Effect of Training on Knowledge, Attitude, and Practice on the Use of Hermetic Storage Technologies among Smallholder Farmers in Tanzania

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ABSTRACT

Knowledge, attitude, and practice (KAP) of farmers in post-harvest management (PHM) are essential for reducing food waste. However, their enhancement also depends on the training programs. Previous studies on the linkage between training programs and farmers' KAP have been conducted with less emphasis on hermetic storage technology (HST) for PHM. This study aimed to assess the effect of training on KAP and, hence, the adoption of HSTs among smallholder farmers. The underlying theory of change of the study assumes that awareness and access to post-harvest technologies have effects on adoption rates, hence improving food security and income. A quasi-experimental matched-pair cluster randomization design was used to establish a cause-and-effect relationship between an independent and dependent variable. Maize farmer groups totalling 637 farmers were randomly selected and followed the experimental design of the "Evidence-based Scaling of Improved On-Farm Storage among Smallholders in Tanzania" intervention from Kilosa and Kondoa districts of Tanzania, whereas the treatment group farmers received training and free five hermetic storage bags each, while the control group farmers did not. However, this study documented the demographic profiles of farmers in association with KAP on HST using a pre-designed structured questionnaire and used ordinary least squares regression to explore this relationship. We find evidence consistent with a positive and significant relationship between training, KAP, and adoption. The results suggest that the KAP score and adoption were high for farmers who received training as an intervention for PHM using hermetic bags. Overall, the results are consistent with the theory that there is an effect between training and KAP and, thus, the adoption of HST. The study recommends placing emphasis on farmer's training programs regarding PHM, thus increasing their knowledge, attitude, and practices, and hence their adoption, to enhance food loss control.

Keywords: Attitude, Hermetic Storage Bag, Knowledge, Post-Harvest Management, Practices

I. INTRODUCTION

An increase in the global population and hunger-related issues has spiked the need for improved storage practices and the adaptation of relevant policies to ensure global food security (van Dijk et al., 2021). Current world debates have recognized the importance of post-harvest loss management as a way to eradicate hunger (Affognon et al., 2015; Baer-Nawrocka & Sadowski, 2019; Sheahan & Barrett, 2017) and improve the quality of the food consumed, including aflatoxin control (Wilson et al., 1997, as cited in Baş et al., 2006). Poor on-farm storage practices have been among the causes of the quantity and quality loss of maize grains, leading to food insecurity and fluctuations in food prices (Brander et al., 2021; Huss et al., 2021; Minot, 2014; Tadesse et al., 2014). The post-harvest loss of food crops, including maize, varies throughout the value chain. Previous studies in Sub-Saharan Africa (SSA) indicate food loss of 39 percent at production and 37 percent during handling and storage levels (Abdelradi, 2018). Practices prior to and following harvest determine the quality and safety of food crops and, hence, the health of consumers. Most farmers opt for insecticides as the first-line treatment for post-harvest loss management in food crops. Such practices are associated with liver cancer due to the indirect consumption of chemicals from treated products (Gemeda et al., 2023; Luu et al., 2023; Mallah et al., 2023; Sharafi et al., 2018; Todd et al., 2008). Among improved on-farm storage technologies, hermetic storage, including hermetic bags, is considered a sustainable approach to reduce post-harvest crop loss and enhance food quality and safety.

