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International Food Safety Standards and the Use of Pesticides in Fresh Export Vegetable Production in Developing Countries: Implications for Farmer Health and the Environment

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1. Introduction

Most developing country farmers producing for international markets rely on pesticides for agricultural production (Thrupp et al, 1995, Maumbe and Swinton, 2003). The warmth and humidity of tropical climates exacerbates the pest and disease problems (Okello, 2005). Due to standards for cosmetic quality in export markets for fresh fruits and vegetables, the use of pesticides has been especially pronounced in production of these products in the tropics.

Production and export of fresh produce from developing countires have witnessed major growth in many developing countries seeking to diversify their production from staples to high value commodities. Growth has especially been greatest in the fresh fruits and vegetables (FFV) and in the flower subsectors. In Africa, for instance, exports of FFV experienced a spurt in growth in the 1980s and 1990s as markets for major traditional exports (e.g., coffee, tea and cocoa) experienced a downturn. Most of these non-traditional exports were destined to Europe (with UK, Holland, Germany, and Italy being the leading importers) (Okello et al, 2008). Figure 1 presents the trends in exports of green beans, a major non-traditional export, by three of the leading exporters of fresh vegetables from Africa. It shows an increase in exports of green beans between 2000 and 2006 in all these countries.

Kenya is one of the leading exporters of fresh vegetables to Europe, and especially the United Kingdom (UK). Figure 2 shows the recent expansion of green bean exports, highlighting the growth in those destined for the UK.

The strong expansion in green bean exports is largely targeted at European consumers who demand aesthetic quality attributes such as spotlessness that generally encourage increased use of pesticides (Farina and Reardon, 2000). The demand for cosmetic quality attributes (color, shape, spotlessness) has been held responsible for increasing pesticide use in the production of fresh exports from developing countries. Thrupp et al (1995) and Ohayo-Mitoko (1997) document cases of widespread use of pesticides in Asia and Kenya respectively. Excessive use of pesticides in Kenyan horticultural industry has also been
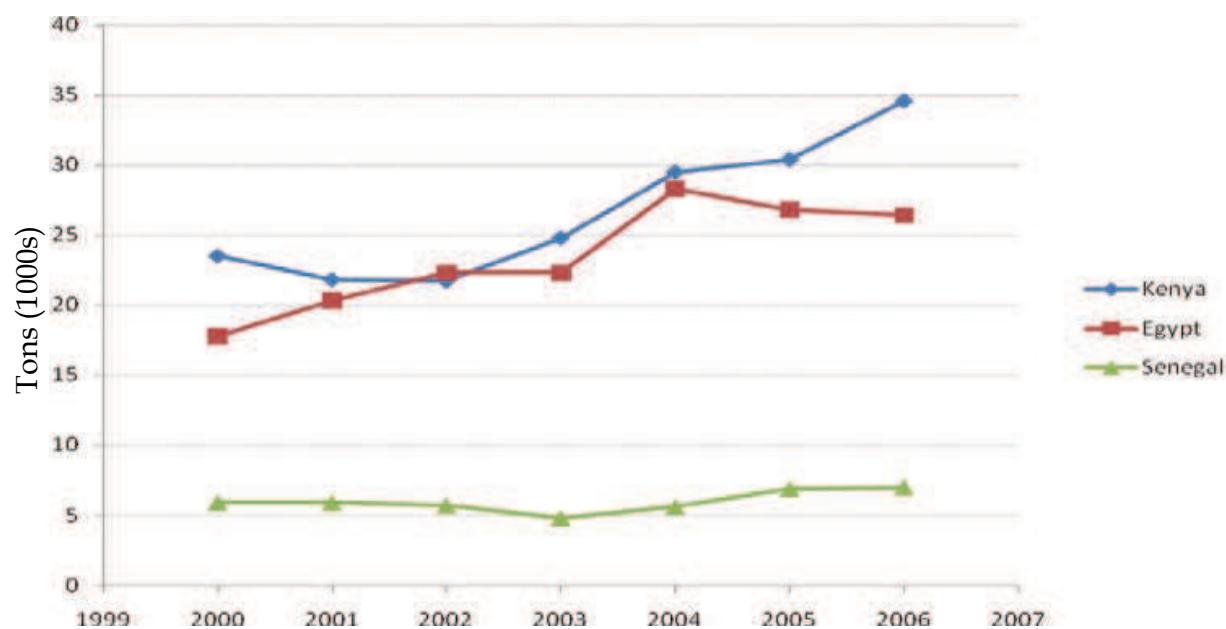
Source: Adapted from Okello (2010)

Fig. 1. Trends in green bean exports ('000 tons) to Europe from some leading African countries, 2000-2006

reported by Mwanthi and Kimani (1990), Okado (2001) and Jaffee (2003). These studies suggest that many Kenyan fresh export vegetable farmers used pesticides indiscriminately, in some cases, applying pesticides meant for other crops (such as coffee) on fresh vegetables. Concern with the health consequences of excessive use of pesticides on consumers' medical health and safety of farm workers and the environment in general led developing country governments to revise their pesticide residue standards. These revised international food safety standards (IFSS) have introduced a new order in the use of pesticides in production of fresh vegetables destined for sale in developed countries. They require that only pesticides that are safe to farmers and farm-workers, other non-target species and the consumers be used in production of vegetables for exports. However, the safer pesticides are often either more expensive or less efficacious (Jaffee, 2003). At the same time, farmers and pesticide applicators are required, under IFSS, to handle, apply and discard leftover pesticides safely in order to reduce the hazards they pose to non-target animal and plant species. These requirements are reinforced by farmer training on safe use, storage and disposal of pesticides and enforced via close monitoring for compliance. African analysts have alleged that the expected benefits to European consumers would impose unacceptable costs on African producers, especially smallholders (Mungai, 2004). Hence, the welfare effects of African producers compliance with European IFSS have been a subject of intense debate.

