African Crop Science Conference Proceedings, Vol. 9. pp. 571 - 578
Printed in Uganda.
ISSN 1023-070X/2009 $ 4.00

From a success story to a tale of daily struggle: The case of leafminer control and compliance with food safety standards in Kenya's snowpea/horticultural industry

Z.M. GITONGA[1], J.J. OKELLO[1], D. MITHOEFER[2], C. OLAYE[2] & C.N. RITHO[1]
[1]Department of Agricultural Economics, University of Nairobi, P.O. Box 29053, Nairobi, Kenya
[2]International Center of Insect Physiology and Ecology (ICIPE), P.O. Box 30772-00100, GPO, Nairobi, Kenya

Abstract Kenyan horticultural industry has often been cited as success story because of the way it has successfully responded to pest challenges and notably the international food safety standards. However, the industry faces a new challenge that emanates from invasion by quarantine leafminer which has recently become a pest of economic importance in Kenya. Controlling leafminer poses serious challenges due to its biology and quarantine status in Kenya's' main fresh produce market. This paper examines farmers' awareness of the leafminer pest and challenges faced by farmers to control it. There is high leafminer awareness among farmers and that pesticides are not effective in controlling it. Majority of snow pea growers use chemical control coupled with pest scouting. However, the timing of chemical control is poor as it occurs when the pest in its larval stage is buried in plant tissue. Results further show that farmers whose production practices are monitored for compliance with GlobalGAP use fewer control strategies. The implication of this study is that leafminer is likely to become a serious challenge unless integrated leafminer management strategy is developed and farmers educated on methods of identifying it in its early stages.

Key words: Food safety standards, Kenya

Introduction

Production of high value horticultural crops in general has been identified as a key pathway out of poverty and a prospect for development because of high land and labour productivity compared to the production of staple crops (McCulloch & Ota, 2002; Mithöfer, 2008). Kenya's horticultural exports accounted for USD 700 million in 2006, making it the second highest income earner after tourism. In 2007 the sub-sector earned the country Kenya Shillings (Ksh.) 45.7 billion of which 1.5 billion came from peas. The sector currently provides livelihood to 500,000 farmers of whom 80% are small and medium-scale. Overall, Kenyan horticultural industry employs over 4 million people both on- and off-farm and contributes almost 13% of Kenya's Gross Domestic Product (FPEAK, 2006; 2007). Hence, Kenya's horticulture industry is very important in meeting the country employment needs and improving livelihoods (McCulloh & Ota, 2000).

Kenya's horticultural industry has often been cited as a success story by past authors (Jaffee, 1995; English *et al.*, 2006). The industry has in the past very versatile and has successfully adapted to various internal and external challenges. As a major supplier of the competitive European market, the industry successfully adapted to the stringent food safety standards adopted by major European retailers to emerge a major competitor (Jaffee, 2003). As the EU supermarkets started enforcing their stringent food safety protocols relating to pesticide residue and food safety hygiene, Kenyan horticultural industry evolved from a supplying bulk produce to supplying pre-packed products. The industry has also been successful in adopting the stringent food safety standards and maintains substantial participation of smallholder farmers contrary to earlier predictions (Farina *et al.*, 2000).

Kenya horticulture industry however currently face a new threat that could undermine its EU based exports business. The threat relates to invasion of the industry with some of the pests in the EU list of quarantine pests (Kedera & Kuria, 2003). These pests are currently the leading cause of Kenya's fresh produce rejection in European market (KEPHIS, 2006). The two leading quarantine pests that have presented a serious challenge to Kenyan horticulture industry comprise of African bollworm (*Helicoverpa* sp.) and leafminer (*Liriomyza* sp.).

Leafminer (*Liriomyza* sp) was first introduced in Kenya in 1976 and is the most important pest of snow peas and sugar snap two high value horticultural crops that employs thousands of smallholder farmers (Njuguna *et al.*, 2001; Kedera & Kuria, 2003). Three factors make leafminer a pest of unique economic importance in snow peas namely: (a) it attacks the marketed part of the crop, (b) the damage created by the larvae may often be unnoticeable until the produce has reached the destination market and, (c) the pest has high ability to develop resistance to pesticides (Lamport *et al.*, 2001; Dinham, 2003; Valera *et al.*, 2004).

