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Comparative analysis of farmer-to-farmer and participatory extension approaches in promoting adoption of maize postharvest handling technologies among smallholder farmers in Uganda

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ABSTRACT
Adoption of recommended postharvest handling (PHH) methods for maize is still low in Uganda due to ineffective dissemination approaches used. This article assessed effectiveness of farmer to farmer (FTF) and participatory (PA) extension approaches in promoting adoption of maize PHH technologies among 21 farmer groups in Apac, Kamuli and Nakasongola districts. Qualitative data were collected using Focus Group Discussions on observed behaviour practices and, analyzed using content and thematic method. Quantitative data was collected using proportionate and random sampling of 210 farmers. Using Statistical Package for Social Sciences, descriptive statistics on technologies used were generated. Correlations were run for relationships between extension approaches and adoption of technologies. It was anticipated that FTF had potential for promoting PHH technologies than PA. However, PA registered higher level in sustainable utilization of adopted technologies compared to FTF. Therefore, collective participation and regular monitoring in agriculture extension is key for sustainable outcomes of interventions.

Key words: Participatory, farmer-to-farmer, extension, postharvest handling technology, adoption, Uganda

RÉSUMÉ
L'adoption des méthodes recommandées de manipulation post-récolte (MPR) pour le maïs est encore faible en Ouganda en raison des approches de diffusion inefficaces utilisées. Cet article a évalué l'efficacité des approches de vulgarisation d'agriculteur à agriculteur (AAA) et participative (AP) dans la promotion de l'adoption des technologies MPR du maïs parmi 21 groupes d'agriculteurs dans les districts d'Apac, Kamuli et Nakasongola. Les données qualitatives ont été recueillies à l'aide de groupes de discussion sur les pratiques comportementales observées et analysées à l'aide d'une méthode de contenu et thématique. Des données quantitatives ont été recueillies à l'aide d'un échantillonnage proportionnel et aléatoire de 210 agriculteurs. À l'aide du package statistique pour les sciences sociales, des statistiques descriptives sur les technologies utilisées ont été générées. Des corrélations ont été établies pour les relations entre les approches de vulgarisation et l'adoption des technologies. Il était prévu que AAA avait le potentiel de promouvoir les technologies MPR plutôt que AP. Cependant, l'AP a enregistré un niveau plus élevé d'utilisation durable des technologies

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adoptées par rapport au AAA. Par conséquent, la participation collective et le suivi régulier de la vulgarisation agricole sont essentiels pour des résultats durables des interventions.

Mots clés : Participatif, agriculteur à agriculteur, Vulgarisation, technologie de manipulation post-récolte, adoption, Ouganda

INTRODUCTION

Maize is the third most important agricultural commodity worldwide (Kornher, 2018). Maize contributes 34-36% of the daily caloric intake in East Africa and is the most important cereal in the region (World Bank, 2011). However, maize production in developing countries is highly characterized by postharvest loss (PHL), contributing to food and nutrition insecurity (African Postharvest Loss Information System (APHLIS), 2017; Borenstein *et al*., 2009). PHL accounts for direct physical or quality loss (Kumar and Kalita, 2017) as well as indirect safety loss. Households' survey in Malawi, Tanzania and Uganda showed that overall PHL of maize grains adds up to 1.4-5.9% of the national maize harvests (Kaminski and Christiaensen, 2014). In addition to quantitative loss, PHL also entails changes in quality attributes leading to reduced economic value of the grains, lower nutritional value and seed viability loss (Boxall, 2001) as well as increase food safety risks. The magnitude of PHL in food supply chain varies among different areas and economies (Kumar and Kalita, 2017). In Uganda, losses have been reported to occur at each postharvest stage of maize. Harvest losses are estimated to be between 6.4-16.4%, with 4.0% during further drying, 1.3% at shelling, 2.4% during transportation and 1.2-5.9% during five to eight months of storage (APHLIS, 2011).

