COMPARATIVE EFFICACIES OF FARMER-LED AND EXTENSION-LED FARMER FIELD SCHOOLS IN THE DISSEMINATION OF PUSH-PULL TECHNOLOGY AMONG SMALLHOLDER FARMERS OF WESTERN KENYA

Seraphine Moraa Atambo

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A Thesis Submitted to the Graduate School in Partial Fulfilment of the Requirements for the Award of the Degree of Master of Science in Agricultural Extension of Egerton University

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DECLARATION

I hereby declare that this research thesis is my original work and that it has not been submitted for an award of a degree or diploma in this or any other University.

Signature ..... Date ...13/10/2010...

Seraphine M. Atambo

EM12/1694/06

RECOMMENDATION

This research proposal has been submitted with our approval as University supervisors

1. Signed ..... Date 13-10-2010.....

Dr David M. Amudavi

Department of Agriculture Education and Extension

Egerton University

2. Signed ..... Date ...13/10/2010.....

Dr Catherine N. Munyua

Applied Community Development Studies

Egerton University

Atambo S.M. 2010

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This thesis is dedicated to my sons Michael Ontita and Patrick Nyachio, who loved me, encouraged me, and prayed for me and to my Father Zachary Atambo who encouraged me to study hard when I was young and helped me to progress academically.

The success of this work is attributed to many persons and institutions. I acknowledge Egerton University for giving me the opportunity to pursue the postgraduate programme and my employer, The Ministry of Agriculture, for giving me a study leave. I acknowledge my lecturers who provided coursework which formed the basis of this study; my supervisors, Dr. David M. Amudavi and Dr. Catherine N. Munyua who guided me and gave their input from proposal preparation to thesis writing. The panel members of my departmental and faculty proposal defences gave valuable input that also helped to refine this document. I acknowledge ICIPE and Dr. Zeyaur Khan & Mbita team (Peter Nyongesa for organizing my accommodation at Mbita, Jimmy Pittchar and Isaac Mbeche and all support and field staff) for their support and for making valuable input to my proposal when I made a presentation to them at Mbita Thomas Odhiambo Campus. I am very grateful to the Association of African Universities (AAU) for awarding me a research grant that helped me to conduct my data collection and also thankful to ICIPE Board of Training and Postgraduate Studies (IBTPS) for handling my grant proposal.

I acknowledge Mr John Makori of the Ministry of Livestock Headquarters in Nairobi for being very instrumental in encouraging me to pursue my graduate study, and giving his valuable input. I am thankful to Mr George Mbiru, my classmate, and other classmates who assisted me on statistical methods. Due to busy work schedules that could not allow me to enter the research data in the code book, the Principal of Bukura Agricultural Training Centre, Mr Morris Wambua, despite heavy work managed to do this on my behalf and I am thankful for that. A lot of thanks go to my classmate, Mr Stephen Maina, who encouraged me to move. Thanks to my sister Norah Bonareri, for assisting me to get some processes regarding my thesis moving at Egerton University, when my study leave had expired. Thanks to colleagues and faculty experts for their critique of the instruments of the study that enabled me make further improvement. Thanks to many other people whose varying contributions in one way or another led to successful completion of this research and Thesis compilation.

I also acknowledge my family including my sons, Michael Ontita and Patrick Nyachio and my father Zachary Atambo, for their moral support, and all those who are not mentioned but who managed to give me much needed assistance and support. Finally I thank God Almighty for helping me through the study, who is forever to be praised.

ABSTRACT

Striga weed combined with stemborer can reduce maize yields up to 100% thus affecting food security. The International Centre for Insect Physiology and Ecology (ICIPE) and other partners have developed an effective management strategy known as 'Push-Pull' Technology (PPT) for the control of stemborer pests and Striga spp. weed. Literature on Farmer Field School (FFS) approach and PPT shows that the FFS approach has had varying successes in disseminating and enhancing many agricultural technologies. To draw on the strengths of the approach, ICIPE and the Ministry of Agriculture (MoA) introduced the use of FFS in the dissemination of PPT. Some FFS were led and managed by farmers (F-FFS) and others by extension staff (E-FFS). The comparative efficacy of F-FFS and E-FFS approaches had however not been investigated. Therefore, the purpose of this study was to identify the most efficacious FFS approach in disseminating the PPT. The study independent variable was type of FFS approach, while dependent variables were the learning outcomes which included farmer's knowledge on PPT, adoption, yields and costs. A cross-sectional survey design was used, in which a population of 211 PPT FFS farmers from Busia and Bungoma South districts were involved. Data was collected using three researcher administered structured questionnaires which had questions on individual farmer characteristics, knowledge and adoption test, and FFS group characteristics. The instrument was validated by a team of experts. Reliability was determined by pilot testing with 40 farmers and the reliability coefficient was estimated using Cronbach's alpha. A reliability coefficient above 0.75 was achieved. Data analyses for both descriptive and inferential statistics were done using the Statistical Package for Social Sciences (SPSS) software. Hypotheses were tested using t-test and Man Whitney U test at 5% level of significance. The FFS approaches were ranked according to their score on the learning outcomes. Both F-FFS and E-FFS approaches proved efficacious in PPT dissemination. However, participation in F-FFS was more efficacious than participation in E-FFS in terms of increased knowledge and farm productivity whereas E-FFS was more efficacious in the adoption and diffusion of PPT. These study results will be availed to relevant stakeholders for improving farmer learning outcomes of PPT and living standards of smallholder farmers.

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LIST OF ACRONYMS AND ABBREVIATIONS

ATC	Agricultural Training Centre
DADO	District Agribusiness Development Officer
D.A.O	District Agricultural Officer
E-FFS	Extension-led Farmer Field Schools
FAO	Food and Agricultural Organization of the United Nations
F-FFS	Farmer-led Farmer Field Schools
FFS	Farmer Field School
ICIPE	International Centre of Insect Physiology and Ecology
ILRI	International Livestock Research Institute
IPM	Integrated Pest Management
ISWM	Integrated Soil and Water Management
KARI	Kenya Agricultural Research Institute
LM	Lower Midland
M.O.A	Ministry of Agriculture
MoLFD	Ministry of Livestock and Fisheries Development
PPT	Push-Pull Technology
SPSS	Statistical Package for Social Sciences
UCB	University of California Berkeley
U.K	United Kingdom
UM	Upper Midland

1.1 Background to the Study

Maize is the major food and cash crop for millions of people in the predominantly mixed crop–livestock farming systems in Kenya (Khan, Pickett, Wadhams, Hassanali & Midega, 2006). On average, Striga weeds infestation can cause up to 70% loss in maize yields to affected farmers, while stemborer infestation causes yield losses reported to vary from 20–40%. Striga is among 28 species of parasitic plants that occur naturally in parts of Africa, Asia, and Australia. In East Africa, there are two common species of the Striga weed, *Striga hermonthica* and *Striga asiatica* and two species of stem borer, *Busseola fusca* and *Chilo partellus*, which cause heavy damage to maize (Khan *et al.*, 2006). Nearly two-thirds of the smallholder farmers throughout sub-Saharan Africa get poor crop yields and low incomes due to Striga infestation (Bromham, Harris, Odera, & Werehire, 2006). In Kenya, Striga infestation is most severe in Nyanza and Western provinces where Striga weed is found in about 75,000 hectares of farmland, resulting in crop losses estimated at about US$ 10–38 million per annum (Woomer *et al.*, 2004). Control of stemborers and Striga weeds by insecticides and herbicides respectively is very expensive for smallholder farmers and environmentally unfriendly (Khan *et al.*, 2005). This makes it necessary to disseminate technologies that can control Striga and stemborer effectively and efficiently, in order to improve the living standards of smallholder farmers.

According to Tsanuo *et al.* (2003) and Cook, Khan and Pickett (2007), the International Centre of Insect Physiology and Ecology (ICIPE) and her collaborators have developed an effective, affordable and environmentally friendly management strategy known as 'Push-Pull' Technology (PPT), for the control of stemborers and suppression of Striga weeds in maize. PPT, sometimes referred to as PPT strategy/ strategies involves the behavioural manipulation of insect pests and their natural enemies via the integration of stimuli that act to make the protected resource unattractive or unsuitable to the pests

(push) while luring them toward an attractor (pull), like Napier grass. Desmodium produces a smell that repels stemborer moths which "pushes" away the stemborer moths from the maize crop. On the other hand, Napier grass is more attractive to stemborer moths and it pulls the moths to lay their eggs on it, but does not allow stemborer larvae to develop on it hence the name "Push-Pull". It has been shown that nitrogen fixed by Desmodium and chemicals produced by the roots are responsible for inhibiting growth of the Striga weed. Desmodium roots produce allelochemicals some of which stimulate Striga seed to germinate while others (isoflavones) inhibit attachment of Striga to maize roots and cause suicidal germination of Striga seed in the soil. Therefore, Striga does not grow where Desmodium is growing

According to Khan (2007), Khan *et al.* (2006) and Cook *et al.* (2007), PPT is a platform or multi-functional technology that contributes the following benefits to the smallholder farmers: Increase in maize yields by 25–30% in the areas where only stemborers are a problem but more than 100% where both stemborer and Striga are problems; increasing supply of livestock feed from Napier grass and *Desmodium* and consequently increasing milk yields; less labour required in weeding the maize crop since *Desmodium* suppresses other weeds; improves soil fertility through nitrogen fixation by *Desmodium* legume, thereby saving on fertilizer costs. The soil cover or mulch provided by *Desmodium* and Napier grass helps conserve soil moisture and reduces stemborer and Striga weeds. *Desmodium* further generates incomes from sale of seed, while Napier grass protects maize from strong winds. The main purpose of the PPT is to minimize crop losses and thus improve farmer maize yields to ensure farmer food security and improve income generation.

Extension is an on-going process of getting useful information to people (the communication dimension) and assisting those people to acquire the necessary knowledge, skills and attitudes to utilize effectively this information or technology (the educational dimension). Generally, the goal of extension is to enable people to use skills, knowledge, and information to improve their quality of life (Swanson, 1984). Extension is also a service or system which assists farm people, through educational procedures, to

improve farming techniques, increase production efficiency and income, hence bettering their standards of living (Maunder, 1973). Several extension approaches have been developed over time in an attempt to enhance effective diffusion of agricultural technologies to smallholder farmers in order to increase agricultural productivity. These approaches include technology transfer, diffusion of innovations, farming systems research, commodity development and production system, integrated agricultural development programmes, integrated rural development programmes, training and visit approaches (Swanson, 1984), and participatory approaches like FFS (Heck, 2003).

Farmer Field School (FFS) approach has been implemented in Kenya on a fairly wide scale but mainly on crops and soil management where it has been successful (Minjauw, Romney & Muriuki, 2003). The FFS training approach was first developed by the FAO and Indonesian National Integrated Pest Management (IPM) Programme in 1989 in which farmers were involved in conducting experiments on study plots which they established and managed as a group (Kimani & Mafa, 2003). F-FFS and E-FFS approaches were used by ICIPE to disseminate the PPT, to farmers, whose comparative efficacies have been determined. These study results will provide agriculture extension agents with insights on the most appropriate approach for PPT dissemination, leading to enhanced learning outcomes, which will translate to higher maize yields, improved food security and higher incomes for smallholder farmers.

1.2 Statement of the Problem

In Kenya, dissemination of PPT using FFS approach was started in 2006 which can only allow a study based on the short-term learning outcomes. Farmer learning outcomes refer to what an FFS farmer knows or does at the end of a learning unit, and consists of four main areas, namely: knowledge, comprehension, application/skills and analysis (Abilene University, 2007). Farmer learning outcomes encompass a wide range of attributes and abilities, which are a measure of how their learning experiences supported their development as individuals. These include demonstrable acquisition of specific knowledge and skills, what farmers know that they didn't know before, and what they can

do (Fry, 2007). Despite using F-FFS and E-FFS approaches, their comparative efficacies in enhancing farmer learning outcomes of PPT had not been established by any prior study. Hence, this study compared the two FFS approaches with the aim of identifying the most efficacious approach for disseminating PPT to farmers in Bungoma South and Busia District of Western Province, Kenya.

1.3 Main Purpose of the Study

The main purpose of this study was to investigate the most effective and efficient approach for dissemination of PPT amongst smallholder farmers in Western Kenya, by comparing the efficacies of F-FFS and E-FFS extension approaches in order to inform on which approach to invest in reaching many farmers with the technology.

1.4 Specific Objectives of the Study

The specific objectives of the study were to:

i. Assess efficacies of F-FFS and E-FFS on farmer knowledge on PPT gained by farmers using these approaches.
ii. Identify efficacies of F-FFS and E-FFS on farmer adoption of PPT by farmers using these approaches.
iii. Determine comparative efficacies of F-FFS and E-FFS in the maize yields achieved by farmers practicing PPT by using these approaches.
iv. Examine comparative efficacies of F-FFS and E-FFS in the learning costs incurred by farmers using these approaches to acquire PPT skills.

1.5 Hypotheses of the Study

The study addressed the following hypotheses:

H_O1 There is no statistically significant difference in the efficacies of F-FFS and E-FFS in the PPT knowledge gained by farmers using these approaches.

H_O2 There is no statistically significant difference in the efficacies F-FFS and E-FFS in PPT skills adoption by farmers using these approaches.

H_O3 There is no statistically significant difference in the efficacy of F-FFS and E-FFS in maize yields achieved through PPT by farmers using these approaches.

H_O4 There is no statistically significant difference in the efficacies of F-FFS and E-FFS in PPT learning costs incurred by farmers using these approaches.

1.6 Significance of the Study

There was need to identify and select agricultural extension approaches that are appropriate for disseminating relevant technologies and practices specific to farmer conditions. PPT, which addresses Striga and stemborer, requires effective and efficient dissemination approaches in order to reduce maize yield losses by the smallholder farmers of western Kenya, and improve their living standards. The information generated in this study, on the comparative efficacies of F-FFS and E-FFS approaches on farmer's learning outcomes will be of importance to researchers, learning institutions, agriculture extension agents, farmers and agricultural policy makers. The study has also contributed to the body of knowledge on efficacies of F-FFS and E-FFS approaches.

1.7 Scope of the Study

The study focused on F-FFS and E-FFS approaches and their learning outcomes. Under FFS, F-FFS and E-FFS approaches were compared in terms of their efficacies. The FFS learning outcomes measured were: the knowledge gained by the FFS farmers, adoption skills, learning costs and maize yields. The study was limited to the activities of F-FFS and E-FFS approaches for the years 2006 to 2008.

1.8 Assumptions of the Study

The time lapse for which FFS had been in place was enough to identify short-term learning outcomes of the PPT.

1.9 Limitations of the Study

The information depended on farmer recollection of past events; since survey designs measure perceptions which vary with time, and this affected the study. The researcher mitigated this limitation by studying the whole population and by ensuring instrument and research design validity and reliability through pilot-testing, expert judgment and

correct data analysis. Similarly, the moderator variables were studied alongside the study variables.

1.10 Definition of Terms

Definitions of terms according to this study include the following.

PPT Farmer is the farmer who plants maize or sorghum using PPT.

Efficacy refers to producing the desired result or effectiveness (Hornby, 1995). Efficacy in this study referred to the same factors as defined here.

Agricultural Extension is an educational process, which has as its goal the communication of useful information to people and helping them to learn how to use it to build a better life for themselves, their families and their communities (Swanson, 1984). Agricultural Extension in this study referred to the same definition by Swanson (1984), and took place within the FFS setting.

Extension Approach is a style of managing extension aimed at passing agricultural information to farmers to enable them to improve their production. In this study the approaches investigated were the F-FFS and E-FFS extension approaches.

Extension–Led FFS (E-FFS) were those schools initiated, facilitated and co-ordinated by the Ministry of Agriculture staff for training farmers on various agricultural technologies (Kimani & Mafa, 2003). In this study E-FFS had the same meaning as explained by Kimani and Mafa (2003) but also includes ICIPE field extension staff.

Farmer Field School (FFS) approach is an informal hands-on school for adults who met in groups in a farm with an experimental plot, on a regular basis for practical learning, based on a season-long curriculum (ICIPE, 2007).

Farmer–Led FFS (F-FFS) are those schools initiated and facilitated by farmers themselves and the planning and organization is in the hands of the FFS group (ILRI, 2003). In this study, F-FFS had the same meaning as defined by ILRI (2003).

Push-Pull Technology is a technology that involves intercropping maize with a fodder legume, silverleaf Desmodium (*Desmodium uncinatum*) and planting Napier grass (*Pennisetum Purpureum*) as a trap crop around the crop field (Khan *et al.*, 2006), in order to control Striga and stemborer in maize.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter reviews literature review related to the importance of agriculture extension services in agricultural development. FFS and other participatory approaches are discussed. PPT dissemination approaches are discussed with special emphasis on the importance of extension, farmer learning outcomes, costs, studies done on FFS, F-FFS and E-FFS approaches. The theories of adult learning relating to FFS approach are presented. The chapter concludes by presenting the theoretical and conceptual framework that guided the proposed study.

2.2 Importance of Agriculture Extension Services

Several agriculture extension approaches have been developed over time in an attempt to enhance effective and efficient dissemination of agricultural technologies in order to increase agricultural productivity. These include technology transfers; diffusion of innovations, farming systems research, commodity development and production system, integrated agricultural development programmes, integrated rural development and training and visit approaches (Swanson, 1984), and participatory approaches (Heck, 2003). Initially, agriculture extension used conventional approaches which were top-down but currently emphasis is on participatory approaches. FFS is one of the participatory approaches being used by ICIPE and her collaborators in the dissemination of PPT, to control both Striga and stemborer consequently leading to increased maize yields.

The goal of agriculture extension is to enable people to use skills, knowledge, and information to improve their quality of life (Swanson, 1984). Agriculture extension is a service or system which assists farm people through educational procedures in improving farming approaches and techniques, increasing production efficiency and income, bettering their levels of living, and lifting the social and educational standards of rural life

(Maunder, 1973). This also applies to the FFS approaches whose main objective is to improve farmer food security, income generation and living standards of the resource poor farmers. ICIPE started using farmer field schools in Bungoma District of Western Province in 2007 in an effort to improve the dissemination of PPT in order to improve farm productivity and food security (Khan *et al.*, 2008).

The agriculture sector in developing nations continues to face significant challenges, and national agriculture extension systems are at important crossroads from where they need to move from conventional approaches to farmer involvement. Continuation of the top-down extension strategy will lead to increased hunger and declining farm incomes among small-scale farmers. To overcome these problems, it will require extension services to be market driven, to use groups, and move to decentralized systems among others (Swanson, 2006). According to Heck (2003), international agencies underscored the main reason for unsuccessful development projects as the lack of active, effective and lasting participation of the intended beneficiaries. To facilitate farmer participation in extension planning and implementation, extension has to encourage farmers to form new groups or strengthen existing ones for farmer participation in decision making in order to get a base for sustained self development efforts. To address the weaknesses of conventional approaches, several participatory approaches have evolved. The current participatory extension approach in Kenya is group approach, which facilitates the formation of common interest groups (CIGs) and FFS, applied by both Government and non-Governmental extension agencies.