If not controlled, leafminer could make Kenya lose its EU market through produce ban. In mid to late 1990s, Guatemala lost its American market for failure to control leafminer pest in snowpea shipment to US resulting to over US$35 Million annual loss in foregone revenue (Norton *et al.*, 2003). However, to control the pest will be very challenging given the nature of its infection of the crop. Unlike other pests, leafminer hatches eggs on the fresh pods which may remain unnoticed until much later in the value chain when its start forming mines on the pods. The control strategies used against leafminer pest must also be in compliance with EU pesticide use restrictions. Available literature has documented leafminer's resistance to most pesticides, (Weintraub & Horowitz, 1998; Lamport *et al.*, 2001; Dinham, 2003; Valera *et al.*, 2004). The objectives of this study are to:

(i) analyse farmers' awareness about leafminer infection and assess the current status of the pest at farm level;

(ii) analyse leafminer control strategies used by snow peas producers; and

(iii) examine the factors affecting the choice of leafminer control strategies in snow peas.

Survey design and empirical methods. The study was carried out in Nyeri and Imenti South Districts in Central and Eastern Provinces of Kenya respectively. These are major snow pea growing districts in Kenya. Five administrative divisions were covered during the study. A multistage sampling procedure was followed. The first stage involved purposive selection of the main snow peas growing regions and the second stage categorized respondents into two strata on the basis of marketing strategy (those contracted by exporters and those selling in the spot market). In the third stage, stratified random sampling procedure was employed to select farmers from the two strata giving rise to a random sample of 220 respondents. Data were collected between April and May, 2008.

Data were collected from the sampled farmers using pre-tested and revised questionnaire. Information obtained from the respondents included farm and farmer characteristics, farmer's asset holding, income, production practices, knowledge of leafminer and its control strategies, and snow peas yield loss at farm level. The information obtained through this quantitative survey was complemented with secondary data on produce interceptions and rejections due to LMF infestation was obtained from KEPHIS.

This study used both descriptive and quantitative analyses. Descriptive analysis was used to assess farmers' awareness of leafminer pest by name and by damage symptoms, their perception of the extent of yield loss caused by the pest and control practices employed.

We also estimated a regression model to examine the factors influencing the number of leafminer control strategies used by the farmer. The dependent variable (number of control strategies) is a discrete count variable taking only integer values. Poisson regression model which explicitly deals with characteristics of count variables (Woold Ridge, 2002; Green, 2003) was fitted into the data. Following Green (2008), the model was specified as follows:

$$E(y_i|x_i) = \exp(\alpha + X'\beta) \qquad y_i = 0,1,...,i$$

Where $\boldsymbol{y_i}$ represents the number of control strategies chosen by a certain farmer ***i***, x_i are farm and non-farm characteristics that determine the number of control strategies chosen by the farmer *i* and â is a vector of unknown parameters to be estimated.

After running a Poisson regression model, a statistical test for over dispersion was carried out. This is because in practical application, it is rarely the case that the basic assumption of equality of the mean and variance imposed by Poisson regression is fulfilled. Following SAS Institute (2000), Deviance and Pearson Chi-Square divided by the degrees of freedom were used to detect over-dispersion or under-dispersion in the Poisson regression. A Pearson chi-square ratio of between 0.8 and 1.2 indicates that the model can be assumed to be appropriate in modeling the data (Trentacoste, 2000). For this case the ratio was found to be 0.74, an indication of the inappropriateness of poisson model for analysis.

Both the ratios of Deviance and Pearson Chi-square to the Degrees of freedom were found to be less than unity implying a case of under-dispersion. The general expression for under-dispersion can be presented shown below (see Green, 2003)

$$V(y_i|x_i) = \hat{\lambda}_i(1-\alpha)$$

Where $\mathrm{E}(y_i|x_i) = e^{X_i'\beta} = \hat{\lambda}_i$

The null hypothesis was specified as $\mathrm{H}_0 : \alpha = 0$

Against the alternative hypotheses $\mathrm{H}_a : \alpha \neq 0$

$\mathrm{H}_a : \alpha > 0$

an auxiliary OLS regression was used to estimate á following Cameron and Trivedi (1999) and Green (2003).

$$z = \frac{(y_i - \hat{\lambda}_i)^2 - y_i}{\hat{\lambda}_i} = \alpha \frac{g(\hat{\lambda}_i)}{\hat{\lambda}_i} + \varepsilon_i$$

Where ε_i is the error term, $\hat{\lambda}$ =L=

From the auxiliary regression, the coefficient á was found to be negative and statistically significant, a further evidence of under-dispersion and a violation the basic assumption of equality of the mean and the variance imposed by the Poisson regression. This is an indication that the events constituting the counts are negatively related (Berk & MacDonald, 2007).

