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Full Length Research Paper

Factors determining the use of botanical insect pest control methods by small-holder farmers in the Lake Victoria basin, Kenya

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A farm survey was conducted in three representative administrative districts of the Lake Victoria Basin (LVB), Kenya to document farmers' indigenous knowledge and the factors that influence the use of botanicals instead of synthetic insecticides in insect pest management. A total of 65 farm households were randomly sampled using stratified sampling procedure. The maximum likelihood log model was used to determine factors that influence use of botanical and synthetic insect pest control methods (PCM). Results revealed that female gender as household head (HH) and age significantly ($P < .001$) increased the likelihood of a household using botanical PCM in the field by 0.15 and 0.021, respectively. In storage, female gender and severity of pest infestation significantly ($P < .001$) increased the probability of a household using botanical insecticide by 0.814 and 0.738, respectively. On the contrary, education of HH (0.342) and ownership of title to land (0.512) significantly ($P < .001$) reduced the likelihood of using botanical PCM in the field, while traditional rank (0.910) and cash rank (0.744) of the crops reduced the likelihood of using botanical insecticides in the store. With respect to synthetic pesticides, gender (3.407), area cultivated (0.295) and expected yield (5.315) significantly ($P < .001$) reduced likelihood of their use in the field, while food rank (3.967) reduced the probability of use in storage. In storage, female gender, crop type, food and traditional rank of crops were also the most important factors determining the use of botanical control methods. In conclusion, the study established that female gender, literacy levels, wealth endowments in form of land and old age are key determinants of botanical insecticides use in small-holder farming systems in the LVB, Kenya. It is recommended that the Government of Kenya enacts policies that empower youth and female gender economically in subsistence farming with the aim of improving their educational levels and farming skills to modernize agriculture among the rural communities.

Key words: Botanical, Synthetic pesticide, Insects, Pest control method, Determinants, Small-holder farmers.

INTRODUCTION

Subsistence farming is predominant in the rural areas of the developing world where it directly employs 50 - 70% of the population. Its' contribution to local and regional food security is crucial since they produce most of the stable food crops (Altieri 1993; MacKay et al., 1993; Tefera, 2004). However, it experiences several crop production and protection challenges such as diseases, insect pests, poverty, access to credit, education level among others (Saxena et al., 1990; Altieri, 1993;). It is estimated that field and storage pests destroy approximately 43% of potential production in developing

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Asian and African countries (Jackobson, 1982; Ahmed and Grainge, 1986; Ogendo et al., 2004).

Furthermore, these smallholder farmers have been bypassed by agricultural modernization as new technologies were not made available to them on favorable terms, while some of which often do not suit their agro-ecological and socio-economic conditions (MacKay *et al.,* 1993). Pest management innovations are no exception. For instance, the promotion of synthetic pesticides in the control of insect pests though effective, is expensive and has raised health and environmental concerns (Talukder, 2006; Isman, 2007). The risks associated with use of synthetic insecticides are even higher among small scale farmers because of poverty and lack of skills to obtain and handle pesticides appropriately (Saxena et al., 1990). Thus, pests particularly insects, continue to ravage crops and without proper protection systems, farmers continue to lose most of their produce.

In recent years there has been an attempt to replace the synthetic insecticides with less expensive, locally available, ecologically safe and socio-friendly options including botanicals (Banwo and Adamu, 2003; Ogendo et al., 2006; Talukder, 2006; Isman, 2007).

However, traditional farmers perceptions of pest problems and indigenous control methods employed are yet to be critically evaluated. The available information is mostly observational/ anecdotal and does not provide quantitative details about various socio-economic factors that influence the indigenous pest control practices (Altieri, 1993). As a result, the development and extension of improved and adaptable pest management technology for small scale farmers in developing countries is being re-examined. Hence, a study was conducted to document farmers' indigenous knowledge and the factors that influence the use of botanicals as alternatives to synthetic insecticides in pest management in the Kenya's Lake Victoria basin. Determination of this information will contribute towards policy intervention framework for improving use of botanical insecticides.

MATERIALS AND METHODS

Sampling procedure

Sampling was done using a stratified simple random procedure between August 19th and September 3rd, 2007 in three administrative districts of Bondo, Busia and Teso according to Ogendo et al. (2004; 2006). Each of the three districts was considered as homogenous sampling block and administrative divisions, locations, sub-locations and villages within each stratum were randomly represented during the sampling. A total of 65 (23, 22 and 20 in Bondo, Busia and Teso respectively) farmers were randomly selected and interviewed for indigenous knowledge and practices of insect pest control using semi-structured questionnaire. Additional observations were made by researchers to confirm respondents' claims on these practices.