Theoretically, IFSS are expected to induce some changes in pesticide usage and in the returns farmers receive from beans. Such changes can affect the profit margins earned but can also theoretically reduce the costs of health impairments as a result of reduced exposure to toxic pesticides. This chapter examines the effect of implementation and enforcement of IFSS in the green bean industry in Kenya. It specifically discusses these effects in the context of benefits to farm households and the environment and costs of complying with IFSS. The chapter focuses on health costs on exposure to pesticides, the use of environmentally-friendly pest and disease control strategies and the changes in consumer margins resulting from compliance with IFSS.
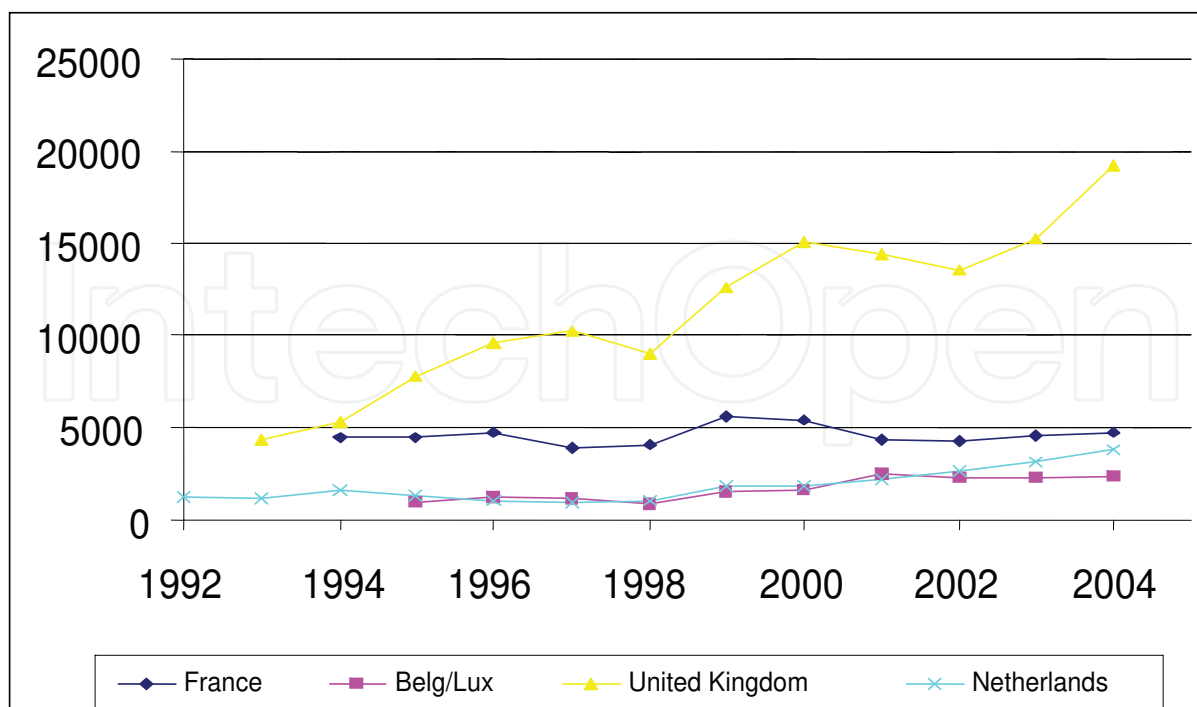
Source: Okello et al (2008)

Fig. 2. Major destination markets for Kenyan green beans (tons) 1992-2004

This chapter draws from a study conducted in Kenya in 2003-2004 involving smallholder farmers growing green beans for export to the European markets. Kenya is one of leading exporters of green beans to Europe, especially the United Kingdom (UK). Europe provides an interesting case study because major European retailers (e.g., Tesco, Waitrose, Mark & Spencer and Sainsbury's) have developed some of the most stringent IFSS. The rest of this paper is organized as follows. Section 2 provides historical overview of the Kenyan green bean industry and highlights the changes in export standards. Section 3 outlines the study methods while Section 4 discusses the results. Section 5 concludes.

2. Historical perspectives of the Kenyan green bean industry and the IFSS

Kenya's fresh export vegetable industry is one of the oldest in Africa, having started in the 1950s with off-season exports of fresh fruits and vegetables (FFV) to the UK (McCulloh and Ota, 2003, Okello, 2010). The shipments started with the launch of regular passenger flights between Kenya and Western Europe. The first consignment was flown to the UK in 1957. Subsequently, few hundred tons of FFV were annually shipped to a single wholesaler in London's Convent Garden Market from where they were eventually sold to high-class hotels, restaurants and department stores (Okello, 2010). The growth of the horticulture industry accelerated considerably during the 1970s. By 1975, annual exports of FFV had surpassed 10,000 tons. Trade in fresh vegetables (led by green beans) expanded most rapidly during the 1980s and 1990s. By the end of 1990s, Kenya was exporting close to 2 million tons of fresh vegetables annually. The expansion in trade was accompanied by the broadening of the destinations.

Kenya traditionally channels virtually all of its fresh vegetable exports to Western Europe, with very small quantities going to Australia/New Zealand, South Africa, and Dubai. The

bulk of the exports go to the UK, Holland, France and Germany. The UK is still the biggest market for Kenyan vegetables absorbing more than 60% of Kenya's green beans per year. Within the UK, the leading retailers of Kenyan beans are Waitrose, Tesco, Marks and Spencer, and Sainsbury's. These major retailers control major share of fresh export business especially in the UK. Indeed, retailers/supermarkets control 70% Kenya green bean trade and 100% of the high-care pre-packed "ready to eat" fresh vegetable trade in general.

Majority of the leading European retailers developed very stringent standards relating to pesticide usage, among others, in response European food safety scandals of the 1990s. They have subsequently passed on these standards to sourcing agents or suppliers in developing countries. Developing-country suppliers have in turn developed their own code of practices relating to how pesticides may be handled, applied, and stored. Thus a developing country farmer is often subject to diverse standards ranging from international to domestic, with the latter induced by the former. Table 1 presents the kinds of standards a green bean farmer growing beans for a European retailer will typically be subject to. The domestic industry, private and public standards are usually drawn from the foreign standards especially those of the markets targeted by the exporter. Most green bean family farmers therefore comply with standards that encompass the requirements of UK industry standards (e.g., British Retail Consortium (BRC) and Global Good Agricultural Practices (GlobalGAP)), private retailer standards (e.g., Nature's Choice and Farm to Fork) and public sanitary and phytosanitary standards (SPS).

