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Factors influencing adoption of cover crops for weed management in Machakos and Makueni counties of Kenya

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ABSTRACT

Despite the many advantages of growing cover crops most farmers have not adopted them in their cropping systems. The objective of this study was to examine adoption and sociological factors associated with adoption of cover crops in Kalama (Machakos county) and Kee (Makueni county), Kenya. A semi-structured questionnaire was administered to 80 randomly selected participants to obtain sociological information including gender, age category, education levels, and adoption of cover crops. Two binary logistic regression models were used to determine the factors affecting cover crops adoption by respondents. Results showed that 80% of the respondents had adopted cover crop technologies at Kalama compared to 57.5% at Kee. Results indicated that gender had a significant ($P < 0.05$) effect on adoption. Men were less likely to adopt. Age category had mixed effects on cover crop adoption. At Kalama age category had a significant ($P < 0.05$) effect on cover crops adoption however age effect was not significant at Kee. Education indicated mixed effects on cover crop adoption suggesting other factors not covered in the study were at play. Views from farmers with experience in growing cover crops revealed that, knowledge and skills, demonstration of gains and related cost had a significant ($P < 0.05$) effect on cover crop adoption. Majority of farmers, adopters or non-adopters used seeds from market. Non-adopters in Kee (37.5%) used relief seed suggesting other factors were required to give the threshold required to influence adoption. This implies research is needed to identify factors with likelihood to reach threshold for adoption under different farming systems. The study recommends capacity building to develop cover crop knowledge and skills, demonstrate gains and related costs to improve men and women's likelihood to adopt. In addition, the study recommends research to shed light on other factors likely to influence adoption.

1. Introduction

Cover crops have been used for centuries to control soil erosion, improve soil quality, reduce nitrogen leaching, and repel insects. But with widespread use of fertilizers, very easy to apply with desired results in a short time, cover crops among other technologies were side-lined (Sundermeier, 1999).

Regions such as Illinois, Indiana, Iowa, and Minnesota (Western US Corn Belt) have low use of cover crops despite their wealth of knowledge on benefits. A study to identify factors associated with adoption of cover crops showed that the number of crops grown on a farm was a significant factor affecting adoption in Iowa. Perceived yield advantage or soil quality improvement indicated positive effect on cover crop adoption. Soil erosion, crop diversity, and adding organic matter were the most important reasons for using cover crops in the Corn Belt.

Information on cost of using cover crop was listed as an important factor and cost sharing could increase use of cover crops in the Corn Belt (Singer et al., 2007). Lichtenberg et al. (1994) reported that 1% increased cost in cover crop reduced adoption by 14%. Other cover crop constraints associated with adoption include return to investment, land ownership and plant biology, availability of information and region specific considerations. In Honduras, velvet bean (*Mucuna* spp.) maize rotation was rapidly adopted then spontaneously dropped. Neill and Lee (2011) showed that though

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velvet bean boosted maize yields, increased biomass production and reduced labor, disadoption was associated with family demography (gender, education, and age), physical characteristics of farm (size, slope, and soil), economic factors (inputs, output prices) and institutional factors (land tenure regime and availability of extension). In Asia, adoption depends on farm and farmer characteristics and the relative importance of these factors differs across sites (Lapar and Pandey, 1999).

Kramberger et al. (2009) and Ngome et al. (2011) indicated that cover crops adoption in maize based cropping systems contributes a range of benefits, however this depend on cover crop type. Benefits include: increased residue crop cover and infiltration (Araya et al., 2012; Ngwira et al., 2011), enhancing soil factors (Abdin et al., 2000; Nyalemegbe et al., 2011), increased maize yields (Chabi-Olaye et al., 2005; Mwangi et al., 2015), managing weeds (Mhlanga et al., 2015; Tim et al., 2000) and is more cost effective with increased gross margins particularly in drier years (Mhlanga et al., 2015; Ngwira et al., 2011) among others.

Increasing cost of fertilizers, realization of the importance of use of cover crops in some regions such as reduced erosion and increasing negative effects of fertilizer among other factors has led to increased adoption in Mexico and Brazil (Nepal, 2010). Lack of knowledge on cover crop management, lack of experience of successfully incorporating cover crops in the cropping system, lack of research to inform specific regions or cropping systems and lack of incentives, could justify why farmers who may have wanted to use cover crops have been reluctant to do so (Nepal, 2010).