Information on farmers' traits

Information on farmer's residential address (village, sub-location, location, division and district), age, farming experience, education and household position was gathered using semi-structured questionnaire. Likewise, information on land ownership in relationship to household head (HH), sex, age, farming experience, education level and primary occupation of farmers were also collected. These variables were considered to have influence on the decision- making and crop- pest management at the farm family level.

Identification of field and storage pests

The major pest species and their infestation status in field and storage were studied. Identification of field and storage insect and non-insect pests was carried out by the researchers on the basis of expertise and available literature materials during the survey (Bohln, 1973; Singh, 1990). Identification also relied on farmers' description and ability to recognize the said pest from own knowledge and amongst other species using pictorial aids (NRI poster, 1999).

Documentation of botanical insecticides and pest control methods

The botanicals and other indigenous products locally used by small scale farmers in the management of field and storage pests were documented. Samples of plants reported to be insecticidal were collected and on the spot identification of individual plant species carried out with the help of expertise, pictorial aids and literature materials (Kokwaro and Johns, 1998). Where the available expertise and literature proved inadequate, pressed plant specimens between used news print papers were forwarded to the plant taxonomist in the Department of Biological Sciences, Egerton University for further identification and authentication.

Data analysis

Determinants of a specific pest control method used in small-holder farming can be defined within probability distribution. Therefore, decision to use either botanical or synthetic insecticides is equal to (1) if the household uses, and (0), if they do not use. This implies that factors with positive influence on PCM usage are those that increase the probability of usage by a given household, while negative factors are those that reduce the probability of usage of the same by a household. The probability estimation of these factors follows a binary Probit model (Greene, 2003), as below:

$$\Pr ob\left[D_i = j\right] = \frac{\mathrm{EXP}(\beta_j X_i)}{s(j = 0 - j)\mathrm{EXP}(\beta_j X_i)}, j = 0,1 \ldots\ldots, J$$

…………………….. (1)

Where 'X_i' is a vector of covariates that define household characteristics, with the log likelihood function expressed as:

$$\Pr(D_i = 1) = \frac{1}{1 + \sum \mathrm{EXP}^{\beta_k^J X_i}} \ldots\ldots\ldots (2).$$

In its reduced form, the model becomes:

$$D(0,1) = Log\left(\frac{p}{1-p}\right) = \beta_0 + \beta_{ij} X_{ij} + \varepsilon,$$

……………………………… (3)

Table 1. Hypothesized effects of explanatory variables on chronic poverty.

Variable	Definition Hypothesized effects	
Age	Age of the head years	(+)
Access to credit H. H.	If access credit (Yes, No)	(-)
experience Education of	Experience of decision maker in years	(+, -)
head Gender of head	Formal education of decision maker in years	(+)
Ownership of title	If decision maker is female (Yes, No)	(+)
access to transfers	If owns title to farm land (Yes, No)	(-)
Distance to the market	If has constant access to transfers (Yes, No)	(-)
Value of livestock assets	Distance to market in km	(+)
Agricultural potential	Value of livestock assets (ksh)	(-)
	If farm is in high tropics (Yes, No)	(-)

Table 2. Comparisons of farmers' mean age, education and farming experience in the three Districts of Bondo, Busia and Teso, Kenya.

District	Gender	Age (yrs)	Education (level)	Experience (yrs)
Bondo	male	56.20 ± 12.41	2.20 ± 01.23	18.90 ± 09.80
	female	52.63 ± 13.71	1.94 ± 00.85	25.19 ± 15.57
Busia	male	50.33 ± 18.23	2.33 ± 00.87	21.78 ± 17.95
	female	50.55 ± 14.81	2.09 ± 00.94	24.18 ± 14.37
Teso	male	66.06 ± 14.65	1.82 ± 00.73	36.29 ± 7.08
	female	47.67± 02.08	2.67 ± 01.53	28.00 ± 07.21
Overall mean		55.74 ± 15.30	2.06 ± 00.93	26.59 ± 15.89

Education level; 0= No formal education, 1= primary, 2= secondary and 3= university education

Where D is the indicator for using the PCM in question, P is the probability of the event's occurrence, while X_i is a vector of household socio-economic characteristics, covering household specific factors such as age, education, household size, ownership of title to land, access to transfers, off-time employment, market characteristics such as time to market and credit markets. $_{0,\ ij}$ are the corresponding vectors of parameters and εis the disturbance term.