Foreign standards	*Domestic standards*
British Retail Consortium (BRC)	*i) Industry*
GlobalGAP	KenyaGAP
Ethical Trading Initiative Initiative	Horticultural Ethical Business
HACCP	*ii) Exporter code of practices*
Tesco's Nature's Choice	*iii) Public*
Marks & Spencer's Farm to Fork	Kenya Bureau of Standards
Sanitary and Phytosanitary Standards (SPS)	HCDA code of practices

Source: Adapted from Okello et al (2008);
HCCP = Hazard Analysis and Critical Control Points; HCDA=Horticultural Crop Development Authority

Table 1. Array of food safety standards in operation in Kenyan green bean industry

The diverse standards are primarily aimed at promoting practices that encourage farmers and pesticide applicators to adopt practices that protect them and the environment from hazards of pesticide exposure. These practices include i) wearing full pesticide protective gear, ii) handling pesticides in ways that ensure safety to farm family members and farm-workers, iii) bathing immediately after spraying or when pesticides accidentally come into contact with the skin, iv) storing pesticides away from foodstuffs in fully secured pesticide storage units with adequate ventilation, v) disposing of pesticide containers and leftover pesticides in ways that do not threaten the health of humans or animals, iv) discontinuing the use of unapproved (usually more toxic) pesticides, and v) using pesticides only when needed (especially when pest scouting reveals the need to apply them).

Farmers and farm-workers can get exposed to pesticides through four primary routes namely ingestion, inhalation, dermal absorption, and absorption through the eyes. Okello

and Swinton (2010) highlight the various ways in which individuals in a farm situation can get exposed to pesticides. These include entry into freshly sprayed field, eating while spraying pesticides, and skin contact with liquid, powder or aerosol forms of pesticides. Exposure to toxic pesticides can result in health hazards in the form of acute or chronic illnesses (Maumbe and swinton, 2003). Common pesticide induced illnesses include skin irritation, eye irritation, gastrointestinal irritation, respiratory irritation, headaches, shortness of breath, dizziness, cancer, neurological problems, stillbirth and abortion.

The rationale behind enforcing IFSS was that they can help reduce the hazards posed to farmers' health and the environment by pesticides. Past studies have documented strategies that avert exposure to pesticides. Such strategies include wearing pesticide protective clothing during mixing and application, using properly secured pesticide storage units and disposing of pesticides in secured disposal pits (Antle and Capalbo, 1994; Maumbe and Swinton, 2003). Other exposure averting strategies include observing the interval between the application of pesticides and date of harvest, washing hands before eating, washing the protective clothing before next use, and combining pesticide application with other pest and disease control strategies. However, farmers can also reduce the health risks of pesticides after exposure has occurred by using mitigating strategies such as washing off pesticides from skin when there is accidental contact, removing clothes and taking a bath when there is accidental leakage of the spray pump, and taking medication. IFSS promote the use of these pesticide exposure averting and mitigating strategies. So how does compliance with this array of standards affect farmer health costs of exposure to pesticides, the use of environmentally-friendly practices and farmer profit margins? We turn to these questions after briefly presenting the methods used in this study.

3. Study methods

3.1 Theoretical framework

In order to examine the effect of IFSS on Kenyan fresh produce industry, we categorized green bean farmers into two groups namely, growers who supply exporters that monitor and enforce IFSS (i.e., monitored farmers) and those that supply non discerning exporters (non-monitored farmers).   Pesticide usage may benefit farmers because it enhances the aesthetic quality of the produce, potentially enabling farmers to sell more quantity at higher prices. However, pesticide exposure may also be harmful to farmer health. The relationship between pesticide handling and usage by a farmer and health status ($h(.)$) can be expressed algebraically as a function of farmer specific variables (*f*), behavioral variables (*b*), exposure to pesticides ($e(.)$) which increases with pesticide inputs use (*x*), but decreases with pesticide exposure averting (*a*) and mitigating (*m*) variables. Health outcome is also assumed to be affected by doctor-prescribed and self administered treatment expenses (*Φ*) and institutional factors (*z*). Thus following previous authors (Cole et al, 1998; Strauss and Thomas, 1998; Hurley et al, 2000):

$$h=h[f, b, e(x, a, m), \Phi(e), z) \qquad (1)$$

Equation 1) implies that the health outcome of a farmer depends upon the set of strategies employed during pesticide handling and application, among other factors. These strategies specifically include pesticide averting (*a*) (e.g., protecting clothing, secured pesticide storage units, fenced disposal pits, and the use alternative pest management strategies) and

mitigating (*m*) strategies (treatment, washing pesticides off the skin when there is accidental contact, removing clothes and bathing when there is accidental leakage of the spray pump). The farmer uses pesticide and non-pesticide inputs to produce output (*q*) given by:

$$q=q[x,v,T,k,z] \tag{2}$$

where *q* is the output of beans, *x* is a vector of pesticide inputs, *v* are non-pesticide inputs (e.g., fertilizer); *T* is the total effective field labor requirement comprising effective family labor, (*l(h)*) and hired labor (*r*). Since exposure to toxic pesticides impairs health, we assume that effective family labor depends on the health outcomes. For instance, illness resulting from pesticide exposure is likely to cause loss in labor time as the victim recovers. We assume that the hired labor bears the cost of health impairments due to exposure to pesticide via inability to work when sick. Finally, *k* is a vector of capital factors, and *z* is as earlier defined.