In Africa (Ethiopia) significant improvement in crop yield and positive effects on runoff and soil loss were achieved with natural resource benefits due to conservation agriculture (CA) (Araya et al., 2012). It advocates minimum soil disturbance, soil cover and crop rotation. Cover crops are plants grown to cover and protect the soil while addressing some of the constraints facing farmers. Cover crops include legumes such as pigeon pea (*Cajanus cajan*), velvet bean (*Mucuna pruriens* (L.) DC), lablab (*Lablab purpureus* L.), beans (*Phaseolus vulgaris*), and hairy vetch (*Vicia villosa*) among others.

In Kenya Machakos county, cover crops were introduced in 2000 under CA. The advantages of legume cover crops under the conditions in Machakos included hard pan management, making soil workable, reduced surface runoff, increased infiltration and moisture conservation and weed suppression contributing to increased maize yields. Use of lablab increased yields from 1.2 t ha^{-1} (local farmer practice) to 3.4 t ha^{-1} (the local variety) and 4.3 t ha^{-1} (drought tolerant variety) (Karuma et al., 2011; Mwangi et al., 2015). The smallholder farmers average yields from the commonly grown local maize variety “Kinyanya” are low and range between 0.3–0.5 t ha^{-1} and 0.9–1.2 t ha^{-1} during the long rains (unreliable) and short rains season (more reliable), respectively, depending on soils, climatic factors and crop management. Despite the many benefits of growing cover crops, information on adoption in Africa is limited and sometimes conflicting (Giller et al., 2009). This research shed some light on some of the social factors associated with adoption of cover crops in Machakos and Makueni counties, Kenya.

1.1. Problem statement and justification

Reports (Chabi-Olaye et al., 2005; Mwangi et al., 2015) have indicated some of the benefits of growing cover crop for some farming systems. Singer et al. (2007) have reported on adoption of cover crop technology for some regions. However, information on cover crop adoption in maize cropping systems in arid and semi-arid regions in Kenya and the factors influencing cover crop adoption are limited. It is crucial to identify the factors with a significant effect on adoption of cover crops by farmers, so that steps to increase adoption may be effective. Factors with significant correlation to cover crops adoption can then be analyzed using binary logistic regression and output used to develop models for predicting farmers' likelihood to adopt or not to adopt. Information on the most significant variables affecting the probability of cover crop adoption could help understand potential barriers to adoption, and contribute to designing successful development projects and setting research priorities for Kenya and similar regions.

1.2. The specific objectives of this study were:

(1) To evaluate adoption level of cover crop technology and (2) determine social factors associated with adoption of cover crops at Kalama and Kee.

1.3. The research questions were:

What are the levels of cover crops adoption at Kalama (region where cover crop technology was introduced) compared to Kee (neighbouring region where the technology was not introduced)?

Do the social factors including age, gender, education, cover crop knowledge sources, seed sources, preferred seeds, reasons for seed preferences, and cover crop constraints have any effect on cover crop adoption? The Null hypotheses (H_o) that guided this study were (1) Age gender or education levels of respondents have no significant effect on cover crops adoption in Kalama and Kee, respectively. (2) Cover crop knowledge sources, seed sources, preferred seeds, reasons for seed preferences or cover crop constraints have no significant effect on adoption at Kalama and Kee, respectively. To analyze the research questions, Binary logistic regression analyses were carried out and Models 1 and 2 constructed. In Model 1, gender, age, and education were included as predictor variables of cover crop adoption. In Model 2, cover crop knowledge sources, seed sources, preferred seeds, and reasons for seed preferences were predictor variables of cover crop adoption. Where necessary, Chi square tested the relationship between the social factors and adoption of cover crops at $P < 0.05$ significant level.

2. Materials and methods

2.1. The study area

A multi-stage sampling technique was adopted. The first stage was purposively selecting Kalama division in Machakos county and Kee division in Makueni county study sites. The two counties are within arid and semi-arid region in Kenya, where unpredictable and unreliable rainfall, flush floods and recurrent droughts are a frequent major threat to food production. The area is dominated by smallholder farmers growing cereals (maize, sorghum, and millet), legumes (beans, cowpeas, and pigeon peas), root tubers (cassava and sweet potato) and fruit trees such as mangoes and papaya in a mixed cropping system. Livestock provide dairy products and manure, and oxen draught power for ploughing and weeding.

Most soils have a declining fertility, low organic matter and are compacted except for top 4 cm loose soil. The pH, organic carbon, moisture content, cation exchange capacity and nutrients are highly variable which is partly attributed to farm management. The monthly soil temperatures range from the lowest (11.1–15.2 °C) to the highest (22.2–27.3 °C). The annual rainfall ranges from 400–800 mm.

