Journal of Soil Science and Environmental Management Vol. 2(11), pp. 354-361, 29 November, 2011
Available online at http://www.academicjournals.org/JSSEM
ISSN 2141-2391 ©2011 Academic Journals

Full Length Research Paper

Determinants of adoption of conservation tillage practices in maize-cowpea cropping systems: The case of Makueni District, Kenya

Jane Mutune[1]*, John Mburu[1], Rose Nyikal[1] and Geoffrey Kironchi[2]

[1]Department of Agricultural Economics, University of Nairobi, Kenya.
[2]Land Resource Management and Agricultural Technology, University of Nairobi, Kenya.

Accepted 23 September, 2011

The low soil moisture cannot support productive agriculture to meet the increasing population in the low rainfall tropical areas. Ripping and tied-ridging are some of the recent technologies introduced by the Food and Agricultural Organization of the United Nations, and is used to conserve moisture in the semi-arid areas. Although farmers are aware of the technical gains of these technologies, the adoption rates have remained below the expectations of researchers and policy makers. The objective of this study was to analyze household and technology characteristics that influence the adoption of ripping and tied-ridging techniques of conservation tillage. Semi-structured questionnaires were used to interview a random sample of 177 farmers. Using a logit model, different factors that influenced farmers' use of ripping and tied-ridging were identified. The significant variables include availability of off-farm employment, closeness to local markets, group membership, availability of family labour, contact with extension services and conservation tillage promoters, and farmers' farming experience. The paper recommends that future demonstrations of ripping and tied-ridging should target farmers who cannot easily access markets for farm inputs and outputs. Moreover, non-adopters should be encouraged to join or form new groups to establish contacts with extension services, and organizations promoting the tillage practices if adoption rates of these technologies are to be improved in the study area.

Key words: Adoption, adoption rate, conservation tillage, ripping, tied-ridging, semiarid areas, Kenya.

INTRODUCTION

The utilization of appropriate agricultural technologies is an important prerequisite for economic development in developing countries as they raise the production possibility frontier of agricultural commodities. Without such technologies, the scope for increasing agricultural production and rural incomes is very limited. However, while technology advancement is necessary for agricultural development, it is not a sufficient step towards increased agricultural production *per se*, unless critical mass adoption is achieved (Feder and Slade, 1984). Farmers' technology adoption decisions are shaped by personal, economic, socio-cultural and environmental influences under which they operate (Wale et al., 2005). Consequently, for any technology to have an impact on farmers' productivity and thus welfare, the factors that influence its adoption should be well understood. Such an understanding forms an important basis for any attempt aimed at introducing change and improving production levels in smallholder farming systems.

The semi-arid areas of Eastern Kenya, including Makueni District, are characterized by low, erratic and poorly distributed bimodal rainfall that makes crop production difficult under rain fed conditions (Biamah et al., 2000). The four major constraints to arable agriculture in the semi-arid areas are severe soil erosion, low soil fertility, soil crusting and low soil moisture. Of the four, soil moisture is the most critical as it directly affects crop production in these areas (Biamah, 2001). Hagmann et al. (1996) indicated that the concern for improvement of

*Corresponding author. Email: j_mutune@yahoo.com. Tel: 0714-986104.

crop productivity in the semi-arid areas calls for a radical shift in relying on erosion control practices to adoption of appropriate techniques which can conserve both soil and water with reduced farming costs.

In the Kenyan semi-arid areas, public extension service providers, researchers and non-governmental organizations have, for the last century, been engaged in various endeavors to counter the effects of low soil moisture in agriculture. Some of these efforts have included advising farmers to plant crops such as millets, sorghum, cowpeas, and specially selected maize varieties which are adapted to water stress. Yet, with the conventional tillage the yields of these crops, and particular those of maize and cowpeas, have remained low compared to those realized from areas with higher rainfall or under irrigation (Mellis et al., 1997). Other sustainable techniques advanced in the semi-arid areas for water harvesting and conservation have included terracing, contour ridging, cover cropping, mulching and sub-soiling (Okwach et al., 2004). While considerable success has been achieved in this regard, there is still decline in land productivity even on the best conserved land suggesting that more needs to be done to improve soil moisture.