Farmers who are monitored for compliance with IFSS produce beans under contracts that specify output volume, output price and other non-pesticide inputs; hence these are assumed to be predetermined. The farmer's optimization problem is to choose *x, a, m* and *Φ* to minimize the combined production and health costs subject to labor availability and contracted output level and quantity *qᵒ*. The optimization function can be expressed as:

$$\underset{x,a,m,\Phi}{Min}\ c\left(x,a\right)= w_x x\ +\ w_a a + w_m m\ + w_\Phi \Phi \tag{3}$$

$$\text{s.t.} \qquad q \geq q^o$$

$$T \geq l(h) + r$$

The farmer minimizes the combined costs subject to two constraints namely that, i) it produces no less than the contracted output ($q \geq q^0$) and ii) the total effective field labor is at least equal the sum of family and hired labor ($T \geq l(h) + r$). This optimization problem can be expressed mathematically by a Lagrangean function (*L*) as:

$$L = w_x x + w_a a + w_m m + w_\Phi \Phi + \varphi\{q^0 - q(.)\} + \lambda(T - l(h) - r) \tag{4}$$

The Lagrange multiplier *φ* represents the marginal value of added output while *λ* is the marginal cost of labor. We assume that the cost and production functions are concave and that exposure to pesticides leads to poor health while using strategies that avert or mitigate exposure to pesticides improves the health status of the farm household. At the same time, doctor-prescribed or self administered treatment expenses improve health status. We further assume that improved health outcome increases the availability of effective family labor.

Solving the Equation 4) yields the medical health and input demand functions (Okello and Swinton, 2010; Okello and Okello, 2010). The input demand functions include the demand for pesticide exposure averting strategies (*a*). One such strategy is the use of alternative pest management strategies, which reduces overdependence on the chemical control of pests and diseases and is therefore friendly to the environment. Comparative static analysis shows that optimal use of pesticides requires consideration of farmer health whose costs can be reduced by using less toxic pesticides, employing more pesticide exposure averting and mitigating strategies and relying on medical treatment.

Green bean exporters supplying major EU supermarkets train their farmers on safe use, storage, and disposal of pesticides as well as the need to use alternative strategies of

managing pests and diseases. As part the training, farmers are educated on health and environmental effects of pesticide exposure and on safe use of pesticides. *We therefore hypothesize that green bean farmers who comply with IFSS benefit by incurring lower health costs of exposure to pesticides. In addition, we hypothesize that monitoring compliance with IFSS increases the use of more environmentally friendly strategies of managing pests and diseases in green beans.*

The use of alternative pest management strategies and switching to safer approved pesticides may however present a challenge to green bean growers. First, the new (safer) pesticides may be less effective in controlling the target pests and diseases (i.e., less efficacious). Second, the new approved/safer pesticides tend to be more expensive than the unapproved ones (Jaffee, 2003; Okello, 2005). Consequently, the switch to new/approved pesticides may increase the cost of production. In sum, if the approved pesticides are less efficacious and more expensive, the overall effect of complying with the standards will be a reduction in margins earned from the sale of the beans. *We therefore hypothesize that farmers who comply with IFSS will receive lower margins than their counterparts.*

3.2 Study area and data

This paper draws from a study based on 180 green bean family farmers in Kirinyaga and Kerugoya-Kutus districts (located in Central province of Kenya) and Kangundo district (located in Eastern province of Kenya). The study was conducted between October 2003 and June 2004. A list of major green bean growing villages (primary sampling units) was drawn. From the list, 30 villages having both IFSS compliant and non-compliant farmers were randomly selected. Six farmers were then randomly sampled from each of the 30 villages, stratified by compliance with IFSS, giving a total of 180 farmers. Information was collected through personal interviews using questionnaires. Information on pesticides used was also collected.

Pesticide toxicity of the pesticides reported by farmers was looked up from the World Health Organization (WHO) toxicity classification and the pesticides categorized as class 1 (very toxic), class 2 (toxic), class 3 (slightly toxic) and class 4 (unharmful) (World Health Organization, 2005). The WHO class 4 pesticides were omitted from further analysis because they are not usually considered hazardous to users (Maumbe and Swinton, 2003).

Detailed cost and output data was gathered from six carefully selected green bean farmers in the study areas. Of the six farmers, three were producing beans for exporters who supplied UK supermarkets and hence routinely monitored compliance with IFSS under a contract while the other three sold their beans in the spot market, hence no IFSS monitoring. All the six farmers had 0.5 acres under green beans, which was the mean farm size for small family farms for the last crop of green beans grown in 2003.

3.3 Empirical methods

In order to address the three hypotheses above, this study used a combination of quantitative techniques. The first technique used was the cost of illness approach. Under this approach, health cost of exposure to pesticides is approximated by the direct and indirect costs incurred as a result of being sick from pesticide poisoning. Specifically, farmers were asked if they experienced pesticide-induced illness symptoms immediately following the application of pesticides in beans. When the answer was affirmative, the farmer was then asked what the illness was, the time taken to recover, time of travel to medical health facility and the cost of medicines. Time lost due to illness was then converted into monetary values using prevailing wage rate. Thus both the direct and indirect costs of

pesticide exposure were collected. The indirect costs were approximated by the days lost (when farmer could not work in the field due to pesticide-induced illness). The direct costs were, on the other hand, measured by the medical doctor-prescribed and self-administered treatment (including consultation fee and cost of medicine) and the cost of travel to health facility. These indirect and direct costs were then summed to obtain the total health costs of exposure to pesticides which was then used as a dependent variable in a health cost regression model to test the benefit of monitoring farmers for compliance with IFSS on the costs of exposure to pesticides.

The health cost model also included several conditioning variables namely, farmer specific variables (e.g., *age*, *gender*, and *education*); farmer's behavioral characteristics (*alcohol intake, cigarette smoking*); institutional characteristics (e.g., *distance to health facility*); pesticide exposure enhancing variables (quantity of *class 1 pesticides* used, quantity of *class 2 pesticides* used, quantity of *class 3 pesticides* used, and dummies for *pesticide applicator and mixer, keeping unwashed gear in the house* and *drink spraying pesticides*); exposure averting and mitigating variables (e.g., *sprayer maintenance, number of gear items used*, and dummies for *pest scouting, change clothes*, and *washing gear* before next use.

The second technique, the Poisson regression model, was used to test the effect of monitoring farmers for IFSS on the use of alternative pest and disease management strategies. The dependent variable in this model was the number of alternative strategies used by the farmer to manage pests and diseases in green beans. The strategies considered included   soil testing for pests, crop rotation, use of pest/disease resistant varieties, fallowing, mulching, uprooting/burning infected plants, pest scouting, using trap crops, use of biological/natural pesticides, use of beneficial insects/organism. The conditioning variables used in this model are similar to those used in the cost of illness model.

