Pesticides in export and domestic agriculture: reconsidering market orientation and pesticide use in Costa Rica

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Abstract:

The environmental impact of agro-export production in developing countries remains an important research topic. The political economy-inspired literature on developing country agro-exports maintains that export crops are pesticide intensive — or, more generally, environmentally destructive — while local and national market crops are less pesticide intensive, or environmentally benign. If used to draw conclusions about the impact of national market versus export market expansion, this view has significant limitations, most importantly the comparison of high-commodity value export crops with low-commodity value crops for national market. To overcome this and other limitations of prior analyses, this paper addresses the question: how does market orientation influence pesticide intensity where the same crops are grown for both the national market and for export? Data from a survey of Costa Rican vegetable farmers are used to compare pesticide intensity of 27 vegetable crops, five of which are produced for both national and export markets. The general pattern that emerges is that national market vegetables are more pesticide intensive than export vegetables in the area. Yet, controlling more for the crop variable is important, and specific comparisons of the five vegetables grown for both markets — carrot, chayote, corn, green beans, and squash — illustrate that market orientation alone does not determine pesticide intensity, but that it is jointly influenced by regulatory risk, crop value, and pest susceptibility, among other factors. Continued attention to both political economy and ecological processes in "second nature" will allow political ecology to make important contributions to understanding pesticide problems and implementing agroecological solutions.

Keywords:

agricultural intensification; globalization; pesticide intensity; nontraditional agricultural exports; national market vegetable production; political ecology; Costa Rica

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1. Introduction

The environmental impact of the globalization of food has become an extremely important research topic in many disciplines and subfields, including geography and political ecology. High-value foods exports — a category that includes fresh fruits and vegetables, meats, dairy products, and shellfish — have increasingly unseated the Global South's traditional and more durable export commodities of coffee, cacao, sugar, and tea (Watts and Goodman, 1997). As of 1989, high-value foods made up five percent of global trade, the same percentage as crude petroleum (Jaffee, 1993, p. 1). Important debates continue concerning developing countries' dependence on agricultural exports and their impacts on development, equity, and the environment (Grossman, 1998; Maxwell and Fernando, 1989). In the export crop debate, proponents expound upon the macroeconomic benefits of increased foreign exchange earnings and agro-exports' potential to alleviate poverty through employment or the participation of small farmers who are at a comparative advantage due to the labor-intensive nature of many of the crops (cf. USAID, 1994). Critics argue that the strategy does not meet the food security needs of the population, increases inequality due to socioeconomic scale biases of the crop-technology package, and is not sustainable due to its reliance on heavy agrichemical inputs which cause environmental degradation and serious human health problems (cf. Lappé et al., 1999).

While sympathetic to critiques of agro-export dependence, here I argue that by exclusively focusing on export crops and neglecting to direct critical attention to the environmental impacts of national markets, the critical literature on the environmental effects of agro-exports makes empirically-questionable assumptions about pesticide use on crops bound for different markets.[1] Specifically, the literature concludes that export crops are pesticide intensive[2] — or, more generally, environmentally destructive — while local and national market crops are less pesticide intensive or environmentally benign (Barry, 1987; Thrupp, 1990, 1991, 1996; Thrupp et al., 1995; Weir and Schapiro, 1981). While generally correct when pesticide intensity data are aggregated at a national level, these prior analyses face three important limitations in drawing conclusions about the local environmental effects of export versus domestic production. First, they compare very different crop types. Second, they assume that staple crops accurately represent domestic agricultural production. Third, they do not pay enough attention to the local social relations of exchange.

This paper seeks to overcome these limitations by addressing the following question: how does market orientation influence pesticide intensity where the same or very similar crops are grown for both the national market and for export? To answer this question I explore together the effects of three important factors that vary by market orientation — regulatory risk,[3] crop value, and pest susceptibilities — on the intensity of pesticide use on vegetable crops. Research methods involved fieldwork in the vegetable producing area of Northern Cartago and the Ujarrás Valley, Costa Rica (Figure 1), where farmers produce more than 30 crops for the domestic and export market. The research combines an understanding of political economy in the area — especially the social

[1] Here I am referring to conventionally produced agro-exports, not to the growing certified market segments like organic or fair trade.

