EU private agrifood standards in African high-value crops: pesticide use and farm-level productivity

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Abstract— **In parallel with changes in official standards, supermarket chains in Europe have developed prescriptive, production-oriented standards, e.g. the European Union Retailers Produce Working Group for Good Agricultural Practices (GlobalGAP), and are asking their suppliers for produce to be certified according to food-safety and quality standards. There are concerns that the proliferation and enhanced stringency of standards that are imposed by high-income countries can negatively affect the competitiveness of producers in developing countries and impede actors from entering or even remaining in high-value food markets. Yet, in some cases, others argue that such standards can play a positive role, providing the catalyst and incentives for the modernization of export supply and regulatory systems and the adoption of safer and more sustainable production practices.**

This article provides an empirical analysis of EU private food-safety standards impact on pesticide use and farm-level productivity among smallholder export vegetable producers in Kenya. We apply an extended three-stage damage control production framework that accounts for multiple endogeneity problems to farm-level data collected from a random cross-section sample of 439 small-scale vegetable producers.

Estimation results show that export producers complying with private standards significantly use less toxic pesticides; however there is no significant difference on the total quantity of pesticides used. Contrary to findings elsewhere, the econometric evidences here show that export vegetable farmers in Kenya use pesticide below the economic optimum. The third stage structural revenue model results demonstrate a positive and significant impact of standards adoption on revenue of vegetable production. While food safety and quality standards can be a barrier for resource poor smallholders to maintain their position in the lucrative export markets, they can also induce positive changes in production systems of small-scale farmers who adopt it as shown by the results presented. Generally this article partly supports the notion that adoption of emerging food-safety standards can serve as a catalyst in transforming the production systems of developing countries towards safer and more sustainable production.

Keywords— **High-value crops, food-safety standards, productivity**

I. INTRODUCTION

The promotion of non-traditional export crops like horticultural commodities has often been proposed as a pro-poor strategy to promote agricultural development in many sub-Saharan countries including Kenya (1). The increase in demand for high-value horticultural produce by developed countries consumers' has encouraged farmers in developing countries to intensify production through the increased use of external inputs. In horticultural crops agrochemical inputs such as pesticides play an important role to meet the quality requirements of wholesale and retail agents, i.e. to deliver produce with specific physical attributes, such as color, shape, size and spotlessness (2).

While agrochemical inputs contributed to increased production, high levels of pesticide use have been associated with negative externalities like short-and-long-term human health effects (3; 4; 5; 6; 7; ecological effects on non-target plants and animals (2; 8) and damage to the soil and water quality of the agro-ecosystem (8). Increasingly, pesticide residues above maximum limit (MRL) have resulted in food safety concerns for both domestic and foreign consumers. Retailers and consumers in the importing European countries have become increasingly concerned about the prevailing production methods in the exporting countries. The European Union (EU), Kenya's major export market, has enacted legislation on traceability, maximum pesticide residue limits, sanitary and phytosanitary requirements. Supermarket chains in Europe have also developed prescriptive, production-oriented standards, e.g. the EU Retailers Produce Working Group for Good Agricultural Practices (EurepGAP), which are relevant for growers of fresh fruit and vegetables and require mandatory certification by an independent internationally accredited certification body. At present, over 250 control points have been identified in EurepGAP for fresh fruit and vegetables, of which over 50% define criteria for the use of chemicals for pre- and post-harvest treatment (9). To comply with these standards producers have to change their production technology, e.g. switch to less harmful pesticides and invest in structures like grading shed, charcoal cooler, disposal pit, toilet washing facilities, pesticide store etc. This paper primarily investigates the impact of EurepGAP[1] standards on small-scale vegetable producers in Kenya.

Some argue that such stringent food-safety standards pose major challenges for continued small-scale producers' success in international markets for high-value food products, such as fruit and vegetables (10). Yet, in some cases, others argue that such standards can play a positive role, providing the catalyst and incentives for the modernization of export supply and regulatory systems and the adoption of safer and more sustainable production and processing practices (11; 12).