Reducing PHLs is important in addressing food, nutrition and income security (Mutungi *et al*., 2012). In Sub Saharan Africa, low cost technologies like hermetic bags, heavy molded-plastic containers, mobile processing units, tarpaulins, raised racks, shellers, metallic silos and improved traditional granaries have been introduced (Ofosu *et al*., 1995; NAADS, 2005; Mrema, 2012). However, though appropriate technologies have been widely disseminated, they are not adopted widely, partly because of ineffective extension approaches (World Bank, 2011). In this study, adoption means the ability of the farmer to embrace the technology, utilize it sustainably and be able to replicate or replace technologies. The past decade has seen a paradigm shift from top bottom to bottom-up approaches (Kiptot and Franzel 2015). PA approach is one of bottom-up approaches commonly used in agricultural extension (Kaihura, 2001). It is based on theoretical argument that an effective extension model spreads agricultural innovations and reaches women and other marginalized groups, at the same time builds farmers' capacities (Ssemakula and Mutimba, 2011). Examples of PA approaches include PA Technology Development (PTD), Farmer PA Research (FPR), and PA Extension Approach (Jurgen *et al*., 1998)

Today, various enterprises have resorted to using FPR, also termed as FTF approach, for disseminating new innovations (Ssemakula and Mutimba, 2011; Kiptot and Franzel, 2014). The FTF approach is based on two social theories: Social interaction which emphases value consensus (Hess *et al*., 2000) and social learning theory which calls for individual interaction to discuss problems and call for solutions (Forsyth, 2006). Equally, PA has been institutionalized in public extension (Kiara, 2011). The interactive engagement under the approach involves smallholder farmers and public extension to generate information and solutions to address food security. Although both FTF and PA extension approaches have been used in different contexts, what remains unknown is which of the approaches is more effective in scaling up and sustaining the adoption of postharvest technologies. Sustainable use of adopted technologies was conceptualised as ability of farmers to continuously utilize the knowledge and technologies without reverting back to ineffective practices . Understanding the context and the conditions for effective and sustained use of post-harvest technologies is critical in increasing farmers' productivity and eradicating hunger and poverty. This study aimed at comparing effectiveness of the two dissemination pathways in promoting PHH technologies through the process of diffusion of PHH technologies in participatory and farmer to farmer extension approaches and evaluation of the level of adoption of PHH technologies in both approaches.

MATERIALS AND METHODS

Study area. The section of this study area was informed by earlier research findings of Tibagonzeka *et al*., (2014) within which this study was situated. The study was conducted in the districts of Apac, Kamuli and Nakasongola from December 2015- July 2017. These districts were purposively selected based on earlier studies, which indicated that despite the many benefits accruing from growing and consumption of cereals, roots and tuber crops, there are challenges of high post-harvest losses resulting from improper post-harvest handling which further leads to low produce quality along with problems such as mycotoxin contamination. (Tibagonzeka *et al*., 2014)

Study design and Sampling strategy. The study employed a longitudinal research design which involved repeated observations of 21 active farmer groups, consisting of women and men, the youths and the elderly. These farmer groups consisted of 20-34 members were purposively sampled because their active involvement in production. The longitudinal design involved both qualitative and quantitative data collection methods and was carried out in three phases i.e. participatory identification of PHH challenges and choice of PHH appropriate intervention commenced in December 2015 to February 2016 as phase one; phase two involved training farmers in appropriate PHH practices and dissemination of preferred PHH technologies in June-August 2016; and phase three of the study involved evaluation of uptake, adoption and sustained use in June-July 2017.

Data Collection. The study collected both qualitative and quantitative data using qualitative methods in all phases and household interviews in a sample survey in phase three for evaluation of adoption and sustained use among farmers.

Phase one: Participatory identification of PHH challenges and appropriate interventions. The initial phase of this study aimed at understanding the existing farmer PHH practices, reasons for such practices, identification of PHH constraints farmers face and possible appropriate interventions. This baseline used FGDs to solicit rich information from the 21 selected farmer groups. The research team held a separate FGD with each selected farmer group at different intervals. Each FGD had between 10 and 14 participants. Probing was done to understand the deeper meanings of PHH matters concerning the maize crop among the small holder farmers.

Phase two: Training on appropriate PHH practices and Dissemination of PHH technologies. After understanding farmer's PHH practices in phase one, the second phase focused on introducing appropriate PHH good practices to the farmer groups through trainings. Prior to training, farmer groups were clustered into participatory and FTF extension approaches. With the help from extension officers, the farmer groups were randomly categorized into PA and Farmer to Farmer extension categories. Out of twenty-one (21) farmer groups in the three districts, twelve (12) and nine (9) farmer groups from the three districts were randomly clustered under the PA and FTF extension approaches, respectively. It was anticipated that FTF had potential of promoting PHH technologies. Since the districts under study experience two harvest seasons in a year (June-August), training of appropriate PHH practices to the farmer groups started in the month of July to

August 2016. This time of the year was appropriate because it was harvest time for the first season plantings. The researcher-farmer interface was guided by a simplified training manual that was rich with pictorial captions on appropriate PHH practices and technologies. The training aimed at increasing farmers' awareness on PHH loss reduction through the use of PHH innovations and maintaining PHH good practices. Training topics included what PHH entailed, appropriate PHH practices throughout the value chain of maize and different technologies used during PHH of maize.