The second stage was to purposively select 12 villages (six villages from Kalama and Kee, respectively) and the third stage was purposively selecting 12 farmer groups to represent the 12 villages, respectively. The study area had many registered farmer groups. On average, each group had 25–30 members (men and women). The members met monthly on a scheduled day to deliberate on matters arising. Groups were governed and guided by their own constitution with rules and regulations. A committee of elected

Table 1
Factors considered in predicting adoption.

Variables (Factors)	Type of measure	Type(s) of response(s) categories
X1 = Gender	Dummy	(1 = male; 0 = female)
X2 = Respondents age	Category in years	(1 = 15–25, 2 = 26–35, 3 = 36–45, 4 = 46–55, 5 > 55)
X3 = Respondents education	Categorical	(1 = primary, 2 = secondary, 3 = tertiary, 4 = illiterate).
X4 = Cover crop lessons sources was categorical	Categorical	(1 = attended training, 2 = on-farm demonstrations, 3 = farmer field schools, 4 = field day, 5 = exchange tours, 6 = mass media),
X5 = Seeds sources was categorical	Categorical	(1 = group, 2 = neighbour, 3 = project. 4 = market, 5 = relief agency),
X6 = Preferred seeds	Categorical	(1 = Pigeon peas, 2 = beans, 3 = Lablab, 4 = Velvet bean),
X7 = Reasons for preferred seeds	Categorical	(1 = domestic use, 2 = protein source, 3 = dual purpose, 4 = drought tolerant, 5 = seed availability),
X8 = Cover crop constraints	Categorical	(1 = seeds, 2 = lack of information, 3 = diseases, 4 = pests, 5 = frost)

Prior to data collection assistants were trained to facilitate recording of data from participants as scheduled.

leaders oversees individual roles and responsibilities in the group activities. There are penalties in breaking rules. Groups are known for their multiplier effect among members, and therefore many change agents work in collaboration to implement their agendas. A group was selected to participate if (1) it was officially registered and active with some on-going development activities or it had previously participated in conservation tillage activities and (2) resources allowed.

Group approach was deemed as a more cost effective strategy, for fair representation of villages and potential to form a base that could be used for comparing change over time. For reference purposes the region is administratively divided into counties > sub counties > divisions > locations > sub-locations > villages. A village was based on the number of households and topography of the area. Each village had about 400 households.

2.2. Data collection

The fourth stage was random selection of 80 farmers from the sample of 12 farmer groups to participate in the study. Individual farmers were randomly selected by allocating a number (1, 2, and 3) to every member of the accessible population. All number ones formed the sample of 40 from Kalama and Kee division, respectively.

The participants were interviewed face to face by the researcher and 2 interviewers using a semi-structured questionnaire. Variables chosen were deemed necessary to bring out information required to determine adoption and factors influencing it.

The questionnaire which had been pretested and adjusted accordingly was administered to each participant. The questionnaire had 30 items and was designed with two parts. Part A of the questionnaire included gender, age, educational level, and locality. Part B focused on issues related to cover crops including adoption. The factors explored were when farmers started growing cover crops (year), where they learnt the use of cover crops, their source of seeds, their preferred cover crops among 1–5 cover crop options, reasons for those preferences and views from participants with practical experiences in growing cover crops (referred to as experts). All adopters had planted legume cover crops for weed management in 2008/9 and non-adopters had not? Independent variables were scores on the dependant variable (adoption), dummy: (1 = Yes to adoption; and 0 = No to adoption) as tabulated (Table 1).

2.3. Analysis of data

The data was cleaned, coded, and keyed into computer. To analyze the research questions IBM SPSS computer software was used to run preliminary Pearson correlation tests. The factors that indicated significant correlation on adoption were subjected to binary logistic regression. Descriptive and inferential statistical tool of frequency counts and percentage was used in the analysis of the research questions while Pearson Chi-square analysis tested the hypothesis using the formula below:

$$x^2 = \sum_{1}^{n} \frac{(O-E)^2}{E}$$

where O = observed frequency, E = expected frequency, n = sample size, x = Chi–square value, df = degree of freedom (n − 1). The null hypotheses stated: (H_O: Men are more likely to adopt cover crops than women), (H_O: Younger persons are more likely to adopt cover crops than older persons. (H_O: The more educated persons are less likely to adopt cover crops than illiterate persons). H_O = those who attended training on cover crop are more likely to adopt than those who learnt from mass media. H_O = Farmers who got seeds from their group were more likely to adopt than those got seeds from relief agency. H_O = those who preferred Pigeon peas are more likely to adopt than those who preferred Velvet bean. H_O = those whose reason for cover crop preference was domestic use are more likely to adopt than those whose reason was seed availability. H_O = Those whose cover crop constraints was seeds were less likely to adopt than those whose constraint was frost). The null hypotheses were tested at $P = 0.05$ level of significance. The null hypotheses were rejected at $P < 0.05$ and conclude that they are statistically significant. Otherwise, we accept at $P > 0.05$ and conclude that there is no overall statistical significance.

