

Determinants of Local Pre-Harvest Pest Management Practices in Maize Production in the Central Rift Valley of Ethiopia

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Abstract
A survey of 150 farmers randomly selected in 3 Peasant Associations (PAs) potentially producing maize was conducted to study the major pre-harvest pests of maize, local practices (LPs) used to manage such pests, farmers' perception of effectiveness of these practices and their determinants. The study was conducted in Adami-Tulu Jedo Kombolcha District, East Showa, Ethiopia. Pre-harvest pests such as insect pests, weeds, diseases and birds were perceived to be important problems in maize production. Hence, farmers adopted a range of LPs to manage these pests. Farmers perceived that local pest management practices (LPMPs) were effective in reducing pre-harvest pest attacks in maize production.A binary logit model employed to analyze determinants of use of LPMPs showed that 7 variables for field insect, 6 for weed management were significant out of the total 12 variables included to the model. They were sex, age, education, labor in man equivalent, farm experience, awareness on the introduction of chemical pesticides in the area, income, credit access and extension contact. The result indicated that the use of LPMPs was determined by socio- economic, socio-psychological and institutional factors.
Keywords: Local practices, pest management, maize production, Ethiopia

1. INTRODUCTION

Crop cultivation in Ethiopia is predominantly in the peasant sector and has hardly advanced beyond the subsistence level. In addition, small scale farmers in this country are constrained by a number of problems, which, among others include crop losses due to pests (Fantahun *et al*., 2003). The expected annual pre-and post-harvest yield losses due to various insect pests, diseases, weeds and vertebrate pests (birds & rodents) is between 30% and 40% (Fantahun *et al*., 2003).

Chemical control often creates a serious imbalance in agro-ecological system that sooner or later can lead to unsustainable pest control (Williamson, 2003) Hence, such recognition of the problems associated with the widespread application of pesticide has led to the development of Integrated Pest Management (IPM) with emphasis on low cost, locally available alternatives with less hazards to humans, animals and the environment (Dasgupta *et al*., 2004).

LPMPs, common in subsistence farming in Africa, are one of the major components of IPM. Before establishing an effective IPM strategy, one need to carefully understand the existing local farming practices. This paper, therefore, reports on farmers' perception of the effectiveness of LPMPs and the determinants of use of these practices.

2. METHODOLOGY

A multi-stage sampling technique was employed in this study. First, the study district, Adami Tulu Jedo Kombolcha, was purposively selected out of the 12 districts found in east Showa Zone of the Oromiya Regional State with the characteristic of proximity and accessibility. Next, 3 out of the 38 Peasant Associations (PAs) in the district with the characteristics of potential maize production and relative occurrence of pest infestation in maize production were purposively selected. Finally, a total of 150 farm household heads (HHs), 37 from Haleku-Bonke, 56 from Annenu-Sheshu, and 57 from Gobechechu-Asebot PAs based on probability proportional to size (PPS) technique were randomly selected and interviewed using a structured interview schedule to collect quantitative and qualitative data.

The quantitative data were analyzed using descriptive statistics. Moreover, a binary logistic regression model was used to identify those variables supposed to determine the use of local pre-harvest pest management practices using SPSS for windows version 12. Following Hosmer and Lemshow (1989), the logistic distribution function for the decision to use the LPMPs can be specified as: -

$$p(i) = \frac{1}{1+e^{-Z(i)}} \quad \text{--} \quad (1)$$

Where *p* (i) is a probability of deciding to use the LPMPs for i^{th} farmer and Z(i) is a function of *m* explanatory variables (Xi) and is expressed as:

$$Z(i) = \beta_{\circ} + \beta_1\chi_1 + \beta_2\chi_2 + ... + \beta_m\chi_m \quad \text{------------ (2)}$$

Where B_o is the intercept and B_i is the slopes parameter in the intercept in the model. The slopes tell how the log-odds in favor of deciding to use LPMPs changes as the independent variables change by a unit.

Since the use and non-use of LPMPs depend on each pest type, the model was run separately for each pre-harvest pest category (Table 3 and 4).