Both the health cost and the Poisson models used survey regression technique with *village* as the primary sampling unit to control for clustering effect of the variance at the village level. Survey regression also has the added advantage of generating estimates that are robust to heteroskedasticity (Vittinghoff et al., 2005, pp. 309-310). In estimating both models, we dropped the practices variables most emphasized under the IFSS (namely, pest scouting, sprayer maintenance, and use of protective gear) because including them alongside the monitoring variable resulted in "double counting". Other variables that added little information to the two models were also dropped when a Wald joint exclusion restriction tests showed that they had no significant effect on the models' explanatory power. Some of the observations contained zero values hence could not be directly transformed into natural logs. These were *health cost, class1 pesticides, class 2 pesticides* and *class 3 pesticides*. Less than six observations in the *health cost* and *class 2 pesticides* had zero observations, hence they were log-transformed after first adding 0.5 to all observations. However, *class 1 pesticides* and *class 3 pesticides* had several zero values and were therefore log-transformed after performing Battese (1997) dummy variable transformation method in order to identify zero-valued observations without bias to the analysis.

The third technique used was the simple gross margin analysis. It involved computing the revenues and costs of producing green beans among the farmers that were monitored for compliance with IFSS and their counterparts. The revenues and variable costs of producing beans were computed for each of the three selected farmers and then averaged over each category of famers to obtain the gross margin/acre. The revenues and costs were measured for the last crop of beans grown in 2003. Two sets of prices were used to compute green bean revenues namely, the contract price for the monitored farmers (i.e., growing beans under contract) and the season's average spot market price for the non-monitored farmers.

Table 2 summarizes the statistics for the key variables and also presents the results of paired t-tests of equality of means between monitored and non- monitored farmers.

Variable	Monitored (N=92)		Unmonitored (N=83)		Test of Means	
	Mean	Std. Dev	Mean	Std. Dev	t-stat	p-val
Dependent variables						
log health cost (Kshs*)	3.25	2.85	3.88	2.54	1.53	0.063
skin irritations (count)	1.58	2.79	2.67	4.73	1.89	0.030
eye irritations (count)	0.84	2.78	1.24	3.23	0.89	0.188
total irritations (count)[+]	2.72	5.44	4.34	7.61	1.63	0.052
apmp (count)	3.82	0.24	2.82	0. 20	-3.23	0.000
Farmer specific and institutional variables						
Female head of household	0.79	0.42	0.80	0.44	0.23	0.411
log age (years)	3.65	0.27	3.56	0.31	-1.81	0.964
log education (years)	1.95	0.09	2.14	0.39	-1.80	0.036
log income	11.37	0.10	11.08	0.10	-2.11	0.982
log distance to clinic (hours)	3.37	0.08	3.47	0.07	0.88	0.190
cigarette smoking (0,1)	0.32	0.04	0.30	0.05	0.30	0.616
alcohol intake (0,1)	0.38	0.05	0.31	0.05	-0.92	0.177
total income ('000 Kshs)	133.6	143.6	95.4	106.5	-1.98	0.025
marketable bean output (kg/acre)	1706	1258	795	740	-5.73	0.000
Exposure enhancing variables						
log class 1 pesticides (g/farm)	-0.47	0.13	-0.20	0.20	1.14	0.127
log class 2 pesticides (g/farm)	5.86	0.14	6.12	0.12	1.40	0.082
log class 3 pesticides (g/farm)	1.11	0.32	1.01	0.37	0.22	0.588
drinks spraying (0,1)	0.17	0.38	0.13	0.33	-0.89	0.813
unwashed gear in house (0,1)	0.26	0.50	0.30	0.50	0.55	0.292
primary applicator (0,1)	0.55	0.50	0.63	0.50	1.25	0.106
primary mixer (0,1)	0.74	0.46	0.75	0.48	0.12	0.553
Exposure averting and mitigating variables						
wash gear (0,1)	0.69	0.05	0.67	0.05	-0.30	0.619
change clothing & wash (0,1)	0.20	0.41	0.22	0.41	0.17	0.434
sprayer maintenance (count/year)	1.03	0.15	0.60	0.15	-2.29	0.011
pest scouting (0,1)	0.78	0.41	0.61	0.49	-2.46	0.008

Source: Adapted from Okello and Swinton (2010)

* Kenya Shillings (Exchange rate in 2003 was US$ 1 = Kshs 78).

[+] Total includes gastrointestinal irritations, which were too infrequent to count separately.

Table 2. Summary statistics of key variables used in the analysis

As shown, monitored farmers experienced lower health costs of exposure to pesticide and used, on average, significantly higher number of alternative pest management practices than the unmonitored. Mean health costs associated with pesticide exposure were Kshs 186 for monitored farmers and Kshs 261 for the non-monitored. At the same time farmers who comply with IFSS received higher but more variable bean yield and income than their counterparts.

Notably, Table 2 shows that there are significant differences in the incidence of acute pesticide-induce illness between the monitored and non-monitored farmers. The former had lower mean number of skin irritations than the latter. Indeed, the average count of total[1] acute pesticide-induced irritations experienced by green bean farmers was much lower and strongly statistically significant among monitored farmers than their counterparts.

With regard to pesticide use, however, there are no significant differences between monitored and non-monitored farmers, except for class 2 pesticides. Indeed t-tests of difference in mean quantity of active ingredients per farm applied by monitored and non-monitored farmers are insignificant. This finding suggests that monitored farmers are still using toxic class 1 pesticides as much as their non-monitored counterparts. The continued use of class 1 pesticides by monitored farmers in controlling pests and diseases in beans is largely due to the dilemma monitored farmers face. The very market that demands the use of less toxic (but often less efficacious) pesticides also demands aesthetic quality attributes (e.g., spotless and straight beans) which are hard to meet without chemical control of pests and diseases. In the section below, we investigate these findings further using regression and gross margin analysis to specifically test if they are caused by monitoring farmers for compliance with IFSS.