[2] I use the term "pesticide intensity" to refer to the quantity of pesticide used per unit land, as in both the academic (Decanio and Norman, 2005) and activist literature (Kegley et al., 2000).

[3] Regulatory risk refers to the risk of economic and market access loss created by enforcement of pesticide residue regulations in industrialized nations (Galt 2007).

relations of exchange in contract farming (cf. Clapp, 1994; Watts, 1992) — with the use of a crop-specific perspective from human-environment geography (Sauer, 1969; Zimmerer, 1996).

The paper is organized as follows. I first review the critical literature on Latin American agro-exports to demonstrate the common view of market orientation and pesticide use. I then provide a brief conceptual revision to conventional wisdom to allow for better comparisons. Methods are then discussed, with most attention given to the farmer survey from which crop-specific pesticide intensity data were obtained. Results show that pesticide use on national market vegetable crops is generally higher than on exported vegetables in the study site, a situation I refer to as the "pesticide paradox." Yet, looking beyond this general finding reveals considerable variability of pesticide intensity *within* market segments, leading me to problematize the binary thinking about pesticide use and market scale in developing countries. By examining specific crop comparisons, I suggest that regulatory risk, crop value, and pest susceptibility all jointly influence pesticide intensity, thereby making it inaccurate to draw conclusions about pesticide intensity based solely on market orientation. In the conclusion I discuss nuanced considerations about the environmental effects of markets, explore the geographical applicability of the conventional wisdom on pesticide use and markets, and highlight the continued need for political ecologists to pay attention to material processes in "second nature," defined by Biersack (2006) as nature that is humanly produced and that is part of, but not entirely within, the human realm.

2. Background: pesticides and markets in the critical agro-export literature

Research from a political economy perspective typically argues that export crop production in developing countries is very pesticide intensive relative to national market production. In their seminal work, *Circle of Poison*, Weir and Schapiro (1981, p. 32) make the argument explicitly:

> over half, and in some countries up to 70 percent, of the pesticides used in underdeveloped countries are applied to crops destined for export to consumers in Europe, Japan, and the United States. The poor and hungry may labor in the fields, exposed daily to pesticide poisoning, but they do not get to eat the crops protected

by pesticides.

They use many examples, including Indonesian plantations growing rubber, coffee, sugar cane, and coconuts, which consume 20 times more pesticides than small farmers producing food for local markets (Weir and Schapiro, 1981, p. 33). Similarly, Barry states that since the 1950s, "pesticides have become an integral part of cash-crop production in Central America" (1987, p. 97). This could mean cash crops for national consumption, but Barry is referring to only cotton, coffee, and banana exports since he goes on to state, "of the 11 pounds of pesticides used per capita in the region annually, only a few drops are applied on food crops for local consumption" (1987, p. 104). Thrupp's early political ecological work in Central America provides another example. She writes, "[t]he largest amounts and most intensive use of pesticides are in large export-crop plantations of cotton, bananas, coffee, and sugarcane, which form the main basis of these small economies" (Thrupp, 1988, p. 41). More recently, Jorgenson (2007, p. 75) states, "As farming systems in less-developed countries are integrated into the international economy, often through the influence and control of foreign capital, crop rotation and recycling of organic matter are more likely to be replaced by high-intensity use of pesticides and synthetic fertilizers."

Critical scholars reproduced the same focus and binary assumptions with the boom in nontraditional agricultural exports (NTAEs) — high-commodity value horticultural crops like broccoli and strawberries, which contrasted with "traditional" agricultural exports of coffee, sugar, bananas, and beef — from Latin American countries in the 1980s. Spurred by World Bank mandated structural adjustment, Latin America's cheaper labor and tropical or counterseasonal climates combined with the development of extended "cool chains" and inexpensive transportation from fossil fuels to create the competitive production of fresh produce in developing countries for industrialized country markets. With the NTAE boom, Latin America now supplies much of the fresh fruits and vegetables available in U.S. supermarkets in winter. Andreatta (1998, p. 357) notes for the Caribbean generally that the "re-creation of chemical intensive agriculture based on the export of nontraditional crops has led to problems similar to those found in traditional monocultural [export] systems." Murray (1994, p. 64) states of the new agro-export boom, "[a]s small farmers were transformed from subsistence or local-market producers into export crop farmers, their reliance on the agrochemical technology increased." Concerning the environmental effects of NTAEs, Rosset (1991, p. 35) hypothesizes, "pest and pesticide residue problems are more common among those who produce nontraditionals than those who produce crops for domestic consumption." Thrupp writes that with NTAEs,