2.3 The Concept and History of FFS

FFS approach was first developed by FAO, assisted by the Indonesian National Integrated Pest Management (IPM) programme in 1989. In Kenya, FAO introduced FFS in 1995, in IPM of crop pests and in Integrated Soil and Water Management (ISWM) practices (Minjaw *et al.*, 2003). Since 1995, the FFS approach has been tested and adapted for a wide range of crop and livestock enterprises. Compared to Asia, FFS has been applied more as a production tool rather than for IPM (ILRI, 2003).

Kimani and Mafa (2003) define an FFS as a group of about 25 farmers, who meet weekly, through an entire growing season to learn through practical experience about integrated production and pest control. PPT FFS are informal hands-on schools for adults, who come together on a regular basis to learn the why and how of PPT. The FFS use participatory approaches to help farmers develop their analytical skills, critical thinking, creativity, and to help farmers learn to make better decisions. Groups meet to do practical learning that is based on a season-long curriculum. The learning combines local knowledge with scientific ecological approaches. Farmers carry out experiments on study plots which they establish and manage as a group (ICIPE, 2007). This study compared F-FFS and E-FFS, which were the two FFS facilitation approaches used in PPT dissemination.

2.4 Farmer-Led and Extension-Led Farmer Field Schools

According to Kimani and Mafa (2003), FFS groups are facilitated by both government extension staff and farmers. Following training, each agriculture extension agent runs between two and four FFS in his/her duty area for one season. These are referred to as E-FFS. Farmers who graduate from the first FFS volunteer to facilitate new FFS in the neighbourhood with close guidance of the extension staff facilitator. Such FFS are referred to as F-FFS. According to ILRI (2003), F-FFS have become an integral part of FFS implementation in Kenya. Farmers who graduated from E-FFS received brief training and have been supported to run their own FFS.

In Western Kenya, the FFS were both Farmer-led and Extension-led. Farmers met once a week for school and had a second day for maintaining the PPT plot in shifts. The school was usually conducted in one farmer's field where they planted a PPT plot and a control plot. They keenly observed the progress of the PPT plot from land preparation to harvesting. They measured, documented and kept records, compared the PPT and control plots, and calculated the profitability. The schools had elected group leaders and facilitators who were either farmers or extension agents. According to ICIPE (2007) demonstrations were conducted by facilitators on planting and other activities, in which

participation by group members was encouraged. Method and result field-days were conducted regularly and farmers went for tours and visits on cost sharing terms.

2.5 Farmer Learning Outcomes

Learning outcomes are statements of the knowledge, skills, and abilities the individual student possesses and can demonstrate upon completion of a learning experience or sequence of learning experiences (Abilene University, 2007). Learning outcomes refer to what a student describes or does at the end of a learning unit. Learning outcomes are written for four areas of learning: knowledge, comprehension, application and analysis (Koetzner, 2007).

ICIPE (2007) has detailed the PPT curriculum for FFS, where season-long sessions cover all aspects of the crop cycle. Farmers learn about land preparation, required planting materials, planting Napier grass, planting maize, intercropping with Desmodium, first and second weeding, maize crop management, management of Napier grass, harvesting maize, management of Desmodium, harvesting and processing of Desmodium and what to do in the second and subsequent seasons. This study measured farmer's knowledge and comprehension on how to plant a PPT plot and its adoption on the farmers' farms.

2.6 FFS Learning Costs

A study conducted by ILRI (2003) on extension staff capacity to reach farmers, found that the number of extension staff in the field is limited, and costs were high for transport due to long distances. They further indicate that FFS was an effective and comparatively cheap tool for speeding up the uptake of improved technologies, at community level. However, no comparison was made between F-FFS and E-FFS to find out if there were differences in the costs of the two FFS approaches. Davis (2006) claims that because of the limited number of studies, there is still much unknown about the approach and issues pertinent to extension, such as financing. Major issues mitigating FFS are discussed as financial sustainability, scaling up, empowerment, participation, and donor driven approaches.

2.7 Studies on Farmer Field Schools

In Kenya, the current Government policy encourages participatory approaches in agriculture extension (MOA & MoLFD, 2004), which means FFS may have a likelihood of success. Bartlett (2005) found that in the Philippines, FFS approach was considered to be successful, but lacked the feasibility and management systems that would permit scaling up. In Vietnam, due to policy environment, FFS were in great demand and the training process created a new role for government staff. In India, they were not favoured by the state, while the IPM programme grew faster in Nepal due to strong leadership and creative management.

Mureithi *et al.* (2006) measured the impact of FFS and found that the approach enhanced the acquisition of knowledge on sustainable agriculture by graduate farmers, changed their attitudes, and improved the farming practices and efficiency of production. One problem encountered in implementing the practice was that the quality of facilitation by farmer and E-FFS trainers deteriorated with time. This was because the facilitators were not well versed with facilitation skills and subject matter of the technologies. Sinja *et al.* (2004) found that diffusion of technologies is significantly enhanced by informal approaches of dissemination, especially from farmer to farmer approaches, which maybe true for PPT. The use of FFS approaches in the dissemination of PPT is aimed at replicating such successes. Despite considering the quality of facilitation in F-FFS and E-FFS, the study did not compare the approaches against the learning outcomes in terms of efficacy.

A case study by Kimani and Mafa (2003) found that FFS had a number of benefits, namely: increased knowledge among farmers on decision-making, different varieties and different production systems brought better understanding of biological control measures, increased use of non-chemical control measures, and increased yields on study plots and in farmers' fields. FFS approaches may be useful in promoting PPT, and farmers who have gone through FFS can pass on their knowledge to others, opening up excellent avenues for information exchange between farmers and other stakeholders, and contributing to community development. However, case studies have the limitation of

low external validity or generalizability, whereby such results may not be replicable outside the study area.

Davis (2006) found that much of what has been written on FFS is found only in grey literature, and is based on studies confined mostly to the World Bank Asian studies. She notes that because of the limited number of studies, there is still much that is unknown about the approach and issues pertinent to extension, such as effectiveness, and sustainability. She further states that, FFS offers one possible approach among many that are viable in sub-Saharan Africa and FFS are indeed a boon to extension. It has shown promise in terms of participatory approaches, gender sensitivity, environmental considerations, and empowerment and productivity gains. The gaps of knowledge noted here need to be filled to add to the pool of knowledge on effectiveness and efficiency of FFS approaches.

Tripp, Wijeratne & Piyadasa (2005) conducted a study in Sri Lanka on what should be expected from FFS, particularly with respect to the type of farmer participant, knowledge transmission and subsequent innovation. Evidence from this study indicates that FFS can contribute significantly to reduction in insecticide use by participants. Several studies on FFS involving rice farmers in Asia also show positive results, but the studies are not sufficiently consistent as they offer unequivocal conclusions. In addition, there is little effective transmission of learning experience to other farmers, and there is inadequate evidence that FFS groups survive on their own or spontaneously develop further activities. Even the strongest supporters of FFS now recognise that the requirements of well-trained facilitators, season-long courses, and first-hand participation make the economics of scaling up problematic among others. They concluded that, while FFS approach has undoubtedly succeeded in lowering insecticide use in a number of FFS involving rice production in Asia, whose judgements on its overall impact however, await further study. The comparative efficacies of E-FFS and F-FFS approaches was not studied, which made it necessary to compare these two approaches.

Bunyatta (2004) conducted a study on the effectiveness of FFS approach in the dissemination and adoption of soil management technologies in Kenya. He found that the FFS farmers, who attended the season-long training under the FFS approach, were better off in terms of knowledge gained in soil management technologies and adoption of these technologies as compared to non-FFS farmers. The socio- economic factors like farmer's education level, age, household size, farm size and attitudes towards FFS process were of less significance in predicting adoption of soil management technologies. Results of the study indicate that the FFS methodology is an effective tool for cultivating farmers' learning, capacity building, knowledge empowerment, adoption and diffusion of technology to fellow non-FFS farmers, compared to the conventional extension approach. In particular, the FFS approach encourages farmers to develop their critical thinking and make sound farm management decisions, resulting in adoption of improved technologies. FFS was studied as an approach in comparison with non-FFS or conventional approach, but the two FFS facilitation approaches (F-FFS and E-FFS) were not studied as was the case in this study.

Mwagi, Onyango, Mureithi, and Mungai (2004), conducted a similar study and found that the adoption of technology on organic and inorganic fertilizer combinations by FFS farmers was significantly higher than those of non-FFS farmers. Onyango (2004) indicated that farmers often fall back to their traditional poor practices in the absence of follow-up, organization and leadership. They further state that apart from empowering farmers on knowledge gain and skills adoption, FFS participatory process also empower them to develop their own internal mechanism of leadership and cohesion. When external facilitation and training is withdrawn, farmers can maintain their groups; extend knowledge and skills to other farmers, and above all become acquisitive in their attitude and behaviour.

A study by Makori (2006) on the influence of FFS extension approach on smallholders' knowledge and skills of dairy management technologies in Nakuru, Kenya found that FFS extension approach enhanced acquisition of knowledge and skills on dairy management technologies more effectively, as compared to conventional approaches and

encouraged more gender balance in its` training programmes. The influence of income levels, age group, formal education, and milk marketing channels on the knowledge and skills that farmers acquired, suggest that these factors would accelerate acquisition of knowledge and skills by farmers to some extent, especially for the more complex knowledge and skills. The more effective dissemination of knowledge and skills through FFS enabled FFS participating farmers achieve higher dairy herd productivity levels as compared to conventional approach participating farmers. This is attributable to FFS extension approach, which enhances the skills and knowledge of smallholder farmers to realise increased dairy herd productivity. This study also was looking at FFS approach versus non-FFS approach, but the F-FFS and E-FFS approaches were not compared.

According to a World Bank research by Feder, Murgai and Quizon (2003), there is absence of significant impact that can be attributed to the FFS programmes. Even if graduates gain knowledge in their training that could over time be reflected in improved performance, the change is rather small and could not be detected in the econometric study, which imposes a specific structural form that is only assumed to reflect reality. The rather impressive gains cited by promoters of the programme likely exaggerate the programme impact because of improper attributions, confusion of selection biases with true programme effects, and extrapolation of observations from small non-representative pilot situations and samples to the wider population. These results contribute a lot to the contradictions in the FFS studies. This made it important to conduct a study within specific farmer conditions, since some or many of these studies may not be replicable due to selection biases non-representative samples and exaggeration of impacts.

Tarus (2003) studied the effectiveness of FFS in training and empowering women farmers. She found significant differences in the perceptions of men and women farmers towards FFS and its effectiveness in changing their attitudes towards extension knowledge, skills acquired, and the extent to which they applied them in their farms. Similarly, in poultry production, there were significant differences between men and women farmers in their perceptions towards FFS and its effectiveness. However, men and women farmers had similar feelings about FFS and its activities, and most farmers

perceived their knowledge and skills to be above average.

Research on diffusion of information among small scale farmers using FFS in Senegal started in 2001 and found out that the degree and intensity of information diffusion is affected by the degree of training exposure as measured by the proportion of farmers trained in a community. The findings of the study suggested that the strategy of having one FFS per community or village should be reconsidered. Small proportions of trained farmers in a village might be insufficient to induce change beyond the participants of the training. This study agrees that a critical mass of trained farmers is needed in order to attain effective dissemination of information and learning among participants and proposes further studies on FFS productivity impacts. The results also support the conclusion that the strengths of FFS projects lie in their use as an intervention in special situations, concentrating efforts and resources on selected sites rather than using it as a substitute for a national extension strategy of introducing participatory approaches (Witt, Wibel & Pemsl, 2006).

The study has considered FFS as an approach in general, but has not compared F-FFS and E-FFS approaches. Studies on FFS approach have not been able to cover all areas. Some researchers are confident of the positive points of FFS; some find many weaknesses, others don't find enough evidence for reliable conclusions, while others recommend further studies. This made it meaningful to conduct this study on the efficacy of F-FFS and E-FFS approaches to add to the existing body of Knowledge.

2.8 Push-Pull Technology

According to Khan (2007) and Khan *et al.* (2006), ICIPE and her partners developed an effective, cheap and environmentally friendly technology known as 'PPT' for the control of stemborers and suppression of Striga weeds in maize. It is an integrated cropping strategy, in which Napier grass and Desmodium legume (silverleaf and greenleaf) are used for control of stemborer and Striga weed in maize fields. Desmodium is planted in between the rows of maize and produces a smell that stemborer moths do not like. The smell "pushes" away the stemborer moths from the maize crop. Napier grass is planted

around the maize crop as a trap plant. Napier grass is more attractive to stemborer moths than maize and it pulls the moths to lay their eggs on it, but does not allow stemborer larvae to develop on it. When the eggs hatch and the small larvae bore into Napier grass stem, the plant produces sticky glue like substance like glue, which traps them and they die from suffocation. As a result, few stemborer larvae survive and maize is saved in the 'Push-Pull' technology.

The ground cover of Desmodium, interplanted among the maize, reduces Striga weeds because Desmodium causes germination of Striga seeds but does not promote further development. It has been shown that nitrogen fixed by Desmodium and chemicals produced by the roots of Desmodium, are responsible for inhibiting growth of the Striga weed. Desmodium stimulates germination of Striga seeds but also inhibits post-germination growth of the parasite's radicle – the part that attaches to the host plant. This is known as 'suicidal germination' and explains why Desmodium can actually reduce the number of Striga seeds in the soil. Desmodium roots produce allelochemicals, some which stimulate Striga seed germination and others (Isoflavones) which inhibit attachment of Striga to maize roots causing suicidal germination of Striga seed in the soil. The Gatsby Charitable Foundation research team have discovered three new isoflavanone compounds (uncinanone A, B, C) and a previously known isoflavanone (genistein). Therefore, Striga does not grow where Desmodium is growing (Tsanuo *et al.*, 2003; The Gatsby Charitable Foundation, 2005).

PPT adoption in Western Kenya involves the process of planting a PPT plot which takes a season. According to ICIPE (2007), farmers prepare plots of not less than 21m square. They make furrows using a sharp pointed stick at 75cm apart and drill fertilizer mixed with manure, followed by 250 to 300g Desmodium seed mixed with 2 parts of soil. Maize is then planted in straight lines between the Desmodium lines, at a spacing of 75x30cm at two maize seeds per hole, 5g of fertilizer and a handful of manure. They leave one meter path around the inner maize and Desmodium area and then plant three lines of Napier grass around the maize plot, at a spacing of 75x75cm with 5g of fertilizer and one handful of manure.

First weeding is done at three weeks, and after three months, Napier grass harvesting starts with the inner row and is mixed with Desmodium for livestock feed. Maize is harvested at physiological maturity, and Desmodium seed is harvested if ready. In the next season, the Desmodium is cut back, digging is done between the rows, maize stover cleared, maize planting is then done again and the cycle continues. This technology has enabled many PPT farmers to keep livestock, because of readily available Desmodium and Napier grass fodder, and some have started planting Desmodium for seed as a business. They also sell Napier grass and Desmodium fodder to their neighbours. Some of the farmers are more food secure with PPT, and are able to get extra incomes from the sales of milk, Napier, Desmodium, and maize (Khan, Amudavi, Midega, Wanyama & Pickett 2008).

When a farm is infested with Striga, the affected plants hardly grow more than one foot tall. The weed does not grow on its own but grows by attaching itself onto the host plants. Each Striga plant can produce up to 20,000-50,000 seeds, which lie dormant in the soil until a cereal crop is planted again. This dormancy can last for over 15 years. As Striga germinates, its roots grow towards the host crop, penetrate the crop's roots and start to draw nutrients from there. This causes severe stunting of the host crop and yield losses (Khan, *et al.*, 2005).

In East Africa, there are two common species of the Striga weed, *Striga hermonthica* and *Striga asiatica. Striga hermonthica* is common around the Lake Victoria basin while *Striga asiatica* is mainly found in the coastal areas. Taking into account the peculiar nature of Striga seeds, farmers are advised to control it before the weed emerges; the reason being that by the time it emerges, much damage will have been caused. Although various control approaches have been proposed, few farmers are able to avoid yield loss by these means. For example, though manual removal reduces re-infestation, it is deemed uneconomical since most damage is done even before the weed emerges (Khan, *et al.*, 2005).

According to Khan *et al.* (2006), in East Africa there are two species of stemborer which cause heavy damage to maize: B*usseola fusca* and C*hilo partellus*. *Busseola fusca* is indigenous to Africa and is present in high and mid altitude areas (3500 ft above sea level). C*hilo partellus* accidentally came from Asia in 1930s. *Chilo partellus* is present on low and mid altitude (zero to 4000 ft above sea level). *Busseola fusca* lays its eggs between stem and leaf sheaths, whereas C*hilo partellus* lays its eggs on plant surface in form of egg batches. After larvae bore into maize stems, they feed and grow within maize stems for 2-3 weeks. When larvae are fully grown, they pupate and remain inside the maize stem. After 7-14 days adults emerge from pupae and come out of the stem.

Farmers in the infested region of Western Kenya need to have access to information on PPT, in order to control both Striga and stemborer and get improved maize yields in order to attain sustainable food security. This makes it necessary to identify the best approaches for PPT dissemination to these farmers. This is the gap this study has partly filled.

2.9 Theoretical Framework

This study used three adult learning theories namely, the social learning theory, the theory of andragogy and the theory of experiential learning. Bandura (1977) states that: "Learning would be exceedingly laborious, not to mention hazardous, if people had to rely solely on the effects of their own actions to inform them what to do. Fortunately, most human behaviour is learned observationally through modelling: from observing others, one forms an idea of how new behaviours are performed, and on later occasions this coded information serves as a guide for action." (p 22). The component processes underlying observational learning involve attention, retention, motor reproduction and motivation. The social learning theory, defines social learning as the process by means of which agents acquire new information in a common environment. Social learning results from social facilitation. Social learning is the phenomenon by means of which the learner updates his/her own knowledge base, by adding to, or removing from given information, or modifying existing knowledge.

Knowles (1984) came up with the theory of andragogy, which refers to the art and science of helping adults learn. Andragogy assumes the following about the design of learning: adults have the need to know why they are learning something, learn through doing/experientially, are problem-solvers and learn best when the subject is of immediate use. Rogers (1969) theory of experiential learning, lists qualities of experiential learning as: personal involvement, self-initiated, evaluated by learner, and pervasive effects on learner. According to Rogers, learning is facilitated when the student participates completely in the learning process. Experiential learning theory, according to Kolb (1984), explains the learning process as consisting of five basic elements: Concrete experience, observation, reflection, forming abstract concepts and testing new situations.