4. Results

4.1 Effect of IFSS on pesticide-related cost of illness

As hypothesized, monitoring farmers for compliance with IFSS significantly reduces pesticide related health costs (Table 3). It reduces the log of health costs of exposure to pesticides by 0.80 units. Several other factors also condition the health costs of exposure to pesticides. Among the farmer specific variables, education reduces health costs while and income increases it. An additional year of education beyond the mean of two reduces health costs of pesticide exposure by 18 percent. The elasticity of health cost with respect to income is 0.53 implying that income is associated with increased health costs of pesticide induced illnesses. That is, farmers who earn greater income from beans (hence likely to have grown larger areas) get more exposed to pesticides and hence incur higher health costs.

As expected, results also show that the primary pesticide applicators incur higher health costs. Although not surprising, it corroborates previous findings by Harper and Zilberman (1992) from U.S. agriculture. Among the mitigating and averting variables, pesticide applicators who change clothing contaminated by pesticides and wash off the pesticides from their bodies (*change clothing*) following accidental leakage by the spray pump experience lower cost of pesticide illness than those who do not, presumably because they reduce duration of skin contact with pesticides.

4.2 Effect of IFSS on the use of alternative pest and disease management strategies

The finding that the use of pesticide averting and mitigating strategies reduces health costs of exposure to pesticides led us to investigate further whether monitoring farmers for compliance with IFSS increases the use of such strategies. In particular, we focused on strategies that are likely to benefit the environment namely, the alternative disease and pest

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[1] Total irritations is the sum of the count of skin, eye, and gastrointestinal irritation experienced by a farmer soon after applying pesticides in green beans

management strategies. We therefore estimated survey Poisson regression model to test the effect of monitoring farmers for compliance with IFSS on number of such strategies used.

Independent variables	Coefficient	p-value
Farmer specific and institutional variables		
female head of the household	-0.055	0.923
log age	-1.524	0.040
education	-0.184	0.009
log income	0.539	0.026
log distance to clinic	-0.444	0.113
cigarette smoking	-0.708	0.125
alcohol intake	0.808	0.056
monitored farm	-0.799	0.055
Exposure enhancing variables		
log class 1 pesticides	-0.098	0.757
log class 2 pesticides	0.002	0.987
log class 3 pesticides	-0.535	0.120
primary applicator	1.184	0.017
unwashed gear in house	0.294	0.506
drinks spraying	0.021	0.965
Exposure averting and mitigating variables		
change clothing & wash	-0.988	0.037
Battese dummy variables		
class 1 pesticides	-1.433	0.513
class 3 pesticides	-3.524	0.106
constant	10.900	0.027
F statistic	2.44	
p-value	0.003	
R-squared	0.194	

Dependent variable: Natural log of farmer's direct and indirect health costs* of pesticide exposure in Kenya Shillings
* To health cost variable, we added 0.5 KSh to all observations before log transformation to accommodate 6 cases of zero health costs; likewise we added 0.5 g/farm to observations of Class 2 pesticide quantity due to 1 zero value. For Class 1 and 3 pesticide quantities, we created new dummy variables to signal zero values, replacing the pesticide quantity zeroes with 1's so that their log transformed values were zero (Battese, 1997) in order to remove bias from the estimation.
Source: Adapted from Okello and Swinton (2010)

Table 3. Determinants of pesticide-related health costs among Kenyan green bean growers, 2004 – Survey OLS regression

We selected a Poisson regression model because the dependent variable, namely the number of pest and disease management practices (*apmp*) used by a farmer, is a count variable. The results of this exercise are presented in Table 4.

As hypothesized, monitoring farmers for compliance with IFSS increases the expected number of alternative pest and disease management strategies used by the farmers. Other things being equal, the expected number of such alternative pest and disease management practices (*apmp*) used by monitored farmers is approximately 30% higher than for those that are not.

Independent variables	Coefficient	p-value
Farmer specific and institutional variables		
female head of household	0.280	0.079
log age	0.202	0.264
log education	0.102	0.081
Log plotsize	-0.134	0.225
Log income	0.022	0.548
cigarette smoking	-0.061	0.007
alcohol intake	0.016	0.597
log distance to clinic	0.197	0.008
EU-PS comply	0.302	0.005
Extension	0.005	0.008
Ownradio	0.206	0.019
Experience	0.004	0.033
Exposure enhancing variables		
log class 1 pesticides	-0.014	0.669
log class 2 pesticides	0.068	0.039
log class 3 pesticides	-0.004	0.798
F statistic	5.19	
p-value	0.001	
N	175	

Dependent variable: Number of alternative pest and disease management practices used by the farmer
Source: Adapted from Okello and Okello (2010)

Table 4. Effect of EU-PS on use of alternative pest management practices, 2004 – survey Poisson regression

A number of the conditioning variables also affect the number of *apmp* used by farmers. Among the farmer specific variables, *gender* and *education* increase the expected number of *apmp* used. The expected number of alternative pest management practices used by male farmers is approximately 28 percent higher than for female farmers. At the same time, increasing the mean years of education from 2 to 3 increases the number of *apmp* by 10 percent. Results also show that cigarette smoking reduces the expected number of *apmp* used by farmers.

A number of institutional factors also affect the number of alternative pest and disease management strategies in green beans. These include distance to clinic, extension, radio and experience. These factors increase the expected number of *apmp* used in controlling pests and diseases in beans. Other things being equal, increasing the log of distance to the clinic by one hour of travel time increases the number of *apmp* by about 20 percent while an additional contact with public extension personnel increases the expected number of *apmp* by 0.5 percent. The results further show that experience in growing beans increases the expected number of *apmp* used, probably because of familiarity with the hazards of exposure to pesticides. Each additional year of farming experience beyond the mean increases the expected number of *apmp* used by 0.4 percent. Among the exposure enhancing

variables, results show that the use of the more toxic class 2 pesticides increases the expected number of *apmp* used.

