosphorus | 0.24 | 0.12 | 0.29 | | 0.35 |
| Iron | 46.05 | 19.0 | 30.0 | 4.44 | 50.0 |
| Zinc | 15.85 | 10.0 | 20.0 | 4.25 | 15.4 |
| Nicotinic acid (mg/100gm) | 0.30 | 1.60 | 2.80 | | 4.84 |
| Protein | 7.30 | 7.50 | 12.1 | 2.80 | 11.0 |
| Fat | 1.30 | 2.40 | 4.60 | | 3.20 |
| Crude fiber | 3.60 | 10.2 | 2.30 | 3.80 | 2.70 |
| Ash | 3.00 | 4.70 | 1.80 | 2.80 | 1.80 |
| Starch | 59.0 | 77.2 | 62.3 | 74.0 | 73.8 |

*Source: Ahmed K, et al, 2014)*

In addition to the nutritional benefits, finger millet is characterized by long storability and lower storage costs, making its production an effective intervention for addressing post-harvest food losses (FAO, 2013). Its production can also support food access in the face of climate change, given its better adaptability to degraded soils and drought (Kihara *et al*., 2016).

In recognition of the crop's potential, the Government of Kenya, working with other agencies such as Kenya Agricultural and Livestock Research Organization (KALRO), International Fund for Agricultural Development (IFAD), and International Crops Research Institute for the Semi-Arid Tropics, (ICRISAT) and National Research Fund (NRF) have been implementing programs and projects seeking to promote the production of finger millet among smallholder farmers. As a result


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of these efforts, new high yielding crop varieties (P224, Gulu E, KAT/FM-1 and Lanet FM-1) have been introduced and a number of improved agronomic practices such as transplanting and row planting in finger millet production have been promoted for adoption among smallholder farmers (GreenlifeKE, 2023). The incubation of SMEs (Small and Medium Entrepreneurs) from among the farmer groups and individuals to develop finger millets products for the market has also been implemented (Opole, 2019). The overall aim is to support the diversification of the agricultural enterprises from a few cereal staples to high-value traditional commodities, and promote market development and poverty reduction through value addition and processing (Amankwah *et al.*, 2017).

Despite the aforementioned efforts and rising demand especially among the health conscious consumers, the finger millet value chain in Kenya remains nascent. This is reflected in the small number of smallholder farmers who have taken up its production at commercial scale, low production quantities, planted area and productivity (Singh, 2005; Yvonne *et al.*, 2016; Grovermann *et al.*, 2018; Mbinda *et al.*, 2021). The country's production trends reveal that the production volumes and area under the crop have generally stagnated over the last two decades (Fig. 1).

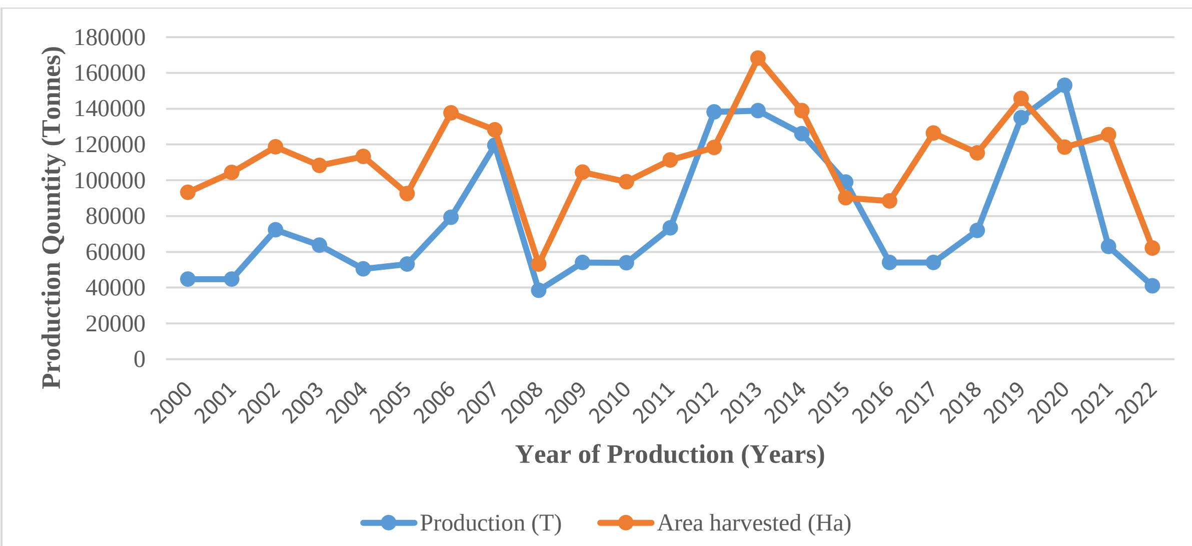


*Fig. 1: Finger millet production (tonnes) and area harvested (ha) trends in Kenya (2000-2021)*
Source: (FAOSTAT, 2023)

While there is a growing body of literature focusing on finger millet in Sub-Saharan Africa (SSA), most of the existing studies have focused more on technological innovations such as uptake of high yielding varieties and fertilizer use (Handschuch & Wollni; 2016; Rebecca *et al.*, 2018) varietal


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improvements (Gitu *et al*., 2018) management practices (Oduori, 2019) and adoption of commercial practices (Koech *et al*., 2016). The uptake of finger millet production among farmers in SSA has received limited research attention. In this article, we use household survey data to explore the finger millet adoption decisions of three categories of farmers. These are, farmers who were growing finger millet at the time of the survey (adopters); farmers who had engaged in the growing of finger millet (in the five years preceding the survey) but had discontinued its production by the time of the survey (Dis-adopters); and farmers who had never practiced the growing of finger millet in the five years preceding the survey (Non-adopters). The case of dis-adoption is uniquely interesting given that this is a contribution that is often ignored in the literature. Specifically, we seek to answer the following questions: i) What are the levels of finger millet adoption ii) How does finger millet adoption vary across household characteristics and iii) What is the influence of knowledge and attitude on finger millet adoption. The focus on the psychosocial variables such as knowledge and attitude is based on evidence showing that the influence of such variables is important in famers' adoption behavior Koech *et al*., 2016; Foguesatto *et al*., 2020). Understanding the levels and determinants of adoption is key for strategies pursuing enhanced food production and security in the face of climate change.