Farmer Field Schools are adult learning fora which have adopted models similar to those underlying some of the adult learning theories. Three of these adult learning theories namely, social learning, andragogy and experiential learning, have similar characteristics to the FFS learning process. These three reflect the same principles of learning as: concrete experience or acquisition of new information and updating of existing information, which was measured as the knowledge gained in FFS sessions. This learning process involves, testing new situations, problem-solving, learning through doing, which is the application of knowledge measured as adoption of PPT skills, and the learning outcomes of maize yields. Social learning, results from social facilitation according to the social learning theory. In this study, the independent variable arose from F-FFS and E-FFS facilitation approaches. These two approaches constituted the main independent variables.

2.10 Conceptual Framework

The conceptual framework in this study is similar to the one discussed under adult learning theories, which was also used by Feder *et al.* (2003), who assert that FFS learning process aims at affecting farmers' knowledge, which can be interpreted to include the possession of analytical skills, critical thinking, ability to make better decisions, familiarity with agricultural practices and understanding of interactions within the agricultural ecosystem. Improved knowledge is, in turn, reflected in farmers'

cultivation procedures, input decisions, and crop yields. This study adopted similar study variables. The independent variable is the type of FFS facilitation approach; F-FFS and E-FFS. These were used to formulate the study objectives, hypotheses and data collection instruments, and data analysis procedures. The dependent variable was learning outcomes, which included knowledge adoption, maize yields and learning costs. Knowledge was measured through percentage score on PPT content test. Adoption was measured in percentage test score. Maize yields and costs for 2006 and 2007 were directly measured.

This study adopted the conceptual framework illustrated in Figure 1, which relates access to extension services on PPT, through FFS, to subsequent learning outcomes. The independent variable is extension approach, whose differences were studied using two independent samples from F-FFS and E-FFS extension approaches. The dependent variable was farmer learning outcomes, which include knowledge, adoption, maize yields and relevant variable costs. The moderator variables included the farmer general characteristics, namely age, gender, marital status, income, occupation, education level and land size.

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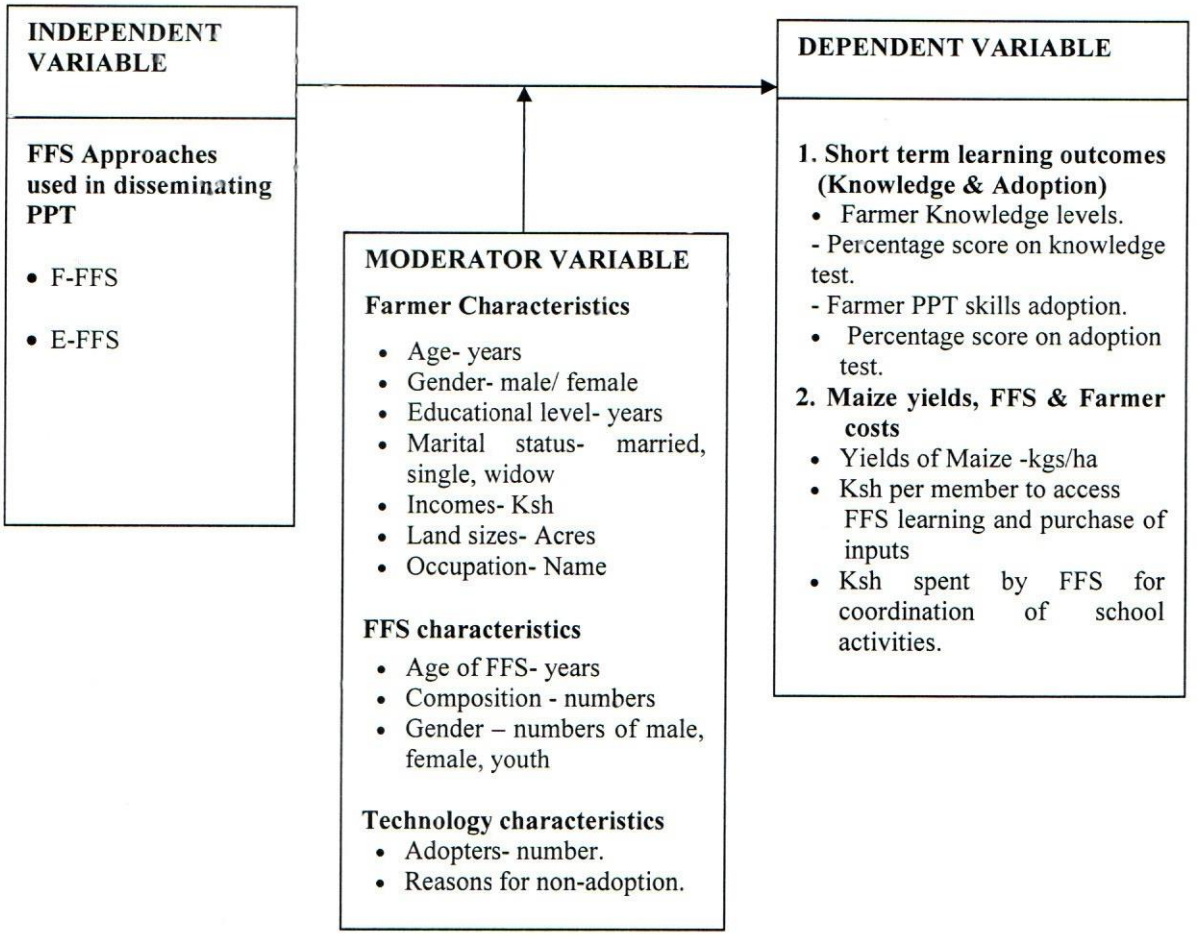


Figure 1 Conceptual Framework showing the independent, dependent and moderator variables used to compare the efficacies of F-FFS and E-FFS Approaches on farmer learning outcomes of PPT (Modified from Feder *et al*'s FFS model and adult learning theories)

CHAPTER THREE
RESEARCH METHODOLOGY

3.1 Introduction

This chapter explains the research methodology employed in the study. It outlines the research design, location of the study, the study population, the sampling procedure, data collection procedures and the analytical procedures used.

3.2 Research Design

A cross-sectional survey research design guided the study, which allows for collection of data from a specific population at one point in time, and examines a naturally occurring treatment. Mugenda and Mugenda (2003) recommend the same for both qualitative and quantitative comparisons of variables. This study established and compared the efficacies of F-FFS and E-FFS. A cross-sectional survey design was chosen because it enables the researcher to obtain information that describes the study phenomenon by asking individuals about their perceptions on the existing status of the study variables at one point in time. The design also provides original data for describing the population, and allows for measurement of characteristics of a large population. In addition, the design allows for study of naturally occurring treatments which is the case in this study The FFS are already established with ongoing schools. The study involved farmers who had adopted PPT for the years 2006 to 2008.

To control for moderator variables which were, gender, age, occupation, farm size, income levels and education levels, the researcher studied these variables alongside the study variables. F-FFS and E-FFS were from different districts which were far apart and therefore no interaction is likely to have occurred between the respondents of F-FFS and E-FFS approaches. F-FFS were established in Bungoma and E-FFS were run in Busia, which have similar socio-economic conditions.

3.3 Location of the Study

The PPT is currently being disseminated in about 20 districts in Western and Nyanza Provinces. The study was carried out in Bungoma South (currently Bungoma South and Bumula Districts) and Busia District (currently Busia and Butula Districts) of western Kenya. Busia District was chosen for this study because it was the only one with PPT E-FFS by the time of this study. Bungoma District was chosen because it had the largest number of PPT F-FFS.

Bungoma South District covers a total area of 2063 km^2, with 1838 km^2 arable land and 1520 km^2 cultivated area. The district has a population of 1,063,180 persons, comprised of 174,330 farm families and an average family size of six, based on projected figures from the 1999 census. The farm holdings were 151,330, with an average farm size of two hectares. Agro-ecological zones range from lower midland one (LM1) to lower midland two (LM2). Soil types are sandy clay loams, sandy loams and clay loams. The altitude ranges from 1,200 to 1,800 metres above sea level, with annual rainfall ranging from 1,000 to 1,800mm per annum. The major crops grown were maize, cassava, sweet potatoes, sorghum, finger millet, beans, bananas and cotton. Bungoma South has five Divisions with 15 locations (D.A.O Bungoma, 2009).

Busia District covers an area of 1262 km^2, with 964 km^2 arable land and 137 km^2 non-arable land and 650 km^2 cultivated land. The projected population based on 1999 census 452,500, with 56,250 farm holdings and 90,490 farm families. The average farm holding was two hectares, with average family sizes of five people. Rainfall is bimodal ranging from 1,000 to 1,800mm per annum. The altitude ranges from 1,179 to 1,485 metres above sea level. Soil types are sandy clay loams, sandy loams and clay loams. The major crops grown were maize, cassava, sweet potatoes, sorghum, finger millet, beans, bananas and cotton. The agro-ecological zones range from LM1 to LM2. Administrative sub-locations were 52 with 17 locations and six Divisions (D.A.O Busia, 2009).

3.4 Study Population

The study population comprised of all FFS PPT farmers in Bungoma South and Busia Districts of western Kenya. Bungoma South District has 14 F-FFS while Busia District has six E-FFS. This gives a total of 20 sampling units. The total FFS membership was 420 while adopters were 211. One F-FFS group from Bungoma South and one E-FFS group from Busia District having a total of 40 members were used for Pilot–testing, reducing the sampling frame from 211 to 171 respondents.

3.5 Sampling Procedure and Sample Size

Purposive sampling was done where the whole study population of 171 PPT adopters was included in the study. This is in accordance with the central limit theorem which states that, the distribution of an average tends to be normal as the sample size increases (Annis, 2008; Mugenda & Mugenda, 2003; Payne & Payne, 2004). Respondents were members of PPT FFS, who had adopted the technology and FFS group leaders. There were 60 and 111 FFS respondents from Bungoma and Busia Districts, respectively, who participated in the study.

McColl (2004), Payne and Payne (2004) and Mugenda and Mugenda (2003), recommend that, since populations are too large and costly to investigate, it becomes necessary to conduct investigations on a sample. However, in this case, it was realised that many farmers had joined FFS groups, but had not yet adopted PPT. So the study population of PPT adopters was not big enough to require sampling. According to Haining (2003), spatial dependence in attribute values indicates that values for the same attribute, measured at locations near to one another, tend to be similar than values separated by larger distances. This was addressed by selecting the two strata from far distances apart.

3.6 Data Collection Instruments

Three sets of structured questionnaires (Appendices B, C & D) on FFS member's learning outcomes were used for collecting primary data from the respondents. Appendix B PPT questionnaire for PPT adopter farmers has the following sections: Section A asked questions on farmer characteristics, which consisted of personal characteristics and

farmer personal PPT and FFS general characteristics. Section B sought to determine farmer maize yields and learning costs as a result of participating in FFS.

Appendix C PPT knowledge and adoption test questionnaire contained test items on PPT knowledge and adoption test questionnaire. Section A consisted of two sets of PPT knowledge test, both for general agronomic practices and on specific spacings of the PPT plots, while section B consisted of PPT skills and adoption test questionnaire.

Appendix D PPT questionnaire for group leaders measured FFS group characteristics and had the following sections: learning costs test questionnaire for the group, FFS group characteristics and recommendations. The respondents filled in the questionnaire themselves. For those farmers who were not able to fill the questionnaires, they gave the answer verbally and it was scored by the researcher.

3.6.1 Validity

Content validity of the study instrument was ensured by seeking expert opinion from faculty members and PPT experts. Validation was based on the degree to which the study variables, objectives, hypotheses, and research methodology and other processes were accurate in measuring the variables they were claimed to be measuring, in line with Kathuri & Pals (1993). The questionnaires were subjected to close expert scrutiny and suggestions and opinions incorporated to improve the quality of the instruments, with the goal of ensuring that the results and inferences of the study were accurate and meaningful (Appendix E). This is in line with recommendations by Mugenda and Mugenda (2003) who say that the usual procedure in assessing the content validity of a measure is to use professionals or experts.

3.6.2 Reliability

Reliability of the instruments was assessed through pilot-testing the questionnaire. Two FFS groups were randomly selected, and all 20 F-FFS and 20 E-FFS PPT adopters were interviewed. In order to guard against possible biases due to the spatial dependence in attribute values, the pilot-testing sites were far apart and had similar socio-economic

characteristics as the study areas. This was in line with Haining (2003) who indicates that values for the same attribute measured at locations near to one another tend to be similar than values separated by larger distances. The internal consistency technique was used to test for reliability. The reliability coefficient was estimated using Cronbach's alpha, because it is appropriate for assessing internal consistency, determined from scores obtained from a single test of the instrument. The calculated alpha was 0.75 which indicated that the instrument was appropriate for use (Kathuri & Pals, 1984; Payne & Payne, 2004; Mugenda & Mugenda, 2003).

3.7 Data Collection Procedure

Before the actual data collection started, a research permit was obtained from the National Council for Science and Technology, Nairobi, through the Graduate School. The questionnaire was administered with the guidance of the FFS and extension Staff in Bungoma and Busia Districts. The respondents for F-FFS and E-FFS were members of the household who participated in the FFS training sessions and were PPT farmers. Questionnaires were administered to farmer groups and filled during farmer field school days.

The researcher explained to the respondents, the purpose of the study before administering the questionnaire. The respondents were given a test pertaining to the push pull knowledge, skills and costs and their responses either personally recorded in the questionnaire, or recorded by the researcher. Administration, follow-ups and non-respondent management took three months.

3.8 Data Analysis

Data was processed using SPSS software, summarized and presented using the arithmetic means, standard deviations, percentages and tables. This was necessary for purposes of organising, describing and exploring the data. Hypotheses were tested using t-test and Mann Whitney U test at 5% level of significance ($\alpha = 0.05$). T-test was used for the ratio variables to test for significance of the differences in the means of the two samples for the test scores on PPT agronomic practices and spacing. Mann Whitney U test was used for

the categorical data which included the two self-rating scales for PPT competence and knowledge. Data analysis is summarized in table 1.

Objective 1 To measure farmers' knowledge on PPT, the researcher considered that the independent variable was the type of approach through which farmers were able to access extension services on PPT, either through F-FFS or E-FFS, while the dependent variable was farmers' knowledge on PPT measured as test score. This was measured using a test score on PPT technical questions. Data was both in ratio and categorical scales expressed as test score and self-rating scales.

Objective 2 To measure farmer's adoption of PPT skills the researcher considered that the independent variable was the approach through which farmers access extension services on PPT through F-FFS or E-FFS, while the dependent variable was farmer acquisition of PPT adoption skills measured in test score. Data was both in ratio and categorical scales expressed as test score and self-rating scales.

Objective 3 To measure farmers' maize yields under the PPT the researcher considered that the independent variable was the approach through which farmers access extension services on PPT through F-FFS or E-FFS, while the dependent variable was farmers' maize yields under PPT measured in kilograms per plot. Data was in ratio scale expressed in kilograms.

Objective 4 To measure farmers' PPT learning costs, the researcher considered that the independent variable was the approach through which farmers access extension services on PPT through F-FFS or E-FFS, while the dependent variable is farmer learning costs measured in Kenya shillings.

Moderator variables were controlled for, by studying them alongside the study variables. Among these were the following farmer characteristics: age in years, gender, either male or female, education level in years, marital status, either married or single, incomes in Kenya shillings, land sizes in acres and occupation by name.

The following FFS characteristics were measured: age of FFS in months or years, composition by membership and gender and a list of FFS activities before PPT. PPT characteristics were measured through the number of members who had adopted and the reasons for non-adoption. Cross tabulations were used to summarise the descriptive characteristics, while Chi-Square was used to test for significance. Significance testing was required to determine the influence the moderator variables had on the results of the study by moderating the results of the study variables.

Table 1: A Summary of Data Analysis

Hypothesis	Independent variable	Dependent variable	Data Analysis
H_O1 There is no statistically significant difference in the efficacies of F-FFS and E-FFS in PPT knowledge gained.	Access to extension: -Farmer led FFS -Extension led FFS	- Farmer knowledge of PPT content trained, using knowledge test	Descriptive statistics. t-test. Mann-Whitney u test.
H_O2 There is no statistically significant difference in the efficacies of F-FFS and E-FFS in PPT adoption.	Access to extension: -Farmer led FFS -Extension led FFS	-Farmer PPT adoption using skills adoption test	Descriptive statistics. t-test Mann-Whitney u test.
H_O3 There is no statistically significant difference in the efficacies of F-FFS and E-FFS in the PPT maize yields achieved	Access to extension: -Farmer led FFS -Extension led FFS	PPT maize yields - Yields in bags/ kgs per plot.	Descriptive statistics. t-test.
H_O4 There is no statistically significant difference in the efficacies of F-FFS and E-FFS in the costs incurred by PPT farmers.	Access to extension: -Farmer led FFS -Extension led FFS	Learning costs -Ksh spent / farmer and /FFS on FFS activities.	Descriptive statistics. t-test.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.0 Introduction

This chapter presents the results of the objectives investigated and the hypotheses tested in the study. It starts with a presentation of the description of individual characteristics of the study sample. This is followed by a discussion of the results for each objective and hypothesis tested.

4.1 Characteristics of Respondents

The general characteristics of the study sample included in the study were respondent's gender, age, highest level of education attained, marital status, occupation, farm size, income per year and number of livestock owned. These general characteristics were also the moderator variables, which were studied alongside the independent variables. The categorical general characteristics were summarised using frequencies and percentages, while the ratio characteristics were summarised using means and standard deviations. The significance of categorical variables was determined using chi-square and t-test was used for analysis of ratio variables. The test of significance was done to determine whether there were significant differences in the key relationships of variables of the F-FFS and E-FFS approaches. Cross-tabulations were used to summarise the descriptive statistics for the general farmer characteristics as presented in the first five tables.

4.1.1 Respondents' age

Table 2 presents the results of data analysis of the respondents' age categories. The majority of respondents in both approaches, who adopted and applied the introduced technologies, fell within the age groups of 31-40 years. There were more farmers of this age category within the FFS approach (73.3 %) than E-FFS (62.1 %). However, age had no significant influence on the uptake of the technologies between F-FFS and E-FFS ($p< 0.05$)

Table 2: Sample Distribution of Respondents' Age (Years) by FFS Approach

Household characteristics	F-FFS Farmers (n=60)		E-FFS Farmers (n=111)		χ^2 value	df	p-value
	Count	%	Count	%			
Age Group							
≤ 20	0	0	2	1.8	4.317	4	0.365
21-30	3	5	15	13,5			
31-40	24	40	38	34.2			
41-50	20	33.3	31	27.9			
Above 50	13	21.7	25	22.5			

4.1.2 Respondents' education level

Table 3 presents the results of data analysis of the respondents' education levels. F-FFS trained farmers had a higher percentage of farmers with secondary education (42.3%) than the E-FFS trained farmers (14.4%). There were more E-FFS respondents having primary education (61.3 %) than those within the F-FFS (40%). The E-FFS approach had more respondents with no formal education at all (21.6%) than the F-FFS approach (5%). There were more F-FFS respondents having college education (8.3%) than those within the E-FFS (1.8%).