Negative binomial regression model. In presence of underdispersion, the estimates in Poisson regression are inefficient and biased which leads to the invalidation of inference based on the estimated standard errors (Winkelmann & Zimmermann, 1995; Famoye *et al.*, 2005; Cameron & Trivedi, 1996). The functional form for the negative binomial regression model relaxes the equidispersion assumption of the Poisson model and takes care of any model misspecification (Green, 2003; 2008). Following Green (2007), the model was specified as:

$$E(y_i|x_i,\varepsilon) = \exp(\alpha + X'\beta + \varepsilon)$$

With variance $\mathrm{Var}(y_i|x_i,\varepsilon) = \hat{\lambda}_i - \alpha\lambda_i^2$

The negative binomial regression model was used to study the Kenyan cutflower interceptions due to quarantine pests in the UK market between 1996 and 2004 (Areal *et al.,* 2008). The study found that for some cutflower species such as veronica and carthamus, the probability of pest detection increased with increase in traded volumes. However, for most of the flower species analyzed, the study demonstrated that increase in volumes traded does not necessarily increase the risk of pest introduction in UK and that the cost of inspection could be reduced through proper targeting of inspection efforts. The variable used in the estimation of the above regression model are presented in Table 1.

Results and discussion

Fresh produce Interceptions due to presence of leafminer in shipments. Results of the analysis of secondary data from KEPHIS are shown in Figure 1. The results Show that snow peas recorded the highest number of interceptions at the destination market followed by cut flowers. The common characteristic of these two crops is that leafminer affects the marketed part of the produce. The flies lay eggs on the surfaces of the produce and hatch when the consignment is on transit or in the destination market. The symptoms are clearly visible and easy to identify due to the mines made by the larvae on the surface. For the rest of the export crops, the pest mainly attacks the vegetative parts of the plant implying that the impact is mainly felt at the farm level.

Leafminer awareness among snow pea growers. The first step in controlling leafminer is farmers' awareness of the pest and ability to identify it. We therefore asked the respondents whether they could identify the pest either through visible symptoms (serpentine mines) on the crop or observing adult leafminer flies. As shown in Figure 1, 96% of the respondents had heard about leafminer while only 88% correctly described the pest either through the adult stage or the damage symptoms. Approximately 87% of the respondent interviewed categorised leafminer as a major pest problem in their farms.

The stage at which farmers identify leafminer in their farms is very important in determining the timing of control intervention, especially pesticide application. Though from Figure 1 farmers' ability to identify the pest is high, the results of this study show that 46% of farmers identify the pest through damage symptoms on the leaves, 2% through cosmetic damage on the pods and only 7.7% identify the pest in its adult stages.

Figure 2 suggest that farmers who wait for such symptoms to initiate leafminer control target the protected life stages (larval and pupae). During this stage the larvae are sandwiched between leaf tissues and are therefore less likely to directly get into contact with the applied pesticide. This lack of optimal contact could explain difficulties in dealing with leafminer infestation. The effective way to control the leafminer is to target the adult stage as studies elsewhere suggest (Hofsvang, 2005).

The ranking by respondents of leafminer damage by season is presented in Figure 3. Damage is most severe in the first quarter of the year and least severe in the second quarter. This could be explained by the long dry spell that runs from December through to early March and the long rains that set in mid March through to June. July is a relatively cold month with short rains setting in around mid October hence fewer respondents reported high score compared to the January-April period. These results corroborate the findings of Hofsvang *et al.* (2005) in Asia which indicated low leafminer populations during the months of March-June due to a long oviposition Period. Their study also indicated a shorter generation cycle (15days) during the warmer months of May-June and a prolonged cycle (25-30days) during the months of October-November. Our findings therefore suggest that pesticides are not effective in controlling leafminer.

Table 1. Variables used for quantitative analysis of determinants number of leafminer control strategies chosen by a farmer.