Training of farmers under PA extension category

The field-based capacity strengthening training was conducted in a back and forth manner where researchers took lead of discussions as farmers listened and asked different questions of their concerns. The training lasted for two days for each farmer group. The training technical personnel demonstrated use of different PHH technologies at different stages of the maize value chain to each farmer group. Farmers were also equipped with routine maintenance skills for different parts of the postharvest handling technologies. The training manuals were later provided to farmers for future reference. After the training, a rapid appraisal was carried out to test whether the trainings were successful. Subsequently, the farmers demonstrated knowledge on PHH and proficiency in the utilization and maintenance of the disseminated technologies.

Training of farmers under FTF extension category. For the FTF category, 18 farmer trainers in the three districts were selected for training. Two farmers were recommended from each group based on gender, literacy and leadership skills as well as farming experience. The ratio of female to male selection of farmer trainers was 1:1 across the farmer' groups in all the districts. A two-day training workshop in each district was conducted and involved researchers and selected farmer trainees. The training was guided by a simplified a training manual that was rich with pictorial captions on appropriate PHH practices and technologies. The training manuals were later provided to each farmer trainer to guide them while training their group members. The team's technical personnel demonstrated the use of different PHH technologies to the farmer trainers. Farmer trainers were also equipped with the routine maintenance skills on the different parts of the different postharvest technologies. At the end of the training, a rapid appraisal was carried out to test whether the trainings were successful and whether the trainees had acquired the knowledge to pass on to other farmers. Eventually, the trainees demonstrated knowledge on PHH and proficiency in the utilization and maintenance of the disseminated technologies.

Subsequently, community-based trainers (CBT) who had experience in agriculture extension, PHH and spoke the local language were selected and trained. Six (6) CBTs from the three districts were trained with a ratio of 1:1 males and females respectively. The CBT were responsible for availing information; linking the group members to the researchers in times where need arose, monitoring the progress, practices and usage of


Figure 1: Farmers receiving drying and shelling technologies.

different technologies for different farmer groups. **Dissemination of PHH Technologies.** After training, the research team disseminated the technologies to farmers basing on their preferred choice of intervention. Whereas drying technologies like the tarpaulins were distributed to all individual farmers in each group, the drying racks were constructed at randomly selected farmers' homes from each farmer group for demonstration purposes. The rest of the farmers were in the FGs were required to replicate this technology at their homes. With shellers, each farmer group received three (3) bench shellers and three (3) hand shellers. These shellers were to be shared amongst members of the group when need arose. Similarly, one (1) motorized maize sheller (with an output capacity of 1.5tonnes/ litre of petrol/hr.) was availed to be shared by all the seven farmer groups per district. It was placed in a central place for easy accessibility by all the farmers groups. Storage facilities like hermetic bags were distributed to farmers who had small maize quantities while metallic silos were distributed to farmers who had relatively bigger quantities across the three districts.

Phase three: Evaluation phase. After 12 months of training, a post intervention evaluation was conducted. The evaluation was carried out at two levels. The first level entailed qualitative evaluation in the month of June 2017 which focused on the rate of adoption of PHH technologies in both FTF and participatory extension approaches. Using the baseline as a yard stick, FGDs were used to collect the information from 21 farmer groups regarding the behavioural change, attitudes, perceptions about and challenges experienced with the new PHH practices in the post-intervention period. The study also used non-participatory observations to appreciate farmer's behavioural change along the value chain in the post intervention. The second level entailed a household sample survey in July 2017 that covered 210 respondents. The survey timed the first season harvest of grains in 2017. The study used Best and Khan (2003) sample size determination criteria which states that a sample size of 20% to 30% of the already existing sample size is ideal for proving reliable quantitative data when selected through random sampling. Therefore, a fraction of 30% of the total number of participants from each group was taken as a sample for the survey. Simple random sampling was used to select 70 farmers from the list of project beneficiaries in each district with a ratio of 40:30 for participatory and farmer to farmer extension category, respectively.

A questionnaire was used to collect quantitative data. It comprised of two sections. The first section sought to address farmer's demographic characteristics and the second section captured level of uptake, and sustainable use of the PHH technologies. Additionally, an observation check-list was also used to scrutinize the sustainable use of PHH technologies and diffusion of the innovations. This was done at individual level to help establish individual farmer's behavioural change after acquiring the PHH technologies.