Table 3: Sample Distribution for Respondents' Education Levels by FFS Approach

Household characteristics	F-FFS Farmers (n=60)		E-FFS Farmers (n=111)		χ^2 value	df	p-value
	Count	%	Count	%			
Education Level							
None	3	5	24	21.6	27.592	3	0.000
Primary	24	40	68	61.3			
Secondary	26	43.6	16	14.4			
College	5	8.3	2	1.8			

Analysis of data showed that education level had significant influence across the two FFS approaches ($p<0.05$). This observation alludes to the fact that educational level might probably have had some influence on the way farmers learnt and used the various technologies. The more educated farmers might have been able to do the measurements on their own and knew them by heart, while the less educated may have not internalized the measurements and depended on the facilitator to do the measurements for them. However, on less complex technology aspects, the education level had no significant influence.

4.1.3 Respondents' marital status

Table 4: Sample Distribution for Respondents' Marital Status by FFS Approach

Household characteristics	F-FFS Farmers (n=60)		E-FFS Farmers (n=111)		$\chi 2$ value	df	p-value
	Count	%	Count	%			
Marital Status							
Married	55	37.4	92	62.6	5.653	2	0.059
Widow	3	14.3	18	85.7			
Single	2	66.7	1	33.3			

Table 4 presents the results of data analysis of the respondents' marital status. There were more married respondents within the E-FFS (62.6%) approach than there were in the F-FFS (37.4%) approach. However, there were no statistically significant differences in the marital status of respondents in the two categories of the study farmers ($p< 0.05$). The results of data analysis indicated that both F-FFS and E-FFS farmers were equally knowledgeable in the uptake and application of the introduced technologies, irrespective of marital status.

4.1.4 Respondents' occupation

Table 5: Sample Distribution for Respondents' Occupation by FFS Approach

Household characteristics	F-FFS Farmers (n=60)		E-FFS Farmers (n=111)		χ^2 value	df	p-value
	Count	%	Count	%			
Occupation							
Farmer	35	58.3	92	82.9	13.845		0.003
Employed	4	6.7	4	3.6			
Small Business	5	8.3	14	12.6			
Any Other	11	18.3	1	0.9			

Table 5 presents the results of data analysis of the respondents' occupations. There were more E-FFS respondents who were farmers (82.9%), doing small businesses (12.6%) and employed (3.6%), than F-FFS which had fewer farmers (58.3%) with other respondents engaged in employment (6.7%) and small businesses (8.3%). The results show that occupation had significant influence across the two FFS approaches in catalyzing the uptake and use of the introduced technologies ($p<0.05$). This was probably because occupation of the respondents would have invariably empowered the farming communities with the resources and capacity to pick and apply the introduced technologies.

4.1.5 Respondents' gender

Table 6 presents the results of data analysis of the respondents' gender. There were more males within F-FFS (57.1%) approach than there were in the E-FFS (42.9%) approach. E-FFS had more female respondents (75.7%) than the F-FFS approach (24.3%).

Table 6: Sample Distribution for Respondents' Gender by FFS Approach

Household characteristics	F-FFS Farmers (n=60)		E-FFS Farmers (n=111)		χ^2 value	df	p-value
	Count	%	Count	%			
Gender							
Male	32	57.1	24	42.9	18.605	2	0.000
Female	28	24.3	87	75.7			

The analysis indicates that gender of the respondents had statistically significant differences across the two FFS approaches and might have catalyzed the uptake and application of the introduced technologies ($p<0.05$). The males may have played a greater role in technology uptake in F-FFS trained farmers than in E-FFS trained farmers.

4.1.6 Distribution of respondents by farm size (Acres)

Table 7 presents the results of data analysis of respondents' farm sizes. F-FFS trained farmers had a slightly higher average farm size (3.57 acres) than E-FFS trained farmers (3.51 acres). The results show that land size had no statistical significance across the two FFS approaches in catalyzing the uptake and application of the introduced technologies ($p<0.05$). The size of the land that a farmer owned may not have influenced the uptake and application of the introduced technology. This may have been due to the fact that land sizes were small for both F-FFS trained farmers and E-FFS trained farmers, therefore giving no significant differences in the results. However, given the small land sizes, PPT was facing competition against many uses for both F-FFS trained farmers as much as for E-FFS trained farmers.

Table 7: Sample Distribution for Respondents' Farm Size by FFS Approach

Household characteristics For Ratio Variables	F-FFS Farmers (n=60)	E-FFS Farmers (n=111)	t-value	df	p-value
Farm Size					
Mean	3.57	3.51	-0.117	152	0.907
(n=171)					

The respondents indicated that crops like sugarcane, sweet potatoes, cassava and local vegetables were among the competing enterprises that both F-FFS and E-FFS trained farmers required for their subsistence in addition to maize. Similarly both F-FFS and E-FFS farmers indicated that they find PPT to be labour intensive, therefore dealing with small plot sizes with almost no expansion.

4.1.7 Respondents' number of livestock owned

Table 8: Sample Distribution for Number of Livestock by FFS Approach

Household characteristics For Ratio Variables	F-FFS Farmers (n=60)	E-FFS Farmers (n=111)	t- value	df	p-value
Number of livestock					
Mean	5	4	0.777	141	0.439

Table 8 presents the results of data analysis of the livestock owned by respondents. F-FFS trained farmers were better endowed with a higher average number of livestock (5) per farmer than the F-FFS trained farmers (4). The results further indicate that the number of livestock had no statistical significance across the two FFS approaches ($p<0.05$). Uptake of the introduced technology was not affected by the size of the herd that a farmer owned.

4.1.8 Respondents' average yearly incomes

Table 9 presents the distribution of respondents by average yearly incomes. The mean average yearly income for F-FFS was higher (Ksh. 12,133) than E-FFS (Ksh. 2448). The results indicate that there were statistically significant differences in average yearly incomes between the two FFS approaches ($p<0.05$). Uptake of the introduced technology may have been influenced by the average incomes the respondents got. The income differences between F-FFS and E-FFS trained farmers may have been due to their occupations, which may be explained by their differences in education levels.

Table 9: Sample Distribution of Average Yearly Incomes by FFS Approach

Household characteristics For Ratio Variables	F-FFS Farmers (n=60)	E-FFS Farmers (n=111)	t-value	df	p-value
Average Monthly income (Ksh)					
Mean	12,133.73	2,448.38	4.919	153	0.000

4.2 Test of the Hypotheses of the Study

The stated four hypotheses were tested, and the results are tabulated and discussed in the following sub-sections.

4.2.1 Knowledge gained by farmers through FFS

H_O1: There is no statistically significant difference in the efficacies of F-FFS and E-FFS in the PPT knowledge gained by farmers trained using these approaches.

Table 10 presents the summary of the percentages of farmers knowledgeable about PPT in the basic agronomic practices. A test was administered to farmers with six technology aspects of PPT referring to agronomic practices. For each question, the respondents had three choices: Yes- 4 Marks, Not Sure-1 mark, No-0 marks. The levels of knowledge, 1-4, were derived from the three choices given per question, on the test. The marks awarded for each of the choices are in the second column. The scores in the next two columns were based on the score by FFS approach.

E-FFS trained farmers had a slightly higher percentage of farmers (90%) knowledgeable on PPT general agronomic practices than F-FFS (85%). E-FFS and F-FFS trained farmers had the same percentages of farmers (2%) who were not sure of some PPT general agronomic practices. F-FFS trained farmers had a slightly higher number of farmers (13 %) who were not knowledgeable on some PPT general agronomic practices than E-FFS trained farmers (8%).

Table 10: Percentage of Farmers Knowledgeable about PPT by FFS Approach

Knowledge Score acquired	Percentage number of farmers	
	F-FFS (n=60)	E-FFS (n=111)
4	85	90
1	2	2
0	13	8
Total	100	100

Table 11 presents the results of t-test for farmer knowledge gained on the basic agronomic practices. Farmers within the two facilitation approaches were subjected to a knowledge test on effects of Desmodium on soil fertility, Striga seed germination, stemborer and maize productivity. In each FFS approach, responses were grouped according to whether they were correct or not. Farmers who answered correctly were categorized as knowledgeable and their mean scores were calculated in each approach. The mean scores of knowledgeable respondents were compared across the two approaches. A higher mean score corresponded to a better facilitation approach than the other.

On whether Desmodium is a "Push" plant, respondents trained under the E-FFS approach had a higher mean score (3.86) than those under trained under the F-FFS (3.80). The E-FFS trained farmers had a higher mean score (3.93) on whether Napier is a "Pull" plant than the F-FFS (3.90) respondents. The same observation was seen on the technology aspect of whether Napier produces a sticky substance that kills stemborer larvae. On this technology aspect, E-FFS trained farmers had a higher mean score (3.92) than the F-FFS (3.80) trained farmers. On whether Desmodium contributes to fertility, E-FFS respondents had a higher mean score (3.89) than the mean of F-FFS trained farmers (3.85). On whether Desmodium hinders Striga seed from germinating, E-FFS respondents had a higher mean score (3.51) than F-FFS trained farmers (3.07). On whether Desmodium causes Striga seed to germinate, E-FFS respondents had a higher mean score (3.29) than F-FFS (2.1).

Table 11: Mean Score of the Knowledge Gained by Respondents on PPT Agronomic Practices by FFS Approach

Technology aspect tested	Approach		Significance of the independent variables						
	F-FFS (n=60)	E-FFS (n=111)	t-value	Ap	Ag	Ge	Ms	Ed	In
1. Desmodium is a "Push" plant	3.80 ± 0.76	3.86 ± 0.63	-0.60	NS	NS	NS	NS	NS	NS
2. Napier is "Pull" plant	3.9 ± 0.54	3.93 ± 0.49	-0.23	NS	NS	NS	NS	NS	NS
3.Napier produces sticky substances	3.8 ± 0.76	3.92 ±0.49	-1.24	NS	NS	NS	NS	NS	NS
4.Desmodium contributes to fertility	3.85 ± 0.66	3.89 ± 0.56	-0.44	NS	NS	NS	NS	NS	NS
5.Desmodium hinders Striga seed germination	3.07±1.39	3.51 ± 1.11	-2.30	**	NS	NS	NS	NS	NS
6.Desmodium causes Striga seed to germinate	2.1 ± 1.46	3.29 ± 1.27	-5.55	***	NS	*	NS	NS	NS
7. Overall mean score	3.42 ± 0.93	3.73 ± 0.65	-1.73	NS	NS	NS	NS	NS	NS

NS = Not significant at $p<0.05$, * = $p<0.05$, ** = $p< 0.01$; *** = $p< 0.001$
Ap = FFS Facilitation Approach, **Ag** = Age; **Ge** =Gender; **Ms** = Marital status; **Ed** = Educational level; **In** = Income per year; **Fs** = Farm size; **Oc** = Occupation.

For two of the technology aspects, there were statistically significant differences between F-FFS trained farmers and E-FFS trained farmers in knowledge, on whether Desmodium hinders Striga seed from germinating, and whether Desmodium causes Striga seed to germinate ($p<0.05$). In these two technology aspects E-FFS trained farmers had higher mean scores than F-FFS trained farmers. E-FFS trained farmers scored a slightly higher overall mean score (3.73) than the F-FFS trained farmers (3.42). However, the difference was not statistically significant ($p<0.05$). These results support the hypothesis that there is no statistically significant difference in the efficacies of F-FFS and E-FFS in the PPT knowledge gained by farmers using these approaches.

Table 12 presents the percentage of farmers acquiring various scores from the knowledge test on the spacing of PPT. Six questions were administered to respondents without any multiple choices. Each question had 10 marks which were converted to percentages.

Table 12: Percentages Farmers Attaining Various Scores in the Knowledge Test on PPT Spacing by FFS Approach

Technology aspect tested	Percentage of farmers											
	1 – 2		3 – 4		5 – 6		7 – 8		9 – 10		Total	
Approach	F-FFS	E-FFS	F-FFS	E-FFS	F-FFS	E-FFS	F-FFS	E-FFS	F-FFS	E-FFS	F-FFS	E-FFS
Rows of Napier planted	10	24	0	1.1	78	59	2	0	10	16	100	100
Napier spacing between plants	77	85	23	15	0	0	0	0	0	0	100	100
Napier spacing between rows	2	36	10	30	19	24	14	6	55	4	100	100
Maize spacing between rows	2	18	6	14	2	24	11	27	79	25	100	100
Maize spacing between plants	12	60	5	11	6.3	9	12	7	65	13	100	100
Desmodium spacing between rows	6.6	34	5	17	5	13	8.4	19	75	17	100	100
Average score	3.3	25.	6.6	41.	36.	26.	53.	7.2	0	0	100	100

On the rows of Napier grass planted, a higher percentage (24%) of the E-FFS trained farmers attained lower scores between 1 and 2 marks than the percentage of F-FFS trained farmers (10%), a higher percentage of F-FFS trained farmers (78%) attained higher scores between 5 to 7 marks than E-FFS trained farmers (59%) while a higher percentage of E-FFS trained farmers (16%) scored higher marks between 9 and 10 than

the percentage of F-FFS farmers (1%). On Napier grass spacing between plants, a higher percentage of E-FFS trained farmers (85%) attained lower scores of between 1 and 2 marks than the percentage of F-FFS trained farmers (77%) , while a higher percentage of F-FFS trained farmers (23%) attained a higher score of between 3 and 4 marks than the percentage of E-FFS trained farmers (15%). On the spacing of Napier grass between rows, a higher percentage of E-FFS trained farmers (36%, 30%, and 24%) attained lower scores between 1 to 6 marks, than the percentage of F-FFS trained farmers (2.1% and 19%), while a higher percentage of F-FFS trained farmers (14 and 55%) attained higher scores between 7 and 10 marks than the percentage of E-FFS trained farmers (6 and 4%).

On maize spacing between rows, a higher percentage of E-FFS trained farmers (18%, 14%, 24%, and 27%) attained lower scores of between 1 and 8 marks than the percentage of F-FFS trained farmers (2%, 6%, 2% and 11 %), while a higher percentage of F-FFS trained farmers (79%) attained higher scores of 9 to 10 marks than the percentage of E-FFS trained farmers (25%). On maize spacing between plants, a higher percentage of E-FFS trained farmers (60, 11 and 9%) attained lower scores between 1 and 6 marks than the percentage of F-FFS trained farmers (12%, 5%, and 6.3 %), while a higher percentage of F-FFS trained farmers (12% and 65%) attained higher scores between 7 and 10 marks than the percentage of E-FFS trained farmers (7% and 13 %). On Desmodium spacing between rows a higher percentage of E-FFS trained farmers (34%, 17%, 13% and 19 %) attained lower scores between 1 and 8 marks, than the percentage of F-FFS trained farmers (6.6%, 5%, 5% and 8.4 %), while a higher percentage of F-FFS trained farmers (75%) attained higher scores between 9 and 10 marks than the percentage of E-FFS trained farmers (17%). On average a less percentage of F-FFS trained farmers (9.9 %) scored less than 10 marks while a higher percentage of E-FFS trained farmers (66.6%) scored less than 10 marks. Also a higher percentage of F-FFS trained farmers (89.9%) scored over 5 marks than E-FFS trained farmers (33.3%).

Table 13 presents results of t-test for knowledge test score. The farmers were given a test on the exact spacing and measurements used in PPT implementation. The score was given after considering the questions answered correctly. Further analysis of data showed that farmers trained through the F-FFS approach had a higher mean score (5.17) on rows of Napier grass planted under PPT than E-FFS trained farmers (4.94).

Table 13: Mean Score for Farmer Knowledge of the Spacing used to Establish PPT by FFS Approach

Technology aspect tested	Score by Approach(Ap)		Significance of the independent variables							
	F-FFS (n=60)	E-FFS (n=111)	t-value	Ap	Ag	Ge	Ms	Ed	In	Fs
1. Rows of Napier grass planted	5.17±2.03	4.94±2.71	0.58	NS	NS	NS	NS	NS	NS	NS
2. Napier spacing between plants	1.55±1.03	1.32±0.75	1.70	NS	NS	NS	NS	NS	NS	NS
3. Napier spacing between rows	7.93±2.60	3.51±1.68	13.48	***	NS	**	NS	**	NS	NS
4. Maize spacing between rows	9.02±2.10	6.36±2.71	6.59	***	NS	**	NS	***	NS	NS
5. Maize spacing between plants	8.02±2.94	4.27±2.95	7.93	***	NS	**	NS	***	NS	NS
6. Desmodium row spacing	8.65±2.62	5.02±3.38	7.22	***	NS	**	NS	***	NS	NS
7. Overall Mean Score	6.72± 1.3	4.24 ±1.7	6.25	***	NS	*	NS	**	NS	NS

df = 171

NS = Not significant at $p<0.05$, * = $p<0.05$, ** = $p< 0.01$; *** = $p< 0.001$
Ap = FFS Facilitation Approach, **Ag** = Age; **Ge** =Gender; **Ms** = Marital status; **Ed** = Educational level; **In** = Income per year; **Fs** = Farm size; **Oc** = Occupation; ± = Mean ± standard deviation

On Napier spacing between plants on the PPT plot, F-FFS trained farmers had a higher mean score (1.55) than the E-FFS trained farmers (1.32). F-FFS respondents had a higher mean score on spacing of Napier grass between rows (7.93) than were the E-FFS trained farmers (3.51). F-FFS trained farmers had a higher mean score on maize spacing between rows (9.02) than the E-FFS trained farmers (6.36). F-FFS trained farmers had a higher mean score on maize spacing between plants (8.02) than the E-FFS trained farmers (4.27). F-FFS trained farmers had a higher mean score on Desmodium spacing between rows (8.65) than the E-FFS trained farmers (5.02). There were significant differences ($p< 0.05$) in farmer knowledge as a result of their training through the F-FFS and E-FFS facilitation approaches.

F-FFS had a higher overall mean score (6.72) and were therefore more knowledgeable on PPT knowledge regarding complex issues than E-FFS trained farmers (4.24). These results do not support the hypothesis that there is no statistically significant difference in the efficacies of F-FFS and E-FFS in the PPT knowledge gained by farmers using these approaches. This observation maybe explained by the fact that the F-FFS facilitation reduces farmer dependence on the extension staff, and makes them more self-reliant in practicing PPT on their farms. The farmers were able to give the measurements of their PPT plots and the spacing of the crops more accurately. The E-FFS farmers may have been dependent on the extension staff: their plots were measured by the extension staff and planting done in the presence and with participation of extension staff. The farmers may have not taken time to internalize the measurements, because they expect the extension staff to measure for them again when they expand. They could not tell the sizes of their PPT plots. However, since the F-FFS trained farmers were more knowledgeable in the majority of the technology aspects tested, the F-FFS may be a better approach than E-FFS in technology dissemination of the knowledge aspects tested.

