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Factors Influencing Willingness to Adopt Recommended Bambara groundnut (*Vigna subterranea* L. Verdc) Agronomic Practices Among Smallholder Farmers in Semi-Arid Lands of Embu County, Kenya

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KEYWORDS

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Agricultural technologies

Dry lands

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ABSTRACT

The study assessed the willingness of smallholder farmers to adopt the recommended agronomic practices of Bambara groundnut in semi-arid lands of Embu County. The study was carried out in three sub-counties i.e. Mbeere North, Mbeere South, and Embu West, of Embu County. Data were extracted with the help of a well-structured questionnaire which was distributed to 384 smallholder farmers who were participants at the farmers' field schools at the three sites. The data were analyzed using means, percentages, and logistic regression. Results of the study revealed that 60.94% of the farmers were willing to adopt the recommended agronomic practices. The willingness of the farmers to adopt the recommended agronomic practices was influenced by farming experience, farm size, extension contact, participation in farmers' groups, cropping technologies adoption, and intercropping system used by the farmers. The application of the farmer participatory approach is an innovative way of introducing and promoting less popular but sustainably proven agricultural technologies among smallholder farmers. This is a climate-smart strategy to address the challenges of food in the area. Awareness creation among the farmers using the right extension channels can increase farmers' willingness to adopt climate-smart technologies such as the production of the highly nutritive and drought tolerant Bambara groundnut in dry areas.

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1 Introduction

Bambara groundnut (*Vigna subterranea* L. Verdc), is an African home-grown pulse (Puozaa et al. 2017) that is tolerant to drought, and high temperature and can thrive well in marginalized soils (Chai et al. 2016). The crop is endemic to Northeastern Nigeria and Northern Cameroon (Temegne 2018). After groundnut and cowpea, the crop is ranked third most important in Sub-Saharan Africa (SSA) (Adzawla et al. 2016). Bambara groundnut is a common diet among the people in the Western, Nyanza, and coastal regions of Kenya (Valerie and Luvembe 2016). The farmers grow Bambara groundnut mainly on small scale for subsistence use.

Although Bambara nut is a popular traditional diet in Western, Coast, and Nyanza regions in Kenya, but its adoption in other areas is dismal (Oyeyinka et al. 2017). Bambara nuts have a high possibility of improving food and nutritional security in the dry lands but it requires more publicity, both as a crop and as food (Ogwu et al. 2018). According to Nyasimi et al. (2017), effective uptake of new sustainable technologies in agriculture largely depends on the information dissemination channels employed. This study, therefore, employed the farmer participatory approach to introduce and promote Bambara groundnut production in dry lands of Embu County. This approach enabled the participants to make well-versed choices on the adoption of the crop.

There is low adoption of best agronomic practices of Bambara groundnut in the dryer parts of Eastern Kenya since the crop is less known in the region (Obura 2021). In this study, it was hypothesized that farmers' willingness to adopt the best agronomic practices on Bambara groundnut would be greatly influenced by farmers' participation in the agronomic evaluation as well as their socio-economic characteristics. Large-scale farmers are risk takers since they can put their land portions to trial (Varble et al. 2016). Researchers and extension agents play a crucial role in the uptake of new agriculture technologies (Chandio and Yuansheng 2018). Minimal contact between the target farmers and change agents has also contributed to the slow adoption trend. Tey et al. (2017) recorded always higher uptake of technologies where farmers closely associate with the change agent.

Farmer field school (FFS) is an extension teaching approach that goes beyond disseminating technical information to farmers. It is a participatory method where farmers are involved in the learning process, imparting practical skills and empowering themselves (Okeoghene 2020). Farmers' participation in extension programs enables them to consider the complexity and usefulness of the projects and therefore helps them in the decision-making (Suvedi et al. 2017). Lailogo et al. (2018) and Bhutto et al. (2018) have suggested that through the farmer participatory approach, the adoption rate has improved and farmers can achieve high and economical production since it responds directly to the needs of the farmers.

This study was anchored on the "adoption of innovation theory" that was developed by Carl Rogers (Oyeyinka et al. 2017). The theory defines adoption as choosing to practice an invention fully as the finest option. Diffusion occurs when individuals adopt new technology, product, or idea. Barrett et al. (2020) define diffusion as a process that includes innovation, communication channels, and adoption. There are two forms of communication channels; the first one is localized where communication is from local leaders and receivers of the same social system example of this type of channel are interpersonal channels while the second one is a cosmopolite channel where the sender of information is from the outside social system e.g. mass media. Another key component of adoption is the social system which is a set of correlated components involved in combined problem solving to achieve a collective objective (Al-Razgan et al. 2021).