3. Results

The sample distribution is shown (Table 2).

3.1. Socio-demographic characteristics of respondents

The profile of respondents is shown (Table 3). Analysis revealed that more 45% females compared to 35% males indicated they had adopted cover crops in Kalama while more 35% males than females (12.5%) indicated they had adopted in Kee.

Majority (87.5% in Kalama and 84.2% in Kee) of the respondents who had adopted indicated cover crops were over 35 years of age. A small proportion (12% in Kalama and 15.8% in Kee) of the respondents who had adopted indicated they were 25–35 years of age. More adopters (21.9%) in Kalama than Kee (15.8%) indicated they were above 55 years old (Table 2).

The study results indicated that majority (96.8%) of the respondents in Kalama had formal education (45.2% primary, 38.7% secondary and 12.9% tertiary education) and 3.2% were illiterate whereas all (100%) respondents in Kee had formal education (15.8% primary, 68.4% secondary and 15.8% tertiary education).

Table 2
Sample distribution.

County	Sub-county	Division	Village	Agroecological zone	Frequency count
			Kalima Mungu	Upper midland 3	1
Machakos	Machakos	Kalama	Katwaa	Upper midland 4	3
			Kyakatolwe	Upper midland 4	1
			Usiwiu	Upper midland 4	1
			Kikumbo	Lower midland 3/4	1
				Upper midland 4	2
			Mikono	Upper midland 3	1
				Upper midland 4	4
			Utooni	Upper midland 3	3
			Ivutini	Upper midland 4	2
			Kathianioni	Upper midland 4	1
			Kiatuni	Upper midland 4	2
			Masungu	Lower midland 4	1
				Upper midland 4	1
			Usiwiu	Lower midland 3	1
				Upper midland 3	1
				Upper midland 4	2
			Centre	Upper midland 4	2
			Kitonyini	Upper midland 4	2
			Kalanzoni	Lower midland 3/4	1
			Kitonyini	Upper midland 3	5
			Ingethya	Upper midland 4	1
Makueni	Kauti	Kee	Watuka	Lower midland 3/4	1
			Uangani	Lower midland 3/4	9
			Kee	Lower midland 3/4	1
			Thoma	Lower midland 3	1
			Kaiti	Lower midland 3	1
			Kiamwalye	Lower midland 3	1
			Kilia	Lower midland 3/4	4
			Kinganga	Lower midland 3	1
			Kyamwalye	Lower midland 3/4	1
			Thoma	Lower midland 3	5
			Kakuyuni	Lower midland 3	1
			Kavyuni	Lower midland 3/4	3
			Mbakoni	Lower midland 3/4	5
			Mutulani	Lower midland 3/4	5
			Kyuluni	Lower midland 3/4	1
			Grand total		80

3.2. Adoption of cover crop technology

Results to the research question: "*Did you plant cover crops in 2008/2009?*" indicated that 80% of the respondents at Kalama had adopted cover crops while 20% had not adopted compared to 52.5% of the respondents who had adopted at Kee and 47.5% who had not adopted. The cover crop adoption is indicated in Fig. 1 as a cumulative of responses to the question *when did you start growing cover crops* (*year*)?

3.2.1. Factors influencing cover crop technology

Social factors considered as potential predictor variables in cover crop adoption binary logistic regression Model 1 were the respondents' age, education, gender, and Model 2 were cover crop knowledge source, seeds sources, preferred seeds, reasons for seeds preference and constraints. A preliminary Pearson correlation test (2-tailed) indicated that all the potential predictor variables had significant ($P < 0.05$) correlation effect on cover crop adoption. These meant the variables considered had potential predictive ability in the model except for cover crop constraints which showed no

Table 3
The sociological profile of respondents (No. of counts).

Factors		Region				
		Kalama		Kee		
Gender	Category	Adoption	Non-adoption	Adoption	Non-adoption	Statistics
	Male	14	5	14	12	Chi square = 4.314
	Female	18	3	5	9	$P = 0.038$
	Total	32	8	19	21	df = 1
Age	25–35	4	0	3	3	Chi square = 1.169
(years)	36–45	8	3	3	6	$P = 0.760$
	46–55	13	2	10	8	df = 3
	>55	7	3	3	1	
	Total	32	8	19	18	
Education	Illiterate	14	1	3	1	Chi square = 4.314
	Primary	12	2	13	7	$P = 0.124$
	Secondary	4	5	3	12	df = 3
	Tertiary	1	0	0	1	1
	Total	31	8	19	21	50

Table 4
Pearson correlations.