Table 14 indicates how farmers rated themselves on PPT knowledge scales. Respondents were given a chance to rate themselves on their understanding of PPT whether they were excellent, very good, good, poor or very poor.

Table 14: Percentage Number of Farmers Acquiring Different Levels of PPT Knowledge by FFS Approach

Level of Knowledge acquired	Score	Percentage number of farmers	
		F-FFS (n=60)	E-FFS (n=111)
Very poor	1	9.58	10.23
Poor	2	19.17	23.4
Good	3	21.04	21.06
Very Good	4	20.42	20.04
Excellent	5	29.79	25.27
Total	15	100	100

A slightly higher percentage of E-FFS trained farmers (10.23%) rated themselves as very poor in PPT knowledge, than F-FFS trained farmers (9.58%). A slightly higher percentage of E-FFS trained farmers rated themselves as poor in PPT knowledge (23.4%) than F-FFS trained farmers (19.17%). An almost equal percentage of E-FFS trained farmers rated themselves as good in PPT knowledge (21.06%) as F-FFS trained farmers (21.04%). An almost equal percentage of F-FFS trained farmers (20.42%) rated themselves as very good in PPT knowledge as E-FFS trained farmers (20.04%). A slightly higher percentage of F-FFS trained farmers (29.97%) rated themselves as excellent as the E-FFS trained farmers (25.57%). A slightly higher overall percentage of F-FFS rated themselves as excellent in the knowledge of Push- Pull technology (29.79%) than E-FFS (25.27%). However, the differences were not significant ($p<0.05$).

Table 15 presents the results of Man-Whitney U two-sample rank-sum test for knowledge self-rated scales. On how Striga affects maize, E-FFS trained farmers had a higher mean rank (79.6%) than F-FFS trained farmers (71.4%). On how Desmodium affects Striga and Stemborer, E-FFS trained farmers ranked themselves as more knowledgeable (78.1%) than F-FFS (74.3%) trained farmers. On how Napier grass affected Stemborer, E-FFS trained farmers rated themselves as more knowledgeable (77.5%) than F-FFS (74.9%) trained farmers. On how PPT increased maize yields, E-FFS trained farmers rated themselves as more knowledgeable (76.6%) than F-FFS trained farmers (75.0%).

Table 15: Percentage Mean Ranks for Farmer Level of PPT Knowledge Acquired by FFS Approach

Technology aspect tested	Approach(Ap)		Significance of Independent Variables							
	F-FFS (n = 60)	E-FFS (n =111)	Man W-U	Ap	Ag	Ge	Ms	Ed	In	Fs
1. How Striga affects maize	71.4	79.6	2453	NS	NS	NS	NS	NS	NS	NS
2. How Des affects Striga & stemborer	74.3	78.1	2612	NS	NS	NS	NS	NS	NS	NS
3. How Napier affects stemborer	74.9	77.5	2666	NS	NS	NS	NS	NS	NS	NS
4. How P-P increase maize yields	75.0	76.6	2657	NS	NS	NS	NS	NS	NS	NS
5. How P-P plot is prepared	78.5	64.7	2109	*	NS	NS	NS	NS	NS	NS
6. How maize is planted	78.4	74.4	2572	NS	NS	NS	NS	NS	NS	NS
7. How Desmodium is planted	77.6	75.8	2694	NS	NS	NS	NS	NS	NS	NS
8. How Napier grass is planted	77.4	75.1	2648	NS	NS	NS	NS	NS	NS	NS
9. Overall Mean rank	75.9	75.2	2551	NS	NS	NS	NS	NS	NS	NS

df = 171

NS = Not significant at $p<0.05$, * = $p<0.05$, ** = $p< 0.01$; *** = $p< 0.001$
Ap = FFS Facilitation Approach, **Ag** = Age; **Ge** =Gender; **Ms** = Marital status; **Ed** = Educational level; **In** = Income per year; **Fs** = Farm size; **Oc** = Occupation

On how PPT plots were prepared, F-FFS trained farmers rated themselves higher (78.5%) than E-FFS trained farmer (64.7%). On this technology aspect, the differences were significant ($p < 0.05$). On how maize was planted, F-FFS trained farmers rated themselves as more knowledgeable (77.6%) than E-FFS trained farmers. On how Desmodium was planted, F-FFS trained farmers rated themselves higher (77.6%) than E-FFS trained farmers (75.8%). On how Napier grass was planted, F-FFS trained farmers rated themselves as more knowledgeable (77.4%) than E-FFS trained farmers (75.1%). The results gave no significant differences between farmers trained through F-FFS and those trained through E-FFS for six of the technology aspects. This may be because the

farmers rated themselves in similar ways. Over 90% rated themselves as excellent and very good in PPT. Both F-FFS and E-FFS respondents believed that they were knowledgeable in PPT.

Table 16 summarises the percentages of farmers who rated themselves on the competence self-rating scales. Respondents rated themselves on how competently they implemented the knowledge they had on PPT, on a scale of very competent = 5, competent = 4, moderately competent = 3, incompetent = 2 and very incompetent = 1.

Table 16: Percentage of Farmers Acquiring Different Levels of Competence in PPT

Level of Competence	Score	Percentage of farmers	
		F-FFS (n=60)	E-FFS (n=111)
Very incompetent	1	12.78	16.37
Incompetent	2	9.72	11.07
Moderately competent	3	25.83	25.34
Competent	4	23.61	23.72
Very competent	5	28.06	23.50

A higher percentage of E-FFS trained farmers (16.37%) rated themselves as very incompetent in PPT implementation, than F-FFS trained farmers (12.78%). A slightly higher percentage of E-FFS trained farmers (11.07%) rated themselves as incompetent in PPT implementation, than F-FFS trained farmers (9.72%). A slightly higher percentage of F-FFS trained farmers (25.83%) rated themselves as moderately competent in PPT implementation, than F-FFS trained farmers (25.34%). A slightly higher percentage of E-FFS trained farmers (23.72%) rated themselves as competent in PPT implementation, than F-FFS trained farmers (23.61%). A higher percentage of F-FFS trained farmers (28.06%) rated themselves as very competent in PPT implementation, than E-FFS trained farmers (23.50%). A slightly higher overall percentage of F-FFS trained farmers (28.06%) rated themselves as very competent in PPT implementation, than E-FFS trained farmers (23.50%).

Table 17 presents the results of Man-Whitney U two-sample rank test for competence scales. The respondents rated themselves on their competence in implementing PPT on their farms.

Table 17: Mean Rank for Respondents' Levels of Competence in PPT by FFS Approach

Technology aspect tested	FFS Approach		Significance of the independent variables							
	F-FFS (n=60)	**E-FFS (n=(111)**	**Man-W U**	**Ap**	Ag	Ge	**Ms**	Ed	**In**	**Fs**
1. Comp on PPT plot layout	75.6	73.2	2640	NS	NS	NS	NS	NS	NS	NS
2. Comp on P-P plot land preparation	82.9	71.0	2212	*	NS	NS	NS	NS	NS	NS
3. Comp on maize Planting	75.3	76.4	2690	NS	NS	NS	NS	NS	NS	NS
4. Comp on Desmodium planting	75.8	76.2	2715	NS	NS	NS	NS	NS	NS	NS
5. Comp on Napier Planting	74.0	78.1	2610	NS	NS	NS	NS	NS	NS	NS
6.Comp on gapping Desmodium	74.3	77.1	2614	NS	NS	NS	NS	NS	NS	NS
7.Comp on weeding PPT plot	78.61	75.13	2633	NS	NS	NS	NS	NS	NS	NS
8.Overall mean Rank	76.6	75.3	2588	NS	NS	NS	NS	NS	NS	NS

df = 171

Comp = Competence; NS= Not significant at $p<0.05$, * = $p<0.05$, ** = $p< 0.01$; *** = $p< 0.001$; **Ap** = FFS Facilitation Approach; **Ag** = Age; **Ge** =Gender; **Ms** = Marital status; **Ed** = Educational level; **In** = Income per year; **Fs** = Farm size; **Oc** = Occupation

Regarding PPT plot layout, F-FFS trained farmers rated themselves as more competent (75.6%) than E-FFS trained framers (73.2%). On PPT plot land preparation, F-FFS trained farmers rated themselves as more competent (82.9%) than E-FFS trained farmers. The differences were significant for this technology aspect ($p<0.05$). On maize planting the E-FFS trained farmers rated themselves as more competent (76.4%) than the F-FFS trained farmers (75.3%). On Desmodium planting, the E-FFS trained farmers rated themselves as more competent (76.2%) than the F-FFS trained farmers. On Napier grass planting, the E-FFS trained farmers rated themselves as more competent (78.1%) than the F-FFS trained farmers (74.0%). Regarding Desmodium gapping, the E-FFS trained farmers rated themselves as more competent (74.3%) than the F-FFS trained farmers (77.1%). On weeding, the PPT plots, the F-FFS trained farmers ranked themselves as more competent (78.1%) than E-FFS trained farmers.

The results gave no significant differences between farmers trained through F-FFS and those trained through E-FFS for six of the technology aspects. This may be because the farmers rated themselves in similar ways. Over 90% rated themselves as excellent in competence and very competent in PPT. Both F-FFS and E-FFS respondents believed that they were very knowledgeable in PPT.

4.2.2 Adoption of PPT skills by FFS participating farmers

H_O2: There is no statistically significant difference in the efficacies of F-FFS and E-FFS in farmers' skills of PPT adoption.

A questionnaire for FFS group leaders was used to collect group characteristics, where number of total FFS membership and total numbers of adopters were indicated. A higher percentage of E-FFS trained farmers (65%) had adopted PPT than E-FFS trained farmers (24%). The differences were statistically significant ($p<0.05$).

Table 18 presents t-test results for PPT adoption by individual farmers. On the year respondents started planting PPT, respondents within the F-FFS approach started planting PPT later (2007) than those from the F-FFS (2006). The E-FFS trained farmers had a higher mean score (3.04) on the number of years they had planted maize under PPT than the F-FFS respondents (2.24). On the initial size of PPT plots established, E-FFS trained farmers had a higher mean size (688.06 m^2) than F-FFS farmers (562.57 m^2). On whether they had expanded their PPT plots, F-FFS farmers had a higher mean score (1.87) than the E-FFS (1.84) trained farmers. On the current size of their PPT plots, E-FFS farmers had a higher mean size (736.66 m^2) than F-FFS farmers (579.61 m^2).

Table 18: Mean Score for PPT Adoption at Individual Farmer Level by FFS Approach

Technology aspect tested	**FFS Approach**		**Significance of the independent variables**								
	F-FFS (n=60)	**E-FFS (n=111)**	**t-value**	**Ap**	Ag	Ge	**Ms**	Ed	**In**	**Fs**	**Oc**
Year started planting	2007	2006	2.413	**	NS	NS	NS	NS	NS	NS	*
Years planted	2.24 ± 0.67	3.04 ± 0.90	-5.931	**	NS	NS	NS	NS	NS	*	NS
Initial plot Size	562.6± 591	688.1± 840	-0.438	NS	NS	NS	NS	NS	NS	NS	NS
If expanded p-p plot	1.87 ± 0.34	1.84 ± 0.37	1.789	NS	NS	NS	NS	NS	NS	NS	NS
Current P-P Plot Size	579.6± 583	736.7±878.9	-0.705	NS	NS	NS	NS	NS	NS	NS	NS

df = 171

NS = Not significant at $p<0.05$, * = $p<0.05$, ** = $p< 0.01$; *** = $p< 0.001$; **Ap** = FFS Facilitation Approach, **Ag** = Age; **Ge** =Gender; **Ms** = Marital status; **Ed** = Educational level; **In** = Income per year; **Fs** = Farm size; **Oc** = Occupation ± = Mean ± standard deviation

There were no significant differences between F-FFS and E-FFS farmers on expansion of their PPT plots since they were first established ($P<0.05$). Over 90% of the PPT plots retain the initial establishment sizes so far. Therefore, the null hypothesis was retained in this case. Farmers gave many reasons why they had not been able to expand. These included, small land sizes, presence of sugarcane on the farm, inability to plant other crops like sweet potatoes under PPT and gender issues where women cannot tell their husbands to give more space for push-pull. These were cross-cutting between the F-FFS and E-FFS approaches.

Table 19 summarises the percentages of adopters within FFS groups. E-FFS approach which had a lower FFS membership (170) had a higher percentage of PPT adopters (65%), as compared to F-FFS approach, which had a higher membership (250), but had a lower percentage of PPT adopters (24%). These differences were statistically significant ($P<0.05$). The differences may be because the E-FFS farmers' major occupation was farming, so they had more time on the farm to adopt PPT, while the F-FFS farmers' major occupation was other activities apart from farming.

Table 19: Percentage of Farmers Adopting PPT by FFS Approach

Level of group adoption	**Percentage number of farmers**			
	F-FFS (n=60)		**E-FFS (n=111)**	
	Count	%	Count	%
	250	100	170	100
Total number of Adopters	60	24	111	65

Table 20 presents t-test results of adoption of PPT by FFS group members. Among the number of FFS members who had adopted PPT, respondents within the E-FFS approach had a higher mean adoption rate (25.17) than those from the F-FFS (7.07). The E-FFS trained farmers had a higher mean adoption rate (19.17) on the number of adopters who were women, than the F-FFS trained respondents (2.64). Among the number of adopters who were men, the E-FFS trained farmers had a higher mean adoption rate (6.0) than F-FFS trained farmers (4.07). Among the number of adopters who were youth, the E-FFS

trained farmers had a higher mean adoption rate (1.0) than the F-FFS trained farmers (0.86). In regard to the number of adopters who were widows, the E-FFS trained farmers had a higher mean adoption rate (3.0) than F-FFS trained farmers (0.43).

There were significant differences between F-FFS and E-FFS for the number of respondents who had adopted PPT ($P<0.05$), for the adopters who were women ($P<0.05$), and for the adopters who were widows ($p<0.05$). These results do not support the null hypothesis; rather they support the alternative hypothesis that the differences in adoption between F-FFS and E-FFS approaches were statistically significant.

Table 20: Mean Score for PPT Adoption at Group Level by FFS Approach

Technology aspect tested	FFS Approach (Ap)		Significance of the independent variables							
	F-FFS (n=14)	E-FFS (n=6)	t-value	Ap	Ge	Ms	Ed	In	Fs	Oc
Year FFS started PPT	2006.5	2006.67	-0.66	NS	NS	NS	NS	NS	NS	NS
How many have adopted PPT	7.07±4.18	25.17±11.2	-5.39	***	NS	NS	NS	NS	NS	NS
How many adopters were men	4.07±2.62	6.00± 3.5	-1.37	NS	NS	NS	NS	NS	NS	NS
How many adopters were women	2.64± 2.53	19.17±9.7	-6.10	***	NS	NS	NS	NS	NS	NS
How many adopters were youth	0.86±1.61	1.00±2.4	-0.16	NS	NS	NS	NS	NS	NS	NS
How many adopters were widows	0.43± 0.85	3.00± 2.6	-3.39	**	NS	NS	NS	NS	NS	NS

df = 171

NS = Not significant at $p<0.05$, * = $p<0.05$, ** = $p< 0.01$; *** = $p< 0.001$; **Ap** = FFS Facilitation Approach, **Ag** = Age; **Ge** =Gender; **Ms** = Marital status; **Ed** = Educational level; **In** = Income per year; **Fs** = Farm size; **Oc** = Occupation ± = Mean ± standard deviation

The E-FFS members have managed to adopt in higher numbers per FFS than F-FFS members. This may be because their facilitators were extension officers who were paid and facilitated by the Government. F-FFS facilitators complained of difficulties in accessing FFS locations because they were neither paid nor facilitated with transport, and therefore, walked long distances or used bicycles to reach the FFS. The F-FFS facilitators were farmers also and therefore, might not have been able to devote all their time to FFS activities, since they needed to work on their farms too. It might be relatively easier therefore, for the E-FFS farmers to get access to trainings, tours and some training requirements than F-FFS.

Table 21 presents the results of t-test for non-adoption of PPT at FFS group level. Among the number of non-adopters who were men, the F-FFS trained farmers had a higher mean adoption rate (5.43) than the E-FFS trained respondents (0.67). Respondents within the F-FFS approach had a higher mean adoption rate (16.5) than those from the E-FFS (2.83).

Table 21: Mean Score for Non-adoption at Group Level by FFS Approach

SR No	Technology aspect tested	FFS Approach (Ap)		Significance of the independent variables								
		F-FFS (n=14)	E-FFS (n=6)	Ap	Ag	Ge	Ms	Ed	In	Fs	Nl	Oc
1	How many FFS members have not adopted	16.5±6.0	2.83±5.6	***	NS	NS	NS	NS	NS	NS	NS	NS
2	Number of male non-adopters	5.43±3.3	0.67±1.2	**	NS	NS	NS	NS	NS	NS	NS	NS
3	Number of Female non-adopters	7.79±5.2	2.17±5.3	*	NS	NS	NS	NS	NS	NS	NS	NS
4	Number of youth non-adopters	3.07±4.4	0.17±0.4	NS	NS	NS	NS	NS	NS	NS	NS	NS
5	Non-adopters who were widows	1.07±1.3	0.17±0.4	NS	NS	NS	NS	NS	NS	NS	NS	NS

df = 171

NS = Not significant at $p<0.05$, * = $p<0.05$, ** = $p< 0.01$; *** = $p< 0.001$; **Ap** = FFS Facilitation Approach, **Ag** = Age; **Ge** =Gender; **Ms** = Marital status; **Ed** = Educational level; **In** = Income per year; **Fs** = Farm size; **Oc** = Occupation; ± = Mean ± standard deviation

Among the non-adopters who were women, the F-FFS trained farmers had a higher mean adoption rate (7.79) than E-FFS (2.17). With regard to the non-adopters who were men F-FFS trained farmers had a higher mean score (5.43) than the E-FFS trained farmers (0.67). Among the non-adopters who were youth, the F-FFS trained farmers had a higher mean adoption rate (3.07) than E-FFS trained respondents (0.17). Among the PPT non-adopters who were widows, F-FFS trained farmers had a higher mean adoption rate (1.07) than E-FFS trained farmers (0.17). There were significant differences between F-FFS and E-FFS for the number of respondents who had not adopted PPT ($p<0.05$), for the non-adopters who were men ($p<0.05$), and for the non-adopters who were women ($p<0.05$). Therefore, the null hypothesis is retained in this case.