> [s]tudies have consistently shown that all kinds of pesticides, including fungicides, insecticides, nematicides and herbicides, are used more intensively for most high-value NTAEs than for other crops. Doses of pesticide applications per unit land in NTAEs exceed those used on subsistence crops and for crops sold in local markets and are similar or even greater per hectare than in many of the traditional export crops such as coffee and sugarcane (Thrupp, 1996, p. 126; see also Thrupp et al., 1995, p. 49).

While the above quotes illustrate explicit comparisons, much of the literature that discusses high levels of pesticide use in export crops does not mention national market production (e.g., Llambi, 1994; Murray and Hoppin, 1992; Stonich, 1993). For example, in writing about export banana production in Costa Rica, Vandermeer and Perfecto (1995, p. 65) state, "[t]o avoid fungal disease, heavy use of fungicides is required." Conroy et al. (1996, p. 111) discuss "nontraditional agriculture's heavy reliance on pesticides." Edelman (1999, p. 90) notes that "intensive agrochemical use" accompanies NTAE production. These statements beg the question: compared to what? The likely answer is compared to national market production, so the implication is that pesticide use on national market crops is low, irrelevant, or both.

The critical agro-export literature described above seems to assume an implicit causal relationship: export crops are more pesticide intensive *because* they are exported. That is, the difference in market orientation causes the discrepancy between export and national market pesticide use. While perhaps correct, drawing this conclusion based upon available studies is problematic because of their methodological limitations and incorrect or unexamined assumptions.

3. Conceptual revisions for more controlled comparisons

Below I identify a number of problematic practices and assumptions in the critical literature concerning pesticide intensity on export and national market crops. I draw these considerations from literatures with which critical researchers do not often engage and also from the local conditions of the study site that served as my area of research.

3.1. Comparing different crop types to explain the effects of markets

Researchers have concluded that export crops are more pesticide intensive than local or national market crops by comparing very different crop types, usually high-commodity value horticultural export crops with national market staple crops. Critical studies of NTAEs typically focus on farmers who changed from producing staple crops like corn and beans for the household or the domestic market to NTAEs like broccoli, melons, peas, and squash (Conroy et al., 1996; Murray, 1994; Rosset, 1991; Stonich, 1993). The analytical problem arises when one compares these different crops and concludes that the differences in pesticide intensity arise from the requirements of the different markets, i.e., the export market is more demanding vis-à-vis esthetic and phytosanitary requirements. This can be a problematic conclusion because one ignores the potential conflating effects of differences in crop value and pest susceptibility. Concerning crop value, work in agricultural economics shows that pesticide use tends to increase with the value of the crop since it makes economic sense for farmers to spray a valuable crop more than a less valuable crop. Fernandez-Cornejo et al. (1998, p. 464) find that, "[p]er-acre pesticide expenditures vary widely, increasing with the value of the crop … . [For example, U.S.] wheat farmers spent annually less than $6 per acre on pesticides, whereas … expenditures by producers of high-value commodities such as strawberries approached $1,600 per acre." An agroecological perspective points to the need to understand crops' differential susceptibilities to pests.[4] For simplicity, here I use "pest susceptibility" as a concept to encompass the different pest burdens that crops face, which depend upon characteristics of the crop species and variety, pest presence, ecological interactions in specific places, and other factors (Letourneau, 1997). In essence, crops like bananas, broccoli, and black beans are extremely different organisms with differential susceptibility to pests (cf. Hill and Waller, 1988a, 1988b).

By comparing high-commodity value, pest susceptible export crops to low-commodity value, pest resistant staple crops, it is impossible to say that export market requirements are causing high pesticide use since differences in crop value and pest susceptibility might be causing them.