According to Qazi et al. (2018), the innovation decision process is an insight-finding and knowledge-refining action, in which a person is encouraged to increase confidence in the advantage and shortcomings of an invention. This process has five steps i.e. knowledge, persuasion, decision, implementation, and confirmation (Sanguinetti et al. 2018). The interpersonal channels play a major role in the knowledge stage while localize channels are more significant at the persuading stage of the innovation-decision process (Ng 2020). The degree of adopting technology is greatly affected by the relative advantage of an innovation, observability, trial-ability, complexity, and compatibility (Qazi et al. 2018).

The recommended agronomic practices are optimum spacing and intercropping sorghum (cereals) with Bambara groundnuts. Farmers have been reported to use different spacing when growing Bambara groundnuts in different regions (Egbe 2016). Most farmers practice intercropping with legumes like beans, peas, and others but have neglected Bambara groundnuts (Oyeyinka et al. 2017). This research, therefore, is sought to assess the willingness of the farmers to adopt the best agronomic practices of Bambara groundnuts.

2 Materials and Methods

The experiment was carried out at Mbeere North, Mbeere South, and Embu West representing the dry parts of Embu County in the Eastern Kenya region. Mbeere North is situated in the lower midland. The elevation of the area is between 500 - 1200 m above sea level. The area is categorized as a hot, semi-arid condition with a mean temperature of 23℃ and receives regular rainfall of around 800 mm annually which is usually bimodal (Kamonge et al. 2020). Mbeere South extends to lower midland within 3, 4, and 5 agro-

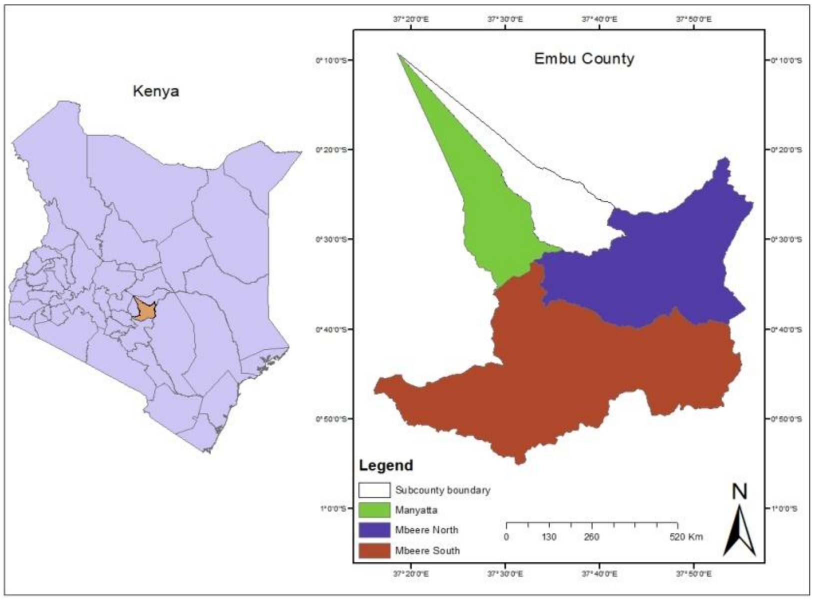

Figure 1 Map of the study site

ecological zones within the coordinates of 0° 20'N and 0° 50' South and longitude 37°16' and 37°56' East. It has an elevation of 500 to 1200 m above sea level. This area is considered as a hot, semi-arid condition with temperatures between 21.7℃ to 22.5℃ and receives medium rainfall between 700 to 900 mm per annum. Embu West site is located in Manyatta and this is found in Upper Midland 2 and 3 agroecological zones. The area has an altitude of 1440m above sea level with coordinates 0º35'25.58"S and 37º25'31.84"E. The area is categorized as a warm and humid climate with an annual temperature of about 20°C with yearly rainfall ranging from 909 mm to 1230 mm that falls in a bimodal pattern (Kangai et al. 2021). The area of the study sites is illustrated in figure 1.

This study drew the sampling units using a multistage spatially stratified random sampling design. Sampling was done from all seven wards. The size of the sample was computed using Cochran formulae as used by Castellini et al. (2018).

$$n_o = \frac{Z^2 pq}{e^2} \quad \text{(i)}$$

Where n^0 = s size of the sample required, Z = t value at 95% confidence level from a normal table (1.96), p = probability that respondent has characteristic being measured, q = (1-p) probability that respondent has no characteristic being measured and e = 5% level of significance

The size of the sample was decided as shown

$$n_o = \frac{(1.96)^2(0.5)(0.5)}{(0.05)^2} = 384$$

This study was carried out in two cropping periods between September 2019 and August 2020. For this, two separate experiments were done over the two periods namely September–December 2019 rainy season and March-May 2020 rainy season. The first experiment was to come up with optimum spacing for growing and yield of selected Bambara groundnut genotypes in dry lands of Embu County, Kenya. The 384 small-scale farmers were distributed in each ward of the selected three sub-counties. In each sub-county, 128 farmers were sampled and training was organized in a Farmer Field School (FFS). They were then trained on the optimum spacing, intercropping sorghum with Bambara grounds, and incorporating Bambara residues in the soil within the rows.