In the turn of the decade, the Food and Agricultural Organization of the United Nations (FAO) introduced ripping and tied- ridging in Makueni and other arid and semi-arid districts of Kenya (Biamah, 2001; FAO, 2004). Ripping is a form of minimum tillage whereby only parallel furrows are cut using a ripper without disturbing the soil between planting rows (Gachene and Kimaru, 2003). Its function is to restore micro-pores for maximum water infiltration and increase root depth. Tied-ridges are usually discontinuous furrows made by cross-ties that interrupt water flow in the furrow thus creating pools to retain water for a while and to promote slow seepage (Gachene and Kimaru, 2003).

There is sufficient evidence that conservation tillage is superior to conventional tillage in terms of crop yields. Ripping and tied-ridging assure farmers of good timing of farming operations and less labour and energy requirements (Chuma et al., 1998). A 50 to 100% increase in grain yields has been possible (Pretty, 1999). Field experiments carried out by Miriti (2005) in the Makueni district to compare the yields of conventional tillage and tied-ridging that that crop yield of maize was higher, by 55%, in tied-ridging. Although the tied-ridges require high labour during preparation, they are permanent and only need minimal maintenance in the subsequent years (Harper, 2002).

Despite the fact that technical gains of conservation tillage practices are known by farmers in Makueni and other semi-arid districts, the adoption rates have remained low ((Bradshaw and Knowler, 2006). This is in spite of the continued promotional efforts of the conservation tillage techniques by various government and non-government organizations since 1998 (Kaumbutho and Josef, 2004). In Makueni District, these organizations include the Kenya Agricultural Research Institute (KARI), KENDAT, the FAO, Ministry of Agriculture (MoA) and the Agricultural Technology Development Center (ATDC).

One of the reasons given for the low adoption rates is that proper targeting of farmers is not done since farm and farmers' characteristics that influence technology uptake are not precisely known, though availability of draught power and extension services have been noted to play an important role (Kaumbutho and Mutua, 2002). Thus, this study takes the case of ripping and tie-ridging in Makueni District to determine which farmers' characteristics and technology aspects influence adoption of conservation tillage practices in arid and semi-arid areas of Kenya. Understanding these factors will facilitate a targeted approach in promoting use of conservation tillage in order to enhance crop production in the study area. Acquiring this knowledge is important since the Kenyan rural population continues to increase, and more people are moving to arid and semi arid areas where they continue to rely on farming for their livelihoods (Central Bureau of Statistics, 2001).

METHODOLOGY

The conceptual background

This study was conceptualized as a technology adoption investigation. Feder and Slade (1984) define adoption as the degree to which a new technology is used in the long run equilibrium when farmers have complete information about the technology. Since farmers are rational consumers of agricultural technologies, they are conceptualized to choose technology packages that give maximum utility. Adoption is assumed to be a function of the farm and household characteristics, and technology specific attributes (Adesina and Zinnah, 1993).

The decision to adopt an innovation is a behavioral response arising from a set of opportunities and constraints facing the decision maker (Leagans, 1979). These opportunities and constraints can be grouped into incentive and disincentives respectively. Adoption proceeds only when the incentives outweigh the disincentives. Economically, incentives are the returns while the disincentives are the costs. If the benefits are more than the costs, the farmers are motivated to take up a new innovation due to the expected high returns on investment.

Economists usually treat adoption of agricultural innovations as the dependent variable while the independent variables are all interdisciplinary factors comprising a primary set of socio-economics, physical and institutional factors. It is therefore the interaction of these factors, including incentives versus disincentives that create tension that motivates action resulting in change and thus adoption or non- adoption (Leagans, 1979; Adesina and Zinnah, 1993).

Study area

Makueni district has a population of over 245, 768 people (CBS, 2001) who are mainly subsistence farmers. The types of crops mainly grown are maize, cowpeas, beans, pigeon peas, cassava, sweet potatoes, local mangoes, sorghum and kales. The district receives bimodal rainfall with the most reliable rains occurring in October to December (short rains). The long rains occurring in April to May are unreliable in both amounts and distribution (Okwach et al., 2004). A lot of rainfall is lost through water surface runoff, and this, together with poor tillage practices, has resulted in low soil moisture thus low crop yields. To address this problem, various water conservation measures and appropriate conservation tillage practices (Gachene and Kimaru, 2003) have been implemented in the district.