## 2.0 Methods

### 2.1 Theoretical framework

This study explores the adoption and dis-adoption decisions of smallholder finger millet farmers in context of SSA. The theoretical framing for the analysis of adoption and dis-adoption behaviour draws from Roger's (Okello, 2020) diffusion of innovation theory. The theory describes the decision-making processes which are key in adoption of an agricultural innovation. According to Rogers, 2003, the decision process follows five steps sequential stages, namely; knowledge, persuasion, decision, implementation and confirmation of an innovation (Fig. 2).


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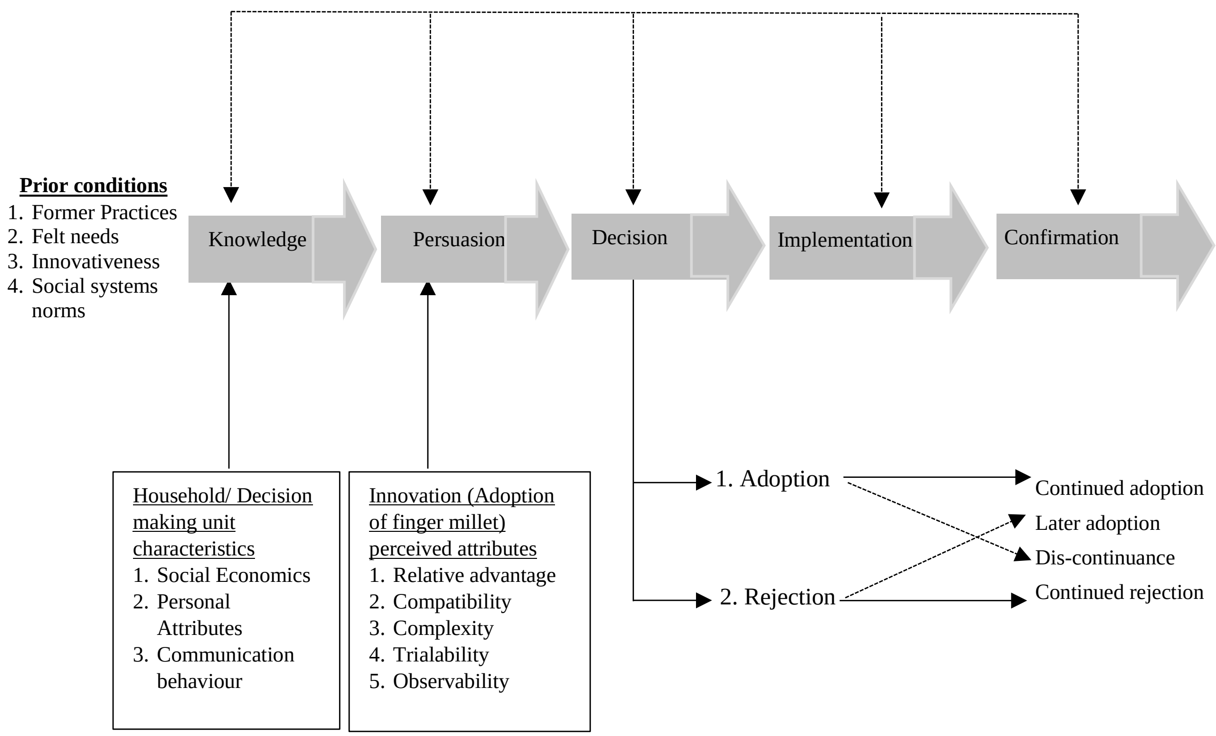


*Fig. 2: Roger's (1962) Diffusion of innovation theory; communication channel*

Following the theory, knowledge takes place when an individual or a decision-making unit gets an exposure to an innovation (e.g., improved finger millet variety or production technique) and attains some understanding on its function (Rogers, 2003). Persuasion happens when the decision-making unit forms attitudes about the innovation, which may be favourable or negative. A decision is created when the individual or decision-making unit employs activities that would lead to acceptance (adoption) or rejection of the innovation (Conley & Udry, 2010). At implementation stage, the innovation is put to use and follows the decision to adopt an innovation immediately unless there are uncertainties. Last is the confirmation stage which strengthens the innovation decision and may reverse the decision if there is evidence of conflicting information about the innovation. Dis- adoption of the innovation may also occur as a result of replacement of the idea. Non-adoption on the other hand is drawn from the dissatisfaction with the innovation performance (Rogers, 1983; 2003).


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Conceptually, the theory allows exploration of the decision behaviour of three categories of smallholder farmers, (adopters, dis-adopters and non- adopters), with regard to the uptake of finger millet production. The study tested the following hypotheses:

i. $H_{O1}$: Knowledge has no influence on smallholder farmers' adoption of finger millet
ii. $H_{O2}$: Attitudes have no effect on smallholder farmers' adoption of finger millet.

## 2.2 Data and study area

The data used in this study were obtained from a household survey of 326 households conducted in Nakuru County of Kenya, between May and June 2021. The county is among the finger millet growing zones in the country (Yvonne *et al*., 2016; Nungo *et al*., 2019) but production of the crop has stagnated in recent years (Yvonne *et al*., 2016; Kamenya *et al*., 2021). The County is centrally located, which is strategic for accessing key urban markets like Nairobi, Eldoret, and Kisumu where demand for finger millet products has been steadily rising (Abdalla *et al*., 2012).

The selection of respondents followed a four-step process. The first step involved a purposive selection of three sub-counties Gilgil, Njoro and Rongai (Fig. 3) that are leading finger millet production areas in the county. In the second step, four wards in each of the three selected sub counties were purposively selected. This selection was informed by the fact that three sub counties were found to have the characteristics that we needed in the sample. We then worked with ward agricultural officers to create a list of households within the villages in the selected wards (step 3). The fourth stage involved a random selection of respondent households from the lists generated in step three above. The number of households selected in each village was proportionate to the population of people in the area. Based on this procedure a total of 326 households were sampled and interviewed.