4.3 Effect of IFSS on margins earned by green bean farmers

A major concern of many developing country exporters upon the onset of IFSS was that the standards would marginalize the poor family farmers (Mungai, 2004; Okello, 2005). Hence we investigated how compliance with IFSS affected the profit margins earned by farmers. Figure 2 presents the results of the analysis. As shown, monitored farmers received higher revenues from growing beans than their counterparts. The higher revenues obtained by monitored farmers resulted primarily from selling more beans due to better access to UK market than the unmonitored. Interestingly, monitored farmers did not receive premium price from their buyers despite having to comply with the IFSS (Okello, 2005). The average price of beans paid to monitored farmers under the contract remained stable at KShs 40/kg during the period.
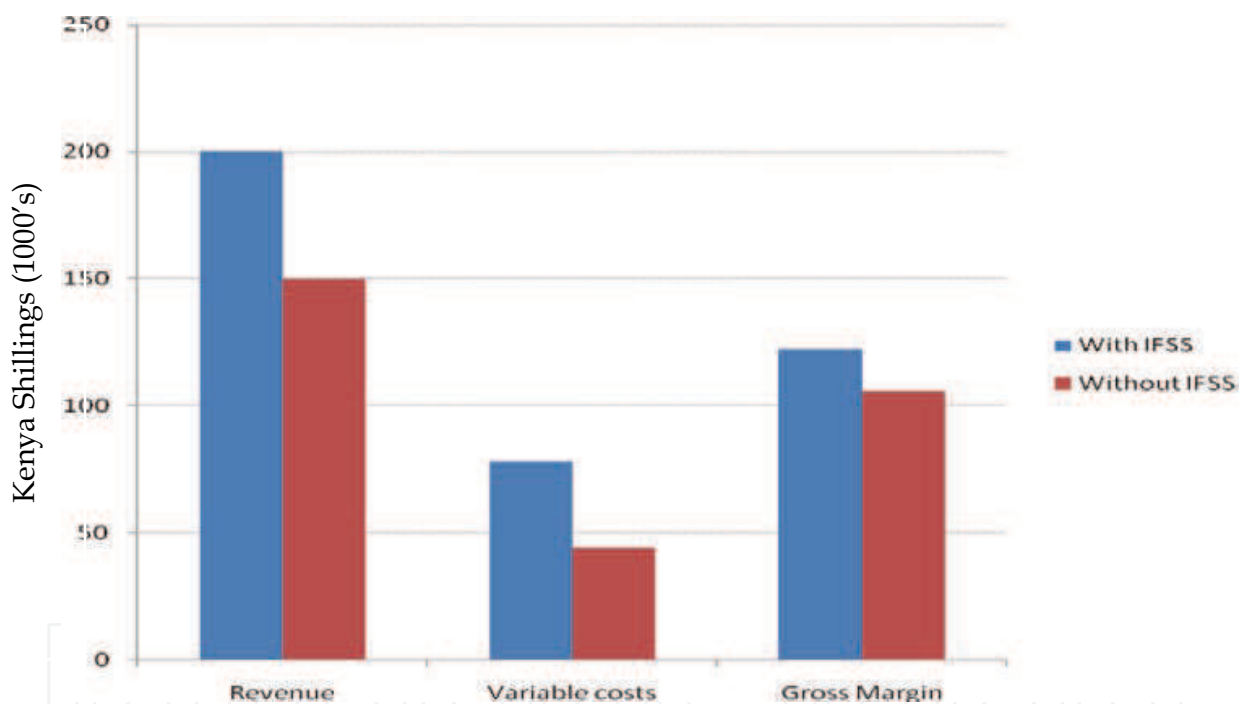
Source: Okello and Swinton (2005)

Fig. 2. Comparison of revenues, costs and gross margins of producing green beans with and with IFSS, Kenya, 2005 (in thousand Ksh)

Monitored farmers incurred higher variable costs of producing beans, as expected. The high variable costs likely resulted from new, more expensive pesticide products. For instance, at the time of this study, farmers were required to switch from the use of Dimethoate (a class 2 fungicide with long required interval between spraying and harvest) to Ortiva (a class 3 fungicide with a shorter interval). However, Ortiva (the new pesticide) cost 2.5 times as much as Dimethoate. Indeed, switching to approved pesticides contributed to 20% of the difference in costs of producing green beans between the monitored and non-monitored farmers.

Overall, contrary to our theoretical expectations, monitored farmers received higher margins from growing beans than their counterparts. The average gross margin for monitored farmers was 13% higher than for their counterparts indicating that IFSS does not really marginalize the poor family farmers who grow beans under strict monitoring for compliance with IFSS.

5. Conclusions

This research finds that compliance with international food safety standards (IFSS) reduces the incidence of pesticide-induced acute illness and the health costs associated with exposure to pesticides. Farmers who were monitored for IFSS compliance incurred much lower health costs and also experienced much fewer acute pesticide-induced illnesses than those who were not. The paper also finds that compliance with IFSS promotes the use of integrated pest and disease management strategies. The judicious use of pesticides has implications for sustainable production of non-traditional fresh exports in developing countries as it reverses the "circle of poison" pattern reported in Asia and instead promotes a circle of virtuous pesticide care in use. We further find that while compliance with IFSS increases the cost of green bean production, higher revenues result in the profit margins earned by IFSS compliant farmers that exceed their domestic counterparts who are not monitored for compliance. These higher margins emanate from greater access to the export market by farmers monitored under contracts.

This study therefore concludes that compliance with IFSS therefore brings health and environmental benefits in addition to the acknowledged access to high value overseas markets. Contrary to early concerns that IFSS compliance would marginalize poor family farmers, IFSS compliance has brought financial gains and many Kenyan smallholder farmers have found cooperative ways to gain access to these export markets (Okello and Swinton, 2007). Despite the health and financial gains, IFSS compliant farmers do not use less toxic pesticide active ingredients in fresh vegetable production than their non-monitored counterparts. The international market demand for clean, well-formed and spotless vegetables continues to require rigorous pest control that favors the use of efficacious pesticides.

6. References

Antle, J. M. & Capalbo, S.M. (1994). Pesticides, productivity and farmer health: Implications for regulatory policy and agricultural research. *American Journal of Agricultural Economics*, 76: 598-602.

Antle, J. M. & Pingali, P. (1994). Pesticides, productivity and farmer health: A Philippine case study. *American Journal of Agricultural Economics* 76: 418-430.