Sampling procedure

This paper used both primary and secondary data. Primary data was collected by using semi-structured questionnaires in Kalawa and Kathozweni divisions in Makueni district from December 2006 to June 2007. These data included household characteristics and the technologies attributes. Secondary data was collected from institutional libraries, that is, World Agro-forestry Centre, University of Nairobi and the Ministry of Agriculture.

In this study, an adopter was identified as a farmer who had been using either ripping or tied ridging or both for the last four years up to the time the study was conducted. A non-adopter was a farmer who had never used the conservation tillage practices and thus purely practiced conventional tillage. A sampling frame of 90 farmers who have adopted conservation tillage practices within maize-cowpea crop systems was gathered from the local non-governmental organizations (mainly Agricultural Technology Development Centre (ATDC) in Machakos) and public extension personnel operating in the study area. All the farmers in this list were selected. However, only 87 of them were interviewed since the rest were unavailable. The sampling frame for the non-adopters consisted of adopters' neighbours who were growing maize and cowpeas but had not adopted the conservation tillage practices. For every adopter, the closest neighbouring household was selected. Thus, a total of 90 non-adopters were sampled and interviewed. The final sample therefore consisted of 177 farm households. All of them were interviewed using a semi structured questionnaires. The data gathered during these interviews included socio-economic characteristics, reasons for adopting/not adopting the conservation tillage practices, agronomic characteristics, market access characteristics and perceptions towards conservation tillage practices.

Econometric model

Since the study was conceptualized as analyzing adoption behaviour, the phenomenon to model was taken as discrete rather than continuous. In this case, the dependent variable took the value of 1 if technology had been adopted and 0 if not adopted.

A form of a qualitative response model was used to analyse this phenomenon. Binary choice models such as logit and probit models are often applied in modelling adoption decisions (Greene, 2004). These models are used for estimating the probability of an event (such as adoption) that can take one of two values (adopt, do not adopt). The basic difference between the two models is that logit assumes a cumulative logistic distribution with a higher variance hence flatter, while probit model assumes cumulative normal distribution with a unit variance hence more bell-shaped. Generally, the interpretation of the two models is similar.

In a logit model, the expectation of the adoption Y is a value P, which is related to the independent variables (X) as follows (Pindyck and Rubenfield, 1991; Maddala, 2001; Greene, 2004):

$$\begin{aligned} E(Y/X) &= P = F(Z) = \alpha + \beta X + \mu \\ &= 1/(1+e^{-z}) \\ &= 1/\{1+e^{-(\alpha+\beta x+\mu)}\} \end{aligned} \qquad 1$$

Where *P(Y=1/X)* = conditional probability of being adopter given the values of independent variables (X); *Z* is the standard normal variable, $Z \sim N(0,\sigma^2)$; α = Constant; β = Regression coefficients; μ = stochastic error term; σ = standard deviation.

In the afore expression, P is referred to as the logistic probability function. When the logistic function is expressed in terms of odds, it is called the logit and takes the following form:

$$probability(event)/(no\ event) = \{P/(1-P)\} = e^{z} = e^{(\alpha+\beta X+\mu)} \qquad 2$$

In order to estimate the logit model, the dependent variable is transformed by taking natural logarithms of both sides to yield "log odds" as follows:

$$In\{P/(1-P) = Z = \alpha + \beta X + \mu \qquad 3$$

Independent variables and their hypotheses

The adoption models were specified using several factors, derived from the adoption literature (Asambu, 1993; CIMMYT, 1993). These were:

i. Education (EDTN): This was the number of years of formal schooling for the household head. Education was hypothesized to positively influence the decision to adopt (Gould *et al*., 1990). This is because more years of schooling tend to make farmers less risk averse thus, enabling them to try out new innovations (Chuma et al., 1998). Well-educated farmers easily acquire and comprehend new information hence, demand and utilize complex agricultural technologies.