Data Processing and Analysis. Qualitative data from the field observations, focus groups were sorted, coded and themes developed in line with; farmers old PHH practices, PHH challenges farmer faced, possible solutions o these challenges and level of adoption and sustainable utilization of the technologies. Quantitative data were coded and entered into Statistical Package for Social Sciences (SPSS) version 17.0. After data cleaning, descriptive statistics were presented in frequency tables and charts to show the level of uptake, sustainable use PHH technologies. Spearman correlations were run to establish the relationships between extension approaches and uptake, adoption and sustainable use of the technologies.

RESULTS

This study evaluated the process of adoption of PHH technologies in participatory and farmer to farmer extension approaches and of the level of sustained use of PHH technologies in each of the approaches. In evaluating the effectiveness of extension approaches, increased adoption of the technologies (conceptualised as the ability of the farmer to embrace the technology and utilize it sustainably) was used to measure success of a particular extension approach over the other.

Pre-Intervention PHH Behaviour, Practice and Challenges. The process of adoption of the PHH innovations was the first objective of this study. It entailed a baseline survey in phase one, training and dissemination of PHH technologies in phase two and evaluation on the effectiveness of the Participatory and FTF dissemination approaches in phase three.

A baseline on farmers' initial PHH practices and technologies. In the study, small-scale maize farmers in the three districts mentioned similar commonly used practices across the value chain of the maize crop. At harvest, for example, different farmer groups within each district reported that they identify ready maize by observing changes in coloration of maize cob husks, the leaves, the stalk and the drying of the tassel. Besides changes in colour, farmers also reported the bending down of the maize ear towards the stalk. This knowledge is mediated by cultural factors. In Apac district, for example, findings generally revealed that harvesting produce is delayed by household and other field-based `chores which compete for the limited time available to women in particular. Several tools and equipment were used at the stage of harvesting. These included knives, sharp sticks which are pierced through the husks on a maize cob for easy removal, hands, baskets, basins, saucepans, sacks and tarpaulins. Knives and sharp sticks were universally reported across the three districts. The rationale for using sharp sticks and knives is that they simplify the task of removing husks from the maize cobs. This was an adaptation shift from relying on locally available resources from households and garden to reducing inefficiency of splitting by hands, such as time consuming, pain and blisters caused by manual harvesting. The innovation was driven by the desire to increase efficiency and curb negative effects of the old practice. These technologies were adopted by both men and women in agricultural production and harvesting activities.

In addition, field observations revealed that most farmers transport produce from gardens to their homes in sacks which they carry either on their heads or on bicycles. However, few male farmers reported that they carry sacks on their shoulders. It is important to note that there are a few large-scale farmers who hire cars to ferry maize from garden. Transporting produce from fields to home relied largely on family labour. Children, both girls and boys, are involved in transporting maize harvest on either their heads or on bicycles.

This study also identified several technologies used in the drying of maize harvest. These included drying on bare ground with or without prior sweeping, drying on ground smeared with cow dung, drying on tarpaulins, sacks and on "*Gomesi*" (Women's traditional dress). Drying on *Gomesi* was the least reported practice except in Kamuli district. Drying on grounds smeared with cow dung was also reported by relatively few respondents across all group discussions in all districts. The most common practice was drying maize on bare ground; followed by the use of sacks and tarpaulins. Through group discussions, several reasons were given to explain why farmers preferred drying maize on bare ground. These included perceptions of faster drying and association of more weight gain.

> *For us we dry our maize on the ground. When you spread maize on ground it dries faster because it is heated from above and below, and the area is wider, since it is thinly spread on the ground. Drying maize on ground is good because maize dried on the ground weighs more kilograms than maize dried on tarpaulins* (Female farmer, Tibikoma FG - Kamuli District).

These perceptions were reported across all FGDs held with farmers across the three districts. Some few respondents within the same group discussions, however, noted several negative effects of drying produce on bare ground. Negative effects of drying on bare ground which were reported in this study included the change in taste and changes in coloration from whitish to brownish colour and the risk of getting wet when it rains. Nevertheless, some farmers reported that they dry their maize harvest on tarpaulins and sacks. Generally, the findings revealed that drying on tarpaulin, "*Gomesi*" and sacks were an exception not the norm. For the farmers who dried on these facilities, the reasons were largely for home consumption but also acknowledged that they dried on the ground if the intention was to sell.