Knowledge, attitude, and practice (KAP) of farmers in post-harvest management is essential for reducing food waste. However, their enhancement also depends on the training programs. Previous studies on the link between training programs and KAP have been conducted in different regions, with more studies on different issues. For example, a KAP study in Iran tested whether training had resulted in increased KAP among farmers on the safe use of pesticides to reduce the negative health effects of pesticide exposure but also to support the ongoing efforts to promote the production of healthy agricultural products, which were adequate among farmers (Sharifzadeh & Abdollahzadeh, 2021). For example, a KAP study in Canada tested whether training resulted in increased food handlers' knowledge, attitudes, and practices related to food safety issues (McIntyre et al., 2013), and similar results from a study conducted in India aimed to evaluate the existing knowledge, attitude, and practice of food safety and hygiene and the change of the same after training interventions (Choudhury et al., 2011) while in Turkey, only knowledge and practices were adequate (Baş et al., 2006), and in Brazil, only knowledge was improved (Da Cunha et al., 2014), and in Scotland, there were no significant improvements observed among food handlers (Ehiri et al., 1997). A KAP study in Malawi tested whether training resulted in increased knowledge, attitudes, and practices and showed that farmers had insufficient pre- and post-harvest crop management to reduce aflatoxin levels and there was a need for behavioural change (Anitha et al., 2019). Another study in Uganda revealed that significant post-harvest losses occur during various stages, including storage, and highlighted several factors contributing to these losses, including poor post-harvest handling and storage facilities (Tibagonzeka et al., 2018). Furthermore, a study in Bangladesh emphasized the importance of conducting KAP surveys to understand current post-harvest management and farmers' perspectives on quality and safety; only knowledge and attitude were adequate among the farmers (Khatun and Rahman, 2020).

1.1 Statement of the Problem

The underlying adoption theory of the study assumes that awareness and access to post-harvest technologies will increase their adoption rate, reduce stored crop losses, and increase total harvest volumes and crop sales, allowing farmers to access better market prices. Since smallholder farmers need skills and knowledge for post-harvest loss management, their exposure to training programs is important for increasing knowledge; however, improved knowledge of food loss control does not always result in a positive change in farmers' post-harvest management practices (Adnan et al., 2018; Alex et al., 2018; Anitha et al., 2019; Antwi et al., 2023; Deress et al., 2018; Migwi, 2016; Mollah et al., 2018; Muleme et al., 2017; Thongpalad et al., 2019). Due to limited knowledge and information on these areas, this study aimed to assess the effect of training on KAP and, hence, the adoption of hermetic storage technologies among smallholder farmers in Kilosa and Kondoa, Tanzania.

1.2 Objective of the Study

(i) Assess the effect of training on knowledge regarding the use of hermetic storage technologies among smallholder farmers
(ii) Assess the effect of training on attitude regarding the use of hermetic storage technologies among smallholder farmers
(iii) Assess the effect of training on practices regarding the use of hermetic storage technologies among smallholder farmers

II. LITERATURE REVIEW

2.1 Theoretical Review

The study was founded on the theory of change. The concept of the theory of change emerged from the fields of program theory and program evaluation in the mid-1990s as a new way of analyzing the theories motivating programs and initiatives working for social and political change (Weiss, 1995). A theory of change (ToC) is a method that explains how a given intervention, or set of interventions, is expected to lead to a specific development change or desired end result, drawing on a causal analysis based on available evidence (Reinholz & Andrews, 2020). However, TOC is not only focused on generating knowledge about whether a program is effective but also on explaining what methods it uses to be effective. Under several eras, ToC has been an integral part of community and international development projects due to its ability to map out a change process in a particular context and is used as a "guiding framework for all stages of thinking, action, and sense-making" when a program intervenes in processes of social change (Van Es et al., 2015). As cited by Deutsch et al. (2021b), ToC can serve multiple purposes in research, including visioning (Belcher et al., 2017; Oberlack et al., 2019), planning (Belcher et al., 2019; Mayne, 2015), communication, monitoring, and outcome evaluation (Belcher et al., 2020; van Drooge & Spaapen, 2022), as well as reflection and learning how and why change is expected to happen in a particular context (Halimanjaya et al., 2018; Posner & Cvitanovic, 2019; Ramirez & Belcher, 2020).