	Kalama			Kee		
Variables	*P*-value	Sig.	Pearson correlation (*r*)	*P*-value	Sig.	Pearson correlation (*r*)
Age	$P<0.001$	**	−0.12	$P<0.014$	**	−0.0266
Education	$P<0.001$	**	−0.127	$P<0.001$	**	0.097
Gender	$P<0.001$	**	0.175	$P<0.001$	**	0.129
Knowledge source	$P=0.781$	NS	0.007	$P<0.001$	**	−0.61
Source of seed		*	−0.063	$P<0.001$	**	−0.175
Cover crops preferred	$P<0.001$	**	0.246	$P<0.001$	**	0.109
Reasons for preference	$P<0.001$	**	0.264	$P<0.001$	**	0.174

* denotes Pearson correlation (*r*) is significant ($P<0.05$) and ($P<0.01$) respectively.
** denotes Pearson correlation (*r*) is significant ($P<0.05$) and ($P<0.01$) respectively.

significant effect on cover crop adoption at Kalama and Kee hence was omitted in the model (Table 4).

Binary logistic regression analysis for Kalama indicated that age of respondents, education, and gender had significant effect ($P<0.05$) on the likelihood to adopt cover crop (Table 5).

Binary logistic regression analysis for Kee indicated that only gender had significant ($P<0.05$) effect on the likelihood to adopt cover crop (Table 6).

3.2.2. Binary logistic regression Model 1, Kalama

Binary logistic regression Model 1 for Kalama gave a Nagelkerke R of 0.315 which implies that the variables included in the model were able to explain 31.5% variance in the model estimation. This was considered decent. Chi Square 525.27, df 7 was significant ($P<0.001$) indicating that all explanatory variables included in the model jointly influenced the likelihood of cover crops adoption. The predictor variables were able to explain 79.4% of the outcomes. Given the fore going goodness of fit measures, it is concluded that binary logistic regression model had integrity and hence appropriate for predicting cover crop adoption (Table 5).

3.2.2.1. Gender in Kalama. There was a significant ($P<0.001$) gender effect on the likelihood to adopt cover crop. Males were 71.1% less likely to adopt cover crops than females.

3.2.2.2. Education in Kalama. There was a significant ($P=0.018$) education effect on the likelihood to adopt cover crop. Respondents with primary education were 73.1% more likely to adopt cover crops than those illiterate. The effect of secondary education was not significant on cover crop adoption. Respondents with secondary education were 31.1% less likely to adopt cover crops than the illiterate. In addition, the effect of tertiary education was not significant on cover crop adoption although respondents were 54.8% more likely to adopt cover crops than the illiterate ones.

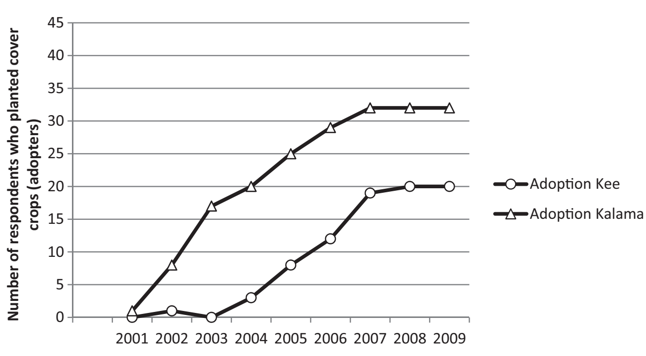

Fig. 1. Cover crop adoption trend between Kalama and Kee from 2001 to 2009.

3.2.2.3. Age in Kalama. There was a significant ($P<0.001$) age effect on the likelihood to adopt cover crops. However the effect was not uniform across age categories. Age category (36–45 years) respondents were 62.8% less likely to adopt cover crops than those over 55 years. Age category (46–55 years) respondents were 78.8% more likely to adopt than those over 55 years. Age category (26–35 years) was 321.5% more likely to adopt cover crops than those over 55 years old but effect was not significant.