After checking the multicolliniarity problem for both continuous and discrete variables, a total of 12 independent variables were included in the model. They were sex (HHSEX), age (HHAGE), education (HHEDU), labor availability in man equivalent (TLABOR), farming experience (FEXP), awareness of chemical pesticide introduction (AWARENES), maize land area (MZELND), total livestock unit (TTLU), income (TINCOME), credit (CREDIT), availability of chemical pesticides (PSAVL) and extension contact (EXTCNCT). Goodness of fit measures, such as Hosmer and Lemeshow and Pearson Chi-square tests were also checked and confirmed that the model fits the data.

3. RESULTS AND DISCUSSION

3.1. Major pre-harvest pests of maize in the study area

Army worms (78%), stalk borers (74%), and termites (60.7%) were the major insect pests reported by the sample farmers causing the most damage to maize. Weeds such as, Black jack (92%), Spiney pigweed (86%), Apple of peru (81.3%), Thorn apple (79.3%), Cocklebur (77.3%), Wandering jew (75.3%), Mexican poppy (73.3%), Spiny cocklebur (68%), Love grass (66%) and Gallant soldier (64%) were reported to be the major ones in their order of importance damaging maize in the area. Seventy six percent of the respondents indicated that both head smut and rust were the major diseases severely affecting maize. Moreover, the major birds reported to have been attacking maize were both Quelea quelea and Pigeons (76%) (Table 1).

Table 1. Sample HHs responses on pests causing the most damage to maize in the area

S.N	Types of pre-harvest pests damaging maize most	HH responses (%)	
		Yes	No
1.	Insect pests:		
	Army worm (*Spodoptera exempta*)	78.0	22.0
	Stalk borer(*Chilo partellus*)	74.0	26.0
	Termites (*Nasutitermes spp*.)	60.7	39.3
	Cut worm (*Agrotis segetum*)	40.7	59.3
2.	Weeds:		
	Black jack (*Bidens pilosa L.*)	92.0	8.0
	Wandering jew (*Commelina benghalensis L.*)	75.3	24.7
	Love grass (*Setaria verticillata L.*)	66.0	34.0
	Mexican fireplant (*Euphorbia heterophylla L.*)	57.3	42.7
	Mexican poppy (*Argemone mexicana L.*)	73.3	26.7
	Gallant soldier (*Galinsoga parviflora cav.*)	64.0	36.0
	Apple of peru (*Nicandra physalodes*)	81.3	18.7
	Cocklebur (*Xanthium strumarium L.*)	77.3	22.7
	Pigweed (*Amaranthus graecizanas L.*)	51.3	48.7
	Spiney pigweed (*Amaranthus spinosus L.*)	86.0	14.0
	Thorn apple (*Datura stramonium L.*)	79.3	20.7
	Congress weeds (*Parthenium hysterophorus L.*)	48.0	52.0
	Purple nutsedge or nut grass (*Cyperus rotundus L.*)	55.3	44.7
	Spiny cocklebur (*Xanthium spinosum L.*)	68.0	32.0
3.	Diseases:		
	Head Smut (*Sphacelotheca spp.*)	10.0	90.0
	Rust (*Puccinia polisora*)	4.0	96.0
	Both	76.0	24.0
4.	Birds:		
	Pigeons (*Columbidee spp.*)	10.7	89.3
	Quelea quelea (*Quelea quelea ethiopica*)	23.3	76.7
	Both	66.0	34.0

3.2. Farmers' perception of effectiveness of LPMPs in maize production

As indicated in Table 2 below, inter-row cultivation (86.7%), hoeing (78%), field sanitation and hand weeding (both 74%), use of clean seed (72.7%), deep plowing (71.3%) and crop rotation (66%) were perceived by the respondents as an effective insect pest and weed management practices.

Farmers apply inter-row cultivation using oxen locally known as '*Shilshallo'* after one month of sowing to control weeds. Negussie (2005) reported that in Jima, Ethiopia, this traditional weeding operation was taken place three times for local maize and was proved to be effective in controlling weeds. Hoeing and hand pulling are the most primitive weed management methods used in maize production in Ethiopia. They are more practical and effective for small-scale farmers (Kassa *et al*., 2001).

Sanitation of crop residues, along with other cultural practices, will reduce the likelihood of insect damage (ESMSU, 1914). Farmers collected crop residues (stalks) and destructed termite mound to remove stalk borer and termites from the field, respectively.