Efforts were made to find out how farmers know that maize is dry enough for storage and processing. According to the findings, farmers test for dryness by biting few seeds randomly selected and noting the sound made: "*If you bite through a few seeds, you can tell. It makes sound and it is harder but one which is not dry enough will not make the noise*" (FGD with Leeta HIV FG in Kamuli district). Other testing techniques reported, albeit by fewer respondents, included pressing figure nails through the seeds, and the use of bottle and table salt technique. Using the latter technique, farmers put table salt and few maize seeds in a bottle, which is then left in the sun for about three minutes. When the bottle turned wet from inside, it meant that the grains were not yet dry but when the bottle remains dry, that meant that the grains were dry. The practice of table salt and bottle was reported in only 2 groups out of the 21 farmer groups across the three districts and by very few voices in the groups. Overall, findings reveal that farmers mostly rely on traditional testing practices to tell that the harvested maize is dry enough and ready for storage or processing.

During shelling, farmers from all three districts expressed that this was the most cumbersome process. Several devices were used for shelling and these included knives, sharp sticks, hands, baskets, and sticks and motorized shelling machines. Knives and sharp sticks were universally reported across the three districts. The rationale for using sharp sticks and knives was that it simplifies the task of shelling. Participants also noted that use of sticks and sacks, where maize cobs are packed in sacks and beaten for the grains to detach, was an adaptation relying on locally available resources for households. Farmers reported problems ranging from being time consuming, painful and causing blisters in the hands during manual shelling. In all three districts, men, women and children used these practices.

In terms of storage, most respondents rarely stored maize for a long time. Two months were recorded as the longest storage time. Most farmers sell produce as soon as they harvest to avoid the costs associated with storage, such as costs for pesticides and the space occupied by the harvest among others. During the first two months of storage, farmers rely on a number of techniques to store the harvest longer. These include use of local plant repellents, red pepper sprays and chemical tablets. Across the FGDs, the practice of keeping maize on pallets was identified as an effective practice for quality maintenance. Use of local plant repellents is the least utilized and was only reported in Kamuli district. Farmers reported that they obtained such knowledge from non-government organizations operating in Kamuli district. This practice was not reported at all in Nakasongola and Apac districts. Farmers also cited different reasons for using these technologies, which included lack of appropriate technologies; traditional practices; need for drying grains fast (in case of bare ground), cost and availability of technologies. However, there are limitation in farmers' knowledge on PHH practices and this may explain the nature of PHH challenges that they face.

Pre-Intervention PHH Challenges faced by Small Scale Maize Farmers. Despite the variation in location, farmers in the selected districts faced similar PHH problems across the maize crop value chain. These challenges include lack of transport facilities from the garden; long distance from the gardens; theft which limits use of cribs; limited drying technologies; dust, mud at drying stage; laborious shelling; accidents during shelling; high costs of procurement at shelling stage; weevil attacks; high procurement costs; theft; termites; rodents; limited storage facilities; poor prices; and limited market. However, through probing, farmers realized that some mentioned constraints were only indicators of more severe underlying causes. Study participants also noted that though they faced a lot of PHH challenges, not all of them were so pressing. Pair-wise ranking was used to isolate the most pressing PHH constrains. Through in-depth engagements, farmers mentioned different appropriate innovations that could mitigate the different PHH challenges that were mentioned. Farmers mentioned the commonly used appropriate technologies and thereafter a list of preferred innovations was generated through the value chain of drying, shelling and storage (see Table 1).

Table 1. List of Postharvest Handling challenges and Preferred Intervention

Value Chain Stage	Farmers' PHH technologies	PHH challenges faced by farmers	Farmers' preferred intervention
Drying	Bare ground, Smeared ground, Mats, drying racks, tarpaulins	Threat of termites in the case of racks with wooden stands, birds, animals, Theft limits use of cribs, dusts, mud.	Tarpaulins, Drying stands, Concrete floors, maize cribs
Shelling	Hands, sticks, knives, sacks, shellers	Laborious shelling, High costs of procurement beyond farmer means	Shelling Technology
Storage	Sacks, cribs, bare floor, jerry canes	Weevil attacks, Theft limits use of cribs, High procurement costs	Hermetic bags, Silos, Collective Bulking stores

Training and disseminating of PHH technologies to farmers under participatory extension category. Out of twenty-one (21) farmer groups in the three districts, twelve (12) and nine (9) farmer groups from the three districts were randomly clustered under the PA and FTF extension approaches, respectively. Training session ended up successful with a total number of 360 farmers trained on recommended PHH practices under the participatory extension category. Of the 360, 70% were female compared to 30% male. Such variations imply that, within the FGs, women actively participated more men. However, during the FGDs, it was observed that men exhibited a lot of interest in controlling the returns on the sales more than the actual process of farming itself.