The study embraced the theory of the innovation-decision model up to the decision-making stage. An adoption survey was conducted at the end of the experiment to assess the willingness of the farmers to adopt the crop. A well-structured questionnaire was pretested and administered to the 384 farmers. The questionnaire was designed to assess the farmers' willingness to adopt the best agronomic practices learned at the FFS and to capture the social and economic characteristics of the small-scale growers. Data collected were related to the household head`s age, years of farming, size of the household, number of adults, size of land, farm income, gender, education level, previous technology adoption, group membership, access to extension service, cropping system adopted by the farmer and willingness to adopt the best agronomic practice of Bambara groundnuts production. To capture the farmers' views, open-ended questions were also included in the questionnaire. The responses were then coded and keyed into an excel sheet for analysis.

Data were analyzed using SPSS (version 27) in mean and percentages. A Probit model was used to examine the socio-economic characteristics that determine farmers' willingness to adopt best agronomic practices and production of Bambara groundnut. This is explained by the equation:

$$y_i * = \beta 0 + \sum_{k=1}^{k} \beta_{ki} x_{ki} + \varepsilon_i \quad \text{(ii)}$$

Where; i stands for the respondent, $X_{ki:}$ k=1 via k independent variable explaining the state for the respondent i, β_k: is the parameter that designates the result of X_k on y*, β_0: intercept that shows the probable rate of y* when all X_k=0, $\varepsilon_{i\,:}$ stochastic error term for respondent i, The latent variable $y_i{}^*$ is continuous, unobserved and ranges from $-\infty$ to $+\infty$, The variable y_i^* creates the recoded dualistic factor;

$$y_i = \begin{cases} 1 \; if \; yi *> 0, \\ 0 \; otherwise. \end{cases} \quad \text{(iii)}$$

Dealing with a willingness to adopt the best agronomic practice of Bambara groundnut production equation 1…….is interpreted as

$$y_i = \begin{cases} 1 \; if \; the \; farmer \; is \; willing \; to \; adopt \\ 0 \; if \; the \; farmer \; is \; not \; willing \; to \; adopt \end{cases}$$

The data was then tested both for multicollinearity and heteroscedasticity. The variables used in modeling factors affecting farmers' willingness to adopt the best agronomic practices of Bambara groundnut production yielded a mean-variance inflation factor (VIF) of 2.020. Each of the variables had a VIF value of less than 10 but greater than 1. According to Marie et al. (2020), VIF values less than 10 show the non-existence of a multicollinearity problem. The contingent valuation method was used in the quantification of the farmers' willingness to adopt the best agronomic practice of Bambara groundnut production.

3 Results and Discussion

3.1 Adoption of the Recommended Bambara Agronomic Practices

The majority (66.67%) of the farmers had previously adopted agricultural technologies and 70.83% were organized into various farmer groups. All the selected farmers were accessing extension services but in various frequencies, where 22.40% received monthly services, 32.29% received the services annually, while 45.31% received irregular services. Consequently, the farmers practiced irregular cropping systems with most of them (49%) practicing crop rotation whereas 21, 13, 9, and 6 percent practiced mixed cropping, intercropping, mono-cropping, and multiple cropping systems respectively. The majority (58.07%) of the farmers preferred the system where Bambara groundnut was intercropped with cereals and its residues incorporated into the soil. However, 31.25% of the farmers were not impressed by any of the intercropping systems. Eventually, 60.94% of the participants were found to be willing to adopt the best agronomic practices of Bambara groundnuts which comprised 47% male and 53% female.

Table 1 Adoption of recommended Bambara agronomic practices

Variable	Description	Percentage(%)
Previous technology adoption	Yes	66.67
Farmers' groups	Yes	70.83
Extension services	Monthly	22.40
	Once a year	32.29
	Irregularly	45.31
Cropping system	Crop rotation	49.22
	Mono-cropping	9.38
	Intercropping	13.8
	Mixed cropping	21.09
	Multiple cropping	6.51
Intercropping system preferred	Groundnut residues removed	10.68
	Groundnut residues incorporated	58.07
	None	31.25
Willingness to adopt Bambara groundnut	Willing	60.94

Table 2 Factors influencing farmers' willingness to adopt the production of Bambara groundnut