Farmers of the study area had the knowledge that sowing a clean seed by selection reduced infestation of insect pests and weeds. In India, farmers stated that seedlings from healthy seeds competed better with weeds and were more tolerant to adverse environments (Moody *et al*., 1997).

Farmers reported that they plowed their land up to three times before sowing maize seeds to minimize both the infestation of weeds and insect pests. Insect populations are not disturbed as much as with conventional tillage practices (ESMSU, 1914). They also noted that preparation of canals/ditches surrounding the maize farm inhibited the movement of an army worm, locally known as *Siqqo*, to the maize field.

Table 2. Farmers' perceptions of effectiveness of local pest management practices

	Responses on effectiveness (%)		
1. Insect pest and weed management practices reported:	Agree	Neutral	Disagree
Crop rotation	66.0	26.7	7.3
Fallowing	37.3	62.7	0.0
Field sanitation	74.0	10.0	16.0
Deep plowing	71.3	20.0	8.7
Repeated plowing	52.7	28.0	19.3
Preparing canals around the farm	56.0	24.7	19.3
Using clean seed	72.7	10.6	16.7
Hand weeding	74.0	0.0	26.0
Hoeing	78.0	0.0	22.0
Cutting	41.3	20.0	30.7
Inter-row cultivation (*shilshalo*)	86.7	0.0	13.3
2. Disease management practices reported:			
Uprooting the diseased plant (HS)	85.3	0.0	14.7
Using resistant variety (HS)	77.0	16.0	7.0
Hoeing (R)	56.0	8.0	36.0
Thin planting (R)	80.7	10.0	9.3
Avoiding inter-row cultivation in rainy days (R)	86.7	1.3	12.0
Avoiding entry of flood to maize land (R)	68.7	13.3	18.0
3. Bird management practices reported			
Scaring with sling	64.7	0.0	35.3
Scaring with whip	78.0	4.7	17.3
Erecting different objects in maize field	69.3	20.7	10.0
Knocking sound producing objects	84.7	0.0	15.3

Key: HS = for head smut management, R = for rust management

The process of planting a different crop in the following season will deprive the pest of an adequate host (Srivastava and Meyer, 1998). Farmers of the study area rotated maize with haricot bean (*Phaseolus vulgaris*) to manage insect pests and weeds and they practically checked its effect in reducing infestation.

Regarding disease management practices, farmers reported that removing the diseased maize plant (85.3%) and using resistant variety (77%) to manage head smut, locally known as *Senbo or waggii* and avoiding inter-row cultivation in rainy days (86.7%), thin planting (80.7%) and avoiding entry of flood to maize land (68.7%) to manage rust, locally known as *udde,* were effective (Table 2).

In thin planting, the existence of wider spacing between and within rows reduces both relative humidity and free moisture on the leaves, and this decreases the disease infection (Tewabech *et a*l., 2001). Selecting and then removing the diseased plant from the field was reported to be the most effective practice in managing head smut. In Tanzania, it is reported that farmers simply uprooted the infected plants, especially for Maize streak virus (MSV) and head smut (Bisanda *et al*., 1998). Farmers also noted that 'changing the seed' which means using resistant variety in the next cropping season was another option to solve the occurrence of this disease.

As indicated in Table 2 above, farmers scared off birds which attacked maize using sound producing materials (84.7%) like knocking worn out tins and iron sheets, using whip (78%), by erecting different objects (69.3%) like forehead of a slaughtered animal, man like objects, used plastic bags, and using sling (64.7%). Bisanda *et al*. (1998) reported that scaring was an effective control method for birds in Tanzania.

3.3. Determinants of use of LPMPs in maize production

Out of the twelve explanatory variables hypothesized to affect farmers' decision to use LPMPs, seven and six variables were found significant in the management of field insects and weeds, respectively. They were sex (HHSEX), age (HHAGE), education (HHEDU), labour availability (TLABOR), farm experience (FEXP), awareness of introduction of chemical pesticides (AWARENES), income (TINCOME), credit (CREDIT) and extension contact (EXTCNCT) (Table 3 & 4).