Dependent variables	Variable description
Numb control	Numb of control strategies (Poisson and NEGBIN regressions)
Independent variables	
Dscore	Damage score [1=low, 2=Medium, 3=High]
ln experience	Years of experience in horticulture farming [Years]
Grp	Dummy for group membership [1=member, 0=otherwise]
Gender	Dummy for gender of the respondents [1=Male, 0=female]
ln yearEDU	Natural log of Years of education completed by the respondent
AgriTraining	Agricultural raining
GlobalGAP	Dummy for acquisition of GlobalGAP certification [1=Yes]
Market	Marketing strategy [1=spot market, 0 = contract]
Pesttarget	Timing of spray
Credit	(Dummy) Credit dummy (1=Yes)
lnIncome	Natural log of income [KES]
lnExpenditure	Natural log of expenditure on pesticide [KES]
District	District dummy (1= Nyeri North, 0= Imenti South)
lnAge	Natural log of age of the respondent [Years]
Records	Keeping of production records (1=Yes, 0=no)

Assessment of leafminer control strategies used by snow peas producers. Table 2 presents that leafminer control measures they used by the surveyed farmers and how frequently they are used.

Overall, 74% of respondents applied pesticides more often than usual, 61% increased pesticide concentration while 58% used broad-spectrum insecticides to avert leafminer damage. The results also show that 40% of farmers interviewed avoided planting or reduced quantities of snow pea planted during periods when they expected leafminer infestation to be high. A similar behavior response was reported in West Sumatra where farmers reduced the acreage of the susceptible potato variety by 40% (Rauf *et al.*, 2000).

Results further show that 70% of farmers scouted for leafminer pest in their farms, although majority of snow pea growers are only able to recognize leafminer infestation using mines on the pods. Though scouting is an important component of integrated pest management for early detection of pest and disease problems, proper and timely diagnosis of the presence of leafminer is even more critical for appropriate intervention. This is not only important at farm level but also at a regional level given the high rate of leafminer invasion and spread to new areas (Murphy & LaSalle, 1999; Hosfvang *et al.*, 2005; Ding *et al.*, 2008;). When asked whether from their experience pesticides are effective in controlling leafminer, 65% of farmers said no while 35% thought they are effective. These findings corroborate those of Rauf *et al*. (2000) who found that 63% of farmers relied on pesticides for control of leafminer though 72% of those interviewed regarded pesticide use as ineffective and uneconomical in controlling the pest. The farmers were then asked what they do when one pesticide fails to control leafminer. Their responses are presented in Table 3.

The results in Table 3 further support findings presented in Table 2 where most farmers increase frequency of spray and mix pesticides. Results show that farmers use control strategies in combination rather than one at a time. These findings corroborate those of Sithanantham (2004) and Wilson & Tisdell (2001) who showed that farmers are more likely to use stronger concentrations of pesticides, increase the quantity and frequency of pesticides applications and increasingly mix

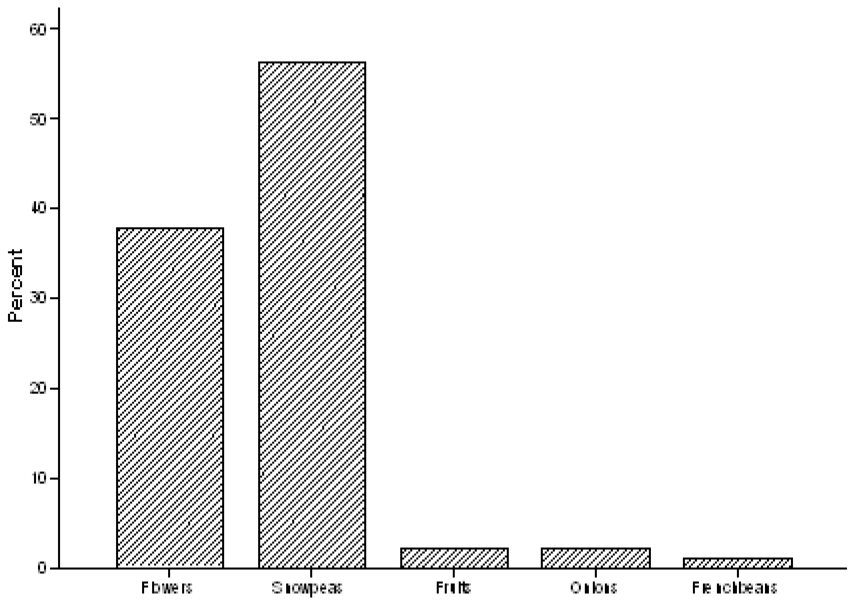

Figure 1. Kenya's horticultural export crops intercepted at destination markets due to presence of leafminer (*Liriomyza* sp.) between 1999-2007.