According to Mayne (2015), the theory of change depicts a causal package of activities plus assumptions that, together, are expected—and sufficient—to contribute to the intended results. The causal relationship derived from utilizing a theory of change process is an important aspect of a farmer's hermetic bag adoption. The causal assumptions in regards to a farmer's hermetic bag adoption would include determining what factors could be used to meet adoption scaling up. Upon improving food security and income for farmers, assumptions amongst stakeholders are made in regards to the interventions that will assist farmers in achieving each outcome through the adoption of hermetic bags. There are many outside factors that play a part in a farmer's adoption of a hermetic bag. The interventions offered in a farmer's adoption may be among the factors causing change in a farmer's knowledge, attitude, and practices while attending trainings. If a farmer does not meet a specific adoption scale, it may or may not be directly related to the intervention used to complete said goal. The theory of change process takes into consideration outside factors or assumptions that may have an effect on the causal relationship being built between activities and meeting course goals.

2.2.1 Training for Performance

Training can be illustrated as the provision of organized activities that offer a chance to acquire knowledge with a positive effect on work-related techniques (Wolor et al., 2020). Trainings (traditional or alternative) received with the instructors, showed a positive correlation with individual's result (score performance) in Indonesia (Constantine et al., 2009; Tanang & Abu, 2014), improved the adoption rate of sustainable land management technologies (mulching, pit planting, crop rotation, strip tillage, contour farming, row planting and improved fallowing) by up to 65% in Mozambique (Kondylis et al., 2017), adoption of new technology and other management practices in Nigeria improved by 100% (Olarinde et al., 2017), increased the use of fertilizer by 52%, transplanting in rows by more than 49%, modern varieties by 90.9% and seed selection by 71.8% through the farmer-to-farmer training program in Tanzania (Nakano et al., 2018). Furthermore, individuals provided with the opportunity to develop themselves through training improve their activity's performance (Akram, 2021; Amirono, 2018; Niati et al., 2021; Vesely et al., 2013).

2.2.2 Knowledge

Knowledge is the result of several activities, including the dissemination and utilization of something that entails information or data. It's a stage where an individual knows an innovation exists but shows no interest due to a lack of information about the new technology. It is typically based on learning, thinking, and a thorough understanding of the problem (Azad et al., 2014). According to Mawere (2010), as cited by Were (2023), knowledge is perceived as valuable in the establishment of a morally virtuous society as it encompasses a range of community-based skills, technologies, and practices that collectively contribute to the community's awareness and capacity to responsibly and sustainably utilize the environment. Were (2023) highlighted that worldviews have a significant role in fostering a sense of community affiliation, hence stimulating communal responsibilities that provide individuals with guiding principles that shape their anticipated conduct (Were, 2023). When knowledge is well disseminated, it results in easy and quick acceptance and embracing, thus increasing the probability of inducing behavioural change in the technology, which may be essential to the community with different levels of power, agency, and social dynamics and navigating diverse communication channels (Karki et al., 2017).

2.2.3 Attitude

Attitude is defined as a person's level of evaluative affect toward target behaviour with the likelihood of enhancing their performance in adoption. An individual may have positive or negative attitudes, low, middle, or high attitudes about an object, accessing different ones at various points in time (Ajzen & Fishbein, 1980), with the ability to provide long-term effects when adopted and stabilized (Pongrácz et al., 2005, as cited by Khatun & Rahman, 2020). Attitude plays a critical role in motivating individuals to participate effectively in accepting and participating in the process (Williams et al., 2019; Barasa et al., 2017; Wamalwa & Wanzala, 2023); however, the relationship between knowledge and attitude appears to be mutually reinforcing; informed individuals tend to be more competent and thus more motivated to participate in the process (Wamalwa & Wanzala, 2023).

2.2.4 Practice

Practices are identified as the real acts carried out by people in the situation in their context and indicate how knowledge and habits work together as opposed to theories relating to them. Best practices are those methods or programs that have been found to be successful in accomplishing their goals and that can be used, or adapted for use, in community circumstances. According to Vishweshwaraiah et al. (2014), poor practices were found to be among the reasons for the post-harvest loss of cereal crops in developing countries. Then, employing a method or program that's been tested and found successful increases the chances that you'll accomplish your goals, and life will therefore be

better for the folks who participate. Deployment of the KAP survey tool is essential to know the existing post-harvest management and enhance both food security and the income of farmers. Since KAP are the components of human behavior that are responsible for any action in dealing with everyday life, the three components are somewhat prerequisites in adopting new knowledge on food waste control.