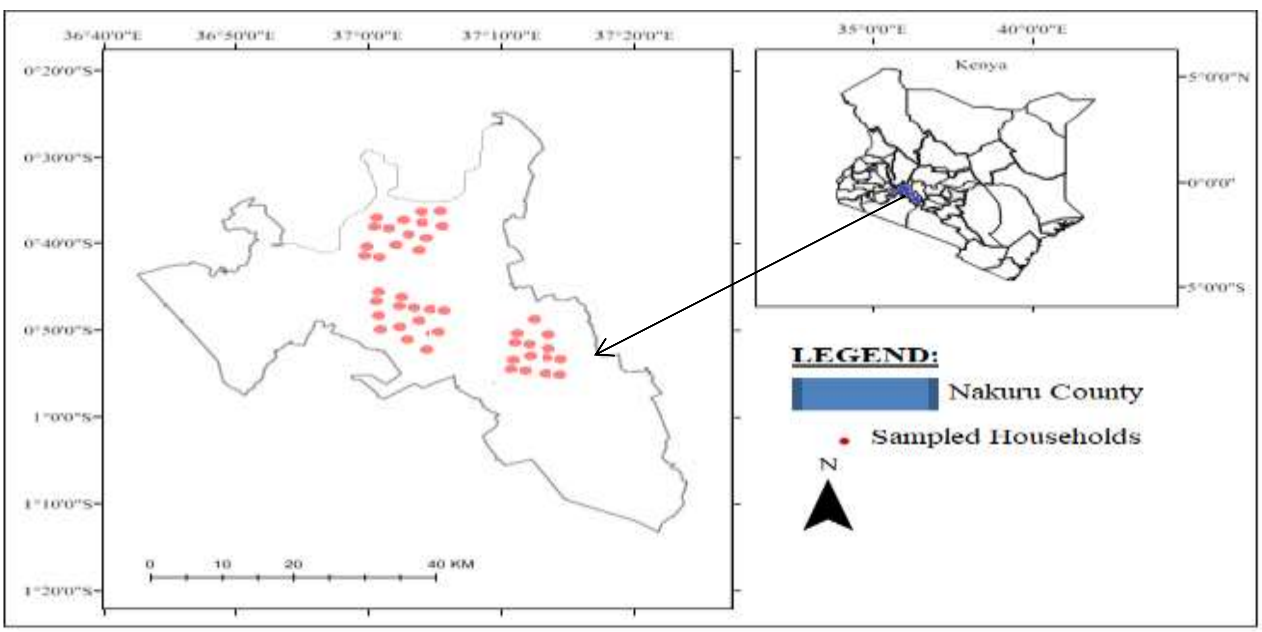



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*Fig. 3: Map showing the study area, Nakuru County*

The household survey collected information on socio-economic and psychosocial factors including; gender of household head, age (years), household size, occupation, income, education levels (years), farming experience (years), and land characteristics and knowledge, attitudes and perceptions about finger millet production. Prior to the household survey, piloting of the tool was done with using 17 farmers drawn from Njoro Sub County, to help in refining the survey instrument.

### 2.3 Estimation strategy and variables

The empirical estimation for the study was achieved using two stages, namely; descriptive analysis and the multinomial logit (MNL), regression model because the dependent variable used had three categories, adoption dis adoption and non-adoption.

#### 2.3.1 Descriptive analysis

Descriptive analysis was based on frequencies, measures of central tendency such as the mean and median and the comparison of differences across the different categories of households (adopters, dis-adopters and non- adopters). The analysis provided descriptive characterization of the sampled households based on demographic and socioeconomic characteristics, levels of adoption of finger millet and the psychosocial indicators considered in the study (knowledge and attitudes). A description and measurement and expected sign of the demographic and socioeconomic variables used in the study is provided in the appendix (Table A.1).

*Table A 1 Description and measurement and expected sign of variables used in the study*

| Variables | Description and measurement | Expected Sign | | |
|---|---|---|---|---|
| | | Adopter | Dis-Adopter | Non-Adopter |
| Dependent variables | | | | |
| Adoption | Farmers' intention to adopt finger millet farming | | | |
| Independent variables | | | | |
| Gender (1=Male; 0=Female) | Sex of the household head (Dummy) | + | - | - |
| Age (Years) | Age of household head in years (Continuous) | + | - | - |
| Household Size (Number) | Total number of members in a household (Continuous) | + | ± | - |
| Household Income (Kshs) | Annual income from all income sources in the household in Kenya Shillings (Ksh) in the year preceding the survey (Discrete) | + | - | - |
| Education Levels (Years) | Total number of years spent in school measured in years (Continuous) | + | - | - |
| Farming Experience (1=Yes) | Farming experience of the household head in farming measured in years spent in general farming (Dummy) | + | - | - |


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| | | | | |
|---|---|---|---|---|
| Land Fertility(1=Fertile; 0=Otherwise | The fertility rate of the farmer assessed by the farmer (Dummy) | - | - | - |
| Knowledge (1=Correct; 0=Incorrect) | The knowledge levels held by a farmer about finger millet (Dummy) | + | - | - |
| Attitude (1=Positive; 0=Negative) | The attitude held by a farmer about finger millet (Dummy) | + | - | - |

In the study the assessment of knowledge was based on a score generated by summing up the number of correct responses to a set of six statements. Out of the six (6) statements which were factually correct or incorrect (Table A.2), a score of one (1) was awarded if a respondent selected *'true'* for a correct statement and *'untrue'* for an incorrect statement. For each statement, selecting *'untrue or unsure'* for correct statements and *'true or unsure'* for incorrect statement was considered to be a wrong response and was therefore awarded a score of zero (0). Respondents with a higher sum of scores across the statement were considered to have more knowledge, and vice versa. The comparison of knowledge across the three categories of farmers was achieved using a two-way analysis of variance (ANOVA).