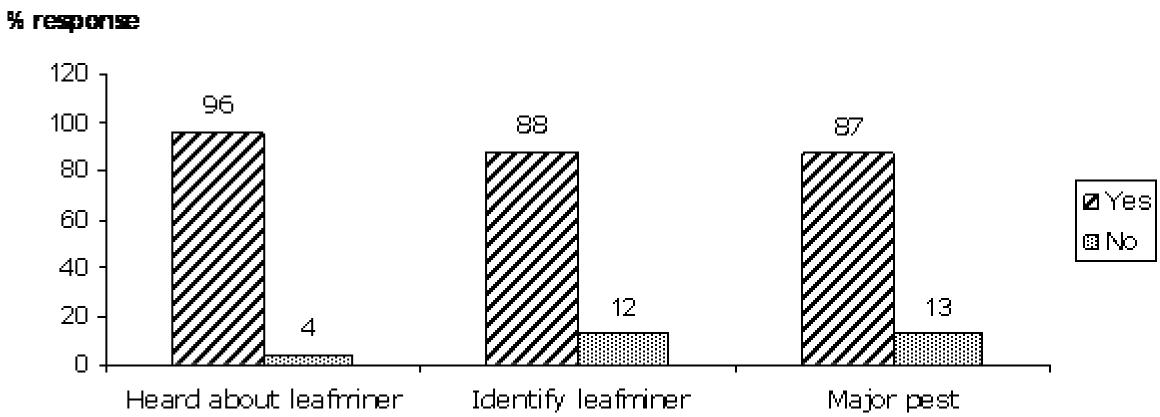

Figure 2. Awareness of leafminer pest among snow pea growers in Kenya, 2008.

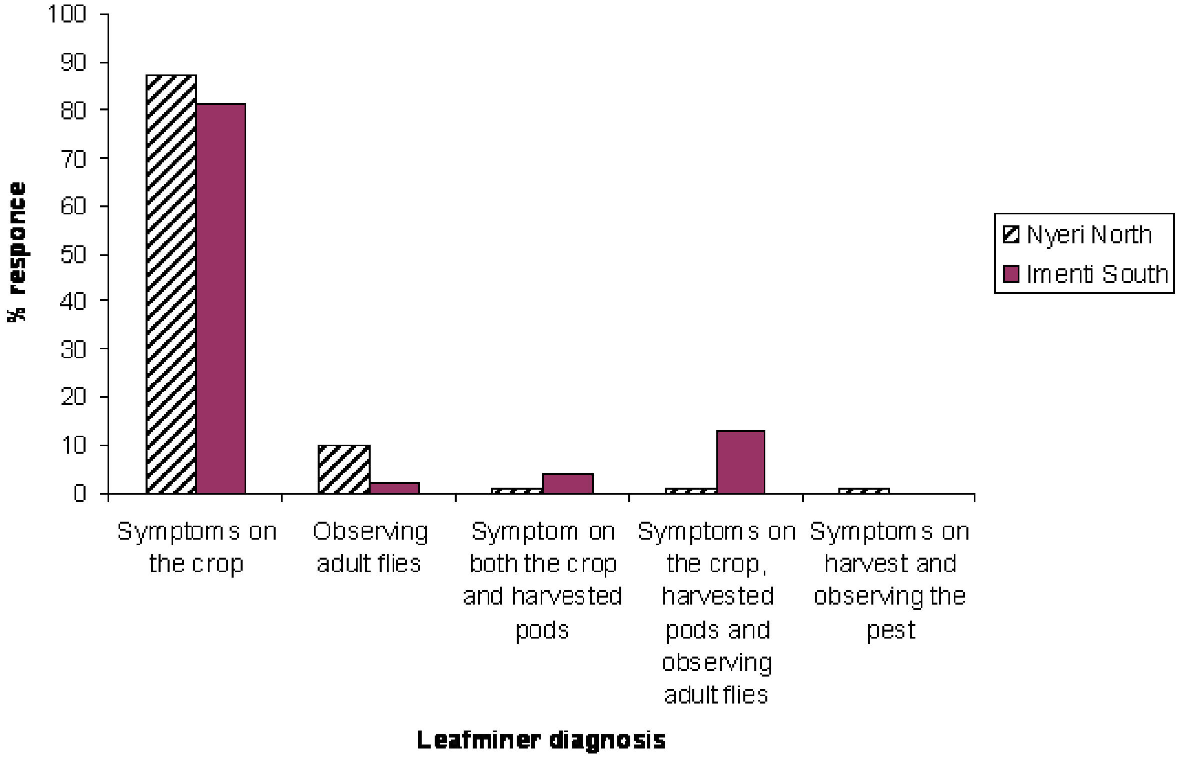

Figure 3. On-farm leafminer identification by farmers in Nyeri North and South Imenti districts.