Table 22 indicates the diffusion rates for PPT from individual farmers in percentages. A slightly higher percentage of farmers (58%) had been reached by E-FFS trained farmers than the percentage of farmers (42%) reached by F-FFS farmers. Also, a higher percentage (60%) of E-FFS trained farmers had learnt and adopted PPT than F-FFS trained farmers (40%).

Table 22: Percentage Diffusion of PPT from Individual Farmers by FFS Approach

Diffusion from individual farmers	**Percentage number of farmers**			
	F-FFS (n=60)		**E-FFS (n=111)**	
	Count	%	Count	%
Non-FFS farmers reached	2,410	42	3,333	58
Non-FFS farmers who adopted	493	40	986	60

This may be because E-FFS farmers had their activities organized, facilitated and funded by extension officers. Also, the extension officers would visit the farmers who had been trained and measured out the PPT plots for them. The F-FFS may not have had enough time and resources to do a lot of promotional and follow-up activities.

Table 23 presents the t-test results of diffusion of PPT from individual farmers. F-FFS reached a higher mean number of farmers (40.17) than E-FFS (30.3) in the diffusion of PPT knowledge from adopters to other farmers. However, E-FFS approach registered a higher average number (9.73) of follower farmers adopting PPT than F-FFS (6.65). The diffusion had no significant differences between F-FFS and E-FFS.

Table 23: Mean Score for the Diffusion of Knowledge from Individual Farmers by FFS Approach

Technology aspect tested	FFS Approach (Ap)		Significance of the independent variables								
	F-FFS (n=60)	E-FFS (n=111)	t-value	Ap	Ag	Ge	Ms	Ed	In	Fs	Oc
Farmers who learnt from farmer	40.17	30.3	-1.55	NS	NS	NS	NS	NS	NS	NS	NS
Number who adopted	6.65	9.73	0.88	NS	NS	NS	NS	NS	NS	NS	NS

df = 171

NS = Not significant at $p<0.05$, * = $p<0.05$, ** = $p< 0.01$; *** = $p< 0.001$
Ap = FFS Facilitation Approach, **Ag** = Age; **Ge** =Gender; **Ms** = Marital status; **Ed** = Educational level; **In** = Income per year; **Fs** = Farm size; **Oc** = Occupation; ± = Mean ± standard deviation

Table 24 summarises the percentage of farmers reached by groups and those who adopted what they learnt. This gives us the diffusion rate for PPT from FFS groups. A higher percentage of farmers (82%) had been reached by F-FFS groups than the percentage of farmers (18%) reached by E-FFS groups. A higher percentage of E-FFS trained farmers

(66%) had adopted PPT than F-FFS trained farmers (34%).

Table 24: Percentage Diffusion of PPT at Group Level by FFS Approach

Level of Diffusion	Percentage number of farmers				
	F-FFS (n=60)		E-FFS (n=111)		Total
	Count	%	Count	%	
Non-FFS Farmers Reached	1921	82	423	18	2344
Non-FFS Farmer who adopted	123	34	237	66	360

This maybe because F-FFS groups were many (12) compared to E-FFS groups (6), which may imply that the activities of F-FFS were wide-spread more than E-FFS activities and therefore, may have managed to reach more follower farmers.

Table 25 presents t-test results for diffusion from FFS groups. Among the farmers who had been reached by FFS groups, F-FFS had a higher mean score (137.21) than E-FFFS (70.50). Among the reached farmers who adopted PPT, E-FFS farmers had a higher mean score (39.50) than F-FFS farmers (8.79).

Table 25: Mean Score for Diffusion of PPT from Groups by FFS Approach

SR No	Technology aspect tested	FFS approach (Ext)		Significance of the independent variables							
		F-FFS (n=60)	E-FFS (n=111)	Ap	Ag	Ge	Ms	Ed	In	Fs	Oc
1	No of N-FFS farmers you reached	137.21 ±146.7	70.50 ±91.58	NS	NS	NS	NS	NS	NS	NS	NS
2	N-FFS Farmers who adopted PPT	8.79 ±12.93	39.50 ±50.81	*	NS	NS	NS	NS	NS	NS	NS
3	How many of them joined your FFS	3.79±2.6	3.83±6.2	NS	NS	NS	NS	NS	NS	NS	NS

df = 171

NS = Not significant at $p<0.05$, * = $p<0.05$, ** = $p< 0.01$; *** = $p< 0.001$; **Ap** = FFS Facilitation Approach, **Ag** = Age; **Ge** =Gender; **Ms** = Marital status; **Ed** = Educational level; **In** = Income per year; **Fs** = Farm size; **Oc** = Occupation; ± = Mean ± standard deviation

Among the reached farmers who had joined the FFS, E-FFS trained farmers had a higher mean score (3.83) than F-FFS trained farmers (3.79). There were significant differences between E-FFS and F-FFS in the number of non FFS farmers who had adopted PPT after being reached by the FFS groups ($p<0.05$). So, there was not enough evidence to support the null hypothesis. There may be a number of reasons for these differences including the ability of extension officers to provide training and even the planting materials like Desmodium which is not easy to access. That is because extension officers may have had an advantage of being facilitated to reach farmers, measure plots for them, and even provide Desmodium seed.

4.2.3 Yields of maize grown under PPT

H_O3 There is no statistically significant difference in the efficacy of F-FFS and E-FFS in maize yields achieved through Technology by farmers using these approaches.

In order to test for significance of the differences in efficacies in maize yields achieved through PPT between F-FFS and E-FFS trained farmers, independent t-test was used and the following results are contained in Table 27: mean scores, standard deviation, t-value, and two-tailed significance (p-value) by approach and moderator variables.

Table 26 presents the percentage of farmers achieving various maize yields for two years, 2006 and 2007. Average yields were computed for purposes of getting the percentages of farmers achieving various yields. A higher percentage (49%) of F-FFS trained farmers achieved higher maize yields (201-700 kgs) from the PPT plot than the percentage of E-FFS trained farmers (22%) who achieved the same high yields (201-700 kgs) from a PPT plot of 10 x 10 metres. The differences were statistically significant ($p< 0.05$).

Table 26: Percentage of Farmers Achieving Various Yield Levels by FFS Approach

Level of maize Yields	Percentage number of farmers	
	F-FFS (n=60)	E-FFS (n=111)
	%	%
≤ 100	2	48
101-200	30	23
201-300	27	7
301-400	8	5
401-500	8	4
501-600	3	2
601-700	3	2
Total	100	100

Table 27 presents the results of t-test for maize yields. In the first year of harvest, F-FFS trained farmers had a higher mean yield (197.28) than E-FFS (103.84). In the second year F-FFS still had a higher mean yield (208.8) than E-FFS (116.86). There were significant differences ($p < 0.05$) in maize yields as a result of farmer training through the F-FFS and E-FFS facilitation approaches.

Table 27: Mean Score for Maize Yields under PPT by FFS Approach

Technology Aspect Measured	FFS Approach (Ap)		Significance of the independent/M variables							
	F-FFS (n=60)	E-FFS (n=111)	t-value	Ap	Ge	Ms	Ed	In	Fs	Oc
Kgs of maize harvested first year	197.28 ±108.3	103.25 ±119.1	5.05	***	NS	NS	NS	NS	NS	NS
Kgs of maize harvested 2nd Year	208.8 ±108.43	116.85 ±127.32	4.74	***	NS	NS	NS	NS	NS	NS

df = 171

NS = Not significant at $p<0.05$, * = $p<0.05$, ** = $p< 0.01$; *** = $p< 0.001$; **Ap** = FFS Facilitation Approach, **Ag** = Age; **Ge** =Gender; **Ms** = Marital status; **Ed** = Educational level; **In** = Income per year; **Fs** = Farm size; **Oc** = Occupation; ± = Mean ± standard deviation

The hypothesis that there is no statistically significant difference in the efficacies of F-FFS and E-FFS in the PPT maize yields attained by farmers using these approaches was not supported with the F-FFS farmers getting higher maize yields than the E-FFS farmers. This observation maybe explained by the fact that the F-FFS respondents may have afforded to purchase and use fertilizer, while the E-FFS trained farmers may have developed a dependence on extension for free inputs, as much as it could be attributed to lower income levels for E-FFS as compared to F-FFS as shown under farmer general characteristics.

4.2.4 Costs incurred by FFS farmers in learning and practicing PPT

H_O4 There is no statistically significant difference in the efficacies of F-FFS and E-FFS in PPT learning costs incurred by farmers.

In order to test for significance of the differences in efficacies in PPT costs between F-FFS and E-FFS trained farmers, independent t-test was used. The summary table for t-test contains mean score, standard deviation, t-value, and two-tailed significance (p-value) by approach and moderator variables. The costs were collected from farmers as ratio variables, but had to be categorized to fit in a sizeable table due to space.

Table 28 presents the percentage numbers of individual farmers incurring various costs. Over 80% of the farmer individual costs, both for F-FFS and E-FFS, lie within the range of Ksh 1000 or less. Six to 38% percent of the costs range from Ksh 1001 to Ksh 2000. The farmer individual costs were almost similar. This is probably because the study areas lie within the same socio-economic region with similar costs for the production factors which are, land, labour and capital. Farm inputs also were sold to farmers at the same prices.

Table 28: Percentage Number of Farmers Incurring Various Costs by FFS Approach

Levels of Farmer Costs (Ksh)		Percentage Number of Farmers	
		F-FFS (n=60)	E-FFS (n=111)
Land preparation	≤ 1000	85	80
	1001-2000	10	12.6
	2001-3000	0	4.5
	3001-4000	0	0
	4001- 5000	0	0
	5001-6000	2	1.8
	≥ 6001	3	1
Maximum Cost	6000		
Input costs	≤ 1000	56.7	78.4
	1001-2000	38.3	8.1
	2001-3000	0	5.4
	3001-4000	1.7	5.4
	4001-5000	0	0
	5001-6000	1.7	0.9
	≥ 6001	1.7	1.8
Maximum Cost	5400		
Weeding costs	≤ 1000	85	87.4
	1001-2000	6.7	9
	2001-3000	6.7	0.9
	3001-4000	0	1.8
	4001- 5000	0	0
	5001-6000	0	0.9
	≥ 6001	0	0
Maximum Cost	6000		
Top-Dressing	≤ 1000	81.7	84.7
	1001-2000	18.3	7.2
	2001-3000	0	6.3
	3001-4000	0	1.8
	4001-5000	0	0
	5001-6000	0	0
	≥ 6001	0	0
Maximum Cost	4000		
Harvesting	≤ 1000	95	87.4
	1001-2000	3.3	9
	2001-3000	0	1.8
	3001-4000	1.7	1.8
	4001-5000	0	0
	5001-6000	0	0
	≥ 6001	0	0
Maximum Cost	3070		

Table 28 continued.

Decobbing	≤ 1000	80	85.6
	1001-2000	11.7	8.1
	2001-3000	6.7	1.8
	3001-4000	0	1.8
	4001-5000	0	1.8
	5001-6000	0	0
	≥ 6001	1.7	0.9
Maximum Cost	8000		
Tours	≤ 1000	66.7	93.7
	1001-2000	21.7	3.6
	2001-3000	6.7	2.7
	3001-4000	5	0
	4001-5000	0	0
	5001-6000	0	0
	≥ 6001	0	0
Maximum Cost	3000		

df = 171

Table 29 presents the results of t-test for farmer individual costs. The costs were collected as specific ratio figures before being categorised. F-FFS costs for the various activities considered in this study show alternating means with F-FFS having higher means for seed, fertilizer, manure costs (992.74), harvesting labour costs (358.11), and contributions to tours (612.02), while E-FFS has higher mean costs for land preparation (780.73), weeding, gapping labour costs (499.905), top-dressing, fertilizer labour costs (528.24), and threshing labour costs (462.48).

Table 29: Mean Score for Farmer Individual Costs by FFS Approach

Technology aspect tested	Extension approach (Ap)		Significance of the independent variables						
	F-FFS (n=60)	E-FFS (n=111)	t - value	Ap	Ag	Ge	Ms	Ed	In	Oc
Land preparation costs	656 ±655	780.73 ±1052.82	-0.78	NS	NS	NS	NS	NS	NS	NS
Seed fertilizer/ manure costs	993 ±900	945.64 ±1421.74	0.23	NS	NS	NS	NS	NS	NS	NS
Weeding gapping labour costs	479 ±817	499.90 ±713.86	-0.17	NS	NS	NS	NS	NS	NS	NS
Top-dressing fertilizer and labour	472 ±459	528.24 ±805.25	-0.48	NS	NS	NS	NS	NS	NS	NS
Harvesting labour costs	359 ±366	353.56 ±586.50	0.06	NS	NS	NS	NS	NS	NS	NS
Decobbing labour costs	342 ±372	462.48 ±1019.68	-0.81	NS	NS	NS	NS	NS	NS	NS
Contributions for tours	612 ±714	105.19 ±249.04	6.41	*	NS	NS	NS	NS	NS	NS
Total cost	4732 ±3606	3929 ±4305	1.19	NS	NS	NS	NS	NS	NS	NS

df = 171

NS = Not significant at $p<0.05$, * = $p<0.05$, ** = $p< 0.01$; *** = $p< 0.001$
Ap = FFS Facilitation Approach, **Ag** = Age; **Ge** =Gender; **Ms** = Marital status; **Ed** = Educational level; **In** = Income per year; **Fs** = Farm size; **Oc** = Occupation; ± = Mean ± standard deviation

There were no statistically significant differences in the FFS farmer individual costs between F-FFS and E-FFS, except on one item of farmer contributions for tours ($P<0.05$). The results support the null hypothesis. The farmers were from study areas in neighbouring districts with similar socio-economic conditions. The costs of inputs and labour were the same, which may explain why there were no statistically significant differences in costs between F-FFS and E-FFS.

Table 30: Percentage of FFS Groups Incurring Various Costs by FFS Approach

Levels of Farmer Costs		Percentage Number of Farmers		Levels of Farmer Costs	
		F-FFS (n=60)		E-FFS (n=111)	
		Count	%	Count	%
Land prep farm inputs costs Yr 1	≤2500	14	100	2	33
	2501-5000	0	0	2	33
	5001-7500	0	0	0	0
	7501-10000	0	0	1	17
	> 10000	0	0	1	17
Land prep farm inputs costs Yr 2	≤2500	12	86	3	50
	2501-5000	1	7	1	17
	5001-7500	1	7	1	17
	7501-10000	0	0	0	0
	> 10000	0	0	1	17
Learning materials costs Yr 1	≤2500	6	43	3	50
	2501-5000	3	21.5	2	33
	5001-7500	3	21.5	1	17
	7501-10000	2	14	0	0
	> 10000	0	0	0	0
Learning materials Costs Yr 2	≤2500	9	64	3	50
	2501-5000	1	14	1	33
	5001-7500	2	14	0	17
	7501-10000	1	7	0	0
	> 10000	0	0	0	0
Land rent for FFS P-Pull plot Yr 1	≤2500	12	86	6	100
	2501-5000	2	14	0	0
	5001-7500	0	0	0	0
	7501-10000	0	0	0	0
	> 10000	0	0	0	0
Land rent for FFS P-Pull plot Yr 2	≤2500	13	93	5	83
	2501-5000	1	7	1	17
	5001-7500	0	0	0	0
	7501-10000	0	0	0	0
	> 10000	0	0	0	0

df = 171

Table 30 presents the costs incurred by FFS groups in various activities. The costs were collected from groups as ratio variables, but had to be categorized to fit in a sizeable summary table. Over 83 % of both F-FFS and F-FFS groups paid Ksh 2000 or less as land rent for FFS activities. Learning materials cost up to Ksh 10,000 for F-FFS groups, and slightly less up to Ksh 7000 for E-FFS groups because F-FFS groups were mostly self-reliant, while E-FFS depended on supplies from Government. Costs of farm inputs

and land preparation were slightly higher for E-FFS than they were for F-FFS. However, the differences were not significant. The farmers were from study areas in neighbouring districts with similar socio-economic conditions. The costs of inputs and labour were the same, which may explain why there were no statistically significant differences in costs between F-FFS and E-FFS.

Table 31 presents the results of t-test for FFS group costs. FFS costs for the various activities considered in this study show alternating means.

Table 31: Mean Score for Group Costs by FFS Approach

SR No	Technology aspect tested	Extension approach (Ap)		Significance of the independent variables							
		F-FFS (n=60)	E-FFS (n=111)	t-value	Ap	Ge	Ms	Ed	In	Fs	Oc
1	Land prep costs Yr1	1181.71 ±680	8255.00 ±1097	-2.49	*	NS	NS	NS	NS	NS	NS
2	Land prep costs Yr2	1362.31 ±1513	3480.00 ±4348	-1.58	NS	NS	NS	NS	NS	NS	NS
3	Learning materials costs Yr 1	3335.71 ±3335	1870.00 ±1634	0.84	NS	NS	NS	NS	NS	NS	NS
4	Learning materials costs Yr 2	2135.38 ±3226	1200.00 ±1904	0.54	NS	NS	NS	NS	NS	NS	NS
5	Land rent for FFS P-Pull plot Yr 1	935.71 ±1059	626.67 ±1085	0.46	NS	NS	NS	NS	NS	NS	NS
6	Land rent for FFS P-Pull plot yr 2	553.85 ±976	840.00 ±1454	-0.42	NS	NS	NS	NS	NS	NS	NS

df = 171

NS = Not significant at $p<0.05$, * = $p<0.05$, ** = $p< 0.01$; *** = $p< 0.001$; **Ap** = FFS Facilitation Approach, **Ag** = Age; **Ge** =Gender; **Ms** = Marital status; **Ed** = Educational level; **In** = Income per year; **Fs** = Farm size; **Oc** = Occupation; ± = Mean ± standard deviation

F-FFS had higher means for learning material costs for year one (Ksh 3335.71) and year two (Ksh 2135.38) and land rent costs for year one (Ksh 935.71). E-FFS had higher mean costs for land preparation in year one (Ksh 8255), land preparation costs in year two (Ksh 3480), and land rent costs for year two (Ksh 840). There were no significant differences for the FFS costs between F-FFS and E-FFS, except on one item of land preparation for year one ($p<0.05$). The costs of inputs and labour were the same in the two study districts given that they have the same socio-economic conditions, which may explain why there were no statistically significant differences in costs between F-FFS and E-FFS approaches.