2.2.5 Hermetic Storage Technologies

Hermetic storage is a method of using sealed, airtight units to maintain controlled conditions for stored dry agricultural commodities, specifically to regulate moisture and insect populations by depleting oxygen and replacing it with carbon dioxide, effectively controlling grain storage pests without using chemical insecticides. This method entails sealing off the interior space to prevent gas exchange between the internal and external environments, lowering oxygen levels to lethal or limiting levels for living organisms such as insects and fungi, and thus stopping insect feeding and starting to die (Williams et al., 2017). These technologies are becoming more widely available in emerging countries, and they have the potential to provide a sustainable and affordable solution for preventing and reducing postharvest loss, thereby increasing global food and nutrition security (Stathers et al., 2020) through improved product safety and quality. There are several types of hermetic storage systems available, including bags labelled PICS, AgroZ, and Mifuko Safi, as well as locally available containers modified for hermetic storage. Systems can range in size from small containers holding only a few kilograms to large ones capable of handling thousands of tons. Hermetic storage is widely used around the world, especially in developing countries, to protect valuable commodities during transit and storage (Spang et al., 2019).

Farmers have historically been disadvantaged in terms of economies of scale (small landholdings), local access to technology and inputs, information and knowledge, enabling infrastructure, credit facilities, and socio-cultural barriers because adoption is a dynamic process, and in the case of postharvest management, it may take several years to fully control food loss (Dar et al., 2020). There is wide empirical evidence on determinants of post-harvest losses and factors influencing the adoption of improved postharvest storage technologies, including hermetic storage using different methodologies (OLS regression analysis, ordered probit model, probit model, and logit model). Cross-sectional data reveal varying results, with some reaching the same consensus but others not (Atibioke et al., 2012; Boateng, 2016; Conteh et al., 2015).

III. METHODOLOGY

3.1 Population, Sampling Procedure and Sample Size

Hermetic storage is a method of using sealed, airtight units to maintain controlled conditions for stored dry agricultural commodities, specifically to regulate moisture and insect populations by depleting oxygen and replacing it with carbon dioxide, effectively controlling grain storage pests without using chemical insecticides. This method entails sealing off the interior space to prevent gas exchange between the internal and external environments, lowering oxygen levels to lethal or limiting levels for living organisms such as insects and fungi, and thus stopping insect feeding and starting to die (Williams et al., 2017). These technologies are becoming more widely available in emerging countries, and they have the potential to provide a sustainable and affordable solution for preventing and reducing postharvest loss, thereby increasing global food and nutrition security (Stathers et al., 2020) through improved product safety and quality. There are several types of hermetic storage systems available, including bags labelled PICS, AgroZ, and Mifuko Safi, as well as locally available containers modified for hermetic storage. Systems can range in size from small containers holding only a few kilograms to large ones capable of handling thousands of tons. Hermetic storage is widely used around the world, especially in developing countries, to protect valuable commodities during transit and storage (Spang et al., 2019).

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3.2 Data Collection

The data collection tool was programmed with the Kobo toolbox to electronically collect data from farmers to understand the KAP regarding post-harvest management technologies. During data collection, participants were assured that their data would be confidential under the project. All 637 farmers approached in farmer group visits

provided their consent to participate. A designed questionnaire survey covered socio-demographics, production, consumption, and storage. Knowledge, attitude, and practice regarding hermetic bags were employed. Five-point Likert scale (Croasmun & Ostrom, 2011) statements (i.e., 1=strongly disagree, 2=disagree, 3=Don't know, 4=agree, and 5=strongly agree) and yes/no questions were deployed to examine respondent agreement levels regarding the above issues.