For the FTF category, 18 farmer trainers in the three districts were selected and trained. The ratio of female to male selected farmer trainers was 1:1 across all the districts. Majority of the farmer trainers (89%) were above 30 years of age and all (100%) had completed primary level education. Each farmer group had a total of 2 farmer trainers who were equipped with knowledge and skills on PHH recommended practices and operating of the disseminated technologies. With regular monitoring by extension field officers, it was noted that the farmer trainers carried on with their work diligently across the three districts. Farmer trainers organized training for the rest of their group members and also carried out demonstrations on the use of the disseminated technologies. It was reported that majority (90%) of the farmer trainers demonstrated management skills and expertise on use of PHH technologies.

Evaluation of Adoption of PHH technologies under the two Extension approaches. The second objective was to evaluate the level of adoption by the extension approach used along the maize PHH value chain. This was measured through;

- **Level of Uptake of PHH technologies in each of the approaches**

The level of uptake of PHH technologies, which was measured by farmers' behaviour change. Findings show that the most embraced PHH technologies were tarpaulins for drying, bench shellers for maize shelling and hermetic bags for storage. Uptake was generally high in all three districts (see Table 2).

Table 2. Level of uptake of PHH maize technologies

Value chain	Adopted technologies	Extension approach FTF		PA		Total		Rho
		Freq.	%	Freq.	%	Freq.	%	
Drying	Tarpaulins	76	90.8	83	83.0	152	86.4	rho =0.119
	Drying racks	2	2.6	0	0.0	2	1.1	Df=17
	Both	5	6.6	17	17.0	22	12.5	P=.116*
	Total	76	100	100	100	176	100	
Shelling	Motorised Sheller (MS)	0	.0	7	7.0	7	4.0	rho =0.182
	Bench Sheller (BS)	44	57.9	62	62.0	106	60.2	Df=13
	Hand Sheller (HS)	3	3.9	2	2.0	5	2.8	P=.105*
	MS and BS	3	3.9	12	12.0	15	8.5	
	BS and HS	13	17.1	10	10.0	23	13.1	
	None	13	17.1	7	7.0	20	11.4	
	Total	76	100.	100	100.	176	100.	
Storage	Silos	2	2.7	16	16.3	18	10.5	rho =0.278
	Hermetic bags	43	57.3	64	65.3	107	62.6	Df=16
	None	31	40.	18	18.4	49	26.9	P=.110*
	Total	76	100.	100	100.	176	100.	

*.Correlation is significant at the 0.05 level (2-tailed)

For the drying disseminated technologies, both farmers under FTF (90.8% and 2.6%) and PA (86.4% and 0.0%) adopted more tarpaulins compared to drying racks respectively. There were cases of those who also adopted both technologies (5% and 17% under FTF and PA, respectively). For shelling, 57.9% of farmers under FTF and 62% for those under PA preferred the bench shellers to motorized and hand shellers. Cases of non-adoption of shelling technologies totalled to 17.1% among farmers under FTF extension approach compared to 7.0% under PA approach. Meanwhile, majority of the farmers under FTF (57.3%) and under PA (65.3%) extension approaches preferred hermetic bags to silos. However, cases of non-adopters of the promoted storage technologies were higher among farmers under FTF (40%) compared to farmers under PA (18.4%) extension approach. Spearman correlation was used to establish whether there is a relationship between extension approaches and uptake of disseminated maize technologies. These statistics indicate that there is no relationship between extension approach and adoption of PHH technologies whatsoever. Apparently, from this study, it was observed that most farmers embraced technologies in the initial stages irrespective of the dissemination pathway because of different associated reasons. This indicated that farmers embraced the technologies for the fact that they had the will i.e. the software not to dry on bare ground but lacked access to affordable hardware. During the FGDs, it was revealed that smallholder farmers exhibited early adoption of the promoted technologies. A female farmer from Kamuli district under participatory extension category also said that;

For us here, we started using these innovations straight away. All members in the household use these technologies. Today as we speak, men have joined children and their mothers to collectively do the work. For example, in times of shelling maize, the old and children, men and women join hands together compared to the past, where *most of this work was done by children and their mothers. The shelling work has been made easy by introducing these innovations and shelling is no longer a problem. In fact, we have experienced what we had never experienced before. We can now shell our maize easily and even store the grains for long time without getting any single weevil. If I remember well, I stored my maize for a period of four month, up to now the grains are still very good without any weevils* (Female farmer, Participatory Farmer group, Kamuli district).

The above assertion means that the average storage time had increased from 2 months to 4 hence impacting significantly to socio-economic and food security implications.