4.3 Summary of the Main Findings

E-FFS trained farmers had a slightly higher percentage of farmers (90%) knowledgeable on PPT general agronomic practices than F-FFS (85%). E-FFS and F-FFS trained farmers had the same percentages of farmers (2%) who were not sure of some PPT general agronomic practices. F-FFS trained farmers had a slightly higher number of farmers (13 %) who were not knowledgeable on some PPT general agronomic practices than E-FFS trained farmers (8%). E-FFS trained farmers scored a slightly higher overall mean score regarding general agronomic practices (3.73) than the F-FFS trained farmers (3.42). In two of the technology aspects tested, E-FFS trained farmers had higher mean scores than F-FFS trained farmers. E-FFS trained farmers scored a higher overall mean score (3.73) than the F-FFS trained farmers (3.42). The difference was not statistically significant ($p<0.05$). These results support the hypothesis that there is no statistically significant difference in the efficacies of F-FFS and E-FFS in the PPT knowledge gained by farmers using these approaches.

Regarding the PPT spacing on average, a less percentage of F-FFS trained farmers (9.9 %) scored less than 10 % while a higher percentage of E-FFS trained farmers (66.6%) scored less than 10 % while a higher percentage of E-FFS trained farmers (89.9%) scored over 50% marks than E-FFS trained farmers (33.3%). F-FFS trained farmers had a higher overall mean score (6.72) and were therefore more knowledgeable on PPT knowledge regarding complex issues than E-FFS trained farmers (4.24). The difference is

no statistically significant difference in the efficacies of F-FFS and E-FFS in the PPT knowledge gained by farmers using these approaches. This observation maybe explained by the fact that the F-FFS facilitation reduces farmer dependence on the extension staff, and makes them more self-reliant in practicing PPT on their farms. They were able to give the measurements of their PPT plots and spacing of the crops. The E-FFS farmers may have been dependent on the extension staffs, their plots were measured by the extension staff and planting done in the presence and with participation of extension staff. They may have not taken time to internalize the measurements, because they expect the extension staff to measure for them again when they expand. They could not tell the sizes of their PPT plots. However, since the F-FFS trained farmers were more knowledgeable in the majority of the technology aspects tested, the F-FFS is thus a better approach in technology dissemination than is the E-FFS, in the knowledge aspects tested.

Regarding PPT knowledge self-rating scales a slightly higher percentage of F-FFS rated themselves as excellent in knowledge of Push- Pull technology (29.79%) than E-FFS (25.27%). However, the differences were not significant ($p<0.05$). The results gave no significant differences between farmers trained through F-FFS and those trained through E-FFS for six of the technology aspects. This maybe because the farmers rated themselves in similar ways, since over 90% of the farmers from both approaches rated themselves as excellent and very good in PPT. Both F-FFS and E-FFS respondents believed that they were very knowledgeable in PPT.

Analysis of data on the competencies of F-FFS and E-FFS trained farmers on a self-rating scale gave no significant differences between farmers trained through F-FFS and those trained through E-FFS for six of the technology aspects. This maybe because the farmers rated themselves in similar ways, over 90% rated themselves as excellent in competence and very competent in PPT. Both F-FFS and E-FFS respondents believed that they were very knowledgeable in PPT. On how PPT plots were prepared, F-FFS trained farmers rated themselves higher (78.5) than E-FFS trained farmers (64.7). On this technology aspect the differences were significant ($p< 0.05$). These findings concur with the ones of Van de Fliert *et al.* (1993) and Godtland, Sadoulet, de Janvry, Murgai, and Ortiz (2004),

that participation in FFS training significantly enhanced farmers` knowledge and production skills. The FFS approach used to train farmers on aspects of PPT may have had a major influence on the level of knowledge.

On the adoption of PPT, the E-FFS groups had more members who had adopted PPT on their farms than the F-FFS groups. E-FFS was better fitted in enhancing the adoption of PPT by FFS members. On PPT diffusion from F-FFS and E-FFS trained farmers, the results showed that E-FFS had a higher number of non-FFS farmers who adopted PPT than F-FFS farmers. There were significant differences between E-FFS and F-FFS in the number of non FFS farmers who had adopted PPT after being reached by the FFS groups. Both F-FFS and E-FFS groups organized Field days and demonstrations to pass PPT knowledge and skills to neighbouring farmers. It may have been more expensive for F-FFS who had to pay for it, as opposed to E-FFS who may have got financial or logistical support from extension agents. That maybe one reason why E-FFS was better at diffusion and adoption of PPT, since even gender issues and understanding of the technology for resenting husbands could have been addressed during such functions.

Regarding expansion of PPT plots at farm level, over 90% of the PPT plots retained the initial establishment sizes. Farmers gave many reasons why they had not been able to expand. These included, small land sizes, presence of sugarcane on the farm, inability to plant other crops like sweet potatoes, sugarcane and cassava under push-pull, gender issues where women cannot tell their husbands to give more space for PPT and general shortage of affordable Desmodium seed . Both F-FFS and E-FFS farmers found PPT to be labour intensive, therefore dealing with small plot sizes with almost no expansion since initial establishment. These reasons were cross-cutting across the F-FFS and E-FFS approaches and they affected both adoption, expansion of PPT plots and diffusion to other farmers outside FFS groups. This is also in accordance with the results of Bunyatta (2006) which showed that significant dissemination of knowledge took place from FFS to non-FFS farmers.

F-FFS trained farmers achieved more yields than E-FFS trained farmers. This might have

been probably because F-FFS had more people educated to secondary school level, therefore, having better paying occupations, and probably better at making decisions, therefore, might have used fertilizer and certified seed, and other farm inputs. This is in accordance with the findings of Makori (2006) and Feder *et al.* (2003) who say "FFS learning process aims to affect farmers' knowledge" which includes the possession of analytical skills, critical thinking, ability to make better decisions, familiarity with agricultural practices and understanding of interactions within the agricultural ecosystem. Therefore, FFS approach empowers smallholder farmers with knowledge and skills. The F-FFS approach was better fitted at enhancing farmer knowledge, and enhancing the productivity of the PPT plots by giving higher maize yields than E-FFS. This observation agrees with Godtland *et al.* (2004) and Medina *et al.* (1999) who found that farmers with higher levels of knowledge and skills got significantly higher levels of productivity. This further agrees with Bartlett (2005) who found that FFS in Asia helped many farmers to improve crop yields and to be empowered in developmental matters.

There were no significant differences between F-FFS and E-FFS in farmer production costs; therefore the null hypothesis was sustained. This may be because the E-FFS and F-FFS respondents were sampled from areas with similar socio-economic conditions whereby the labour costs and input costs were almost similar therefore, giving no differences. However, many of the respondents used family labour which was costed according to prevailing rates of casual labour, for the particular years. Some used manure and that was costed at market rates too.

Some of the matters affecting productivity include, farmers use of own maize as seed instead of certified seed due to what some explained as low purchasing power, or shortage of funds. According to this study, the average production costs per farmer per FFS plot was US $ 55, while the mean yield was 18 Kg per plot, which gave US $ 46 earnings for the farmer. The time had not come for farmers to realize financial benefits from PPT plot yields, because the first goal is food security, which is yet to be attained given the small sizes of the plots, with minimal expansion over the years. This does not fully concur with a study by Bartlett (2005) which indicated that the average production

costs per FFS participant ranges from US $ 18 to US $ 250. The results of Bartlett's study led to the conclusion that the FFS benefits to participants in a single cropping season were considerably greater than the costs of conducting the training. This may be because the study area and population had different socio-economic conditions than those of in this study.

Table 32: Main Study Findings by FFS Approach

Characteristic	Main Findings	
	F-FFS (n=60)	**E-FFS (n=111)**
Farmer knowledge	Better at complex aspects of the PPT like spacing and measurements. Good at the basic agronomic practices	Good at basic agronomic practices Poor at measurements and spacing
Adoption	Poor at adoption with only 30% adoption rate	Good at adoption with 70% adoption rate
Yields	Achieving higher maize yields	Achieving less maize yields
Costs	No significant differences	No significant differences

Results of data analysis stipulate that there were more males within the F-FFS (63.3%) than the E-FFS (36.7%) approach. The E-FFS had more female (73.8%) respondents than the F-FFS category. The analysis indicates that the gender of the respondents had statistically significant ($p< 0.05$) influence on the uptake and application of the introduced technologies.

The results show that occupation significantly differs across the two FFS approaches in catalyzing the uptake and use of the introduced technologies ($p<0.05$). More E-FFS respondents were farmers (63%), while E-FFS had fewer farmers (37%), with other respondents engaged in employment (3.6%), and small businesses (1.7%). The occupation of the respondents may empower the farming communities with the resources and capacity to pick and apply the introduced technologies.

There were higher percentages of farmers with secondary education within the F-FFS

(45.5%) than the E-FFS (14.0%) category. There were more E-FFS (63.4 %) respondents having primary education than those within the F-FFS (40.4 %). The E-FFS had more respondents (21.5%) with no formal education at all, than the F-FFS (5.3%). Analysis of data showed that education level had statistically significant influence on the uptake and application of the introduced technologies ($p<0.005$). The more educated farmers could do the measurements on their own and know them by heart, while the less educated had not internalized the measurements and might have depended on the facilitator to do the measurements for them.

This, however, contradicts the findings of Makori (2006) who found out that deriving higher knowledge and skills from participation in dairy FFS was not in any way affected by the level of education of the participants. The same conclusion was made by Godtland *et al.* (2004) who, when evaluating the impact of sweet potato FFS on knowledge and productivity of sweet potatoes in the Peruvian Andes, found that the level of education had no effect on farmers' knowledge and skills. The results they found do concur with this study findings on general agronomic practices, which had no significant differences. However, when it comes to complex aspects of the PPT, formal education had significant influence. This may apply to any other technology that has complex practices involving many specific measurements in one small place.

The mean average yearly incomes for F-FFS were higher (Ksh. 12,133) than E-FFS (Ksh. 2,448). The results indicated significant differences in average yearly incomes between the two FFS approaches ($p<0.05$). Uptake of the introduced technology may have been influenced by the average incomes the respondents got. The income differences between F-FFS and E-FFS trained farmers may have been due to their occupations which may be explained by differences in education levels.

The results showed that land size had no statistical significance across the two types of FFS approaches in catalyzing the uptake and application of the introduced technologies ($p < 0.05$). The size of the land that a farmer owns may have not influenced the uptake and application of the introduced technology. This may be due to the fact that land sizes

were small, against many competing uses both for F-FFS trained farmers and E-FFS farmers. Crops like sugarcane, sweet potatoes, cassava and local vegetables were among the competing enterprises that both F-FFS and E-FFS required for their subsistence, in addition to maize. Similarly, both F-FFS and E-FFS farmers found PPT to be labour intensive, therefore dealing with small plot sizes with almost no expansion.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter presents a summary of the study, the conclusions drawn and recommendations given based on the key findings. The chapter is organised to highlight the key components of the study, based on the details presented in the previous chapters.

5.2 Summary

FFS extension approach was initially conceptualised to enhance knowledge and skills in management of crops, crop pests, soil and water conservation technologies (Minjauw *et al.*, 2003). To replicate its successes, FFS was extended to PPT and smallholder dairy production, among others, as an alternative to the conventional extension approaches. FFS started by training extension staff as facilitators, who trained farmers for a season and made farmer graduates, who were also mandated to go and start FFS groups. In the process, the two facilitation approaches were in use, with some efforts to phase out E-FFS approach, in order to empower farmers to manage their own affairs. This study aimed at comparing the efficacies of F-FFS approach and E-FFS approaches, with the ultimate aim of identifying the most efficacious facilitation approach that best enhances farmer knowledge acquisition, adoption and higher yields at lesser costs. The knowledge and adoption test and self-rated scales were based on the FFS curriculum, which is similar in the F-FFS and E-FFS. The objectives of this study were developed from the context of the FFS curriculum. The hypotheses tested were that, there is no statistically significant difference in knowledge acquired, in adoption levels achieved, in yields of maize achieved, and in costs incurred, between farmers trained on PPT through the F-FFS and E-FFS approaches, under smallholder conditions in Bungoma South and Busia Districts.

Many management aspects of crops, crop pests, and soil and water conservation were not similar to those used in maize production using PPT. This raises the question as to whether the successes of FFS in crops, integrated pest management, soil and water

management, can be replicated successfully in disseminating PPT to smallholder maize production systems. This study adopted a conceptual framework based on a modified version of Feder *et al*'s FFS model and adult learning theories which stipulate that FFS learning process aims to affect farmers' knowledge, which can be interpreted to include the possession of analytical skills, critical thinking, and ability to make better decisions. Improved knowledge is, in turn, reflected in farmers' cultivation procedures, input decisions, and crop yields.

Farmers' participation in FFS extension approach was the main independent variable that was in focus. Farmers' knowledge, adoption, maize yields and costs incurred were the dependent variables measured in this study. Purposive sampling procedure was undertaken where all the FFS farmers, who have adopted PPT, were included in the study. This was because, despite the big figures of FFS memberships, not all the farmers had adopted PPT on their farms. The study population covered PPT adopters, where the dependent variables were knowledge of PPT adoption, costs and maize yields.

Data collection was done using two structured questionnaires containing items on knowledge adoption, costs and yields. The first questionnaire included farmer individual characteristics, farmer individual learning costs, PPT knowledge and adoption test score, self-rating scales on knowledge and competence on PPT aspects. The second questionnaire was for group characteristics and adoption of PPT at FFS level, which included FFS general characteristics, adoption statistics and learning costs.

The questionnaire's reliability was assessed for ease of comprehension and clarity using the internal consistency technique. Its validation was through intense discussions and modifications by peers and faculty experts who ensured it measured what it was actually meant to measure. The researcher physically administered the questionnaire. The data was organized, cleaned, edited and entered into SPSS version 11.5 software for further processing and analysis. Knowledge was measured on ability to correctly answer questions on PPT agronomic practices, whose answers were true or false, and stating the measurements they had used on their PPT plots. Farmers self-rated their knowledge and

Hypothesis testing was done at 5% level of significance. T-test was used to compare the differences in means of the farmer knowledge on PPT agronomic practices measured in percentage test score. This was done by fitting extension approach (F-FFS and E-FFS) as the independent variable and farmer's knowledge, adoption, maize yields and production costs as the dependent variables. Man-Whitney U test was used to compare the proportions of F-FFS and E-FFFS farmers according to the way they rated themselves on knowledge and competence scales. Statistical tests on most of the dependent variables that were examined rejected the null hypothesis that there were no statistically significant differences in the knowledge, adoption and yields, between farmers trained through the F-FFS and E-FFS extension approaches. Tests of all the four hypotheses of the study were based on the premise that, both F-FFS and E-FFS approaches had no statistically significant influence on knowledge, adoption, yields and costs of PPT implementation.

Three of the tested hypotheses revealed significant differences in efficacies of the two FFS approaches in PPT dissemination and adoption. Three of the hypotheses were rejected. FFS facilitation approach showed significant differences in efficacy between the F-FFS and E-FFS farmers, in knowledge acquired, adoption of PPT, and average maize yields achieved by farmers. Improved knowledge is, in turn, reflected in farmers' cultivation procedures, input decisions, and crop yields.

5.3 Conclusions

Results of data analysis support the conclusion that FFS approach enhanced farmers` knowledge of technologies and practices. F-FFS approach increased the smallholder farmer knowledge for both general agronomic practices and for the more complex technology aspects, while E-FFS increased farmer knowledge mainly on the general agronomic practices. F-FFS trained farmers were able to train more non-FFS farmers on PPT than E-FFS trained farmers causing PPT to diffuse beyond the FFS group members. On the self-rated scales regarding competence in implementing PPT and knowledge of PPT, the results gave no significant differences between farmers trained through F-FFS

and those trained through E-FFS. Over 90% of both F-FFS and E-FFS trained farmers, rated themselves as excellent in PPT knowledge and competence. Both F-FFS and E-FFS respondents believed that they were very knowledgeable in PPT and very competent in the implementation of PPT.

There was a significant difference in PPT adoption as a result of farmer training through the F-FFS and E-EFFS facilitation approaches. E-FFS approach significantly increased adoption of PPT among the group members than the F-FFS approach. For these PPT adopters, the results of data analysis indicated no significant differences between F-FFS and E-FFS on expansion of PPT plots, since initial establishment. Over 90% of the PPT plots retained the initial establishment sizes. Farmers gave many reasons why they had not been able to expand, which included: small land sizes, presence of sugarcane on the farm, inability to plant other crops like sweet potatoes, sugarcane and cassava under push-pull, gender issues where women may have not been able tell their husbands to give more space for PPT and general shortage of accessible and affordable Desmodium seed. These reasons were cross-cutting between the F-FFS and E-FFS approaches.

The results of data analysis on diffusion of PPT knowledge indicated that a higher number of non-FFS farmers, reached by E-FFS trained farmers adopted PPT than farmers reached by F-FFS trained farmers. There were significant differences between E-FFS and F-FFS in the number of non-FFS farmers who have adopted, after being reached by the FFS individual members and FFS groups. FFS groups reached farmers through field days and demonstrations, while individual farmers transferred knowledge to farmers who came on study tours or visits.

The results of data analysis indicated that there were significant differences in maize yields as a result of farmer training through the F-FFS and E-EFFS facilitation approaches. F-FFS trained farmers achieved higher maize yields than E-FFS trained farmers in the second year of PPT adoption. Maize yields increase is a sum total of the use of fertilizer, certified maize seed, the effects of Desmodium in nitrogen fixation, humus input into the soil and proper PPT plot management.

The results of data analysis indicated that there were no significant differences between F-FFS and E-FFS approaches, regarding variable costs of PPT learning and adoption. The farmer individual costs and FFS group costs were almost similar, probably because the study areas were within the same socio-economic region, with similar costs for the production factors which are land, labour and capital.

Analysis of data showed that education level significantly differed between F-FFS and E-FFS approaches. This observation alludes to the view that educational level probably had an influence on the way farmers learnt and used PPT. Occupation of farmers significantly differed between F-FFS and E-FFS approaches. E-FFS had more respondents, whose occupation was farming, than F-FFS trained farmers. This observation probably explains why the E-FFS trained farmers had adopted PPT more than F-FFS trained farmers. Gender diferred significantly between F-FFS and E-FFS approaches. The E-FFS had more female respondents than the F-FFS category. This observation may explain why PPT adoption was higher in E-FFS trained farmers than F-FFS trained farmers, since women were the farmers in majority of the cases. Income levels differed significantly between F-FFS trained farmers and E-FFS trained farmers. This meant that the average yearly incomes for F-FFS trained farmers, was higher than that of E-FFS trained farmers.

5.4 Recommendations

The following recommendations have been suggested from the findings and conclusions of the study and will be availed for possible use by ICIPE, M.O.A, M.o.L.D, KARI, and FFS Farmers in specific and all other stakeholders.

1. This is the only study known to the researcher that addressed efficacies of F-FFS and E-FFS, and only provides the foundational results, in which case more studies on this subject are required to provide a significant body of knowledge on the same. In addition to this, a number of moderator variables like education, gender and occupation, significantly intervened in the results of this study. It is important therefore that further studies are conducted in different socio-economic

conditions to assess whether these results can be replicated to other areas outside the study areas.