ii. Gender: This variable was coded as a dummy variable, representing the sex of the household head, where male =1, and female = 0. Female-headed households were expected to adopt technologies more as they tend to have less income compared to their male counterparts (Blackden and Bhanu, 1998). In addition the conservation tillage practices are labour intensive in the initial years and women provide most of the labour for food production.

iii. Off farm employment (OFFEMP): This variable was coded as a dummy variable, 1 = household heads with off farm employment and 0 = for those without off farm employment. The financial resources obtained through off farm employments enables a family to acquire the implements, herbicide, sprayers and other inputs needed for conservation tillage practices (CIMMTY, 1997). The presence of a business is also likely to raise the opportunity cost of family labour. This is related once again to cash flow on the farm, given that someone with a side business is likely to have more cash on hand. Off farm employment is therefore expected to have a positive influence on the adoption of conservation tillage.

iv. Family labor (FAMLB): This was the quantity of labour in man-days per year available to the household for farming. The amount of family labour available on-farm was estimated based on the composition of the family and the participation of family members.

Smallholder farmers have a low propensity to hire labour outside their farms, because they are resource constrained. They mainly use family labour to do most of the farm work (CIMMYT, 1997). Family labour is increasingly scarce in the study area. The quantity of family labour available was hypothesized to have a positive influence on the adoption of the conservation tillage practices since they are labour-intensive technologies.

v. Farm size: This was the size of land, in acres, cultivated for maize and cowpea production. Farmers with bigger farm sizes may have extra land to try the new practices before they decide switching from the conventional practices. The larger the acreage under crop production, the greater the likelihood a farmer will be motivated to invest in equipment for conservation tillage (Kaumbutho and Kienzle, 2007). Larger farm sizes are associated with wealth and therefore farmers may plant perennial crops allowing the practice of conservation tillage on nurse crops on the same piece of land. Therefore, farmers with bigger farm sizes were hypothesized to adopt ripping and tied ridging than those with smaller sizes of land.

vi. Experience (EXP): This was the number of years of farming experience of the household head. Frank (1997) observed that individuals assess the utility of new practices by relating their perception of the practice to their experience. Consequently, years of farming experience and exposure are likely to aid adoption.

vii. Extension services and technology promoters (EXTORG): This was the number of times a farmer has had contact with the researchers and extension officers in the last four years. The respondents were asked to recall or refer to farm records for the number of times the extension officers or technology promoters had visited them for the purpose of helping them with conservation tillage. It was hypothesized that the degree of contact would highly enhance adoption.

viii. Membership in farmer organizations (GRPMB): This variable was coded as a dummy variable, where members to a group = 1, and non-members = 0. Members of an organization for instance, farmer groups, and non-governmental organizations are more privileged compared to other farmers in terms of access to information on agricultural innovations (de Harrera and Sain, 1999). Groups in Kenya have taken an active role in mitigating drought impacts on their members and the scope of drought mitigation appeared to expand as groups mature over time (Coopock et al., 2005). Membership in a farmer organization is therefore expected to relate positively to the adoption of conservation tillage practices.

ix. Distance to the nearest market (DTM): This variable was measured as the number of kilometers (km) from the farm to the nearest local market. Farmers who are closer to input and output markets have better access to production inputs and can easily sell their farm produce. Long distance to the market disconnects farmers from the supply chain (Jonas et al., 2008). Low use of farm inputs by smallholder farmers in Sub-Saharan Africa is responsible for the gap between potential farmers yield and actual crop yields at farm level (Jonas et al., 2008). It was hypothesized that the distance to the nearest market (DTM) is negatively related to the adoption process.

RESULTS

Descriptive statistics of explanatory variables used in the model

Table 1 presents the descriptive analysis of some discrete variable for the adopters of ripping and/or tied-ridging. The adopters were more in off farm employment (Table 1). Off farm employment provided more cash flow to the household. The adopters reported to have used off farm income to purchase farm inputs for ripping and/or tied ridging. The inputs included rippers, ridgers, herbicides and wages for hired labour. Personal interview with the adopters found out that most of the rippers (at 4%) and ridgers (at 5%) were owned by farmers in off farm employment. Hence farmers in off farm employment were more likely to adopt ripping and/or tied ridging.