3.2. Assuming low and homogenous pesticide use on national market crops

In comparisons of pesticide intensity of export and national market crops, critical researchers typically ignore national market vegetable crops, assuming that either (1) crops for domestic consumption are only staple crops like corn and beans, or (2) national market vegetables are not heavily sprayed. Both of these assumptions are false.

While staple crops generally cover a greater area in most developing countries, national market vegetable production occurs and is expanding as populations grow and wealth increases (Horst, 1987). This expansion has been documented in numerous places, including Cameroon (Gockowski and Ndoumbe, 2004), Nepal (Pujara and Khanal, 2002) and the broader Hindu Kush-Himalaya (Tulachan, 2001), Malaysia (Midmore et al., 1996), the Philippines (Lewis, 1992), Guatemala and Ecuador (Horst, 1987; Keese, 1998), and Peru (Zimmerer, 1991, 1999). In Costa Rica, vegetables are important national market crops because of their prominence in the national diet, and their production is especially important in Northern Cartago and the Ujarrás Valley, where my field research was conducted.

[4] I use "pest" broadly to refer to pathogens, insect pests, and weeds.

Although generally not studied by critical researchers in the context of understanding agro-exports, the limited evidence available suggests that national market vegetables — the logical comparative partner for vegetable NTAEs — are very pesticide intensive (Arbona, 1998; Dinham, 1993, 2003; Galt, 2006; Jungbluth, 1997). Many factors explain high pesticide use on national market vegetables, and most coincide with those for vegetable NTAEs: high aesthetic requirements exist; the crops are generally very valuable and almost always grown for sale and profit; and pests are often major problems (Dinham, 2003; Jungbluth, 1997). One important difference between national and export markets is that lack of pesticide residue enforcement in the national market means there is little pressure for farmers to reduce pesticide use on national market vegetables (Arbona, 1998; Galt, 2006). This suggests that the assumption about an environmentally benign national market needs to be questioned.

3.3. Assuming ever-increasing pesticide use in export production

Export farmers face contradictory market pressures. In the case of exporting to the U.S., they must: (1) conform to U.S. phytosanitary standards that require a complete absence of pests and pathogens, a requirement that pressures toward higher levels of pesticide use; (2) meet high aesthetic standards for unblemished produce, which also pressures toward higher pesticide use; and (3) comply with the Environmental Protection Agency's pesticide residue regulations, which pressure toward lower or more rational pesticide use (Thrupp et al., 1995). In discussing the resolution of these contradictory pressures, Thrupp et al. (1995, p. 51) ultimately state, "[t]he immediate pressures to increase pesticide use tend to outweigh other considerations." Others reach similar conclusions yet provide little empirical evidence as to why this is the case (Conroy et al., 1996; Murray, 1994; Wright, 1990).

In contrast, I found that pressures to comply with export market pesticide residue regulations were strong in Northern Cartago and the Ujarrás Valley. Past economic losses from rejections due to illegal pesticide residues have caused exporters to police export farmers' pesticide use. Export farmers have rationalized pesticide use somewhat in response to regulatory risk (Galt, 2007). Thus, the export market actually pressures farmers to reduce pesticide use in the study site.

4. Methods

The above revisions mean that addressing the impacts of different market requirements on pesticide intensity requires "controlling for" the variability between crop value and pest susceptibility as much as possible. This means that researchers should compare the same crop species grown in similar production systems oriented to different markets. I chose the study site of Northern Cartago and the Ujarrás Valley, Costa Rica (Figure 1), because it offered this opportunity.

4.1 Study site

Northern Cartago and the Ujarrás Valley is Costa Rica's "vegetable basket," where truck farmers take advantage of a range of climates and fertile volcanic and alluvial soils to produce more than 30 tropical and temperate vegetables for national and export markets. Commercial vegetable production for the national market began in 1910 with potato (Ramírez Aguilar, 1994, p. 419), followed by other national market crops including cabbage, carrot, and onion. Two NTAE sectors currently exist in the area: chayote and mini-vegetables. Chayote, a cucurbit with a pear-shaped fruit native to the region, began to be produced for export in the mid-1970s (Bolaños et al., 1993), while the mini-vegetables were introduced and exported in the mid-1980s (Breslin, 1996). The vast majority of the exports go to the U.S. and Canada, although the E.U. is also a small market for chayote.