Variables and hypothesized effects

The questionnaire was presented through face to face interviews with questions ranging from household specific characteristics such as age, gender, education, household size, income levels and asset endowments. Farm specific questions addressed issues such as land ownership, farm size and related production activities, while market factors included distance to the local market and access to credit market. Table 1 presents explanatory variables with their hypothesized effects on use of botanical control methods, and as indicated, use of botanicals and access to education were also hypothesized to reduce usage, implying that the more educated the decision maker the better skilled and more exposed to modern synthetic pesticides he or she is and consequently the less the use of local materials. Female gender in decision making was hypothesized to have a positive effect. In Africa more women than men are involved in rural agricultural economic sub-sector but at the same time majority of them have no rights to property, a factor that infringes on their access to purchased inputs, which drags their households using local materials.

Land holding, on the other hand, releases the binding land constraint for all enterprises and is also an asset which enables households to easily access both input and credit markets. Literature on land ownership indicates that land enhances the chances of diversification into a variety of enterprises with the effect of improving on the overall farm profitability and reducing poverty levels. Consequently, households with titles to land were hypothesized to use synthetic pesticides as opposed to botanicals. Constant access to credit, presents households with additional income for productive purchased inputs, investment and/ or consumption smoothing, both of which are expected to have a negative impact on use of botanicals. However, with respect to time to the market, farmers located far away from both input as well as product markets are expected to use more of botanicals as high transactions costs prevent them from use of synthetic pesticides.

RESULTS

Farmers' traits

Results showed that the respondents were dominated by males, with 60 and 40% males and females respectively. The age and educational levels of the farmers in the three districts did not show major variations. However, farming experiences differed remarkably among them. For instance, Teso district had older farmers with mean age of 63 years compared to 54 and 50 years for Bondo and Busia, respectively. Education status, on the other hand, was similar across the districts with most having gone through primary level and above (Table 2).

Table 3a: Frequency of major field pests of crops in the three Districts of Bondo, Busia and Teso, Kenya

Pest	Bondo	Busia	Teso	Total
Stem borer (*Busseola, Chilo* spp)	10	19	13	42
Aphids (*Aphis* spp)	14	14	8	36
None	15	9	9	33
Rodents (*Rattus* spp)	3	11	17	31
Cutworm (*Agrotis* spp)	5	5	8	18
Aphid/pod feeder/bean fly	10	2	5	17
Aphid/stemborer	5	6	5	16
Pod feeder (*Maruca* spp)	5	1	5	11
Termites (*Macrotermes* spp)	6	2	1	9
Birds	2	1	6	9
Stem borer / Army worm/Aphid	4	2	2	8
Stem borer/grain weevil	3	1	4	8
Rodents/sweet potato beetle	1	5	2	8
Pollen beetle (*Meligethes* spp)	1	2	5	8
Birds, aphids & stemborer	3	2	2	7
Stem borer /termites	3	1	3	7
Sweet potato weevil (*Sylas* spp)	1	3	3	7
Armyworms (*Spodoptera exempta*)	0	2	5	7
Grasshoppers	2	2	2	6
Others	24	18	24	66
Total	117	108	129	354

Conversely, farming experience showed a considerable variation across the districts, with Teso having the highest experience (mean of 36 years) followed by Busia and Bondo with 23 and 22 years respectively (Table 2). Generally there was no gender disparity across the districts in age, education and farming experience except in Teso where male farmers were 10 years older than their female counterparts (Table 2).

Field and storage pests

Although farmers reported an array of pests across the three districts, it emerged that most crop types were infested by similar major pests. Stem-borers were reported as major cereal pests by 45, 31 and 24% of farmers in Busia, Teso and Bondo respectively.

Rodents and birds were the major non-insect pests recorded in the three districts (Table 3 a, b). Aphids were the most severe field insect pests reported by 47 and 32% of farmers in Bondo and Busia, respectively. In Teso pollen beetles and pod- feeder were observed as major legume field insect pests by 71 and 43% of farmers, respectively. Rodents were the major non-insect pests in Teso and Busia followed by birds. Overall, Teso district had the largest assemblage of field pests. On average, >40% of farmers reported grain weevils (*Sitophilus* spp.) in their stored cereal grains in Bondo and Busia districts with 20% in Teso. Other storage insect pests reported were grain moths (*Sitotroga cerealella*), larger grain borer (*Prostephantus truncatus*), rodents and flour beetles (*Tribolium castaenum)*. Dried stored cassava was damaged by rodents in all districts (14 - 22%).