3.2.3. Binary logistic regression Model 1, Kee

The Binary logistic regression Model 1 for Kee gave a Nagelkerke R of 0.022 which implies that the predictors were able to explain 2.2% of the variance included in binary logistic model estimation. The chi square 37.997, 1 df was significant ($P<0.001$) indicated that explanatory variable included in the model influenced the likelihood of cover crops adoption. The predictor variables were able to explain 55.3% of the outcome which was a slight improvement from 52.6% without predictors indicating the model was good with predictive ability. Given the fore going goodness of fit measures, it was concluded that binary logistic regression model had integrity and hence was appropriate (Table 6) for predicting adoption of cover crops at Kee.

3.2.3.1. Gender at Kee. There was a significant ($P<0.001$) gender effect on the likelihood to adopt cover crops at Kee. Men were 42.3% less likely to adopt than women.

3.2.3.2. Age category and education level in Kee. There was no statistical significant age or education effect on the likelihood to adopt cover crops at Kee. Therefore the variables were dropped from the final model for cover crop adoption at Kee (Table 6).

3.2.3.3. The binary logistic regression Model 2. The variables included: cover crop knowledge source, seeds sources, preferred seeds and reasons for seed preferences indicated no statistical significant effect on the likelihood to adopt cover crop at Kalama and Kee so they were dropped from final model for cover crop adoption.

3.2.4. Experts' views on cover crops and adoption

The experts' views on cover crops were responses to the question, *any comment or observation to share based on practical experiences of growing cover crops in Kalama and Kee*? Views expressed were categorized into three factor groups (a) 38/165 of the responses in Kalama compared to 48/165 of the responses in Kee indicated technological knowledge and knowhow, (b) 31/165 in Kalama compared to 13/165 in Kee indicated economic gains from using the technology and (c) 10/165 in Kalama compared to 25/165 indicated the cost associated with growing cover crops. The three factors had significant ($P<0.001$) effects on the likelihood to influence cover crop adoption. The probability associated with the chi square statistic 14.684 was less than 0.05 indicating that, there was a relationship between experts' views and regional likelihood

Table 5
Variables in the binary logistic regression model equation (Kalama).
Number of observations = 2400, LR Chi Square 527.25 (df 7), Log likelihood = 2307.5, Nagelkerke = 0.315, Predicted = 79.4%.

Variables in the equation							
	Predictors	B	S.E.	Wald	df	Sig.	Exp (B)
Step 1[a]	Gender (1 = male)	−1.240	0.135	83.900	1	0.000	0.289
	Education category			51.311	3	0.000	
	1 = Primary	0.549	0.233	5.554	1	0.018	1.731
	2 = Secondary	−0.372	0.220	2.880	1	0.090	0.689
	3 = Tertiary	21.160	2510.883	0.000	1	0.993	1.548E9
	Age category (years)			103.555	3	0.000	
	1 = 25–35	19.859	2427.921	0.000	1	0.993	4.215E8
	2 = 36–45	−0.988	0.156	39.964	1	0.000	0.372
	3 = 46–55	0.581	0.144	16.385	1	0.000	1.788
	Constant	1.734	0.262	43.721	1	0.000	5.664

[a] Variable(s) entered on step 1: Gender, education, and age.

Table 6
Variables in the binary logistic regression model equation Kee.
Number of observations = 2400, LR Chi Square = 37.997, (df = 1), Log likelihood = 3116.435, Nagelkerke = 0.022, Predicted = 55.3%.

95% C.I. for Exp (B)									
	Predictor	B	S.E.	Wald	df	Sig.	Exp (B)	Lower	Upper
Step 1[a]	Gender (1 = Male)	−0.55	0.09	37.409	1	0	0.577	0.484	0.688
	Constant	0.47	0.074	40.782	1	0	1.6		

[a] Variable(s) entered on step 1: Gender.

Table 7
The relationship between experts' views and the division (numbers of responses).

Experts views		Division		
Variables	Description	Kalama	Kee	Total
Cover crop knowledge and Knowhow required	Cover crops should be promoted through training Requires knowledge and technical skills to optimize benefits. Group field trips and visits gave vital lessons and knowledge Management skills are required for cover crops use	38	48	86
Cover crop related costs	Financial support such as credit is lacking. Appropriate cover crops seeds are lacking	10	25	35
Demonstrated gains from cover crop technology	Improved /retained soil moisture, generated income Increased maize yields over three times farmers practice yield Other suitable food crops should be provided for cover crops Insured crop failure during drought and provided food security	31	13	44
	Total	79	86	165
	Statistics	Chi square = 14.684, df = 2, $P < 0.001$.		

Table 8
Experts' recommendation.