The study found out that public extension officers and non-government organisations promoting ripping and tied ridging preferred working with farmers who showed common interests and hence in groups. Group membership is crucial in the study area since most of the demonstrations and farm trials on ripping and tied ridging were carried out among farmers in groups. The groups are also important in the procurement and ownership of implements for conservation tillage practices. Eighty two percent of the adopters were member to farmers' group (Table 1). Majority of the non-adopters reported that the status was due to lack of information which is accessible from groups. This illustrates that non-adopters joining groups or forming new ones could lead to more adoption of the technologies. The groups mainly included self-help groups, common interest groups and farmer co-operatives. The main objective of these groups was to improve the farm incomes by procuring the farm inputs and marketing the products, collectively.

More women were found to have adopted ripping and tied ridging than their male counterpart 63 % of the adopters were female compared to 37% males (Table 1). This is attributed to the fact that women provide most of the family labour for crop production. In addition, the practices contribute to increased crop yields as a result of soil moisture conservation hence more food to the household. Table 2 compares the crop yields of both maize and cowpea under conservation and conventional tillage.

Descriptive analysis of the sample socio-economic characteristics

The sample socio-economic characteristics for adopters and non adopters were analyzed and presented in Table 3. The mean, standard deviation, maximum and minimum analyses of each continuous variable were considered. Contact with technology promoters and public extension agents were found to increase the probability of using the technologies. Backstopping and information provision for ripping and tied ridging was done by both the governmental and nongovernmental organizations. The major technology promoters in the area of study were reported as KENDAT, MoA and the FAO and promoted the technologies at 36, 21 and 9% respectively in the last four years. Table 3 shows that farmers had been contacted at least once by these organizations for the last four years.

On the average, the distance walked by farmers to the nearest market was 3 km (Table 3). The study found that 45% of the adopters were at least one kilometer away

Table 1. Descriptive analysis of discrete variables for the adopters.

Variable	Category	Number reporting	Percent
Gender	Female	55	63
	Male	32	37
Group membership	No	16	18.4
	Yes	71	81.6
Off-farm employment	No	21	24.4
	Yes	66	75.8

Table 2. Yields of maize and cowpea under conservation tillage and conventional tillage in 90 kg bag per hectare.

Variable	Minimum	Maximum	Mean	Std. dev.	Case (n)
Yield under	3.000	20.000	8.538	5.0102	90
Conventional tillage	(0.747)	(4.000)	(5.9)	(5.234)	
Yield under	7.000	30.000	7.384	6.752	87
Conservation tillage	(2.780)	(7.000)	(10.4)	(8.750)	

The figures in brackets are for cowpea yields.

Table 3. Descriptive analysis of some continuous variables for the adopters and non adopters.

Variable	Definition	Min.	Max.	Mean N=177	S.D
Extension services	Number of contact by technology promoters for last four years	1.451	3.042	1.122	0.74
Farming experience	Farming experience of the household head in years	1.046	49.01	18.769	1.876
Farm size	Total farm size in hectares	1.046	15.43	4.676	0.856
Education	Level of education in years in formal school	7.99	15.78	9.231	0.961
Family labour	Family size as per number of family members providing farm labour	1.00	13.00	1.413	2.469
Distance to market	Number of kilometers from farm to nearest local market	0.20	18.09	2.970	1.623
Farm size under crops	Farm size under maize and cowpea in hectares	0.150	3.772	1.109	0.171
Age	Age of farmer in years	16.00	75.00	43.39	9.75

from the market, hence could easily access farm inputs like herbicides, rippers and effectively market their farm produce. The study found out that farmers far away from the market used other conservation measures to improve the soil moisture. Hence accessibility to the market is likely to contribute to adoption of ripping and tied ridging.

Most of the respondents had acquired up to primary education level (Table 3). The adopters and non-adopters were almost equally educated implying that the technologies were simple enough to be understood by all farmers at any educational level. The mean farming experience of the households was 18.8 years while mean landholding size was 4.7 acres. This landholding size can be considered large when compared with that of high rainfall areas (Jaetzold and Schmidt, 1983). Further, the technologies do not require lot of farm labour especially when the crop is in the field. This may be one of the reasons why the household had an average of one person proving farm labour (Table 2)

The mean distance of the household from the nearest market center was about 3 km. This was a considerable distance if farmers have to walk to buy inputs and sell

Table 4. Factors influencing adoption of conservation tillage practices.