As a center of national market vegetable production and two NTAE sectors, many of the same crops are grown by farmers who sell exclusively to the national market and other farmers who sell their produce for export. There are five vegetable crops for which this situation exists: carrot, chayote, corn, green bean, and squash. The Mokum variety of mini-carrot is produced for export while the Bradford and Bersky varieties are produced for the national market. *Quelite* chayote is the export variety while *negro*, *blanco*, and *cocoro* chayote are all grown almost exclusively for the national market. Primetime sweet corn (considered a mini-vegetable since it is sold to the mini-vegetable exporters and broken into pieces for market) is exported while native (*criollo*) field corn varieties are grown for the national market. Masai mini-green beans are exported while the Provider variety is for the national market. Lastly, mini-squash — scallop squash and zucchini — are grown for export while ayote and zapallo squash go to the national market.[5]

The markets for all of the above crops are strongly segmented, meaning that specific varieties go to specific markets, with the exception of chayote. Export farmers orient their production of mini-vegetables — carrot, corn, green bean, and squash — to the export market, although some of their produce is sold nationally as well. The portion sold nationally is not determined by farmers, however, since the mini-vegetable exporters buy all of the mini-vegetables produced and decide the level of quality that goes for export and to the national market. The chayote market is less segmented since the export variety can be sold openly on the national market. While *quelite* is known as the export variety of chayote, some farmers grow it entirely for the national market, and export farmers are not obligated to sell all of their *quelite* to the exporter, nor do they (Mannon, 2005). The chayote market remains highly segmented, however, because farmers growing the *negro*, *blanco*, and *cocoro* varieties grow them almost exclusively for the national market.

4.2. Farmer survey

To compare the pesticide intensities of national and export market crops I rely on data from

[5] The squash analysis compares crops in the same genus but of different species: *Cucurbita pepo* (scallop squash and zucchini), *C. moschata* (ayote), and *C. maxima* (zapallo). While it would be ideal from an experimental design perspectives if farmers oriented to the different markets grew the same species, the real world situation in the study site does not allow for this.

a face-to-face farmer survey I conducted between April 23, 2003, and January 4, 2004, in the study site. The survey was created based on seven weeks of previous research in the area in 2000. It included questions about personal, household, and farm and field characteristics, crops planted and market orientation, and many detailed questions on various aspects of pesticide use to obtain crop- and field-specific data on pesticide type, dose, and the time required between application and harvest (known as preharvest interval, or PHI). Many open-ended questions at the end of the survey allowed for in-depth discussions of market requirements for the export and domestic markets (for the survey instrument see Galt, 2006, p. 496-503). The vast majority of farmers in the area are the on-farm decision-makers vis-à-vis pesticide applications. For the few firms included in the survey, the farm manager in charge of spraying decisions was surveyed.

By necessity, sampling was somewhat different for the different markets. Export farmers in Northern Cartago who produce mini-vegetables are few in number compared to national market farmers. Starting with the export farmer contacts I had made in 2000, I used a "snowball" technique (Patton 2002) of asking them for the contact information of other farmers oriented to the export and/or national market. I then used farmer lists from the two mini-vegetable exporters to determine if I had an adequate sample of the export farmers in the area.

Sampling of national market farmers and chayote export farmers occurred in part through the snowball technique described above. Additionally, I made important contacts, who also became good friends and key informants, in a number of towns: Calle Naranjo and Birrís in the Ujarrás Valley, and Cot, Cipreses, San Martín de Santa Rosa, and Buenos Aires de Pacayas in Northern Cartago (Figure 1). These key informants introduced me to many national market and export chayote farmers in their communities and in surrounding towns. Sampling in this manner included farmers with different landholding sizes since I told the key informants that I wanted to include a range of farmers from small-scale to large-scale. Another sampling technique was to approach farmers while they were working their fields. Although it is impossible to tell if these sampling techniques sampled a subpopulation that is representative of farmers of the area, the combination of the sampling strategies likely helped to avoid serious biases concerning farm size or other important characteristics. Table 1 shows farmer and farm household characteristics from the survey.