Table 3. Logistic regression estimates of determinants of LPMPs for field insect management

Explanatory variables	Estimated coefficient (B)	S.E	Wald statistics	Sig. level	Exp (B)
HHSEX	-.868	1.467	.350	.554	.420
HHAGE	.377	.158	5.696	.017**	1.458
HHEDU	-.316	.132	5.736	.017**	.729
TLABOR	.950	.452	4.417	.036**	2.585
FEXP	.134	.081	2.726	.099*	.875
AWARENES	-2.029	1.103	3.383	.066*	.131
MZELND	-.271	.714	.144	.705	.763
TTLU	-.021	.050	.174	.676	.979
TINCOME	-.001	.000	2.758	.097*	.999
CREDIT	-.557	.937	.354	.552	.573
PSAVL	-1.740	1.317	1.744	.187	.176
EXTCNCT	-2.201	.621	12.571	.000***	.111
Constant	-5.085	3.776	1.814	.178	.006
Pearson χ^2 value		114.37***			
-2 Log Likelihood		43.702			
Hosmer & Lemeshow test χ^2 value		1.34			

*, **, *** = Significant at 10%, 5% and 1% probability level, respectively

Age was found to be significant at $P < 0.05$ and was positively related with the use of LPs for the management of field insects and weeds. Keeping all other factors constant, the odds ratio indicates that the probability of using LPs increases by a factor of 1.458 and 1.254, respectively, as the age of the household head increases by one year. Elders play an important role in preserving indigenous knowledge (DCFRN, 2007). They learn best from experience, which in the case of farmers means from observations in the field (Williamson, 2003). As can be seen from the result, elder farmers applied the LPMPs than the younger. It is reported that older farmers, having rich experience and knowledge, depended on traditional control practices than younger farmers (Negussie, 2005).

Education was significant at $P < 0.05$ for field insect and weed management. In both cases, it was related negatively with the use of LPs. Keeping some other factors constant, the probability of using LPs decreases by a factor of 0.729 and 0.755, respectively, as the education level of a household head increases by one school year. Formal schooling, often, reinforces the negative attitude towards using indigenous knowledge and practices (Grenier, 1998). In the eyes of formal schooling, IK is said to be primitive, superstitious, or unscientific (DCFRN, 2007) as modern education is a promoter of Eurocentric cultures (Battiste, 2004). As a result, uneducated or less educated farmers are more inclined to utilize their local knowledge for pest management than the educated ones.

Labor availability was significant and positively related with the use of LPs in managing field insects ($P < 0.05$) and weeds ($P < 0.10$). Holding all other factors constant, the likelihood ratio indicates that the probability of using LPs increases by a factor of 2.585 and 2.009, respectively, as labor availability increases by one-man equivalent. Family labor is the small farm households' primary productive unit (Sands, 1986). Labor unavailability among others is the major force that drives farmers to become pesticide dependent (Moody *et al.*, 1997). In this study, those who had more family labor were more inclined to apply LPMPs than those who had less labor availability. A study conducted in Tanzania indicated that one of the reasons that farmers abandoned the traditional ways of controlling insect pests and diseases was that chemical pesticides require less time and therefore less labor for preparation and application (Mugmia, 2001).

Table 4. Logistic regression estimates of determinants of LPMPs for weed management

Explanatory variables	Estimated coefficient (B)	S.E	Wald statistics	Sig. level	Exp (B)
HHSEX	-.634	1.247	.259	.611	.530
HHAGE	.227	.115	3.903	.048**	1.254
HHEDU	-.281	.124	5.155	.023**	.755
TLABOR	.698	.367	3.614	.057**	2.009
FEXP	-.068	.067	1.010	.315	.934
AWARENES	-2.115	.991	4.559	.033**	.121
MZELND	-.112	.577	.037	.846	.894
TTLU	.000	.047	.000	.997	1.000
TINCOME	-.003	.001	3.759	.053*	.997
CREDIT	-.348	.826	.177	.674	.706
PSAVL	-.348	1.069	.106	.745	.706
EXTCNCT	-2.143	.528	16.479	.000***	.117
Constant	-2.651	3.108	.727	.394	.071
Pearson χ^2 value		111.41***			
-2 Log Likelihood		51.569			
Hosmer & Lemeshow test χ^2 value		4.26			