Variable	Coefficient	Standard error	P-values
GENDER	0.2448	0.6288	0.9919
EDTN	-0.2479	0.0936	0.3364
FMSZ	-0.3092	0.1539	0.7478
OFFEMP	0.7774*	0.4532	0.0074
FARMEXP	0.03642**	0.0196	0.0406
FAMLOB	0.2532**	0.1790	0.0307
EXT	1.3171*	0.6295	0.0001
GRPMEBR	0.3445**	0.7383	0.0015
DISMRKT	-3.440*	0.6315	0.0524

Model N= 177, Pseudo R^2=0.358; Percent correctly predicted =89.231045, model chi-square = 69.941***; Log likelihood function (LnL) = -101.4686, Log likelihood function (LnLo) = -157.9848; ***, **, * significant at 1%, 5% and 10% level of error probability respectively.

their farm outputs. With this poor accessibility to market, market visits are confined to a single market day in a week in the study area.

Factors influencing adoption of ripping and tied-ridging conservation practices

The results of marginal effects for the factors influencing the adoption of the conservation tillage practices were analyzed by use of the logit model as shown in Table 4. The table also includes the list of independent variables used in the model and the expected effect.

Off farm employment was significant at $P < 0.1$. At the mean score, a unit increase in off farm employment increased the log-odds of adopting ripping and tied ridging by 0.778 when the other variables are held constant.This meant that farmers with off farm employment were more likely to adopt the conservation tillage practices than those without. This agrees with the qualitative information collected in the study. It was found that the presence of off farm employment is important in raising the opportunity cost of family labour.

The coefficient of farming experience was positive as hypothesized and significant at $P < 0.05$. This implies that farmers with more farming experience were more likely to adopt ripping and tied ridging. This relationship shows that as farmers gain experience, their decisions on the choice of conservation tillage practices are influenced positively (Adesina and Zinnah, 1993). At the mean score, a unit increase in farming experience increased the log-odds of adopting ripping and tied ridging by 0.036 when the other variables are held constant (Table 4). This result agrees with the human capital theory, which holds that farmers become less risk averse as they gain more experience (Welch, 1979). Thus, farmers with more farming experience make decisions faster and are able to adopt new technologies at higher rates.

The coefficient of family labour was positive and significant at $P < 0.05$. Hence, households with more members were better placed to adopt ripping and/or tied ridging than those with fewer members. This might be so because of the explanation provided earlier that the conservation tillage practices are labour intensive and particularly when furrows and depressions are being prepared. At the mean score, a unit increase in family labour increased the log-odds of adopting ripping and tied ridging by 0.253 when the other variables are held constant (Table 4).

The coefficient of contact with extension service and technology promoters was positive and significant at 10% level. Direct contact with extension services and organizations promoting the technologies provided technical backstopping in terms of information, rippers, farm demonstrations and other inputs to the farmers. This implies that there is need for frequent farmer contacts with promoters of the technology in order to enhance adoption. At the mean value, a unit increase in public extension contact and technology promoters increased the log-odds of adopting ripping and tied ridging by 1.317 when the other variables are held constant. The results are congruent to those of Kaumbutho and Mutua (2002) who found that provision of information on the existing draught animal resources could boost the use of conservation tillage practices in Makueni District.

At $P < 0.05$, the coefficient of group membership was positive and significant (Table 4). This implies that farmers are more likely to adopt conservation tillage when they are in groups. From personal interviews with farmer groups, it was revealed that non-governmental and governmental organisations preferred disseminating information to farmers in groups mainly due to scarcity of personnel and other resources. This implies that group membership is important in the dissemination of technologies at the grass root level. At the mean score, a unit increase in group membership increased the log-odds of adopting ripping and tied ridging by 0.344 when the other variables are held constant.These findings confirm work done by Grootaert (2001) who described group formation as one way of generating social capital which positively contributes to farm and non-farm economic activities in the rural communities.