2. These study results and literature review provided evidence that FFS approach increased farmer knowledge and adoption and also provided for diffusion of knowledge to other farmers who were not members of FFS groups. Both F-FFS and E-FFS approaches proved beneficial with F-FFS, showing better efficacy in farmer knowledge gained, and higher maize yields, and E-FFS having better efficacy in the adoption and diffusion of PPT. It will be beneficial for further research to be conducted to determine how to tap the benefits of both FFS facilitation approaches instead of thinking of phasing out one and concentrating on another.

3. This study recommends that where majority of the farmers tend to be illiterate, slow in learning and with low income levels, it may be beneficial to start E-FFS groups and train them to a point where they get more self-reliant, then they can be converted to F-FFS groups. Where farmers take in the knowledge faster, either because they were more literate or more committed or have access to higher incomes and can afford basic inputs, they may be given the basic foundational training on PPT and encouraged to proceed on as F-FFS. However, more studies are required in this subject for more solid conclusions, given that various researches had not revealed studies comparing these two FFS approaches (F-FFS and E-FFS).

4. The major reasons provided by respondents that had reduced adoption and expansion of PPT plots at farm level in F-FFS approach included lack of affordable and accessible Desmodium seed, small land sizes, presence of sugarcane that takes many years on the farm, the difficulty of planting other crops like sweet potatoes in the PPT plots and husbands not cooperating when wives wish to get space to plant maize under PPT or expand an existing plot (where only the women were FFS members). It is the recommendation of this study that

Desmodium be availed to farmers at affordable prices and that studies be done to see how to include other major crops in PPT plots in a beneficial manner, instead of some farmers uprooting the plots to get space for other crops. The sugarcane, which is a cash crop in the study areas, was a major hindrance to adoption and expansion of PPT. It is therefore important to study how sugarcane may be part of PPT because it is a major cash crop, a permanent crop on the farms, takes long on the farm, and most farmers may not do without it.

5. Adoption of PPT for F-FFS trained farmers was low partly because the F-FFS facilitators were overworked and not rewarded. They worked as volunteers with no pay attached to those positions, and had sometimes to walk long distances or go by bicycle to facilitate FFS under them. This meant that they had to put aside their personal chores and time to work on their farms, leading to laxity and lack of commitment for some, generally slowing down the process of PPT adoption. The Farmer facilitators under F-FFS require a system of remuneration in terms of compensation for their time spent doing FFS work, and transport for moving to and from the FFS, so that they may put more effort into facilitation. This may be considered and planned for at the FFS groups and networks, in collaboration with the extension staff.

6. Bartlett (2005) noted that it was difficult to generalise on costs of Farmer Field Schools, because there was no agreement about factors to be taken into account, and there was a high degree of variation in the value of individual factors. To bridge this gap in knowledge, further studies are required in F-FFS and E-FFS specifically identifying and setting the individual factors to be considered when studying FFS costs. The variable costs studied gave similar figures across the two study districts, which gave no significant differences in costs between the two FFS approaches. It is therefore necessary that studies comparing F-FFS and E-FFS approaches be conducted in places with different socio-economic conditions, and that through such studies, factors of production be standardized.

7. Some farmers whose wives were in FFS had not taken time to understand what PPT is and may have been opposing adoption or expansion out of ignorance of the actual benefits that go along with it. Therefore, targeted trainings and focus group meetings may need to be organized for the spouses who seem opposed to the technology, to let them make informed decisions.

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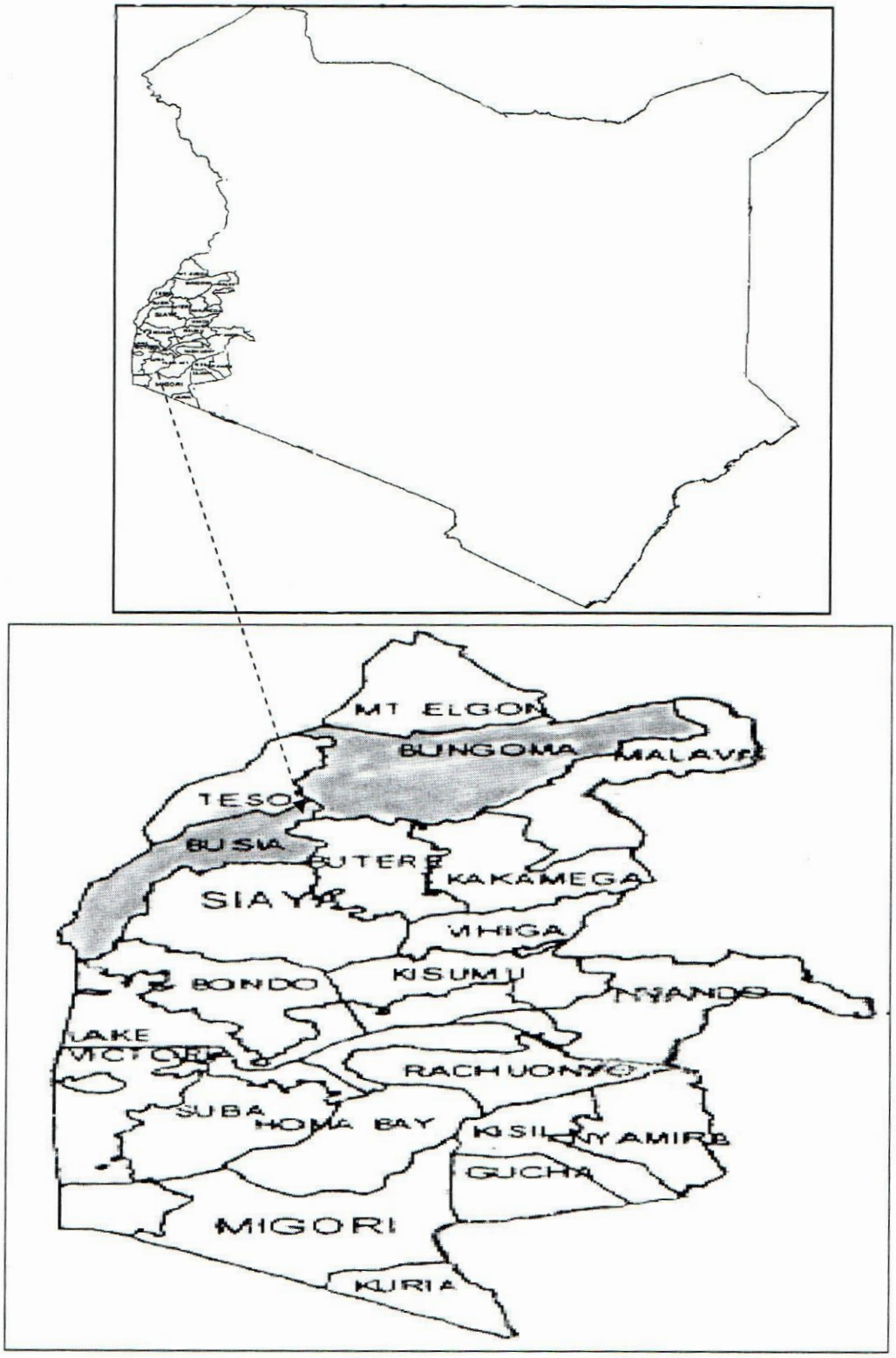
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APPENDICES

APPENDIX A: MAP OF THE STUDY LOCATION



APPENDIX B

PPT QUESTIONNAIRE FOR FFS PPTFARMERS

This study is intended to compare the various approaches used in dissemination of PPT. You have been selected to provide information for this study. Please answer the questions to the best of your knowledge. The information will be kept confidential.

SECTION A: FARMER CHARACTERISTICS

Date: _____ Case Number. _____

1. Please answer the questions by ticking in the bracket or writing in the line within the table below.

Mobile/home Phone number _____	Village _____	Sub-location _____	Location _____	Division _____	District _____
Marital status	Married [ ]	Widow [ ]	Single [ ]	None [ ]	
Gender	Male [ ]	Female [ ]			
Your Age group	≤ 20 [ ]	21-30 [ ]	31-40 [ ]	41-50 [ ]	Above 51 [ ]
Education level	None [ ]	Primary [ ]	Secondary [ ]	College [ ]	University [ ]
How much land do you own/rent?	Own(Acres) _____	Rent(acres) _____	Total(acres) _____		
Number of livestock owned	Local cattle _____ Crosses ____	Grade cattle _____	Dairy Goats _____	Local goats _____	Local sheep _____
Income per Year (Ksh.)	From farming _____	From business _____	Casual job _____	Employment _____	Any other _____
Occupation	Farmer _____	Employee _____	Small business _____	Any other _____	
Land tenure	Leasehold [ ]	Freehold [ ]	Communal	Any other [ ]	

2. Please indicate the year and season when you first planted maize using PPT, and the years and seasons you expanded your push pull fields and your current size of PPT field, including the plot sizes in the table below. Indicate the years, the seasons and the sizes in metres.

Year	Season	
	Long rains [ ]. Area: ____m x ___m	Short rains [ ]. Area: ____m x ___m
	Long rains [ ]. Area: ____m x ___m	Short rains [ ]. Area: ____m x ___m
	Long rains [ ]. Area: ____m x ___m	Short rains [ ]. Area: ____m x ___m
	Long rains [ ]. Area: ____m x ___m	Short rains [ ]. Area: ____m x ___m

3. Please indicate in the table below, the number of farmers who have learnt from you about push-pull, the number who have adopted after learning from you and the year they learnt from you.

Item	**In the Year**	**Number of farmers from your village**	**Number of farmers from outside your village**
How many farmers in total have inquired/learnt	**2006**		

from you on PPT?	**2007**		
	2008		
How many farmers planted PPT after learning from you?	**2006**		
	2007		
	2008		

4. Please indicate the **yields** from your PPT plots for the years **2006, 2007 and 2008** ***(Indicate in the table below)***.

Items	**Year**			
	2005	**2006**	**2007**	**2008**
How many Kgs or bags of maize did you harvest from your **PPT plot(s)**	a. _____ kgs **or** b. _____ bags	a. _____ kgs b. _____ bags	a. _____ kgs b. _____ bags	a. _____ kgs **or** b. _____ bags
Was the harvested maize enough for the family from the whole farm?	Until the next Harvest Yes [ ] No [ ]	Until the next harvest Yes [ ] No [ ]	Until the next harvest Yes [ ] No [ ]	Until the next Harvest Yes [ ] No [ ]
If **No** which months did you buy maize for your family?	_____	_____	_____	_____

5. Have some of your neighbours who were PPT farmers stopped planting maize using PPT in the last two years?

1. Yes [ ] 2. No [ ]

If **Yes,** how many have stopped planting push-pull? _____

If **Yes.** why do you think they stopped planting push-pull? _____

_____

_____

SECTION B FARMER INDIVIDUAL LEARNING COSTS

Please indicate the costs you incurred for the activities in the table below. Any other costs can be indicated in the extra rows.

Activities	2004	2005	2006	2007	2008
Land preparation costs.					
Seed and Fertilizer/manure costs					
Planting/ labour costs for Desmodium, maize and Napier grass (PPT plot)					
Weeding and gapping costs – Labour costs.					
Top-dressing costs- Fertilizer/ Manure and labour					
Harvesting costs- Labour and transport costs.					
Decobbing costs- Labour costs.					
How much did it cost you to go for tours?					

APPENDIX C

PPT KNOWLEDGE AND ADOPTION TEST

This test questionnaire shall measure farmer knowledge on PPT adoption. This includes a self-rating scale

1. Please read the statements in the table and ***indicate by ticking*** whether it is true or false or you are not sure (mark)

Indicators of Knowledge in PPT	**True**	**False**	**Not sure**
29. Desmodium is used as a repellent or 'push plant' in a PPT			
30. Napier grass is used as a trap plant or 'pull plant' in push-pull			
33. Napier grass produces sticky substance that kills moth larva.			
34. Desmodium legume contributes to soil fertility in PPT fields			
35. Desmodium produces a chemical that causes Striga seed to germinate			
36. Desmodium produces a chemical that hinders germinated Striga seed from attaching to the maize roots			

2. Please respond ***by ticking*** your level of knowledge on PPT according to the following scale.
   1. **Excellent**
   2. **Very good**
   3. **Good**
   4. **Poor**
   5. **Very poor**

Indicator of knowledge	**Level of Knowledge**				
	1	**2**	**3**	**4**	**5**
40. How Striga weed affects the maize plant.					
41. How Desmodium affects Striga and Stemborer in push-pull					
42. How Napier grass affects stemborer in push-pull					
43. How PPT increases yields of maize					
44. How to prepare land for a PPT plot					
45. How to Plant maize on a PPT plot					
46. How to plant Desmodium on a PPT plot					
47. How to plant Napier grass on a PPT plot					

3. Please indicate your competence to perform the skills for each of the following skills. The following scales are used:

1. Very competent
2. Fairly competent
3. Moderately competent
4. Incompetent
5. Very Incompetent

Please circle the number that best represents your response for each item.					
PPT Skills	***Competence Level***				
51. Layout of a PPT plot	1	2	3	4	5
52. Planting maize on a PPT plot	1	2	3	4	5
53. Planting Desmodium on a PP plot	1	2	3	4	5
54. Planting Napier grass on a PPT plot	1	2	3	4	5
56. Gapping Desmodium on a PPT plot	1	2	3	4	5
57. Weeding a PPT plot	1	2	3	4	5

4. How many rows of Napier grass did you plant around the maize in your PPT plot? (*Please tick in the space provided)*

a.) 2 [ ] b.) 3 [ ] c.) Any other (*indicate*) _____

5. At what spacing did you plant Napier grass between rows? (*Please indicate in the space below*) _____ cm

6. At what spacing did you plant Napier grass between plants in a row? (*Please indicate in the space below*) _____ cm

7. What spacing did you use to plant maize between rows on your PPT plot? (*Please indicate in the space below)* _____ cm,

8. At what spacing did you plant maize between plants in a row on your PPT plot? (*Please indicate in the space below)* _____ cm

9. At what distance did you plant Desmodium between rows? _____ cm

APPENDIX D

PPT QUESTIONNAIRE FOR FFS GROUP LEADERS

This questionnaire will be answered by FFS group leaders only.

SECTION A: FFS CHARACTERISTICS AND ADOPTION OF PUSH-PULL

This section measures the FFS group characteristics and learning costs incurred by the FFS as a group. This will give information on group characteristics and PPT adoption among FFS members.

1. Which year was your FFS started? _____

2. Did it start off as a PPT FFS? Yes [ ] No [ ]. If your answer is **No** then

   a) What activities was your FFS involved in before members started planting maize using PPT

_____ _____ _____ _____

   b). Which year did your FFS start PPT? _____

3. (a) How many members are there in your FFS? _____

   (b) How many of them are men? _____, women? _____, Youth? _____

widows? _____, widowers? _____, any other category indicate

_____ _____

4. (a) How many FFS members have adopted PPT on their farms? _____

   (b) How many of these adopters are men? _____, women? _____, Youth? _____, widows? _____, widowers? _____, any other category indicate

_____

5. Please fill this table, by indicating the number of farmers who joined the FFS per year **since it started to train on PPT**, the year they joined, and when they started planting maize using PPT.

Number of FFS farmers Who joined **per year**	**Year** they joined **FFS**	**Year** they planted **push-pull**

6. About how many non-FFS farmers neighbouring your FFS area have attended your PPT field days and demonstrations? _____

7. About how many of these non-FFS farmers have adopted PPT on their farms? _____

8. About how many of them have become members of your FFS? _____

9. Give five most important reasons why you have managed to adopt PPT?

_____
_____
_____
_____
_____

10. Have some PPT adopter farmers in your FFS or neighbourhood stopped planting maize using PPT? _____

11. Why do you think they stopped planting maize using PPT? _____
_____
_____

12. (a) How many FFS members have not adopted PPT on their farms? _____

(b) How many of these non-adopters are men? _____, women? _____, Youth? _____, widows? _____, widowers? _____, any other category (indicate) _____

13. Why have they not adopted?

_____
_____
_____
_____

14. How many non-FFS farmers from far have visited your FFS and learned about push-pull? _____

15. Which types of farm records were you trained on?

_____ _____
_____ _____
_____ _____

SECTION B: FFS LEARNING COSTS TEST QUESTIONNAIRE

16. Please provide the major FFS group costs enumerated in the table below. Indicate any other costs in the blank rows.

Activities	Unit	Quantity kgs/gms or bags	Cost per unit	Ksh for 2006	Ksh. For 2007
Planting materials for the group PPT plot					
Learning Materials					
Land Rent (if any)					

17. How did you select the facilitator for your FFS? Tick one or more options

a) Election by vote [ ] b) Based on training on PPT [ ]

c) Group Consensus [ ] d) Any other (Indicate) _____

APPENDIX E

A LIST OF EXPERTS AND COLLEAGUES WHO VALIDATED THE INSTRUMENTS

1. Dr. David M. Amudavi (Supervisor)
2. Dr. Catherine Ngendo Munyua (Supervisor)
3. Dr. Zeyaur Khan (ICIPE)
3. Mr Isaac Mbeche (ICIPE)
4. Mr Jimmy Pitcher (ICIPE)
5. Mr J. M. Wanyama (ICIPE)

APPENDIX F

RESEARCH PERMIT

PAGE 2

THIS IS TO CERTIFY THAT:

Prof./Dr./Mr./Mrs./Miss. SERAPHINE MORAA ATAMBO

of (Address) EGERTON UNIVERSITY PO BOX 536 NJORO

has been permitted to conduct research in

Location, BUNGOMA AND BUSIA District, s WESTERN Province,

on the topic. Comparative Efficacies of Farmer Led and Extension Led Farmer Field Schools in the Dissemination of Push-Pull Technology Among Small Holder Farmers of Western Kenya

for a period ending 30TH NOV ,20 09

PAGE 3

Research Permit No. NCST/5/002/R/902

Date of issue 12.10.2009

Fee received SHS 1000



Applicant's Signature

Secretary
National Council for
Science and Technology

CONDITIONS

1. You must report to the District Commissioner and the District Education Officer of the area before embarking on your research. Failure to do that may lead to the cancellation of your permit
2. Government Officers will not be interviewed with-out prior appointment.
3. No questionnaire will be used unless it has been approved.
4. Excavation, filming and collection of biological specimens are subject to further permission from the relevant Government Ministries.
5. You are required to submit at least two(2)/four(4) bound copies of your final report for Kenyans and non-Kenyans respectively.
6. The Government of Kenya reserves the right to modify the conditions of this permit including its cancellation without notice

REPUBLIC OF KENYA

RESEARCH CLEARANCE PERMIT

GPK6055(3mt)10/2009

(CONDITIONS— see back page)

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