Generally, rodents were the only non-insect pest attacking all the stored cereal grains and produce across the districts (Table 3 a, b).

Botanical insecticides

The inventory of botanical insecticides and other indigenous products used in traditional control of insect pests has shown that majority of farmers never uses botanicals to control insect pests in the field (76%) and storage (79%), respectively. In the field, aqueous concoction of wild sunflower, (*Tithonia diversifolia.)* was the most commonly used (9% of farmers) for insect pests control. Pepper (*Capsicum annum* L.), neem (A*zadirachta indica)*, "Emusi" (*Urera hypseldendron*), "Mululushia" (*Vernonia amygdalina*), *Acacia sial,* Mexican Marigold (*Tagetes miniuta)*", *Eucalyptus spp* and Sodom apple (*Solanum incanum* L.) extracts were also used by the farmers as sources of insecticides (Tables 4a and b). Indigenous options involving general and cow-dung ashes were the dominant methods of protecting grains in storage used by 15% and 3% of farmers respectively. Other specific plant ashes such as bean husks, Acacia, maize cobs, Sisal and others were also used in the

Table 3b. Frequency of major storage pests by crop type in the three districts of Bondo, Busia and Teso, Kenya.

Pest	Other Crops	Tubers	Legume	Cereals	Total
None	59	15	24	6	104
Grain weevil (*Sitophilus* spp)	6	3	3	43	55
Bean beetle (*Acanthoscelides obtectus*)	1		34		35
Grain weevil/Grain moth	2			26	28
Grain Weevil/LGB	1			17	18
Rodents (*Rattus* spp)	1	1	3	9	14
Pulse beetle (*Callosobruchus* spp)		1	11		12
Grain weevil & rodents	1	2	1	7	11
Flour beetle (*Tribolium* spp.)	2	1	1	4	8
Larger grain borer (*Prostephanus truncatus*)		1	1	6	8
Grain Weevil/flour beetle/LGB	1		1	5	7
Grain weevil/flour beetle/gain moth				6	6
Grain weevil/flour beetle	1	1		3	5
Grain moth (*Sitotroga cereallela*)	1	1	1	1	4
Warehouse month (*Ephestia cautella*)			2		2
Lesser GB (*Rhyzopertha dominica*)		1			1
Rodent/birds			1		1
Khapra beetle (*Trogoderma* spp)			1		1
Flat grain beetle (*Oryzaephilus spp)*				1	1
Bean beetle/pulse beetle				1	1
Total	76	27	84	135	362

Table 4a. Botanicals used in the control of field pests in the three districts of Bondo, Busia and Teso, Kenya.

Botanicals Control Methods	Bondo	Busia	Teso	Total and (%)
None	109	110	103	322 (76%)
Tithonia (*Tithonia diversifolia*)	9	10	20	39 (9%)
Papper (*Capsicum annum*)	12		1	13 (3%)
Neem leaves (*Azedracht indica*)	5	6	1	12 (3%)
Emusi (*Urera hypseldendron*)			9	9 (2%)
Mululusia (*Vernonia amygdalina*)		8		8 (1.8%)
Acacia (*Acacia sial*)	7			7 (1.6)%
Tagetes (*Tagetes minuta*)	6			6 (1.4%)
Eucalyptus (*Eucalyptus spp.*)	3			3 (1%)
Sodom apple (*Solanum incanum*)			3	3 (1%)
Total	151	134	137	422

Table 4b. Botanicals and other indigenous products used in the control of storage pests in the three districts of Bondo, Busia and Teso, Kenya.

Botanicals Control Methods	Bondo	Busia	Teso	Total and (%)
None used	75	101	109	285 (79%)
General ash	30	9	14	53 (15%)
Cow-dung ash	7	3		10 (3%)
Bean husk			3	3 (0.01%)
Sisal ash	2			2 (0.01%)
Mululusia		2		2 (0.01%)
Neem leaves		1	1	2 (0.01%)
Maize husk			1	1 (0.002%)
Total	113	119	130	362

protection of stored produce (grains) across the districts.