As hypothesized, distance to the nearest market negatively influenced the adoption of ripping and tied ridging. The coefficient of this factor was significant at $P < 0.1$. As explained earlier, these results were realized because farmers far from the markets do not have access to farm inputs and information on ripping and tied ridging. Also, farmers far from the market may not be able to market their additional farm yield effectively. This result supports Jonas et al. (2008) argument that long distance disconnects villagers from input supply chain, making them lack market information and miss chances of adopting new technologies. At the mean score, a unit increase in distance to the nearest market decreased the log-odds of adopting ripping and tied ridging by 3.44 when the other variables are held constant (Table 4).

CONCLUSIONS AND POLICY IMPLICATION

This study examined factors that influence the adoption of the conservation tillage practices and used a logistic regression to identify the significant variables. Understanding these factors will facilitate a targeted approach in promoting use of conservation tillage in order to enhance maize and cowpea production in the semi-arid areas. The factors that significantly influenced the adoption of ripping and tied ridging were group membership, off farm employment, farming experience, extension contacts and distance to the market. Therefore, these factors should be incorporated in the design of policies and strategies developed to promote the use of conservation tillage practices.

Some farmers in the district under study are using the tillage practices, an indication that they have acquired the necessary technological knowledge and skills. This already acquired knowledge could be exploited to benefit other farmers and especially the non-adopters. This can be done by encouraging non-adopters to join existing groups or form new ones in order to learn practically from each other and access benefits that adopters in farmer groups have been enjoying.

Extension providers and promoters were found to enhance the confidence of farmers in adopting ripping and tied ridging through demonstrations and farm trials. This is because direct contact with extension services and organizations promoting the technologies provided information and technical backstopping on these technologies. Therefore, extension services and technology demonstration could be intensified among farmers to enhance practice of conservation tillage. It is important to note that this should not be limited to farmers far from the road or market places if the current adoption rate is to be enhanced.

REFERENCES

Adesina AA, Zinnah MM (1993). Technology characteristics, farmer perception and adoption decision. A Tobit model application in Sierra Leone. Agric. Econ., 9: 298-310.

Asambu FK (1993). Farmers' perception and economic analysis of factors affecting farm level maize enterprise performance and adoption of agricultural technological innovations in Semi-Arid South Eastern Kenya. MSc. thesis, University of Guelph.

Blackden CM, Bhanu C (1998). Gender growth and poverty reduction: Special program of assistance for Africa, status reports on poverty in the sub-Saharan Africa. In collaboration with the poverty and social policy working group of the special programme of assistance for Africa. World Bank Technical Paper No. 428. World Bank Washington, D.C.

Biamah EK (2001). Seasonal conservation tillage reports (1999) for Iiuni Conservation Tillage Trials Site, Machakos, Kenya. RELMA/Sida Report, Nairobi, Kenya.

Biamah EK, Rockstrom J, Okwach GE (2000). Conservation tillage for dry land Farming. Technical option and experience in Eastern and Southern Africa. Workshop Report 8-11 April, Bloemfontein, South Africa. Regional Land and Management Unit, Kenya.

Central Bureau of Statistics (CBS), Kenya (2001). Population projection. CBS, Kenya.

CIMMYT (1993). The Adoption of agricultural technology survey for survey design. Mexico.

CIMMYT (1997). The adoption of conservation tillage in a hillside maize production system in Motozintla, Chiapas. Natural Resource Group. Mexico.

Chuma R, Benites J, Fowler J, Kienzle Nyangumbo K, Steiner R, Molopong J (1998). Conservation tillage for sustainable agriculture. International workshop, Harare Zimbabwe. Deutsche Gesellschaft, Eschborn Germany.

Coopock DL, Desta S, Wako A, Aden I (2005). Origins, Governance, And Roles in Poverty Reduction Women's Groups in Arid Northern Kenya.

de Harrera AP, Sain G (1999). Adoption of maize conservation tillage in Azuero, Panama. Economics Working Paper 99-01. CIMMYT.

Feder G, Slade R (1984). The acquisition of information and the adoption of new technology. Am. J. Agric. Econ., 66: 312-320.