Attitudes on the other hand were measured using a Likert's rating scale statements (unsure, strongly disagree, disagree, agree, and strongly agree). Out the five (5) statements, four (4) were factually desired (marked positive). While one (1) was factually undesired (marked negative), see table A.1. Attitudes were categorized as being positive if the respondents strongly agreed or agreed with desired (D) statements or if they strongly disagreed or disagreed with undesired (UD) statements. The responses were categorized as being negative if respondents disagreed or strongly disagreed with desired (D) statements or if they strongly agreed or agreed to undesired (UD) statements. The two-way analysis of variance (ANOVA) was also used to compare differences in attitudes among the categories of farmers in the study sample. The knowledge and attitude statements applied are shown in appendix Table A.2.

*Table A 2 Knowledge and attitude statement*

| Statement | Correct / Incorrect |
|---|---|
| **Knowledge** | |
| Use of certified seed is associated with higher yields | Correct |
| Finger millet can be planted using broadcasting method or row planting | Correct |
| The crop is grown and does well in harsh climatic conditions/areas | Correct |
| Certified seed has high productive tillering ability | Correct |
| The healthy benefits associated with finger millet promotes its uptake. (e.g digestive health) | Correct |
| Finger millet has long storage life | Correct |
| **Attitude** | |
| Planting Process of finger millet is tedious and difficult | Undesired |
| It is always difficult to get markets for finger millet | Undesired |
| Finger millet has low economic value as compared to other cereals | Undesired |
| Consumption of finger millet promotes human health | Desired |
| Finger millet farming is for specific clans | Undesired |


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## 2.3.2 The multinomial logit (MNL), regression model

The assessment of the factors determining the likelihood of a smallholder farmer adopting finger millet was achieved using the multinomial logit regression model (MNL), whose parameters were estimated using maximum likelihood method (Garson, 2021). The model deals with one nominal/ordinal response variable that has more than two categories, whether nominal or ordinal variable. The MNL model allows the simultaneous comparison of more than one contrast, that is, the log odds of three or more contrasts are estimated simultaneously (Greene, 1997). In this study the response variable (farmer category) had three categories (adopters, dis-adopters and non-adopters). Using MNL model we were able to define the relationship between the group of explanatory variables (knowledge, attitude and other selected social-economic variables) and the response variable (farmer category).

Let Y be the unordered categorical dependent variable for each of the *J* choices. The model for adoption can be given by the general form of the MNL as:

$$\Pr\left(\mathrm{Y}_i = j\right) = \frac{\exp\left(\beta_j' H_n\right)}{\sum_{j=0}^{J} \exp\left(\beta' j\, H_i\right)} \quad for\ \ j = 1,2,3 \qquad (2)$$

Where:

- Pr ($Y_j$) $i$ = is the probability of being an adopter, dis adopter or non-adopter with adopters as the reference adoption category,
- J is the number of adoptions in the choice set, while j = 1 adoption, j= 2 dis-adoption, j = 3 is non-adoption.
- $H_i$ is a vector of explanatory factors conditioning the choice of the j[th] alternatives and $\beta$ is a vector of the estimated parameter.

The estimated equations provide a set of probabilities for the $J + 1$ choice restricted for a decision maker with characteristics. In order to remove an indeterminacy in the model, a convenient normalization that solves the problem is β0 = 0. Therefore, one can define the general form of the probability that individual i[th] choose the alternative j[th] in the following way:

$$\Pr\left(\mathrm{Y}_i = j\,|_i = X_i\right) = \frac{\exp\left(\beta' j\, X_i\right)}{1 + \sum_{j=0}^{J} \exp\left(\beta' j\, X_i\right)'} \quad for\ all\ J \triangleright 0 \qquad (3)$$

The MNL coefficients are challenging to interpret and associating the $\beta j$ with the $j^{th}$ outcome is


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tempting and ambiguous. To interpret the effects of explanatory variables on the probabilities, marginal effects are usually used and derived following Greene (1997):

$$\delta_J = \frac{\partial P_j}{\partial X_j} = P_j\left[\beta_j - \sum_{j=1}^{j} P_j\beta_j\right] = P_j\left[\beta_j - \bar{\beta}\right] \quad (4)$$

The marginal effects measure the expected change in probability of a particular outcome being made with respect to a unit change in an explanatory variable (Gibbon, 2011).

## 3.0 Results and Discussion

### 3.1 Descriptive analysis

#### 3.1.1 Demographic and socioeconomic characteristics

The results in Table 2 show that adopters of finger millet were significantly older (51 years) compared to dis-adopters and non-adopters (48, 37 years; p <0.05) respectively. The results also indicate that majority of the adopting households were female (62.8 %) compared to their male counterparts (37.2%). It was also observed that adopting households had a significantly higher number of household members (5 members) with higher amount of annual household income (KES 504,831.70) than the dis-adopting and non-adopting households (KES 299.832.50; KEs 284,421.50). There were no observed differences in education across the three farmer categories (P=0.102).

*Table 2: Descriptive statistics*

| Variables | *N=326* | | *n=129* | *n=99* | *n=98* | P_Value |
|---|---|---|---|---|---|---|
| | Pool Sample | Std. Dev | Adopters | Dis-adopters | Non-adopters | |
| Age of Household head (Years) | 45.86 | 10.89 | 51.02 | 47.69 | 37.42 | 0.009 |
| Male Household Head (%) | 63.50 | | 37.20 | 59.60 | 68.40 | 0.032 |
| Female Household Head (%) | 36.50 | | 62.80 | 40.40 | 31.60 | |
| Education Levels (Years) | 10.47 | 4.13 | 12.22 | 12.24 | 9.44 | 0.102 |
| House Hold Size | 3.68 | 1.76 | 4.90 | 3.08 | 2.65 | 0.023 |
| Household Income (KES annual) | 363,028.57 | 100,467.15 | 504,831.70 | 299,832.50 | 284,421.50 | 0.043 |
| Farming Experience (Years) | 6.53 | 4.50 | 6.80 | 6.50 | 6.20 | 0.199 |
| Land Fertility (1=Yes) | 23.23 | 1.92 | 25.80 | 22.70 | 21.20 | 0.287 |
| Knowledge(1=Positive) | 63.5 | | 81.4 | 45.5 | 58.5 | 0.001 |
| Attitude (1=Positive) | 25.5 | | 61.20 | 25.30 | 8.20 | 0.011 |

*2-way ANOVA | >0.05 significant*


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### 3.1.2 Assessment of knowledge

Table 3 presents the results of finger millet knowledge levels across the adoption categories. The 2-way ANOVA reveals that there are statistical differences among the three groups across a number of characteristics including, the association between certified seed and better yields, planting method, crop's potential to grow in harsh climatic conditions and the healthy benefits associated with finger millet. The results in Table 3 also reveal that knowledge levels were generally higher among the adopters (81.4%), compared to the dis-adopters (45.5%) and non-adopters (58.5%). Knowledge in this research refers all pertinent information on the adoption practice towards finger millet among smallholder farmers. This may relate to information on land preparation, sowing, thinning, fertilization, harvesting and post harvesting, storage, marketing and consumption practices that comprises the production of finger millet (Mohammed *et al*., 2019).