*, **, *** = Significant at 10%, 5% and 1% probability level, respectively

Experience was found significant at P < 0.10 in the management of field insect and was positively related with the use of LPs. The positive sign indicates that those household heads that had more farming experience were in a better position to use LPs in managing insect pests than who had lower experiences. Keeping all other factors constant, the probability of using LPs to manage insect pests increases by a factor of 0.875 when the experience of the household head increases by one year. From an indigenous perspective, traditional knowledge is developed from experience gained over the centuries and adapted to the local culture and environment (SPFII, 2005). It was seen that more experienced farmers utilized their local knowledge for pest management than less/little experienced farmers. Experience improves farmer's knowledge and skill in the production process. A more experienced grower has lower level of uncertainty about the performance of the technology or practice (Ebrahim, 2006).

Awareness on the introduction of chemical pesticides was significant in the case of field insect (P < 0.10) and weed (P < 0.05) management. It was related negatively with the use of LPs. Assuming all other factors constant, the odds of using LPs decreases by a factor of 0.131 and 0.121, respectively, when a household head becomes aware of the introduction of chemical pesticides in his/her area. In areas and regions where pesticide use is not widespread or even non-existent, the chances of promoting site appropriate measures or maintaining and improving traditional practices are fundamentally good (PAN, 1995). In this study, those who were ignorant of the introduction of chemical pesticides depended on the use of LPs than those who were aware of them. Negussie (2005) reported that the provision of commercial insecticides along with the extension packages (maize) threatened the use of traditional pest control practices in Jima, Ethiopia. Similarly, a study in Tanzania showed that farmers rapidly abandoned the traditional ways of controlling insect pests and diseases and opted for industrial agro-chemicals after their introduction (Mugmia, 2001).

In this study, income was found significant and was negatively related with the use of LPs for the management of field insects and weeds at P < 0.10. Keeping all factors unchanged, the probability of using LPs decreases by a factor of 0.999 and 0.997, respectively, when income of the household head increases by one birr. It was observed that those who had relatively less income were inclined to use LPMPs than those who had more income. It is indicated that poor farmers who can't afford commercial pesticides favored traditional crop protection practices (Abraham, 2003, Tadele, 2004 and Negussie, 2005). In Kenya, it is reported that, on small farms, cultural practices (planting in rows and weeding more than once), were more widely adopted than recommended inputs requiring cash such as commercial fertilizer or the application of insecticide on stored maize (Sands, 1986).

The number of extension contacts that a household head had per month was significant at P < 0.01 in the case of field insect and weed management. It was related negatively with the use of LPs. Holding all other factors constant, the odds of using LPs decreases by a factor of 0.111 and 0.117, respectively with a unit increase in extension contact. In Africa, many government extension programs encourage the use of pesticides for pest management (Tsedeke *et al*., 2000) than the traditional practices. Farmers are made to think that using pesticides is a 'modern' practice (Groot, 2000). In this study, those farmers who had less/little extension contact depended on LPs to manage pests than those who had a frequent contact. A study on rice farmers in Philippines also revealed that most of the development agent technicians' recommendations on pest management included using either spray or granular insecticides (Warburton *et al*., 1997) than traditional practices.

4. Conclusion and recommendation

Maize is one the most important cereal crops serving as a staple food for millions of people in Ethiopia. The smallholder farmers producing maize in the study area faced pre-harvest insect pests and weeds which limited their production. Thereby, they adopted a range of LPMPs and perceived that the majority of the practices were effective in tackling these pests. However, these practices are mainly applied by those who are less educated, older, economically poor, less contacted by extension agents but highly experienced subsistent farmers. That means, the LPMPs seem to be left to the socially and economically marginalized sections of the community as a last resort to solve their problems. Therefore, the extension and research organizations should closely work with farmers to document, promote and further improve the efficacy of these practices to minimize the pre-harvest loses and hence increase maize production in the area. Besides, these organizations along with other stakeholders should provide a considerable attention to the local practices as they do to the modern ones. This is because, available local technologies and practices are environment friendly, less costly, effective (as they are tested over centuries from generation to generation) in addressing the small farmers' problems in particular and the problems of the subsistent agriculture in general.

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