Food and Agricultural Organization (FAO) of the United Nations (2004). Soil and water
conservation in the semi arid lands. Natural resource management and environment department. FAO, Rome.

Frank BR (1997). Constrained limiting innovation adoption in northern Queensland beef industry. A socio economic means of maintaining a balanced lifestyle. Agric. Syst., p. 49.

Gachene CK, Kimaru G (2003). Soil fertility and land productivity. A guide for extension workers in Eastern Africa region. Regional Land and Management Unit, Kenya.

Greene WH (2004). Econometric Analysis. Fourth edition. Prentice Hall International Upper Saddle River, USA.

Grootaert C (2001). Does social capital help the poor? A synthesis of findings from the local level institutions studies in Bolivia, Burkina Faso, and Indonesia. World Bank Local Level Institutions Working Paper No. 10. Washington, DC. World Bank.

Gould BW, Saupe WE, Klemme RM (1990). Conservation tillage: the role of farm and operator characteristics and the perception of soil erosion. Land Econ., 65(2): 167-182.

Hagmann J, Murwira K, Chuma E (1996). Learning together: Development and extension of soil and water conservation in Zimbabwe. Q. J. Int. Agric., 35(2): 142-162.

Harper JK (2002). Economics of Conservation Tillage. Conservation Tillage series no.6, College of Agricultural Sciences, Penn state University.

Jaetzold R, Schmidt H (1983). Farm Management Handbook of Kenya. Vol. II/B. Central Kenya. Ministry of Agriculture, Nairobi, Kenya

Jonas NC, Mairura F, Ekise I, Chianu JN (2008). Farm input marketing in western Kenya: Challenges and opportunities Tropical Soil Biology and Fertility institute of the International Centre for Tropical Agriculture, Afr. J. Agric. Res., 3(3): 167-173.

Kaumbutho P, Kienzle J (2007). Conservation agriculture as practiced in Kenya: two case studies. Nairobi. African Conservation Tillage Network and Food and Agriculture Organization of the United Nations.

Kaumbutho PG, Mutua JM (2002). Experience from on farm conservation tillage trial in Kenya. Proceedings of a regional workshop on conservation tillage held in Lusaka, Zambia. Regional Land and Management Unit, Kenya.

Leagans JP (1979). Adoption of modern agricultural technology by small farm operators. Cornell international agricultural mimeograph no. 69, Cornell University, New York.

Maddala GS (2001). Introduction to Econometrics. 3rd edition. Cambridge University Press.

Mellis D, Matsaert H, Micheni A (1997). Rainwater harvesting for crops in semi-arid areas. In: Kang'ara, Participatory dryland agricultural research east of Mount Kenya, DAREP, RRC, Embu, Kenya. pp. 142-161.

Miriti JM (2005). Tied-riding and integrated nutrient management options for sustainable crop production in the semi-arid eastern Kenya. PhD. Thesis, University of Nairobi.

Okwach EG, Shepherd KD, Kwenah KM, Owiti AO, Omuto CT (2004). Assessment of land degradation in Machakos, Makueni and Kitui districts. Collaboration on Agricultural/Resource modeling and applications in Semi-Arid Kenya (CARMASAK) Technical report presented to Rockefeller Foundation.

Pretty (1999). "Can sustainable agriculture feed Africa? Evidence on progress, processes and impacts." Environ. Dev. Sustain., 1: 253-274.

Pindyck RS, Rubenfield DL (1991). Econometric models and economic forecast. McGraw-Hill New York.

Wale E, Holm-Müller K, Mburu J, Zeller M (2005). "Economic Analysis of Farmers' Preferences for Coffee Variety Attributes: Lessons for On-farm Conservation and Variety Adoption in Ethiopia". Q. J. Int. Agric., 44(2): 121-139.

Waswa F, Mburu J (2006). Potential of Dryland Farming in Kenya and Environmental Implications. In: Waswa F, Otor S, Mugendi D, Eds. Environment and Sustainable Development: A Guide for Tertiary Education in Kenya, Vol. 1. School of Environmental Studies and Human Science, Kenyatta University, Downtown Printing Works Ltd, Nairobi, pp. 70-90.

Welch F (1979). Education in publication. J. Polit. Econ., 78: 32-59.