3.3 Data Analysis

The quantitative data obtained from the questionnaire survey were subjected to statistical analyses, including descriptive statistics, to summarize the variable frequencies. The overall knowledge, attitude, and practice will be calculated through their indices (see equation 1) and a multiple linear regression model to identify the effect of training on farmers' knowledge, attitudes, and practices, and adoption of hermetic storage bags (see equation 2).

$$\text{KAP Score} = \frac{\text{Score obtained by respondents}}{\text{Maximum obtainable score}} \quad \text{..... Equation (1)}$$

$$Y = \alpha + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_n X_n \quad \text{.....Equation (2)}$$

Where; Y is the dependent variable; α is the constant; $ß_1$, $ß_2$,…, $ß_n$ are the beta coefficients for the independent variables, and X_1, X_2,…, X_n are the independent variables

IV. FINDINGS & DISCUSSIONS

4.1 Findings

4.1.1 Association between Farmer's Knowledge of Hermetic Bag and Demographic Variables

Table 1 displays the relationship between the sociodemographic characteristics and knowledge scores.

Table 1

Association between Farmer's Knowledge of Hermetic Bag and Demographic Variables

Variable	Knowledge (%)			Combined (N)	chi-square	p-value
	Low	Moderate	High			
Sex					2.836	0.242
Male	52.91	16.86	30.23	172		
Female	59.14	16.99	23.87	465		
Age (years)					14.176	0.028**
18-35	69.15	15.38	18.46	130		
36-45	60.95	15.71	23.33	210		
46-65	49.62	20	30.38	260		
Above 65	62.16	8.11	29.73	37		
Marital status					14.1	0.079*
Married living with a spouse/s	56.24	16.7	27.06	473		
Married but spouse away	42.86	0	57.14	7		
Divorced/Separated	59.72	22.22	18.06	72		
Widow/Widower	54.55	18.18	27.27	55		
Never married	80	10	10	30		
Education level					20.003	0.010***
No education	84.31	5.88	9.8	51		
Primary	55.01	18.15	26.84	529		
Secondary	57.69	17.31	25	52		
Technical/Vocation training	50	0	50	2		
University	33.33	0	66.67	3		
Occupation					9.4	0.152
Farming (Crop or Livestock)	58.2	16.89	24.92	610		
Employed (Informal sector)	38.89	27.78	33.33	18		
Employed (Formal sector)	25	0	75	4		
Business	60	0	40	5		

The results in Table 1 show a significant relationship between the age of the respondents and the knowledge score (P< 0.05), and the farmers aged 46–65 years scored higher (30.57%) than the other age categories. The findings also reveal a statistically significant relationship between the marital status of the respondents and their knowledge score (P< 0.1); married farmers scored higher (more than 57%) than single-parent households. Furthermore, Table 2

results show that there is a statistically significant relationship between the level of education attained and knowledge score (P = 0.01) and show that farmers holding a higher education, such as a university degree, scored (66.67%) higher than the respondents who did not attend school. On average, farmers who received training scored higher in knowledge acquired than those who did not receive training (27% and 23%, respectively).

4.1.2 Association between Farmer's Attitude on Hermetic Bag and Demographic Variables

Table 2 displays the relationship between sociodemographic characteristics and attitude dimensions.

Table 2

Association between Farmer's Attitude on Hermetic Bag and Demographic Variables

Variable	Attitude (%)		Combined	chi-square	p-value
	Low	High			
Sex				1.904	0.168
Male	40.12	59.88	172		
Female	46.24	53.76	465		
Age (years)				20.887	0.000***
18-35	59.23	40.77	130		
36-45	47.62	52.38	210		
46-65	36.15	63.85	260		
Above 65	35.14	64.86	37		
Marital status				14.723	0.005***
Married living with a spouse/s	42.49	57.51	473		
Married but spouse away	14.29	85.71	7		
Divorced/Separated	56.94	43.06	72		
Widow/Widower	38.18	61.82	55		
Never married	66.67	33.33	30		
Education level				17.181	0.002***
No education	68.63	31.37	51		
Primary	41.21	58.79	529		
Secondary	55.71	44.23	52		
Technical/Vocation training	50	50	2		
University	33.33	66.37	3		
Main occupation				6.315	0.097*
Farming (Crop or Livestock)	45.25	54.75	610		
Employed (Informal sector)	16.67	83.33	18		
Employed (Formal sector)	50	50	4		
Business	60	40	5		