*Table 3: knowledge held by farmer*

| Knowledge Statements | Category | Adopters *(n=129)* | Dis-Adopters *(n=99)* | Non-Adopters *(n=98)* | P_Value |
|---|---|---|---|---|---|
| Use of certified seed is associated with higher yields | Incorrect | 13.2 | 20.9 | 23.9 | 0.001 |
| | Correct | 26.4 | 9.5 | 6.1 | |
| Finger millet can be planted using broadcasting method or row planting | Incorrect | 10.1 | 21.2 | 28.5 | 0.008 |
| | Correct | 29.4 | 9.2 | 1.6 | |
| The crop is grown and does well in harsh climatic conditions/areas | Incorrect | 8.6 | 19 | 27.9 | 0.001 |
| | Correct | 31.0 | 11.3 | 2.2 | |
| Certified seed has high productive Tillering ability | Incorrect | 3.1 | 20.6 | 28.5 | 0.029 |
| | Correct | 36.5 | 9.8 | 1.5 | |
| The healthy benefits associated with finger millet promotes its uptake. (cholesterol control, diabetes control and digestive health) | Incorrect | 2.8 | 23 | 28.2 | 0.001 |
| | Correct | 36.8 | 7.4 | 1.8 | |
| Finger millet has long storage life | Incorrect | 3.1 | 19.3 | 28.8 | 0.031 |
| | Correct | 36.5 | 11 | 1.3 | |
| Overall knowledge assessment | Incorrect | 18.6 | 54.4 | 41.8 | 0.012 |
| | Correct | 81.4 | 45.6 | 58.2 | |

*2-way ANOVA | >0.05 Significant*

### 3.1.3 Assessment of attitudes

The results in table 4 show that different categories of farmers had diverse attitude levels regarding production and consumption of finger millet. The differences across the three categories of adoption was compared using one-way ANOVA. The ANOVA results on attitude distribution show statistically significant differences on statements around planting process, economic value, consumption and association of the crop to specific ethnic groups where finger millet is traditionally and produced in larger volumes compared to other communities in Kenya such as Kalenjin, Luhya and Kisii.


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*Table 4: Attitude held by farmer*

| Statement about attitude | Category | Adopters *(n=129)* | Dis-Adopters *(n=99)* | Non-Adopters *(n=98)* | P_Value |
|---|---|---|---|---|---|
| Planting Process of finger millet is tedious and difficult | Positive | 32.80 | 8.30 | 4.00 | 0.001 |
| | Negative | 6.70 | 22.10 | 26.1 | |
| It is always difficult to get markets for finger millet | Positive | 35.0 | 18.70 | 30.1 | 0.004 |
| | Negative | 4.60 | 11.70 | 0.00 | |
| Finger millet has low economic value as compared to other cereals | Positive | 39.6 | 8.30 | 8.30 | 0.013 |
| | Negative | 0.00 | 22.10 | 21.80 | |
| Consumption of finger millet promotes human health | Positive | 39.6 | 0.00 | 0.00 | 0.010 |
| | Negative | 0.00 | 30.40 | 30.01 | |
| Finger millet farming is for specific clans | Positive | 20.20 | 17.5 | 19.0 | 0.001 |
| | Negative | 19.30 | 12.90 | 11.00 | |
| Overall attitude assessment | Positive | 61.2 | 25.6 | 8.2 | 0.013 |
| | Negative | 38.8 | 74.4 | 91.8 | |

*2-way ANOVA | >0.05 significant*

The results (Table 4) indicate that cumulatively, majority of the respondents had a negative attitude concerning the planting process of finger millet and consumption (54.9% and 60.41% respectively). However, on market access, economic value and to whether finger millet is for specific communities, there was a positive attitude across the three adoption groups. Findings are consistent with rising market potential for the crop. A 90kg bag of finger millet was retailing at KES 13,000 during the survey compared to KES 8,600 and KES 3,800 for rice and maize respectively. Overall, adopters had a generally positive attitude towards production of finger millet (61.2%), compared to dis-adopters (25.6%) and non-adopters (8.2%).

### 3.2 Determinants of finger millet adoption, dis-adoption and non-adoption

Table 5 presents the results of the econometric analysis of the determinants of adoption, dis-adoption and non-adoption of finger millet. The dependent variable takes a value of unit 1, if a farmer is an adopter, 2 if a farmer is a dis-adopter and 3 if the farmer is non-adopter. Based on the multivariate nature of the dependent variable, a multinomial logit regression approach was used for the estimation. Using robust standard error estimation to check for heteroskedasticity we report the marginal effects coefficients of the logit estimation. The study shows that higher


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knowledge and positive attitudes had a positive influence on adoption and as expected negative influence on dis-adoption and non-adoption. Increase in knowledge on finger millet adoption increased the likelihood of adopting finger millet by 18% while decreasing the likelihood of dis-adoption by 15%. This suggests the importance of extension and training on finger millet as important determinants of adoption. As expected, positive attitudes also had a positive influence on adoption while concurrently negatively influencing dis-adoption. The other factors that had a positive influence on adoption were education, income, farming experience while gender (being female), education (higher), and income had negative influence on dis-adoption. These results suggest the importance of finger millet to female household heads and resource endowment factors (e.g education and income) in sustaining adoption decisions.