The adoption rate under this study was attributed to different reported elements. The participatory identification of these PHH innovations, for example, simplicity of the disseminated technologies and farmers' urge to try out new innovations attracted most farmers in both extension categories to adopt the innovations. These findings agree with Rogers' theory of diffusion of innovations. Rogers (2003) noted that characteristics of the innovations that offer more relative advantage, and are simple to use trigger high adoption among the users. The initial participatory involvement of farmers before dissemination and the characteristics of technologies like being simple to use contributed to triggering such results.

In addition, farmers showed high level of competences and knowledge in the utilization of these technologies. Their attitudes and mentalities changed from the traditional practice to better postharvest handling practices. All these affirmations from the different farmers across the districts of Kamuli, Apac, and Nakasongola, confirmed that the participatory identification of the PHH technologies was effective in influencing the farmers' decisions to embrace the innovations. However, it is important to note that although most farmers under each of the two extension approaches adopted the disseminated PHH technologies, there were more reported cases of non-adoption in FTF extension category compared to participatory category which had less or even none. The study established that some farmers never adopted some technologies like the shelling and storage technologies. When the issue was further investigated, one elderly woman from Kamuli district under FTF noted that:

I have never used any innovation for shelling. I still use the old practice of knives and sticks. Our chairperson (who happens to be a farmer trainer) has personalized these technologies. She only gives them to her friends. Actually, we only come together as a group when visitors are coming to meet us. Otherwise things have never been the same. (Female farmer, FTF, Kamuli district)

Such views cannot be neglected. These weaknesses within the extension approaches affect the adoption process and range from administrative challenges and gender to group conflicts. A lot of concerns relating to administrative issues in FTF arose after the dissemination of the PHH technologies. Mistrust among group members was noted across the three districts. Some farmers in the group intimidated farmer trainers and made their work difficult. The most interesting part was that some female farmer trainers were not having any leadership roles in the group initially. These incidences were highly reported in the districts of Nakasongola and Apac. In Nakasongola district, for example, the female selected farmer trainer was intimidated by her group members who reportedly claimed that she was incompetent. Farmers reported that this particular farmer trainer stayed far away from the other FG members and this made her work difficult. Another incidence was reported in Apac district where farmers claimed that their farmer trainer gained most from the availed PHH materials. Most farmers were shunning away from the trainings when called upon because of mistrust towards their farmer trainers.

Furthermore, the issue of power dynamics arose under FTF extension approaches. The farmers, who were relatively wealthier, more vocal and some farmer trainers tended to overpower the weaker and less resourced farmers. These influential farmers in the group reportedly personalized the shared technologies and selfishly used them for their own personal gains leaving other farmers as non-adopters because of access challenges. Personalizing the shared technologies like the sheller, especially the bench sheller raised a lot of tension among the farmers within their groups. Farmers felt that these technologies would have been distributed to individuals as the items used for drying although this is neither cost-effective nor sustainable. Further, assertions of influential farmers personalizing items meant for shared use clearly indicates that technology adoption may be influenced by administrative issues not directly related to the technology. Such challenges, in addition to affecting the level of adoption of the PHH technologies among farmers under FTF, could also cause tension within the groups which would easily contribute to group disintegration.

Sustainable utilization of Adopted Maize PHH technologies. Sustainability is an aspect of technology adoption that is paramount for research and extension. Sustainable use of technologies was measured in the post intervention period. Results show that at drying value chain, the farmers under the participatory approach had 100 % (n=120) utilization compared to 97.3 % (n=90) in the FTF approach. With respect to shelling, 92.5% (n=120) of farmers under participatory approach utilized the technologies compared to 63.5 % (n=90) in the FTF approach. In relation to the storage, the participatory approach had 76.3 % (n=120) utilization compared to 60% (n=90) in the FTF approach. There was a positive correlation between extension approach and sustainable utilization of PHH technologies (Rho (14) = 0.161, p>0.05), (Rho (12) = 0.01, p>0.05), (Rho (14) = 0.301, p>0.05), for drying, shelling and storage technologies). This meant that the nature of an extension approach influenced the rate of sustainable utilization of an adopted technology. Field reports indicated that periodic monitoring of farmers under PA by the researchers created a bond between the farmers and researchers. This what a male farmer from Apur Pekun FG under PA in Apac district had to say;

I must say am grateful for the opportunity you gave us. I thank the researchers who continued checking on us time to time. We see them as family now. This encouraged us more because we became more open to them. For example if I need some advice on how to access other technologies, they would quickly avail information. Not only on technologies but also other things like better quality seeds. (Male farmer, PA, Apac district)

This kind of bond and trust the farmers had towards the researcher could have triggered sustainable adoption of the disseminated technologies as Lawal and Oluyole (2008) noted that when adopters had a link with technical staff, and had regular visits, sustainability would be enhanced. The study concluded that the more the number of visits by scientists to the farmers, the more the research results will be adopted and consequently higher productivity leading to improved welfare.