The findings in Table 2 revealed a significant correlation between the age of the respondents and the attitude score (P < 0.001). The results showed that farmers aged above 65 years scored 63% higher than the mean attitude score compared to the other age categories. The results also reveal a statistically significant correlation between the marital status of the respondents and attitude score (P < 0.001) and show that married farmers scored higher on mean attitude scores than single-headed households. The results in Table 2 show the correlation between the level of education and attitude score (P < 0.001), indicating that farmers who went to school had a higher attitude score than those who did not attend school. In addition, the results showed a significant correlation between the occupation of the respondents and their attitude score (P < 0.1). Respondents who were employed in other sectors (informal employment) had higher attitude scores than those who depended on other occupations. Moreover, the results showed a significant correlation between the training and attitude scores (P < 0.001). On average, farmers who received training scored higher in attitude than those who did not (63% and 45%, respectively).

4.1.3 Association between Farmer's Practices on Hermetic Bag and Demographic Variables

Table 3 displays the correlation between the demographic characteristics and practice dimensions.

Table 3

Association between Farmer's Practices on Hermetic Bag and Demographic Variables

Variable	Practice (%)		Combined	chi-square	p-value
	Low	High			
Sex				0.004	0.947
Male	51.74	48.26	172		
Female	52.04	47.96	465		
Age (years)				8.0943	0.044**
18-35	60.77	39.23	130		
36-45	54.29	45.71	210		
46-65	46.54	53.46	260		
Above 65	45.95	54.05	37		
Marital status				3.3185	0.506
Married living with a spouse/s	51.37	48.63	473		
Married but spouse away	28.57	71.43	7		
Divorced/Separated	54.17	45.83	72		
Widow/Widower	50.91	49.09	55		
Never married	63.33	36.67	30		
Education level				10.462	0.033**
No education	68.63	31.37	51		
Primary	49.34	50.66	529		
Secondary	59.62	40.38	52		
Technical/Vocation training	100.00	0.00	2		
University	66.67	33.33	3		
Main occupation				10.7304	0.013**
Farming (Crop or Livestock)	52.79	47.21	610		
Employed (Informal sector)	16.67	83.33	18		
Employed (Formal sector)	50.00	50.00	4		
Business	80.00	20.00	5		

The results in Table 3 showed a significant relationship between the age of the respondents and the practice score ($P < 0.001$). The results show that farmers aged above 35 had higher practice scores than those in the younger age groups. The results revealed a statistically significant correlation between education level and practice scores ($P < 0.05$). The results showed that farmers with a primary education level scored higher (about 71%) in practice regarding hermetic storage bags than the others. Moreover, the findings revealed a significant relationship between the training and practice scores ($P < 0.001$). On average, farmers who received training scored higher in practice than those who received training (59% and 34%, respectively).

4.1.4 KAP and Adoption of Farmers Regarding the Technology with and without Intervention

Table 4 shows the results for knowledge, attitude, practices, and adoption score differences between trained and untrained farmers regarding post-harvest management using hermetic storage bags, and mean values were determined by an independent sample t-test.

Table 4

KAP and Adoption of Farmers Regarding the Technology with and without Intervention

Outcome	Training		t-statistics
	Treatment	Control	
Adoption	0.6341 (0.0255)	0.4982 (0.03)	3.4682***
Knowledge	4.9721 (0.1801)	3.8566 (0.2192)	3.9670***
Attitude	25.2514 (0.172)	23.7706 (0.2162)	5.4293***
Practice	22.9804 (0.1249)	21.3899 (0.1453)	8.3817***

The figures in parenthesis are standard errors; ***P< 0.01; **P< 0.05; *P< 0.1.