Table 2. Leafminer pest control strategies.

Strategies[1]	Number of respondents	Percentage response
Spray more often	150	74
Scout for early detection	143	71
Increase pesticide concentration when one pesticide fails	124	61
Use broad spectrum pesticides for the control of leaf miner	118	58
Use selective pesticides	107	53
Encourage control of miner by natural enemies	92	46
Mix pesticides when one pesticide fails	89	44
Plant less snowpea and sugar snaps when incidence is high	81	40
Remove host plants that harbours leaf miner	71	35
Create a barrier between the snowpea plot and other plots	71	35
Use bio pesticides	32	16
Use concoctions in control of leaf miner	4	2

Source: Survey results, 2008.

[1]Number of control strategies is a multiple response variable. Respondents reported to have used more than one strategy to tackle leafminer problem and in total there were 202 valid responses.

several pesticides if the perceive pesticides as ineffective. This vicious cycle of pesticide resistance and increased pesticide use compromises the ability of natural enemies to effectively control such pests and puts to test the sustainability of agro-chemical dependent agricultural production.

Analysis of determinants of the number of control strategies chosen by farmers. Table 4 presents the results of a negative binomial regression model fitted to examine the factors conditioning the number of leafminer control strategies chosen by farmer.

The results show that acquisition of GlobalGAP certification by respondents reduces the number of leafminer control strategies by 20.9% suggesting that the type of control strategies being used by snow pea farmers to control leafminer are not compatible with good agricultural practices required under GlobalGAP standards. The strict monitoring and adherence to particular agricultural practices and pesticide regime as required by GlobalGAP explain less use of these practices. Non-contracted farmers (i.e., farmers who sell their produce in the spot market hence not monitored) have 23.8% higher

Table 3. Farmers' response to leafminer pesticide resistance.

What do you do when one pesticide fails to control leafminer?	Frequency	Percent
N A	31	15.3
Mix pesticides	23	11.3
Increase pesticide concentration	16	7.9
Spray more often	49	24.1
Mix pesticides and increase pesticide co	17	8.4
Mix pesticides, increase pesticide concentration	10	4.9
Mix pesticides and spray more often	22	10.8
Increase concentration and spray more of	13	6.4
Change to another pesticide	20	9.9
Report to buyer	1	0.5
Nothing	1	0.5
	203	100.0

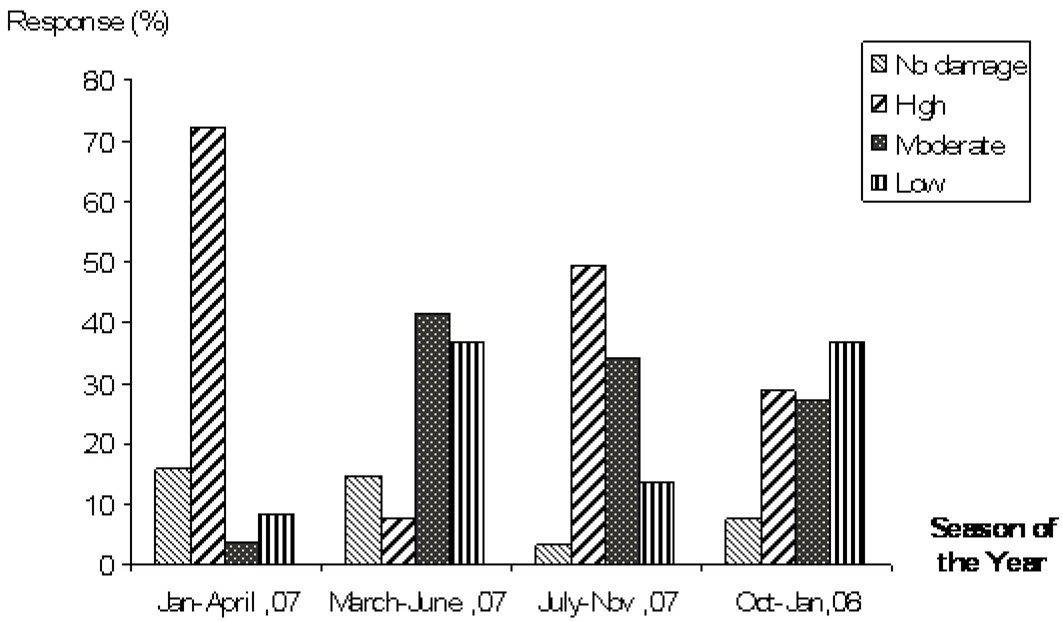

Figure 4. Snow pea farmers' score of leafminer damage by season, 2008.

chance of using multiple strategies than those contracted by exporters.