4.2.1. Calculating pesticide use intensity

With 145 complete farmer surveys, I obtained data on 424 field-specific crop spraying schedules for vegetable crops, which is the unit of analysis used in the results and analysis below. Obtaining complete data to calculate field-specific crop spraying schedules in kilograms of active ingredient (ai)[6] per hectare per crop cycle (kg ai/ha/cycle) involves a series of questions. This was accomplished by the use of a large table in the survey. The first question was, "On crop ABC, which insecticides do you use?" I recorded this list, dividing it according to granulated and sprayed (liquid/powder) formulations. I then asked the same question for fungicides and herbicides used on crop ABC. With this complete list, I asked the following questions about each pesticide used on crop ABC: (1) "How much of pesticide XYZ do you use per *estañón* (50-gallon drum)?," (2) "During what part of the cycle do you use pesticide XYZ?," (3) "How frequently do you use pesticide XYZ?" or if that question did not yield an answer about frequency, "How many times in the cycle do you use pesticide XYZ?," and (4) questions concerning pre-harvest interval (PHI, or the time between the application and harvest). I also asked about the amount of land sprayed with the contents of an *estañón* for each crop. I proceeded in this manner for each different crop in which I was interested. Each farmer survey contained between one and six field-specific crop spraying schedules, with an

[6] Pesticide measurements are typically given in active ingredient (ai) or formulated product (fp), which is the combination of active and other ingredients. Active ingredient refers to the compound that kills, mitigates, or repels the pest organism and is used most commonly in agronomic comparisons.

average of 2.97 per farmer.

4.3. Complementary methods

In addition to the farmer survey, I used qualitative methods to corroborate information from the survey concerning markets and pesticide intensity. This involved participant and non-participant observation on farms, farmer focus groups, semi-standardized follow-up interviews and informal discussions with farmers, and in-depth interviews with produce buyers and agrochemical salespeople. Visiting farms unannounced often resulted in witnessing pesticide mixing and application, which was used as a general check on the pesticide use that farmers reported during the survey. I also discussed general patterns of pesticide use that emerged from the survey with key informants and agrochemical salespeople. My data concerning farmers' understandings of market requirements from the survey were augmented by open-ended follow-up interviews aimed at understanding reasons for change over time.

4.4. Comparative plantings of different varieties

Different varieties in the study site are grown for different markets. These varieties have potentially different susceptibilities to pests, which could be an important influence on the amounts of pesticides applied to them. To help control for the differences in varieties, I set up my own vegetable field in the organic agriculture school of the Instituto Nacional de Aprendizaje near Cuesta La Chinchilla, Northern Cartago (known locally as the INA). I obtained the common varieties of carrot, green bean, and squash grown for both markets and planted them according to local cultural practices, except for the use of agrochemicals. Pre-plant pesticide applications were not used and the fertilizer was organic because the plot was on the INA's land.[7] The varieties planted were Mokum mini-carrots and Bersky carrots, Masai mini-green beans and Provider green beans, and

[7] I am indebted to Salomón Montenegro, who was instrumental in helping me lay out, till, fertilize, and plant the plot. He remained in charge of fertilizer and organic pesticide applications.

Nova yellow mini-scallop squash, Jaguar green mini-zucchini, and *criollo* zapallo. I conducted simple insect counts and disease estimates on these plots to compare the susceptibility of the different varieties to the same pests (Table 2). The results from these plots should not be considered definitive since (1) the cultural practices were not entirely the same as in farmers' fields, (2) the results are only from a single season, and (3) I could not conduct counts for all insects and diseases because of limitations of time and expertise. They do, however, serve to give some idea as to the differential susceptibility of the different varieties. As supplemental information, I asked farmers who had recent experience with both export and national market varieties about the differences in their pest susceptibility.