Results based on the intervention indicate that trained farmers acquired more knowledge, were conscious of high positive attitudes, and practiced hermetic storage use as compared to untrained farmers and hence adoption. Statistically significant results show that the mean adoption score was significantly higher for trained farmers than for

farmers who did not receive training at the 1% significance level. Likewise, the mean scores for knowledge, attitude, and practices were higher in the treatment group than in the control group, both positive and significant at the 1% significance level.

4.1.5 Econometric Results

From table 5, the socio-demographics of the respondents by participation status and how they alter their knowledge, attitudes, and practices on hermetic storage technology. For the entire sample, training for improved on-farm store technology was positively and significantly related to adoption, knowledge, attitudes, and practices. Having benefited from training on post-harvest management, including the use of improved on-farm storage technology such as hermetic storage bags, shows that when holding all other variables constant, farmers who had benefited from training were approximately 0.2 times more likely to adopt the hermetic bag than farmers who did not receive training at the 1% significance level. The fact of having benefited from training on post-harvest management, including the use of improved on-farm storage technology such as hermetic storage bags, shows that when holding all other variables constant, farmers who had benefited from training were 1.28 times more likely to have higher knowledge on the hermetic bag and its usage than farmers who did not receive training, at the 1% significance level. Having benefited from training on post-harvest management, including the use of improved on-farm storage technology such as hermetic storage bags, shows that when holding all other variables constant, farmers who had benefited from training were 1.78 times more likely to have a higher positive attitude toward the hermetic bag and its usage than farmers who did not benefit from training, at the 1% significance level. Moreover, having benefited from training on post-harvest management, including the use of improved on-farm storage technology such as hermetic storage bags, shows that when holding all other variables constant, farmers who had benefited from training were 1.78 times more likely to have higher practice on the hermetic bag than farmers who did not benefit from training in improved on-farm storage technology at the 1% significance level. Age was positively and significantly related to knowledge, attitudes, and practices. This means that an increase in age affected our outcome variables. Older farmers were likely to have higher knowledge, attitudes, and practices regarding hermetic storage technology used as improved on-farm storage technology for post-harvest management and are likely to adopt more than younger farmers at the 1% significance level. Farmers with larger farms allocated for maize production were likely to have higher knowledge, attitudes, and practices regarding hermetic storage technology at the 5% significance level and adopt more than those with small-sized farms allocated for maize production at the 1% significance level.

Table 5

Socio-Demographic Characteristics with Knowledge, Attitude and Practices

Outcome	Training	Sex	Age	Education level	Marital status	Main occupation	Maize farm size	Maize yield
Adoption	0.1558***	0.0926**	0.0045***	0.269***	0.1289***	-0.2994***	0.0522***	-0.0017*
	(0.0379)	(0.0441)	(0.0016)	(0.0693)	(0.0454)	(0.0923)	(0.0178)	(0.001)
Knowledge	1.2844***	0.2897	0.0549***	2.4056***	0.832**	-1.7154***	0.2553**	-0.0102
	(0.2715)	(0.3163)	(0.0113)	(0.4968)	(0.3257)	(0.6613)	(0.1276)	(0.0071)
Attitude	1.7841***	0.2996	0.0627***	2.2081***	0.9593***	-1.3482**	0.2463**	-0.0255***
	(0.2610)	(0.3042)	(0.0109)	(0.4776)	(0.3132)	(0.6358)	(0.1227)	(0.0068)
Practice	1.7812***	0.0944	0.0323***	1.174	0.2084	-0.7506	0.2151**	-0.0218***
	(0.1875)	(0.2185)	(0.0078)	(0.3431)	(0.225)	(0.4568)	(0.0882)	(0.0049)

The figures in parenthesis are standard errors; ***P< 0.01; **P< 0.05; *P< 0.1.

The results in Table 6 show that the use of hermetic storage bags was positively and significantly related to KAP. Farmers with greater knowledge, attitudes, and practices regarding hermetic bags were likely to adopt improved on-farm storage technology at the 1% significance level.