Battese, G.E. (1997). A note on the estimation of Cobb-Douglas production functions when some explanatory variables have zero values. *Journal of Agricultural Economics*. 48:250-252

Cole, D., Carpio, C. F., Julian, J.A. & Leon, N. (1998). "Health impacts of pesticide use in Carchi farm populations". In *Economic, Environmental and Health Tradeoffs in Agriculture: Pesticides and Sustainability of Andean Potato Production*. ed. C.C. Crissman, J.M. Antle, and S.M. Capalbo. Boston: Kluwer

Dolan, C. & Humphrey, J. (2000). Governance and trade in fresh vegetables: Impact of UK supermarkets on the African horticultural industry. *Journal of Development Studies* 37: 147-177.

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

Harper, C. R. & Zilberman, D. (1992). Pesticides and Worker Safety. *American Journal of Agricultural Economics* 72: 68-78.

Jaffee, S. (2003). From Challenge to Opportunity: The Transformation of the Kenyan Fresh Vegetable Trade in the Context of Emerging Food Safety and Other Standards. PRMTR Division, World Bank. Washington, DC (May 2003).

Jaffee, S. & Morton, J. (1995). *Marketing Africa's High Value Foods: Comparative Experiences of Emergent Private Sector*. World Bank. Washington DC.

Jensen, M. F. (n.d). Food safety requirements and smallholders: A case study of Kenyan fresh produce exports. The Royal Veterinary and Agricultural University. Unpublished Draft.

Maumbe, B. M. & Swinton, S.M. (2003). Hidden costs of pesticide use in Zimbabwe's smallholder cotton growers. Social Science & Medicine, 57:1559-1571.

Mungai, N. (2004). EU rules could destroy horticulture: the protocol on good agricultural practices will have a profound impact on both large and small-scale farmers, although the biggest impact will be on the latter. *Daily Nation*. May 7, 2004, p11.

Mwanthi, M.A. & Kimani, V.N. (1990). Agrochemicals: a potential health hazard among Kenya's small-scale farmers. (In G. Forget, T. Goodman, and A. de Villiers (Eds.) Impact of Pesticides on Health in Developing Countries (pp 21-34). Ottawa: IDRC).

Okado, M.(2001). Background Paper on Kenya off-season and specialty fresh fruits and vegetables: Lessons of experience from the Kenya horticultural industry. Presented at United Nations Conference on Trade and Development Regional workshop for horticultural economies in Africa. Nairobi, Kenya. May 29-31, 2001 (URL): http//r0.unctad.org/infocomm/diversification/nairobi/Keny0901.doc.

Ohayo-Mitoko, G. J. A. (1997). Occupational pesticide exposure among Kenyan agricultural workers: an epidemiological and public health perspectives. Dissertation, Wagenigen Agricultural University.

Okello, J.J. 2010. Implications of extension of US trade preferences for Agricultural export market development in Africa – the case of horticulture in Kenya. A report submitted to Oxfam- America, March 29, 2010.

Okello, J.J. and R.M Okello. 2010. Do EU pesticide standards promote environmentally-friendly production of fresh export vegetables in developing countries? Evidence from Kenyan green bean industry. *Environment, Development and Sustainability*, 12 (3): 341-355

Okello, J.J. and S.M Swinton. 2010. From circle of poison to circle of virtue: pesticides, export standards and Kenya's green bean industry. *Journal of Agricultural Economics*, 61, 209-224

Okello, J.J., C. Narrod and D. Roy. 2008. "Compliance with international foods safety standards is not a fantasy: Evidence African green bean growers" *Fresh Perspectives*. No. 15, April 2008. Available for download at:

Okello, J. J. and S. M. Swinton. 2007. Compliance with international food safety standards in Kenya's green bean industry: comparison of a small and a large scale family farm producing for export. *Review of Agricultural Economics* 29: 269-285.

Okello, J.J. 2005. "Compliance with international food safety standards: The case of green bean production in Kenyan family farms." Ph.D. dissertation, Agricultural Economics, Michigan State University, East Lansing, Michigan, USA.

Okello, J.J. and S. M. Swinton. 2005. A race to the top, but at what cost? Kenyan green bean farmers' struggle to comply with international food safety standards. Selected poster paper presented at American Agricultural Economics Association meeting, Providence, Rhode Island, 24-27, 2005

Pingali, P.L. & Rogers, P.A. 1995. Impact of Pesticides on Farmer Health and the Rice Environment. (Boston: Kluwer Academic Publishers)

Strauss, J. & Thomas, D. (1998). Health, nutrition and economic development. *Journal of Economic Literature*, 82, 766-817 Thrupp, L. A., G, Bergeron, and W. F. Waters.1995. *Bittersweet Harvest for Global Supermarkets: Challenges in Latin America's Export Boom*. Washington, DC: Natural Resources Institute.

Vittinghoff, E., Glidden, D.V., Shiboski, S.C., & McCulloch, C.E. (2005). *Regression Methods in Biostatistics: Linear, Logistic, Survival and Repeated Measures Models*. New York: Springer.

World Health Organization. (2005). The WHO recommended classification of pesticides by hazard and guidelines to classification 2004. (Geneva: World Health Organization)
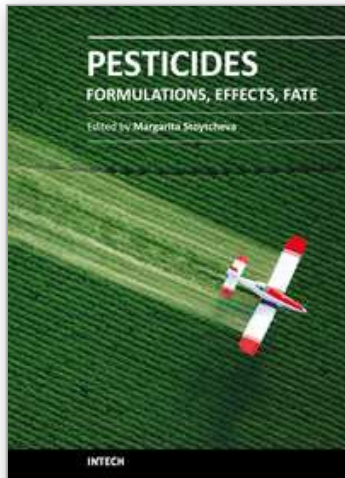
Pesticides - Formulations, Effects, Fate

Edited by Prof. Margarita Stoytcheva

This book provides an overview on a large variety of pesticide-related topics, organized in three sections. The first part is dedicated to the "safer" pesticides derived from natural materials, the design and the optimization of pesticides formulations, and the techniques for pesticides application. The second part is intended to demonstrate the agricultural products, environmental and biota pesticides contamination and the impacts of the pesticides presence on the ecosystems. The third part presents current investigations of the naturally occurring pesticides degradation phenomena, the environmental effects of the break down products, and different approaches to pesticides residues treatment. Written by leading experts in their respective areas, the book is highly recommended to the professionals, interested in pesticides issues.

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