Using a farm-level data collected from a random cross-section sample of 439 Kenyan small-scale export vegetable producers, this paper deals with the following questions: i) Does the adoption of production standards affect the overall use of pesticides among export producers? and (ii) Does the adoption of production standards affect the revenue of export producers? To answer these questions an econometric model was applied taking into account potential problems of endogeneity and/or selectivity with respect to pesticide use and the adoption of standards.

The remainder of this article is organized as follows. Section 2 discusses the data, section 3 presents the analytical model, section 4 presents the empirical results and section 5 ends the article with conclusions and implications.

II. DATA

A multi-stage sampling procedure was used to select districts, sub-locations[2] and small-scale vegetable producers, respectively. At the first stage five districts were purposively selected from the two major export vegetable producing provinces (namely Nyeri, Kirinyaga, and Murang'a Districts in Central Province and Meru Central and Makueni Districts in Eastern Province) based on the intensity of export vegetable production, agro-ecology, types of crop produced and accessibility. Meru District is located at higher altitude primarily producing French beans while Nyeri, Kirinyaga, and Murang'a Districts are situated at middle altitude producing a range of green beans and peas. Makueni District is located at lower altitude mainly producing Asian vegetables such as okra, chilies, Aubergines etc. These districts represent the major export vegetable producing areas, which cover approximately half of all smallholder vegetable export producers. Since the number of export vegetable producers among the districts varies and to ensure that every element in the target population has an equal chance of being included in the sample, we used Probability Proportional to Size (PPS) sampling technique. Overall, 21 sub-locations were randomly selected from the five districts by PPS sampling procedures and a total of 439 export vegetable producer households were selected randomly for the interviews. Of these 149 are EurepGAP adopter export farmers and 290 are non-adopter export farmers. EurepGAP adopters in this case is defined as small-scale export producers who have either already obtained EurepGAP certificate or are in the process of

[1] Beside EurepGAP there are other standards such as British Retail Consortium (BRC), Hazard Analysis Critical Control Point (HACCP), TNC (Tesco's Nature Choice) and ISO 9001:2000 that are relevant for the sector in Kenya nevertheless these standards are more stringent than EurepGAP and primarily adopted by large-scale producers. There is no smallholder group certified under these standards during our survey period and hence our study mainly focuses on smallholders producing under EurepGAP.

[2] Sub-location is the lowest administrative unit in Kenya

obtaining the certificate under Option 2[3]. Data collection took place during the 2005/2006 cropping season. For each randomly selected farmer the survey combined a single visit (re-call survey) and a season-long monitoring of household production practices.

III. ANALYTICAL MODEL

Following the works of (13; 6; 14; 15; 16; 17; 18), this study takes a 'damage control' approach to establish pesticide productivity and computing economic optima for pesticide use. The Cobb Douglas production function with logistic damage control function can be represented as:

$$Ln(Q) = Ln(a) + \sum_{i=1}^{n} \beta_i Ln(W_i) + \gamma G_i + Ln(1+\exp(\lambda - \alpha x_p))^{-1} + v \quad (1)$$

where Q denotes total revenue per acre from export vegetables, the vector W_i includes labour, fertilizer, seed, number of vegetable crops grown, other farm-specific factors that affect total revenue such as age of the household head and location-specific factors (a set of district dummy variables) and G_i denote adoption of EurepGAP standards. The β_i's are the respective coefficients to be estimated, λ is constant and α is the parameter to be estimated for pesticides in logistic damage function framework.

One long-standing problem with direct estimation of the production function is that the inputs are treated as exogenous, when the farmers decide their levels. Although this problem applies to all inputs, it is especially true of pesticides, since they are often applied in response to pest pressure (14). Hence, it is possible that the covariance of x_p and the residuals of the revenue function is non-zero, a condition that would bias parameter estimates of the impact of pesticides on output. The model specified above also does not account for the possible selection bias of the adoption of EurepGAP, G_i , in the production function equation. The decision to adopt standards may be determined by unobservable variables that may also affect productivity. If this is the case, it leads to biased estimates of the impact of adopting EurepGAP.

Table 1 gives an overview of model specification for revenue and pesticide use function (without consideration of potential endogeneity problem) and definition of variables included in the model.