Factors influencing use of botanical pest control methods

Presented in Table 5 are the factors that influenced use of botanical PCMs in the field and storage. The model log likelihood ratios X^2s were 31 and 85 for field and storage equations respectively, and were significant, indicating that the explanatory variables included were significant in explaining changes in respective botanical control methods used among the sampled households. Besides, the pseudo R^2 are also above 20%, which is the statistically minimum level, further confirming that a large proportion of changes in the dependents are attributable to the exogenous factors considered. Empirical results showed that female gender (0.15) and age of the HH (0.021) significantly increased the probability of household using botanicals in field, while education (0.342) and ownership of title to farmland (0.512) significantly reduced the probability of using botanicals in the field. Traditional (0.910) and cash rank (0.744) of the crops reduced the likelihood of using botanicals in the store, while, gender (0.814) and severity of the pest infestation (0.738) increased the likelihood of use of the same.

Factors influencing use of synthetic pest control methods

With respect to synthetic pesticides (Table 6), gender (3.407), area cultivated (0.295) and expected yield (5.315) significantly reduced likelihood of using the control method in the field, while food rank (3.967) reduced the probability of use. In storage, female gender (2.567), crop type (0.799), food rank (0.06) and traditional rank (1.407) are also the most important factors.

DISCUSSION

The significant effects of female gender as household head on use of botanical insecticides indicate the impact of poor wealth endowments among female headed households in up-taking costly pest control methods such as use of synthetic pesticides. A majority of women in Africa lack rights to property ownership, a factor that deprives them of purchasing power (Owuor et al., 2007). Consequently, they tend to resort to traditional farming technologies. Policy that would focus on promoting traditional technologies should thus consider targeting more female decision makers to succeed. The effects of age point to the role of experience in understanding and having adequate time to test local botanical materials and eventually identifying with them. Younger households may not have had adequate time to understand and appreciate different plant materials in controlling field pests. Besides, young farmers tend to adopt modern methods learnt from schools, than the traditional methods passed from generation to generation. This problem is compounded largely by virtue that modern school curriculum allows little time to the youth to interact with older members of the society.

The effects of education indicates that more educated farmers tend to avoid traditional farming technologies as they spend quite minimal time with older members of the society to learn traditional methods of pest control. This may require policy intervention that incorporates useful traditional technologies in the agricultural training curriculum as well as equipping extension personnel with a well packaged traditional field pest control methods to transfer to farmers, particularly young and modern farmers. The effects of education on adoption of botanical insecticides corroborate similar findings among cocoa farmers in Osun State, Nigeria (Tijani et al., 2007).

The negative effects of ownership of title to farmland may indicate the effects of wealth endowment on use of traditional farming technologies. Because such farmers can sell or lease part of their land and acquire cash, they have a higher likelihood of seeking more expensive synthetic pesticides than the cheap botanical ones. Results on anticipated yield indicate that when farmers expect good yields they tend not to use botanical PCMs, in fact, in many instances farmers would not bother with pest control at all. Expectations of good harvest are more often than not an important factor during adequate rainfall seasons. Reliable rainy seasons also experience low field pest infestations. Factors that influence probability of a household using botanical PCM against storage pests, show that households headed by female, and severity of storage pests increased the probability of using botanical method against storage pest. The findings on wealth effects on adoption of modern technologies relative to traditional methods resonates similar ones in Kenya where the number of livestock units have been strongly established to influence household adoption of modern farming methods and per capita income (Gamba, et al, 2006). Besides, Gine and Klonner (2006), point out that factor such as livestock wealth and financial capacities improves aversion to risk and access to information which are important in explaining why adoption of improved agricultural technologies has not been faster in developing economies.

On the contrary, traditional rank, and food rank of the crop grown reduced the probability of using the botanical control methods. Results on female gender, further confirms our findings on low wealth endowments and lack of rights to property. The positive effects of food rank in both field and storage indicate that the farmers tend to use synthetic pesticides on crops that are highly valued for food. Furthermore, these crops tend also to be stored for a longer period thus requiring storage pest management interventions.

While severity also shows that the magnitude of the pest

Table 5. Factors that influence likelihood of using botanical insecticides (Dependent variable= if a household used botanical pest control in the field> 0=No, 1=Yes).