Division	Recommendation	Observed	Expected	Residual	Statistics
Kalama	Management intervention	32	24	8	Chi = 4.08, df = 2, $P = 0.130$
	More varieties	19	24	−5	
	Short season	21	24	−3	
Kee	Management intervention	8	19	−11	Chi = 9.58, df = 2, $P = 0.008$
	More varieties	25	19	6	
	Short season	24	19	5	

Table 9
Relationship between adoption and seed sources (No. of responses) for Kalama and Kee division.

Division	Sources of seed	Adoption	Non adoption	Statistics
Kalama	Group	18	2	(Chi = 2.525, df = 4, $p = 0.640$)
	Neighbour	6	2	
	Project	12	3	
	Market	20	6	
	Relief	4	0	
Kee	Group	4	1	(Chi = 10.90, df = 4, $p = 0.028$)
	Neighbour	3	5	
	Project	3	1	
	Market	22	13	
	Relief	3	12	

to adopt cover crop (Table 7). Kee respondents indicated need for more types of cover crop varieties, short season and management skills which had a significant relationship as highlighted in expert's recommendation (Table 8). There was a significant relationship between seed sources and adoption (Table 9).

4. Discussion

4.1. Adoption of cover crops

The study showed that adoption at Kalama was higher than Kee. There was a steady increase in adoption of cover crops at Kalama from 2001 to 2007 which was attributed to cover crop knowledge and knowhow, expected gains and incentives, while a halt could be associated with the national drought (2008–2009). Knowledge and technical knowhow in cover crop was developed through various capacity building activities. These included: field days, experts sharing of lessons, field tours, on-farm adaptive trials, practical training to develop skills using group dynamics, dissemination of communication products. Incentives included seeds, fertilizers, and tools for on-farm experimentation trials. Adoption was much lower at Kee than Kalama which could be attributed to regional considerations such as lack of incentives and poor infrastructure to facilitate provision of support services and reduce market cost for farmers. This result concurs with Chomba (2004) report that lack of necessary support services and incentives, location physical constraint, lack of human capital and skills are key factors affecting small holder farmers' adoption of technologies.

4.2. Factors influencing adoption of cover crops

This study focused on socio profile of respondents to understand social factors associated with adoption of cover crops at Kalama compared to Kee. Adoption is a decision at the individual farmer level subject to various factors (Kabede et al., 1990). Findings on the likelihood to adopt cover crops or not could guide the stakeholders in making appropriate intervention measures.

Gender indicated significant effect on likelihood to adopt cover crops, suggesting that gender considerations are necessary in designing intervention measures to influence likelihood to adopt cover crops. In Kalama men were 71.1% less likely to adopt cover crops than women compared men in Kee who were 42.3% less likely to adopt cover crops than to women. This means intervention considerations need to be region specific. In addition, the result suggests that intervention measures should consider factors associated with men's perception on usefulness of cover crops and women ease of use of cover crops to increase their likelihood to adopt. The result was contrary to Doss and Morris (2001) findings that gender had an insignificant effect in improved maize technology adoption. The result suggests that intervention measures should consider factors associated with men's perception on use of cover crops to increase their likelihood to adopt. Morris and Vankatesh (2000) reported that women were more strongly influenced by perception on ease of use while men were strongly influenced by their perception on usefulness of a technology.

Age indicated mixed effects on likelihood to adopt cover crops in Kalama suggesting that there could have been some unknown factor influence in play which was not included in model that could be explored.

This agrees with Lapar and Pandey (1999) who have indicated that age of farmer on adoption decision can be a composite of effects of farming experience and planning horizon. While longer farming experience equated with older farmers is expected to have positive effect on adoption, younger farmers may have longer planning horizons and therefore maybe likely to adopt cover crops. In addition, results showed that the farming community was aging as majority of cover crop adopters were over 35 years with few young people. This means that as the population increases, more food will be required on each unit of land and the capacity to produce will rest on the youth. Hence, though age indicated no significant effect on the likelihood to adopt cover crops in Kee age could have implications on food production. This result agrees with Mwangi (2006) who reported that there was lack of agricultural professional skills among the youth (under 34 years). Results suggest that creating support systems to involve and engage youth actively could bridge the age gap while developing knowledge and skills could contribute to the likelihood to adopt cover crops. Age is an important factor that influences the probability to adopt new technologies because it is primarily a latent characteristic in adoption decision. However, there is contention on the direction of age effect on adoption (Akudugu et al., 2012; Kabede et al., 1990). The direction probably could be determined by the technology and exposure suggesting that all the age categories should be exposed to cover crops to increase the likelihood to adopt. Neill and Lee (2001) found that the age of household was negatively and significantly associated with adoption of velvet bean-maize relay crop.