Results also show that an increase in framers' annual income increases the number of leafminer control strategies employed by snow pea producers. This finding may be capturing the effect of ability to purchase pesticides by those with higher incomes.

Conclusion and policy implications

This study examines the challenges Kenyan smallholder horticultural producers face in controlling the leafminer pest. It analysed awareness of the pest among snow pea growers and the control strategies used by the farmers to leafminer. Results indicate that there is high level of awareness of the pest among farmers although majority are only able identify it by its symptoms namely mines on the snow pea pods. Chemical control of the leafminer at this stage is ineffective because it is buried in the pod in its larval stage. The study also finds that farmers use a number of strategies to control leafminer. However, the most common strategy is chemical control coupled with pest scouting.

Results of quantitative analysis suggest that farmers whose pesticide use practices are monitored under GlobalGAP use fewer pesticides than their counterparts. The implication of these results is that the inability of farmers to identify leafminer at a stage when it can be most effectively controlled is likely to aid its spread and cause greater losses during heavy infestation. The findings also imply that leafminer control in the absence of an integrated leafminer management practices (i.e., leafminer IPM) will be a serious challenge. Leafminer will therefore remain a serious threat to Kenyan horticulture industry unless concerted efforts are made to develop its IPM strategy and educate farmers on methods of identifying it early in its life cycle.

Table 4. Factors affecting number of leafminer control strategies used by farmers.

Numb control	Coef.		p-value
Damage score (DScore)	0.052		0.367
Marketing strategy (Market)	0.238		0.001
Pest targeting (PestTarget)	0.009		0.064
Access to credit (Credit)	0.120		0.143
Farmer's annual income (lnincome)	0.066		0.069
Pesticide expenditure (lnExpendit~e)	0.045		0.221
Years of snowpeas farming (lnExperience)	-0.092		0.139
District dummy	0.319		0.006
Membership to a farmer-group (Grp)	-0.091		0.357
Gender dummy	-0.077		0.311
Attended agricultural training (AgriTraining)	0.107		0.181
Keeping of production records (Records)	-0.019		0.811
GLOBALGAP certification status (GLOBALGAP)	-0.209		0.014
Age of the respondent (lnAge)	0.092		0.324
Years of schooling (lnYrsEDU)	0.018		0.213
Number of obs	180		
Wald chi2 (15)	3181.77		
Prob> chi2	0.000		
Log likelihood	-382.127		
/lnalpha	-16.876	265.919	
Alpha	4.68E-08	1.25E-05	

Negative binomial regression; likelihood-ratio test of alpha=0: chibar2 (01) = 0.00E+00 Prob>=chibar2 =0.5.

Acknowledgement

We are heartily indebted to BMZ for financing this research. We thank the staff of ministry of Agriculture who was involved in the focus group discussions and survey. Our sincere thanks go to all the farmers who willingly volunteered information and enumerators for their exquisite efforts. The study was facilitated by International Centre of Insect Physiology and Ecology (ICIPE).

References

Areal, F.J., Touza J., MacLeod A., Dehnen-Schmutz K., Perrings C., Palmieri M.G. & Spence N.J. 2008. Integrating drivers influencing the detection of plant pests carried in the international cut flower trade. Journal of Environmental Management 89 (2008) 300–307.

Cameron, A. C. & Trivedi, P. K. 1999. Essentials of Count Data Regression: June 30 1999.

Ding, J., Mack ,R.N., Lu, P., Ren, M. & Huang, H. 2008. China's Booming Economy is Sparking and Accelerating Biological Invasions. Bioscience **58(4),** 317– 324.

English, P., Jaffee, S. & Okello, J.J. 2006. Exporting out of Africa: The Kenya Horticulture Success Story. In: R. B. Liebenthal and M.L Fox (Eds) Attacking Africa's Poverty: Experiences from the Ground. World Bank, Washington DC.

Famoye, F., Wulu, J.T. & Singh, K.P. 2004. On the Generalized Poisson Regression Model with an Application to Accident Data. Journal of Data Science **2,** 287-295.