[3] EurepGAP offers four types of certification, although currently in Kenya only two of them are applied. Under Option 1 individual farmers apply for certification and under option 2 a group of farmers applies for a group certificate. Farmers must invest in the infrastructure necessary for EurepGAP, establish an internal management and control system, perform individual self-inspections and group internal inspections before receiving an external verification by a certification body (9).

Table 1. Model specification and definition of variables

Model specification without considering potential endogeneity problems	
TRVG = f [SEED, FERT,LABO, PRES, CRNU, PEST, ADOP , AGEH, district dummies]	
PEST = f [ADOP, PEPR, FEPR, PRES, HHSI, CONT, AGEH, DIST, GROU, SYPT, FACI, TRAI, CRED, APPL, district dummies]	
Variable	Definition
TRVG	Total revenue of export vegetables per acre per cropping season (KSh)
PEST	Total cost of pesticide use per acre per cropping season (KSh)
AGEH	1. Age of the household head (yrs)
EDU1	Highest grade attained by household head (yrs)
EDU2	Highest grade attained by other adult household members (yrs)
HHSI	Household size (adult equivalent)
LITU	Number of Tropical Livestock Unit owned
SEED	Seed cost per acre per cropping season (KSh)
FERT	Fertilizer cost per acre per cropping season (KSh)
LABO	Labor cost per acre per cropping season (KSh)
LAEX	Land size under export vegetables (acres)
CRNU	Number of vegetable crops grown per cropping season
PRES	Pressure of pest (scores from 1 to 9)
ADOP	Adoption of EurepGAP standards dummy
PEPR	Price of pesticide (KSh/g)
FEPR	Price of fertilizer (KSh/kg)
SYPT	Pesticide poisoning cases one year prior to the survey
FACI[4]	Facility index
TRAI	Number of major agricultural training subjects attended in the past three years prior 2005
GROU	Number of years the household head has been a group member
CONT	Number of years the household had a formal contract
DIST	Distance to extension service (km)
CRED	Amount of credit used for the past three years prior 2005 (‘000 KSh)
APPL	Primary applicator of pesticide (1, if household member, 0 casual labor)

[4] Facility index: $D_h = \Sigma D_{ih}$ (1-P_i) $P_i = n_i/n$
where D_{ih} = 1 if household h has access to facility i ; the facilities are having cemented floor, number of rooms, access to pipe water, and being less than 100 meter from water source; P_i is the probability of having facility i; n_i = number of households which have a facility i; and n = total number of households (19).

A Wu-Hausman specification test (20) is performed to test the null hypotheses that (a) pesticide use and EurepGAP adoption are exogenous in the revenue function; and (b) EurepGAP adoption is exogenous in pesticide use function before further econometric analysis. The estimated Wu-Hausman chi-square statistics are reported in table 2.

Table 2. Results of Wu-Hausman specification tests

Null hypothesis	Wu-Hausman F-test statistics	P-value[a]
Exogeneity of EurepGAP adoption discrete choice in revenue function	3.78	0.053*
Exogeneity of pesticide inputs use in revenue function	1.55	0.138+
Exogeneity of EurepGAP adoption discrete choice in pesticide use function	4.15	0.043**

[a] Statistical significance at the 0.05 (**) , 0.1 (*) and 0.15(+) level of probability

The P-values of the estimated F-test statistics show that the exogeneity hypothesis is rejected in the revenue function for EurepGAP adoption and pesticide use at the 10% and 15% level of significance, respectively. The exogeneity hypothesis for EurepGAP adoption in pesticide use function is also rejected at 5% level of significance. The results of the Wu-Hausman specification test suggest that farmers decision to adopt EurepGAP and pesticide input use are endogenous in the production function model and need to be accounted for to get efficient and consistent estimation.