N field		271		Store		271
Chi-Square		31.560				85.710
Prob of Chi-Square		0.007				0.000
Pseudo R^2		0.214				0.228
Log likelihood ratio		-171.24				-144.9
	Coef.	**Std. Err.**	**P>|z|**	**Coef.**	**Std. Err.**	**P>|z|**
If head is female (0,1)	15.133	6.510	0.020	0.814	0.394	0.039
Age of head (yrs)	0.021	0.011	0.047	0.011	0.011	0.303
Head education (yrs)	-0.342	0.175	0.051	-0.099	0.100	0.326
If own title to farmland (0.1)	-1.833	0.806	0.023	-1.138	0.783	0.146
Access to extension (0,1)	-0.512	0.404	0.205	-0.433	0.437	0.322
Crop type(1=tubers, 2=legume 3=cereal)	0.007	0.129	0.959	0.167	0.160	0.296
Area cultivated in acres	-0.060	0.094	0.522	0.047	0.094	0.621
Expected harvest prior to cultivation (kg)	0.000	0.000	0.110	0.000	0.000	0.324
Traditional rank of crop	-0.034	0.315	0.913	-0.910	0.346	0.009
Food rank of crop	-0.076	0.300	0.801	0.483	0.330	0.143
Cash rank of crop	-0.299	0.323	0.356	-0.744	0.356	0.036
Severity of field pest (1-4)	0.110	0.188	0.561	-0.086	0.204	0.672
Severity of storage pest (1-4)	0.004	0.048	0.933	0.738	0.145	0.000
Effectiveness of synthetic pest control method	-0.010	0.117	0.934	0.084	0.129	0.514
Intercept	-13.657	6.222	0.028	2.723	1.912	0.154

Table 6. Factors influencing likelihood of a household using synthetic insecticides in the field (Dependent variable= if a household used synthetic pest control in the field> 0=No, 1=Yes).

Log estimates field	N	258.000		Store		271.000
Chi-Square		40.560				27.910
Prob of Chi-Square		0.000				0.015
Pseudo R^2		0.446				0.155
Log likelihood ratio		-25.18				-76.102
	Coef.	**Std. Err.**	**P>|z|**	**Coef.**	**Std. Err.**	**P>|z|**
If head is female (0,1)	-3.407	1.629	0.036	-2.567	1.091	0.019
Age of head (yrs)	0.034	0.033	0.303	0.004	0.017	0.799
Head education (yrs)	-0.098	0.396	0.805	-0.012	0.113	0.918
If own title to farmland (0.1)	1.575	2.058	0.444	-0.095	1.146	0.934
Access to extension (0,1)	1.285	0.854	0.132	0.495	0.603	0.411
Crop type(1=tubers, 2=legume 3=cereal)	-0.009	0.526	0.987	0.552	0.274	0.044
Area cultivated in acres	-0.295	0.147	0.045	-0.057	0.181	0.751
Expected harvest prior to cultivation (kg)	-5.318	2.781	0.056	-0.001	0.001	0.332
Trade rank of crop	1.679	1.629	0.303	0.799	0.443	0.071
Food rank of crop	3.767	1.965	0.055	1.407	0.700	0.044
Cash rank of crops	0.254	0.517	0.623	0.472	0.559	0.399
Severity of field pest (1-4)	0.791	0.561	0.158	0.178	0.286	0.534
Severity of storage pest (1-4)	0.420	0.350	0.231	0.045	0.061	0.463
Intercept	-16.510	9.213	0.073	0.222	0.180	0.217

infestation drives farmers to use local methods, pointing at the importance of botanical methods as the most reliable and easily available materials whenever the pest situations become severe. A study conducted on efficacy of botanicals on cowpea and maize in Igalaland, Nigeria found that botanicals have advantages on cost and availability over commercial insecticides (Morse et al., 2002). However, the study concluded that while technical efficacy of botanicals is an important element, there are others such as the logistics of production and preparation that need to be considered. A better understanding of the balance between these factors and how context-specific they may be is required in order to maximize their adoption. Results of this study indicate that botanical methods could be more effective than synthetic insecticides as they become the only options used under severe infestations.

The negative effects of trade and cash rank on use of botanical control methods in storage could point at the low importance of cash crop storage. Storage could be more relevant for food purposes. Furthermore, because of low production levels, smallholder farmers usually sell off part of the produce immediately after harvest, and only store that portion of the produce targeted for consumption.

Conclusions and Recommendations

Female gender, literacy levels, wealth endowments in form of land and old age are key factors to consider for intervention for botanical pest controls in the field and storage.

Female headed households tend to use botanicals more as compared to male headed households, factors key to promotion of botanicals. In relation to education and wealth, these factors infringe on botanical usage, pointing at the popularity of the botanicals among the illiterate and resource poor households. To intervene, scientists need to upgrade local botanicals into marketable products that can attract all cadres of farm households. The positive effects of age indicate the prevalence of botanicals among the old, who struggle to preserve local knowledge and practices. These points at another important entry point for interventions to promote local materials such as inclusion of indigenous knowledge in school curriculum.

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