In Kalama findings indicated a significant ($P < 0.05$) primary education effect on the likelihood to adopt cover crops than the illiterate. Primary education respondents' were 73.1% more likely to adopt cover crops than the illiterate. This result agrees with other reports (Feder et al., 1985; Kabede et al., 1990) that education had a positive effect on adoption. However secondary and tertiary education effect was not significant. In addition, this study revealed that majority of the respondents at Kee was more educated at primary and secondary levels of formal education which probably explains why Kee indicated more likelihood to adopt cover crops than Kalama. Uematsu and Mishra (2010) have reported that technology complexity has a negative effect on adoption and this could only be dealt with through education. The study results suggested that adoption of cover crops was influenced by regional differences between Kalama and Kee.

Members from groups which had earlier participated in growing cover crops referred to as experts contributed views which had significant effect on adoption of cover crops. This suggests that experience was probably the most important social factor which could have assisted farmers to analyze the gains and costs of the cover crop on the basis of own experiments or through analysis of information from other adopters or key informants. This further suggests that investing in farmer's knowledge and knowhow in cover crop, enhancing farmers' ability to analyze practical gains and making cover crops related costs such as seeds, fertilizer, and credit affordable were key factors that influenced the likelihood to adopt cover crops. This agrees with Kabede et al. (1990) who indicated that experience was the most significant factor in adoption of agricultural technologies. In addition the result indicated need for region specific consideration for effective intervention measures with likelihood to influence adoption of cover crop. This is in line with Asfaw et al. (2011) report on adoption of other agricultural technologies. This was emphasized by respondents' comments "*Use of cover crop technology had tremendous benefits in the region because where maize failed due to harsh weather conditions*; *the cover crops sustained farmers with grains, vegetables and forage while covering soil managed weeds, and improved water storage efficiency. This translated to increased yields*". The finding agrees with other reports (Mwangi et al., 2015; Ngome et al., 2011; Olorunmaiye, 2010) that cover crops suppressed weeds and increased maize yields. Based on their views, experienced farmers recommended more drought tolerant, short season cover crop varieties and management intervention. This suggests that lack of suitable cover crops to fit into farmers' specific farming system, lack of drought tolerant varieties to cope with weather related risks and lack of management interventions to apply in different cover crops types influenced the likelihood to adopt. Perhaps this explains why though majority of adopters and non-adopters bought seeds from market; and majority of non-adopters in Kee used relief seeds, having seeds was not adequate to give them a reaction threshold to adopt. In this study a certain value of stimulus below the threshold no adoption was observed whereas at critical threshold value adoption was stimulated. As Akudugu, et al. (2012) reported that the threshold is dependent on a certain set of factors. Research could shed light on factors needed to give thresholds for cover crop adoption in specific farming systems. Giller et al. (2009) indicated that it is important to use nonlinear, flexible approach when disseminating CA (cover crops) with emphasize on capacity building and with room for adaptations to local conditions.

5. Conclusion

This paper highlights adoption of cover crops and some of the social factors likely to influence adoption at Kalama and Kee. Although reports indicate tremendous benefits associated with growing legume cover crops, information on factors likely to influence adoption in some farming systems are limited. Identification of factors that influence farmer adoption of cover crops in the cropping system would contribute to the elaboration of strategies to achieve increased likelihood to adopt. Several lessons useful to the development of strategies to influence cover crop adoption in farming systems emerge from the case study presented in this paper. This study thesis was that social factors had no significant effect on cover crops adoption at Kalama and Kee. Binary Logistic Model for predicting adoption indicated that men were less likely to adopt cover crops than women. The implication is that capacity building for men to change perception in usefulness of cover crops and women ease in growing cover crops could increase the likelihood to adopt. Development agents and policy makers should not target cover crop on basis of age or education. This is because there was inconsistency in age and education effects on the likelihood to adopt cover crops.

The study revealed that views from cover crop experienced farmers influenced adoption. From farmers' views, knowledge and technical knowhow on growing cover crops, demonstrated gains and meeting cover crop related costs influenced the likelihood to adopt cover crop. Adopters and non-adopters had different seeds sources suggesting that a reaction threshold to adopt was dependent on other factors beyond this study. Research could shed light on factors needed to give thresholds likely to influence adoption in unique farming conditions.

Based on findings, this study recommends first, capacity building for men and women to increase likelihood to adopt cover crops. Secondly, further research to identify other factors likely to influence adoption; analyze the gains and related direct and indirect costs of adopting cover crops in target cropping systems to remove uncertainty for men and women more likely to adopt cover crops. Thirdly, policy formulation to facilitate knowledge and skills, empower farmers meet related costs, and remove location/regional barriers to cover crop adoption.

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