To empirically account for this multiple endogeneity and/or selectivity problem in the production function, we use a model that consists of three stages and looks as follows (21; 22; 23):

Stage one: Adoption equation

$$G_i^* = \beta X_i + u_i \quad (2)$$

Stage two: Reduced form regression

$$Y_i^* = \alpha V_i + \gamma G_i + e_i \quad (3)$$

$$G_i = \begin{cases} 1 & if\ G_i^* > 1 \\ 0 & otherwise \end{cases} \quad (4)$$

Stage three: Structural equation

$$Q_i = \alpha W_i + \gamma G_i + \beta Y_i + v_i \qquad (5)$$

where G_i^* is the unobservable or latent variable for EurepGAP adoption, X_i is a non-stochastic vector of observed farm and non-farm characteristics determining adoption, Y_i^* denotes the expenditure on chemical pesticides, V_i is a vector of exogenous variables thought to affect pesticide use, G_i is the predicted value of EurepGAP adoption from stage one, Q_i denotes total revenue per acre from export vegetables, W_i represent covariates expected to influence structural revenue equation, Y_i denotes predicted value of pesticide use from stage two, and u_i, e_i and v_i are random disturbances associated with the adoption of EurepGAP, pesticide use and the revenue model. The purpose of stage one and two is to eliminate the problem of endogeneity of EurepGAP adoption and pesticide use in the structural model. To solve this problem, the endogenous variable is first regressed on the instruments and then the estimated value of the endogenous variable is included in the structural equation instead of the endogenous variable itself.

IV. ESIMATION RESULTS[5]

A. Pesticide use model results

The results of the pesticide use functions demonstrate that the model performed well in explaining pesticide use with reasonable explanatory power (adjusted R-squared of 0.34)

On the pesticide use function estimated for export farmers, we observe no significant difference between EurepGAP adopters and non-adopters in terms of value of pesticide use, which indicate that the EurepGAP adoption has no significant impact on reduction of expenditure on pesticide use among smallholder export producers[6]. This might be attributed to three factors. First, exporters who monitor and enforce compliance with EurepGAP give much emphasis on physical appearance of the produce (e.g. spotless), which implicitly encourages chemical control of pests and diseases. Second, although EurepGAP requirements advocate the use of alternative pest control strategies like Integrated Pest Management (IPM), export farmers rarely resort to this alternative due to the risk associated with outbreak and rapid multiplication of pests, the challenge that is exacerbated by the tropical climate. Third, export companies that enforce EurepGAP also indirectly promote the use of chemical control by handing farmers a weekly spray program and sometime involving in direct spraying by their technical personnel. These chemicals are often expensive compared to some chemicals available in the market. The studies by Okello (24) supported these findings, which presented no significant difference between compliant and non-compliant green bean growers in terms of types and quantities of pesticides used. We estimated alternative function using the ratio of WHO Hazard Category I and II pesticides to the total pesticides as a dependent variable to examine if adoption of standards affects types of pesticide used. Contrary to Okello's findings, the estimation results[7] demonstrate that the adopter categories are distinguishable in types of pesticide used i.e. non-adopters uses significantly higher amount of WHO Hazard Category I and II pesticides compared to non-adopters.

The coefficients on variable FERP is negative and statistically significant whereas the price of pesticide (PEPR) is positively associated. This suggests that the expenditure on pesticide use is inversely related with the price of fertilizer and directly related with pesticide price in line with our expectation. This depicts that farmers at the same time adjust their total expenditures on pesticide use depending on the change in price of other inputs. On the other hand farmers having access to credit services (CRED) spend significantly higher amount on pesticides, which

[5] The estimation results of the first stage (adoption equation) are not presented due to space limitation.

[6] We also estimated alternative function using quantity of pesticide used as a dependent variable and found no significant difference between adopter categories.

[7] The estimation results could be available on request.

portray financial constraints as one impediment for pesticide use among export farmers. As expected the coefficients on pest pressure (PRES) is positive although it's not significant. This indicates that farmers spending pattern on chemical pesticide inputs also depends on the prevalence of insect and diseases outbreak.

Table 3. Stage two: estimates of pesticide use function

Variable	Amount of pesticide use: Ln-total cost (KSh/acre)		
	Estimated coefficient [a]	Standard error	t-value
Constant	7.627***	0.525	14.52
ADOP estimated	-0.051	0.158	-0.32
PEPR	0.128***	0.035	3.57
FEPR	-0.028***	0.007	-3.76
AGEH	-0.010*	0.006	-1.74
HHSI	-0.041*	0.027	-1.61
PRES	0.052	0.036	1.42
CONT	0.051	0.034	1.50
GROU	0.042	0.028	1.48
SYPT	0.048	0.041	1.17
FACI	-0.242**	0.107	-2.27
TRAI	-0.027	0.021	-1.32
DIST	0.074***	0.023	3.11
CRED	0.001*	0.000	1.68
APPL	0.382**	0.180	2.12
DISTRICTS			
MERU (Base)			
KIRINYAGA	-0.229	0.253	-0.91
MURANGA	0.848**	0.401	2.12
NYERI	0.157	0.231	0.68
MAKUENI	-1.009**	0.404	-2.50
Number of observation	439		
R-square	0.383		
Adjusted R-square	0.336		