*Table 5: Results from the multinomial logit model for adoption*

| *Variables* | *Adopters* | | | *Dis-Adopters* | | | *Non-Adopters* | | |
|---|---|---|---|---|---|---|---|---|---|
| | *M.E* | *S.E* | *P>z* | *M.E* | *S.E* | *P>z* | *M.E* | *S.E* | *P>z* |
| Knowledge Levels | 0.186 | 0.107 | 0.042 | -0.156 | 0.100 | 0.020 | 0.030 | 0.095 | 0.102 |
| Attitude Levels | 0.058 | 0.108 | 0.040 | -0.083 | 0.101 | 0.013 | -0.025 | 0.096 | 0.006 |
| Gender of Household head | -0.004 | 0.050 | 0.042 | -0.041 | 0.047 | 0.032 | 0.045 | 0.041 | 0.268 |
| Age of House Head | 0.004 | 0.002 | 0.016 | -0.006 | 0.002 | 0.005 | -0.010 | 0.002 | 0.000 |
| Household Size | 0.019 | 0.014 | 0.165 | -0.030 | 0.013 | 0.024 | -0.049 | 0.010 | 0.000 |
| Education Levels | 0.006 | 0.021 | 0.002 | -0.017 | 0.020 | 0.407 | 0.011 | 0.017 | 0.531 |
| Household Income | 0.061 | 0.028 | 0.027 | -0.114 | 0.027 | 0.000 | 0.175 | 0.017 | 0.000 |
| Farming Experience | 0.004 | 0.005 | 0.017 | -0.001 | 0.005 | 0.787 | -0.002 | 0.004 | 0.608 |
| Extension Services | 0.035 | 0.019 | 0.013 | -0.041 | 0.021 | 0.081 | -0.015 | 0.029 | 0.003 |
| Land Fertility | 0.045 | 0.029 | 0.117 | -0.010 | 0.028 | 0.031 | -0.035 | 0.024 | 0.143 |

*a. Model Fitting Information (Sig.) 0.000 | b. Goodness-of-Fit (Sig.) 0.003 | c. Pseudo R-Square (Nagelkerke) 0.892 | d. Classification (Overall) 86.20% | e. P<0.05, Significant.*

## 4.0 Results

Results from Table 5 above indicate that knowledge had positive significant marginal coefficient for adopters and a negative significant marginal coefficient for dis-adopters. This is to indicate that knowledge contribute significantly towards adoption and dis-adoption. An increase in knowledge level on finger millet increased the likelihood of adopting finger millet by 18% while decreasing the likelihood of dis-adoption by 15%. The results indicate that smallholder farmers with correct knowledge were significantly likely to adopt finger millet farming while also reducing the likelihood of dis-adoption. These results are consistent with (Mohammed *et al*., 2019; Gebreyohannes *et al*., 2021) whose findings revealed a positive relationship between knowledge and technology adoption.


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Attitude on the other hand had positive significant marginal coefficient for adopters and a negative significant marginal coefficient for dis-adopters and non-adopters. This is to imply that positive attitude towards finger millet increases the likelihood of adoption while also reducing the likelihood of dis-adoption or non-adoption. A positive attitude increased the likelihood of adopting finger millet by 5.8% while decreasing the likelihood of dis-adoption and non-adoption by 8.3% and 2.5% respectively. This finding is in line with (Mohammed *et al*., 2019; Gebreyohannes *et al*., 2021) who observed a positive relationship between attitude on agricultural technologies and adoption decisions.
Gender had a negative significant marginal coefficient indicating male household are less likely to adopt finger millet farming. However, male farmers currently farming finger millet were less likely to dis-adopt. The age of the farmer had a positive and significant marginal coefficient for adopting farmers indicating that increasing the age of household head by one year, increased the likelihood of adoption by 0.04%. Similarly, an increase in age decreased the likelihood of dis-adoption and non-adoption by 0.06% and 0.01% respectively. Our findings are consistent with Rebecca *et al*., 2018 who found that increase in age had a positive influence on adoption of finger millet innovations and productivity in Kenya. The study showed that young persons were more likely to dis-adopt or be non-adopters due to the high labour needs of finger millet production (Key, 2017). Other studies have shown that older farmers have more experience in farming and are better able to evaluate the health benefits and economic characteristics of finger millet than younger farmers, and therefore are better able to evaluate the worthiness of a farming enterprise compared to young farmers who are less risk averse (Duressa, 2022).

A higher household size was more likely to negatively influence dis-adoption and non-adoption. Results revealed that larger households were less likely to dis-adopt and non-adopt finger millet farming by 0.3% and 4.9% respectively. This could be because finger millet requires high levels of labor which is more likely to be available in households with large number of members. Our finding is consistent with Duressa, 2022, who found that larger household sizes provide affordable human labour in millet farms due to their labour intensive nature. Other studies have shown that households with larger numbers of members are more likely to embrace finger millet farming to increase their food security needs (Yvonne *et al*., 2016).

The educational level of the household head is an important variable affecting the adoption of finger millet farming while at the same time negatively affecting the likelihood of dis-adoption. Increase in the education level of a household head increased the probability of adoption by 0.06 percent while reducing the probability for dis-adoption by 0.02 percent respectively. This may be because household heads with higher levels of education may be more aware of health benefits associated with finger millet farming, its economic benefits, and are more able to get market information of their produce. Adem 2020, found out that household heads with higher levels of


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education increased the probability of diversifying farming sources. In the study, the education level had a positive association with adopters of finger millet farming and less influential to dis-adoption of finger millet farming. A year older in school was found to influence adoption by 0.6% and discouraged dis-adoption by 1.7%, suggesting that improving on household head's educational attainment can support adoption of diversification of farming enterprises for food production like finger millet. Similarly, Key, 2017, found that both the educational level of the farmer and the farming experience had important influence on the decision to adopt diversified cropping systems in Bangladesh.

The results also show that household income had a strong association with the adoption of finger millet farming. The results showed that a unit increase in household income would increase the likelihood of finger millet farming adoption by 6.1%. The results also show that household income had significant effect at *p* value 0.027, 0.00 and 0.00 for the adopters, dis-adopters and the non-adopters respectively, an increase in household income, increased the likelihood of adoption and decreased the likelihood of dis-adoption, however increased the likelihood of non-adoption. This result is consistent with other existing literature which observed that household income variability affects key household farming decisions. Such household farming decisions include how much labour to use on-farm versus off-farm, how much income to save as a cushion for low-earning years, how much income to invest in machinery or land and which combinations of cropping enterprises or livestock to produce (Key, 2017). This finding suggests that because household income variability influences key household farming decisions, it can strongly affect agricultural production and household well-being.