Farina, E. M. M. Q. & Reardon, T. 2000. Agrifood grades and standards in extended Mercosur: Their role in the changing agrifood systems. American Journal of Agricultural Economics **82,** 1170-76.

Greene, H. W. 2003. Econometric analysis: Pearson Education Inc. New York University.

Greene, H.W. 2007. Functional Form and Heterogeneity in Models for Count Data: Department of Economics, Stern School of Business, New York University, April, 2007.

Greene, W. 2008. Functional forms for the negative binomial model for count data. Economics Letters **99,** 585–590.

Hofsvang, T., Berit S., Andersen A., Heidi H., & Le Ngoc Anh 2005. Liriomyza Sativae (Diptera: Agromyzidae), An Invasive Species In South-East Asia: Studies on its Biology In Northern Vietnam International Journal of Pest Management, January –March 2005; 51(1): 71 – 80

Jaffee, S.M. 2003. From Challenge to Opportunity: The transformation of the Kenyan fresh vegetable trade in the context of emerging food safety and other standards." Agriculture and Rural Development Discussion Paper 1, World Bank. Washington, DC.

Jaffee, S.M. 1995. The Many Faces of Success: the Development of Kenyan Horticultural Exports, in Steven Jaffee and John Morton, eds. Marketing Africa's High-Value Foods. 319-374. Washington, D.C.: World Bank.

Kedera, C. & Kuria, B. 2003. Identification of Risks and Management of Invasive Alien Species using the IPPC framework Proceedings of a workshop in Braunschweig, Germany 22–26 September 2003.

KEPHIS. 2006. Annual Report and Financial Statements July 2005-June 2006.

KEPHIS. 2007. Strategic Corporate Business Plan (2007-2011).

Lamport, P. P., Weller, S.C., Sullivan, G. H., Edwards, C. R. & Sanchez, G. E. 2001. Improved IPM Strategies in Snow Peas through Genotype Testing, Varietal Improvements, and more Efficient Production Practices: Eighth Annual Report of the Integrated Pest Management Collaborative Research Support Program (IPM CRSP) 2000-2001.

McCulloch, N. & Ota, M. 2002. Export Horticulture and Poverty in Kenya: Institute of Development Studies, University of Sussex, Brighton.

Mithöfer, D. 2008. Linking smallholders to high-value crop markets: how does the group approach work? Agrifoodstandards.net 2008.

Murphy, S.T. & La Salle, J. 1999. Balancing Biological Control strategies in the IPM of the New World Invasive Liriomyza leafminers in field vegetable crops: Biocontrol **20,** 91N-104N

Njuguna, L., Kibaki, J., Muchui, M., Kambo, M. C., Munene, S. & Wepukhulu, B. S. 2001. Snow Pea and Sugar Snap Production in Mt. Kenya Region: Status, Challenges, and Opportunities: Proceedings of the Horticulture Seminar on Sustainable Horticultural Production in the Tropics. Published By the Department of Horticulture, JKUAT.

Norton, W. G., Sanchez, E.G., Harris D. C. & Traoré, H. K. 2003. Food Safety in Food Security and Food Trade: Reducing Pesticide Residues on Horticultural Crops. IFPRI Focus 10 Brief 10 of 17 September 2003.

Rauf, Aunu, Shepard, B. Merle & Johnson, Marshall, W. 2000. Leaf miners in vegetables, ornamental plants and weeds in Indonesia: surveys of host crops, species composition and parasitoids', International Journal of Pest Management **46(4),** 257 – 266.

Sithanantham, S. 2004. Development and dissemination of IPM for vegetables in Eastern Africa. Icipe science Press.

Trentacoste, M.F. 2000. Statistical Models of At-Grade Intersection Accidents—Addendum Publication No. FHWA-RD-99-094 March 2000.

Weintraub, P. G. & Horowitz, R. A. 1995. The Newest Leaf miner Pest in Israel. Phytoparasitica **23,** 177-184.

Wilson, C.& Tisdell, C. 2001. Why farmers continue to use pesticides despite environmental, health and sustainability costs: School of Economics, The University of Queensland, and Brisbane.

Woodridge, J.M. 2002. Econometric Analysis of Cross sectional Data.

Valera, A. M. & Seif, A. A. 2004. A Guide to IPM and Hygiene Standards in Okra Production in Kenya: International Centre for Insect Physiology and Ecology (ICIPE) Science Press.