[a] Statistical significance at the 0.01 (***), 0.05 (**) and 0.1 (*) level of probability

Although the coefficient is not significant below 10%, the parameter estimate for level of training (TRAI) is negative pointing to the positive effect of agricultural training on reduction of pesticide use. As expected the coefficient of distance to extension service (DIST), which is used as a proxy for access to information and advice, is positively and significantly associated with the expenditure on chemical pesticide. This coefficient suggests that farmers who reside near the extension service can make use of the information and consultancies service, which have a negative impact on their decision of spending on chemical pesticide. Access to effective government extension service can help the farmers in Kenya to resort to more environmental friendly pest control strategies rather than relying on chemical pesticides.

Household size (HHSI) is negatively correlated with pesticide use. This suggests that the more members the household has, the more labor available for activities like weeding, which leads to low quantity of herbicides use. Age of the household head also seem to negatively affect the spending in pesticides i.e. younger vegetable farmers spend less amount of money on pesticides compared to their older counter parts. This might be due to the openness of the young farmers to new method of pest control mechanism like IPM rather than the conventional use of pesticides. The most interesting result is the coefficient of primary applicator (APPL). It had been expected that the more the household relied on hired casual labor to spray chemicals, the higher quantity (high spending) s/he would use because of the shift of risk associated with pesticide spraying to another party. However our result depicts a positive and significant correlation between the household head as primary applicator of pesticide and the spending on pesticides. Possibly farmers who spray themselves save the money, which otherwise would have been spent on casual laborers and used it for purchase of chemical pesticides.

B. Structural revenue model results

The estimation of production functions are aimed to investigate potential differences in the productivity of pesticides and total output revenue between EurepGAP adopters versus non-adopters. The results of the parameter estimates are presented in table 5. The models have a sound explanatory power with adjusted R-square of 0.31, which are reasonable for cross-sectional data set.

The results show that, the expenditure on seed, pesticide, and labor are the most important determinants of the final output obtained in vegetable fields. All these variables have the expected sign.

Surprisingly the coefficient of fertilizer is not significant. The coefficient of pesticide (PEST) shows that a 1% increase in pesticide expenditure in vegetable fields will increase the value of vegetable output proportionally by 0.003%.

Table 4. Stage three: estimates of the revenue function

Variable	Revenue function: Ln-total revenue (KSh/acre) Estimated [a] coefficient	Standard error	t-value
Constant	5.603***	1.053	5.32
ADOP estimated	0.273**	0.118	2.30
SEED	0.222***	0.062	3.54
FERT	0.073	0.071	1.02
LABO	0.368***	0.082	4.49
AGEH	-0.276	0.197	-1.40
CRNU	0.231*	0.149	1.64
DISTRICTS			
MERU (Base)			
KIRINYAGA	-0.495***	0.151	-3.27
MURANGA	-0.417*	0.245	-1.70
NYERI	-0.007	0.174	-0.04
MAKUENI	0.649*	0.119	2.30
Damage control function			
Constant (λ)	0.679*	0.392	1.73
PEST estimated	0.003**	0.001	2.46
Number of observation	439		
R-square	0.335		
Adjusted R-square	0.308		

[a] Statistical significance at the 0.01 (***), 0.05 (**) and 0.1 (*) level of probability