The results further show that experience was significant at 5% inferring presence of differences among farming experience and adopters categories of finger millet farming. More experienced farmers were found more likely to adopt finger millet farming compared to the other categories of farmers (dis-adopters and non-adopters). Increase in farming experience increased the likelihood of adopting finger millet farming by 0.04% compared to other categories of dis-adopters (0.02%) and non-adopters (0.01%). Zhou et al., 2022 also found out that farming experience plays an important role in the adoption of agricultural technologies and also determines its retention over time in Uganda. This suggests that farming experience is an important determinant in the adoption and continuous adoption of agricultural technologies. On land fertility, the results indicated that households with fertile land were less likely to dis-adopt finger millet farming. This suggests that adopting farmers who evaluated their land as fertile are encouraged to adopting finger millet farming. Our results are similar to (Wik *et al*., 2004; Ndugu *et al*., 2017) who found that poor soil fertility is a major problem constraining adoption of diversified cropping systems by smallholder farmers in SSA.


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## 5.0 Conclusion/ Policy implications

### 5.1 Conclusions

Finger millet adoption has the potential to enhance food security and nutrition in the context of climate change. Despite these potential and promotional efforts by governments and other stakeholders, the adoption level of finger millet in the study area is low and inconsistent. The study found significant differences in key psychosocial, demographic and household characteristics that have an association with adoption. Adopters were statistically different from non-adopters and dis-adopters on key variables including; knowledge and attitude, age, gender, education, income, household size, farming experience and extension services. Further findings reveal that adopters had more knowledge and positive attitudes towards finger millet production compared to dis-adopters and non-adopters. The findings suggest that finger millet growers should be encouraged towards developing positive attitude towards finger millet production. Moreover, stakeholders promoting finger millet should consider psychosocial factors, which could influence adoption of the finger millet in Nakuru, and other finger millet producing regions in Kenya

### 5.2 Policy implications

The results in this paper contain significant implications for communities in the study area and various stakeholders. First, the study shows that both knowledge and attitude are key determinants in finger millet adoption, dis-adoption and non-adoption decision, it is therefore viable to investment in extension services to promote the adoption of this crop. Secondly, results indicate that a significant majority agree that finger millet has a ready market with favorable prices, amalgamated with its health benefits, therefore open up opportunities for investment. However, stakeholders seeking to invest in finger millet may consider to invest in continues data collection to inform decisions on psychosocial development, training and input supply (to mitigate on labor intensive) which in turn will boost food production towards food security and promotes malnutrition especially for developing countries.

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### 7.2 General acknowledgement

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### 7.3 Declaration of interest

None

### 7.4 Ethical clearance

None


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### 7.5 Conflict of interest

None

### 7.6 Data availability statement

None.

## 8.0 References

Abdalla, M., & El-Habil (2012). An application on multinomial logistic regression model. Pakistan Journal of Statistics and Operation Research, 8(2), 271. https://doi.org/10.18187/pjsor.v8i2.234

Adem, M. and Tesafa, F. (2020). Intensity of income diversification among small-holder farmers in Asayita Woreda, Afar Region, Ethiopia. Cogent Economics & Finance, 8:1-15. https://doi.org/10.1080/23322039.2020.1759394

Amankwah, R. O., Ruveinkamp, G., Essegbey, G., & Frempong G. (2017). The Nature, Extent and Effect of Diversification on Livelihoods of Farmers: A Case Study of the Cocoa Farmers in Ghana. International Journal of Agriculture Innovations and Research, 2319-1473.

Conley, T. G., & Udry, C. R. (2010). Learning about a new technology: Pineapple in Ghana. American Economic Review, 100, 35-69. doi:10.1257/aer.100.1.35

Duressa, M., Berhanu, & A. B., (2022). Popularization of Finger Millet Production, Value Addition, and Marketing in Wayu Tuka Wereda. Modern Phytomorphology, 83-92 https://doi.org/10.5281/zenodo.200121

FAO, (2013). Constrains of food production and hunger management. Annual report. Food and agriculture organization of the United Nations Rome,Italy.

FAO, (2022). The State of Food Security and Nutrition in the World. Food and Agriculture Organization of the United States Rome, Italy.

FAOSTAT, (2023). Annual Food Production report. The Statistical Division. Statistics Division 2013. United States Rome,Italy.

Foguesatto, C. R., Felipe, D. A., Edson, T., & Machado, J. S. D., (2020). Correction to: What shapes farmers' perception of climate change? https://doi.org/10.1007/s10668-020-00634-z (Accessed on 18.01.2024).

Garson, G. D. (2011). "Logistic Regression", from Statnotes: Topics in Multivariate Analysis.http://faculty.chass.ncsu.edu/garson/pa765/statnote. (Accessed on 18.01.2024)

Gebreyohannes, A., Shimelis, H., Laing, M., Mathew, I., Odeny, D. A., & Ojulong, H. (2023). Correction: Gebreyohannes et al. Finger Millet Production in Ethiopia: Opportunities, Problem Diagnosis, Key Challenges and Recommendations for Breeding. Sustainability 2021, 13, 13463. Sustainability, 15(15), 11650. https://doi.org/10.3390/su151511650

Gibbon, D. (2011). Save and Grow: A Policymaker's Guide to the Sustainable Intensification of Smallholder Crop Production. Rome, Italy: Food and Agriculture Organization of the United


ISSN 1561-7645 (online)
doi: 10.4314/jagst.v23i4.7

Nations (2011), pp. 112, US$45.00. ISBN 978-92-5-106871-7. Experimental Agriculture, 48(1), 154. https://doi.org/10.1017/s0014479711001049

Gitu, W., Onyango, A., & Obara, A. (2018). Selected Factors Affecting Adoption of Improved Finger Millet Varieties by Small-Scale Farmers in the Semi-Arid Mogotio District, Kenya. International Journal of Sciences, Basic and Applied Research 13:134-135.