Farmers' ability to purchase additional technologies or replace the worn out ones was also seen as part of sustainable use of adopted PHH technologies. After 12 months post intervention, this study showed that purchase of the additional technologies was relatively low in both approaches. An average of 35.5% (n=90) and 48.5% (n=120) of the target farmers purchased drying technologies in the FTF and participatory extension approaches, respectively.

Most of these farmers purchased tarpaulins, with the majority buying 1-5 tarpaulins each. On the other hand, none of the farmers purchased additional shelling technologies in both approaches. Meanwhile, 4.1% (n=90) and 9.5 %(n=120) of the farmers in the FTF and PA extension groups, respectively, purchased additional storage facilities (see Figure 2). The hermetic bags were the most purchased storage technologies, with majority of the farmers under FTF and participatory purchasing 1-5 bags. The spearman rho correlation coefficients and chi-square test of independence indicated that there was no significant relationship between extension approach category and purchase of additional PHH technologies to sustain the adoption.

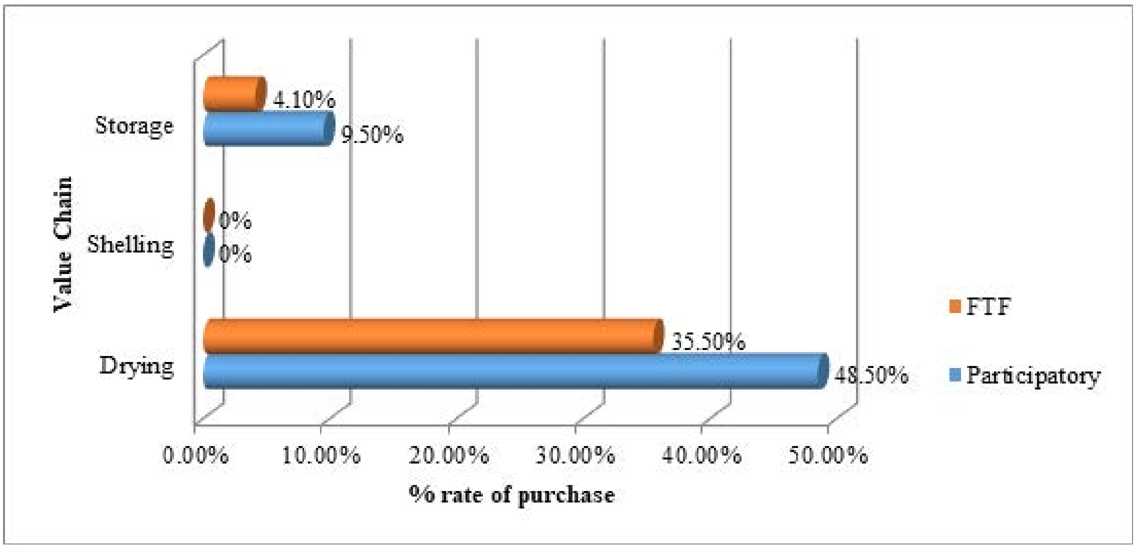

Figure 2. Purchase of additional PHH innovations

CONCLUSION

Maize farmers in Uganda experience PHH challenges and most of them are willing to overcome them. However, the nature of an extension approach plays an important role in sustainable adoption of PHH technologies. This study set out to test the hypothesis that FTF has a higher potential in scaling up and sustaining adoption of PHH technologies than PA. However, findings of this research have shown the contrary. Collective engagement of farmers, right from the initial stages of the project contribute towards building positive perceptions right from the inception, influencing adoption and sustained use of PHH technologies among farmers. Whereas collective engagement of farmers at initial stages triggered high adoption rate, participatory extension approach registered higher level in sustainable utilization of adopted technologies compared to FTF. Sustainable utilization of adopted technologies under PA category was attributed to periodic monitoring of farmers by the researchers which created a bond between the two parties. Therefore, the number of visits by scientists to the farmers, created avenues of sustainable adoption and consequently reduced PHH losses leading to improved welfare. When it comes to sustainable technology adoption, PA stands higher chances than FTF extension approaches. Therefore, a new approach to agriculture extension which involves collective participation and regular monitoring of farmers should be embraced in order to attain better results.

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STATEMENT OF NO CONFLICT OF INTEREST

The authors declare that there is no conflict of interest in this paper.

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