Variable	Marginal effects	Standard Error	Z Score
Age of the farmer	-0.0887	0.0825	-1.08
Household head gender	0.3848	0.2190	1.76
Level of education of the farmer	0.0943	0.1142	0.08
Farming experience	0.4414	0.2049	2.15*
Size of the household	0.4118	0.4173	-0.99
Source of labor	0.5326	0.3343	1.59
Household farm size (acres)	0.5667	0.2151	2.63*
Access to extension services	0.2287	0.8242	2.77
Membership in farmers' groups	0.4648	0.1597	2.91
Type of cropping system	-0.1948	0.6789	-2.87
Household income	0.0001	0.0001	1.87
Off-farm income	-0.2260	0.1419	-1.59
Access to credits	0.5844	0.1074	-0.54
Previous adoption of technology	0.2660	0.5025	5.30
Irrigation method	0.5949	0.3420	1.74
Time of planting	-0.7502	0.2665	-2.81
Intercropping system preference	0.0953	0.2196	0.43

*P≤0.05; Prob > chi (1) = 0.0000; R-squared = 60.43

3.2 Factors Influencing Farmers' Willingness to Adopt Bambara Groundnut

Results presented in table 2 indicate the factors influencing the willingness of farmers to adopt Bambara groundnut production. The probit model has binary dependent variables (1= willing to adopt best agronomic practices of Bambara groundnuts, 0= not willing to adopt best agronomic practices of Bambara groundnuts).

The farming experience was significant (0.4414) in the farmers' willingness to adopt Bambara groundnut production. This means that an increase in the farmers' experience in farming by one year increases the chances of the farmer adopting Bambara groundnuts by 44.14%. This is because as farmer accumulates experience over time, they switch from conventional agriculture to modern agricultural practices (Paustian and Theuvsen 2017). Barnes et al. (2019) recorded that increase in the farmers' experience increases the adoption rate.

The size of the farm had a positive marginal effect (0.5667) and is significantly related to the willingness of the farmer to adopt the Bambara groundnut production. This means that when the size of the farm increases by a unit it resulted in farmers' willingness to adopt Bambara groundnut production increasing by 56.67%. Consistent results were recorded by Ntshangase et al. (2018) who found that growers who have greater parcels have higher chances of adopting new agricultural technologies compared to those with small parcels of land.

Extension services access was significant (0.2287) on the willingness of the farmers to adopt the best agronomic practices of Bambara groundnut. This hinted that regular extension service access by the farmers enhanced their willingness to adopt Bambara groundnut production by 22.87%. This underpins the importance of change agents when promoting the uptake of new ideas in agriculture. Findings by Suvedi et al. (2017) recorded that increase in farmer-extension contacts enhanced farmers' education and adoption of agricultural technologies. Group membership had a positive marginal effect (0.4648) on the willingness of the farmers to adopt the best agronomic practices of Bambara groundnut production. The willingness of the farmer to adopt the best agronomic practices of Bambara groundnuts increased (46.48%) with group membership. Most of the farmers who adopt new agricultural technologies are members of various agricultural organized groups (Mango et al. 2017).

The previous adoption of various cropping technologies was significant (0.2660) in the willingness of the farmer to adopt Bambara groundnut production. When the farmers had previously adopted other cropping technologies, they are more willing to adopt Bambara groundnut production by 26.6%. Singh et al. (2016) recorded that those farmers who had previously adopted new cropping technologies are risk takers and early adopters of new agricultural technologies.

Finally, 60.94% of the participants have the willingness to adopt the best agronomic practices of Bambara groundnuts which comprised 47% male and 53% female. Based on gender, this is contrary to a study by Rola-Rubzen et al. (2020) who reported that more men adopt technologies in agriculture than women. Verkaart et al. (2019) recorded that for a technology to be adopted widely, it must be environmentally sustainable and has more economic benefits than conventional methods.

Conclusion and Recommendations

Results of the study can be concluded that farmers were willing to adopt the best agronomic practices of Bambara groundnut production. Results showed that farming experience, household farm size, extension contact, participation in farmers' group, type of cropping system, and intercropping system used by the farmer were found to be significant in the willingness of the farmers to adopt best agronomic practices and production of the legume. Awareness creation among the farmers using the right extension channels can increase farmers' willingness to adopt climate-smart technologies such as the production of the highly nutritive and drought tolerant Bambara groundnut in dry areas. Therefore, policy interventions should target the training of farmers and promotion of best agronomic practices of Bambara groundnut production, as a drought intervention mechanism to promote food security, especially in dry areas. Additionally, the ministry of agriculture should focus on the increasing frequency of contact between agricultural extension personnel and farmers since this will enable farmers to be informed on current agricultural technologies and innovations.

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Declaration

The authors did not report any conflict of interest

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