Greene, W. (1997). Econometric Analysis, 3rd Ed., Prentice Hall, Saddle River.

GreenlifeKE. (2023). Finger Millet Farming | GreenLife | 2024 Update. Greenlife Crop Protection Africa. https://www.greenlife.co.ke/finger-millet-farming/ (accessed on 13 April, 2024).

Grovermann, C., Umesh, K., Quiedeville, S., Kumar, B., & Moakes, S. (2018). The economic reality of underutilized crops for climate resilience, food security and nutrition: Assessing finger millet productivity in India. Agriculture, 8(9), 131. https://doi.org/10.3390/agriculture8090131

Handschuch, C., & Wollni, M. (2016). Improved production systems for traditional food crops: the case of finger millet in western Kenya. Food Security 8(4):783-797. https://hdl.handle.net/10419/90581

Kamenya, S. N., Mikwa, E. O., Song, B., & Odeny, D. A. (2021). Genetics and breeding for climate change in Orphan crops. Theoretical and Applied Genetics, 134(6), 1787–1815. https://doi.org/10.1007/s00122-020-03755-1

Key, N., Prager, D., & Burns, C. (2017). Farm Household Income Volatility: An analysis using panel data from a national survey. Economic Research Report. https://doi.org/10.22004/ag.econ.256710

Ahmed, K., Muhammad S., Muhammad N., Akhtar and Zafar I. (2014). Chemical analysis of different cereals to access nutritional components vital for human health. International Journal of Chemical and Biochemical Sciences (ISSN 2226-9614). https://doi.org/10.13140/RG.2.2.30783.43684

Kihara, J., Nziguheba, G., Zingore, S., Coulibaly, A., Esilaba, A.,& Kabambe, V., (2016). Understanding variability in crop response to fertilizer and amendments in sub-Saharan. Journal of Sciences, Basic and Applied Research 13:134-135. https://doi.org/ 10.1016/j.agee.2016.05.012

Koech, V. (2016). Analysis of factors affecting the adoption of commercial finger millet enterprises among small scale farmers in Keiyo district. http://hdl.handle.net/123456789/4762 (Accessed on 11.02.2024)

Mbinda, W., Kavoo, A., Maina, F., Odeph, M., Mweu, C., Nzilani, N., & Ngugi, M. (2021). Farmers' knowledge and perception of finger millet blast disease and its control practices in western Kenya. Agriculture and Bioscience, 2(1). https://doi.org/10.1186/s43170-021-00033-y

Mohammed Galadima, Salim Hassan, Norsida Man and Ibrahim Abdul Abu, (2019). Role of Knowledge, Attitude, on the Adoption of Improved Pearl Millet by Farmers in North-east, Nigeria International Journal of Recent Technology and Engineering (IJRTE), 2019ISSN: 2277-3878. 10.35940/ijrte.D8784.118419

Ndungu-Magiroi, K. W., Kasozi, A., Kaizzi, K. C., Mwangi, T., Koech, M., Kibunja, C. N., Wamae, D., & Wortmann, C. S. (2017). Finger millet response to nitrogen, phosphorus and potassium in Kenya and Uganda. Nutrient Cycling in Agroecosystems, 108(3), 297–308. https://doi.org/10.1007/s10705-017-9857-7

Nungo, R., & Oduori, C., (2019). Inventory of Climate Smart Agriculture Finger Millet Technologies, Innovations & Management Practices https://www.Rachel.org/sites/timps/kcsap

Oduori, C. (2019). The importance and research status of finger millet in Africa. Presented at the McKnight Foundation Collabourative Crop Research Program Workshop on Tef and Finger Millet: Comparative Genomics of the Chloridoid Cereals at the Biosciences for East and Central Africa (BECA). Nairobi, Kenya, 28 - 30 June 2019. 10.18697/ajfand.84.BLFB1004

Okello, D. (2020). Gender effect of entrepreneurial orientation on dairy farming career resilience in Kenya. Cogent Food & Agriculture, 6(1), 1863565. https://doi.org/10.1080/23311932.2020.1863565

Opole, R. A. (2019). Assessment on the opportunities for enhancing finger millet production African Journal of Food, Agriculture, Nutrition and Development. African Journal of Food, Agriculture, Nutrition and Development 13863-13882. https://doi.org/10.18697/ajfand.84.BLFB1004

Rebecca, J., Peter, D., George, O., Patience, M., Paul, K., Maximilian, W., & Gideon, H. (2018). Factors affecting the adoption of agricultural innovations on underutilized cereals: The case of finger millet among smallholder farmers in Kenya. African Journal of Agricultural Research, 13(36), 1888–1900. https://doi.org/10.5897/ajar2018.13357

Rogers, E. M. (2003). Diffusion of innovations (5th ed.). Free Press. https://doi.org/10.1016/j.jmig.2007.07.001

Singh, S. (2005). Changing structure and organisation of agriculture and small farmers in India. Social Change. 35(4), 1–31. https://doi.org/10.1177/004908570503500401

Tadele, Z. and Bartels, D. (2019). Promoting orphan crops research and development. Planta 250: 675–676. https://doi.org/10.1007/s00425-019-03235-x

Wik, M.T.A., Kebede, B., Olvar, & Holden, S. (2004). On the Measurement of Risk Aversion from Experimental Data. Applied Economics 36(21): 2443–51. https://doi.org/10.1080/0003684042000280580

Yvonne, M., Richard, O., Solomon, S., & George, K. (2016). Farmer Perception and Adaptation Strategies on Climate Change in Lower Eastern Kenya: A Case of Finger Millet (Eleusine coracana (L.) Gaertn) Production. Journal of Agricultural Science. 8:33–40. 10.5539/jas.v8n12p33

Zhou, D., & Li, L. (2022). Farming experience, personal characteristics, and entrepreneurial decisions of urban residents: Empirical evidence from China. Frontiers in Psychology, 13. https://doi.org/10.3389/fpsyg.2022.859936


ISSN 1561-7645 (online)
doi: 10.4314/jagst.v23i4.7