The coefficients of seed (SEED) and labor (LABO) are positive and significant pointing to the positive impact of these inputs on the output. The expenditure in seed captures variety specifics such as the potential yield for a variety and is a quality indicator, for instance in terms of germination rate. Theoretically, it would be expected that farm output would increase significantly as the management ability (measured in terms of farmer's age) of farmer increases. However the results demonstrate that farmer's age (AGEH) has a negative impact on the output of vegetables. This could be explained perhaps by the fact that young farmers are more likely to face the risks associated with innovations, which could lead to high output. Two of the four district dummy coefficients (KIRINYAGA and MURANGA) have a negative sign whereas the coefficient of one district (MAKUENI) has positive sign and significantly explains the variation in output. These indicate that farmers in Meru District have significantly higher revenue from vegetable production compared to Kirinyaga and Muranga Districts but less compared to farmers in Makueni Districts. Meru District is located at higher altitude, which has favorable climatic condition for most export and domestic vegetable crops. This entails high productivity, high quality and high price for the produce. On the other hand farmers in Makueni District have the advantage of using irrigation water since it's situated at lower altitude.

Using the estimated coefficients presented in table 4, the associated marginal value products (MVPs), actual and optimal amount of pesticides for EurepGAP adopters, non-adopters and domestic farmers are computed and presented in table 5. The results demonstrate that the production function model integrating damage control function generate marginal value products per unit cost of pesticide greater than unity for all the cases suggesting that both EurepGAP adopters or non-adopters use pesticides below the economic optimum. For example, EurepGAP adopters spend on pesticide 630 KSh/acre less than would be optimal and non-adopters use nearly 185 KSh/acre less than optimal. This under-use might be for two basic reasons. First there are financial reasons for most smallholders in Kenya for economically suboptimal pesticide use. Second, for export vegetable farmers there is high level of monitoring from the exporters on the quantity and type of pesticide used for the fear of maximum pesticide residue limit in the importing countries. These results go in line with the findings of (13) that reveal smallholders in South Africa to be currently under using pesticide under non-Bt and Bt technologies for cotton production. However in Chain, (23) demonstrated the over-use of pesticide in cotton production.

Table 5. Estimated marginal value product of chemical pesticides in [KSh]

Variables	Export market producers (N= 439)		
	EurepGAP Adopters	Non-adopters	Total
Marginal value products (KSh)	5.61	1.64	5.84
Actual pesticide use (KSh/acre)	1503	1860	1730
Optimal pesticide use (KSh/acre)	2135	2045	2595

V. CONCULUSIONS

This study contributes to the growing literature on food-safety standards by elucidating the impact of emerging EU standards on developing-country farmers' production system using a household data from Kenyan vegetable producers. This study showed that the adoption of standards by the export farmers doesn't have a significant impact on total expenditure on pesticides. The fact is that both adopters and non-adopters use pesticides below the economic optimum in export vegetables. On the other hand the adopter categories are distinguishable in terms of types of pesticide used i.e. adopters use safer pesticides based on WHO classification. The third stage structural revenue model results demonstrate a positive and significant impact of standards adoption on revenue of vegetable production.

While food safety and quality standards can be a barrier for resource poor smallholders to maintain their position in the lucrative export markets (24), they can also induce positive changes in production systems of small-scale farmers who adopt it as shown by the results presented. A shift to less hazardous pesticides as a result of EurepGAP adoption implies less pesticide intoxication by farmers and farm workers, less adverse impact on the environment as well as enhanced food safety.

Generally, the empirical results presented in this paper partially support the notion that the adoption of emerging food-safety standards can play a positive role by serving as a catalyst of transforming the production systems towards safer and more sustainable production. Hence these standards can have health and environmental benefits aside from the benefits that accrue for industrial country consumer. Nevertheless to extrapolate these results to the whole vegetable sector in Kenya, it is crucial to look closely at the scale of adoption of standards nationwide. According to data from FoodPlus secretariat, the legal body of EurepGAP, the scale of adoption among export vegetable producers seems to be rather low for achieving a direct significant impact within the smallholder vegetable export sector. In order to promote the scale of adoption of the emerging standards among smallholders, interventions in promoting the capacity of the farmers are warranted. The government and the private sector can help farmers expand and upgrade their range of assets and practices to meet the new requirements of supermarkets and other coordinated supply chains. The options include public investments in increasing farmers' productivity and connectivity to markets, and public-private partnerships to promote collective action and build the technical capacity of farmers to meet the new standards.

ACKNOWLEDGMENT

The authors gratefully acknowledge financial support by the German Development Cooperation (BMZ/GTZ) and the technical support by the Kenyan Ministry of Agriculture and export companies.

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