Table 6

The Relation of the three Variables (KAP) with Technology Adoption

Outcome	Knowledge	Attitude	Practice
Adoption	0.092***	0.0606***	0.0734***
	(0.0042)	(0.0051)	(0.0071)
F-statistics	77.44	28.57	24.15
Prob>F	0.0000	0.0000	0.0000
R-squared	0.4966	0.2668	0.2353

The figures in parenthesis are standard errors; ***P< 0.01; **P< 0.05; *P< 0.1.

4.2 Discussions

The analysis was adjusted for age, sex, educational level, marital status, occupation as the main income source, and farm size allocated for maize and maize yield.

The results in Tables 1–6 ascertain that the training intervention was effective in promoting the farmers' knowledge, attitude, and practice of post-harvest management using hermetic storage bags as an improved on-farm storage technology. Essentially, knowledge promotion requires access to and from information and the provision of a chance for interpretation and understanding of transferred information, which may lead to rethinking individual actions or receiving feedback from participants, which is consistent with the findings of Jani et al. (2013), Salina et al. (2021), and Victor and Kathaluwage (2019). However, being in a group can help shape constructive attitudes and practices. Since the effect of training on knowledge, attitude, and practices regarding post-harvest management is positive and statistically significant at the 1% level, these results indicate that farmers who participated in the training on improved on-farm storage technologies were likely to have higher knowledge, attitude, and better practices of hermetic storage bags to improve their understanding and awareness of the importance of hermetic storage bags in controlling food loss, insect resistance, food quality maintenance, and free aflatoxin. These results are consistent with those of Samdrup (22019) which support the idea of active participation or attendance in field demonstrations and training.

Older farmers seem to have more farming experience and are thus more adaptive when facing challenges in post-harvest loss control. Meanwhile, the extensive use of improved on-farm technology, such as hermetic storage bags, has fewer risks of food loss and much greater resilience. Thus, farmers who use hermetic storage bags are more likely to be food secure and improve their household income. In addition, training interventions for knowledge, attitude, and practices regarding food control loss policies will enable farmers to easily adapt improved on-farm storage technologies because of comprehensive information sources regarding food security. These results are contrary to those of Kamano et al. (2021), who found that older maize farmers were less likely to have higher knowledge scores.

Educational level was found to affect only the attitude and practice of post-harvest management using hermetic storage as an improved on-farm storage technology, which shows that education enables farmers to easily understand and recognize the improved on-farm technologies, the problem of food loss, and consequently changes the actual practices into profitable practices based on the skills they acquired; similar results were found by Red et al. (2021). Thus, food loss control should specifically target the initial segments of the food supply chain where the most losses occur by improving farmers' knowledge and exposure to improved storage facilities.

V. CONCLUSIONS & RECOMMENDATIONS

5.1 Conclusions

Training smallholder farmers in Tanzania has been shown to have a positive impact on their knowledge, attitudes, and practices, and hence on the adoption of post-harvest management technologies. This study highlights the significance of assessing participants' knowledge, attitudes, and practices with program intervention, including training on post-harvest management and using improved on-farm storage technologies, including hermetic storage bags. This study contributes to the accessibility of effective and continuous educational interventions (formal and informal) for households subjected to food insecurity by providing an appropriate strategy to enhance knowledge, attitude, and practice regarding hermetic storage use to control food loss problems. Therefore, it can be concluded that training significantly affects the knowledge, attitude, practices, and adoption of post-harvest management technologies for smallholder farmers in Tanzania.

5.2 Recommendations

Hence, promoting further training and extension services should prioritize efforts to improve the sources of knowledge, attitudes, and practices regarding post-harvest management by using improved on-farm storage technologies, as it are important to design strategies and action plans to reduce food loss and improve food security and income. This study concludes that the knowledge, attitude, and practice regarding hermetic storage technologies, including bags, are influenced by the training intervention, including formal and/or informal, and the farmer's age, which implies the experience of farming activities.

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