5. Results and analysis

5.1. General patterns of pesticide intensity within and between markets

Table 3 shows the average pesticide intensity in kilograms of active ingredient per hectare per crop cycle (kg ai/ha/cycle) for all vegetable crops included in the survey, with the data grouped by market type. "Open national" refers to produce sold to consumers at farmers' markets or to intermediaries or businesses that do not enforce any pesticide residue standards. "Controlled national" refers to crops produced for businesses with some pesticide residue controls under the national Blue Seal program run by supermarkets and the Costa Rican Ministry of Agriculture.[8] "Export (NAm or EU)" are those crops produced for the U.S., Canadian, and E.U. markets. As a whole, national market vegetables are more pesticide intensive than vegetables produced for export (46.1 kg ai/ha/cycle compared to 19.3 kg ai/ha/cycle), a situation that is conventional wisdom in the study site, but which I call the "pesticide paradox" since it runs counter to the situation

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[8] This voluntary program is designed mostly for supermarkets or large intermediaries that supply supermarkets, with the goal of certifying produce that complies with pesticide tolerances (Kopper, 2002).

described in the literature. Yet, just as I critiqued the literature that implies conclusions about markets by comparing horticultural crops with staple crops, very different crops are being compared even within the category of vegetables in the study site.

To assess the common view of pesticide use and markets in the literature, I find pesticide intensity categorization useful. Based on Chaverri's (1999) estimate of average agricultural pesticide intensity in Costa Rica, I developed a classification system of pesticide intensity for the different vegetables by standardizing all measures of pesticide intensity by kg ai/ha/week. I use the following criteria: "not pesticide intensive" is less than the national average, "pesticide intensive" is one to three times the national average, "very pesticide intensive" is three to six times the national average, and "extremely pesticide intensive" is more than six times the national average (Figure 2).[9]

Figure 2 reveals that the common conception of pesticide intensity and markets — that export crops are pesticide intensive and national market crops are not — is too simplistic. If the binary view held up, national market crops would fall into the "not pesticide intensive" category, while export crops would be "pesticide intensive" or above. Regardless of market orientation, most vegetable crops grown in Northern Cartago and the Ujarrás Valley fall into the "pesticide intensive" and above categories. Potato, produced almost exclusively for the national market with infrequent exports to Nicaragua, is the most pesticide intensive crop (with a sample size greater than four) at 11.5 times the national average.[10] Yet, national market crops exhibit wide variation, ranging from

[9] While these divisions are necessarily somewhat arbitrary, the benefit of this classification system is that it allows for a more precise gradations of the term "pesticide intensive," a phrase that is too often used without supporting or comparative data.

[10] One beet farmer sprays his beets with a very high level of pesticides, making the average estimate very high, and likely unrepresentative of beet production in the area.

"not pesticide intensive" to "extremely pesticide intensive." Nor can export crops be said to be uniformly pesticide intensive. While it is true that all export vegetable crops in the area are more pesticide intensive than the Costa Rican average, data from Castillo et al. (1997) on coffee and sugar cane, which are grown for export in the study site but were not included in the survey, suggest that these export crops are not pesticide intensive. Overall, the wide vertical range within the different market orientations in Figure 2 means that no matter the classification system (i.e., the vertical position of the horizontal lines), the data cannot be made to fit the conception of export produce as pesticide intensive and national market produce as not pesticide intensive.

5.1.1. Important sources of variability in general patterns

Based on political economy, agricultural economics, and agroecology literatures on pesticide use discussed in Section 3, I suggest that this variability may have three basic sources: regulatory risk, crop value, and pest susceptibility. The comparisons made in Table 3 and Figure 2 allow for an analysis of these factors.

As I detail elsewhere, the enforcement of export market requirements pressure export farmers to rationalize pesticide use in the study site (Galt, 2007). This has important effects on pesticide intensity. To avoid problematic residues, export farmers in the study site rely more on pyrethroid insecticides, while open national market farmers — who face little enforcement of pesticide residue regulations — use more organophosphate insecticides, which typically leave higher levels of residues. Dose and active ingredient (ai) rates for organophosphates are much higher, which means that national market farmers are applying more ai than export farmers for insect control. For example, the organophosphate methamidophos is applied at a rate of 0.3 to 0.9 kg ai/ha. The pyrethroid deltamethrin is applied at 0.012 kg ai/ha. These order of magnitude differences result in a large difference in pesticide intensity over the entire crop cycle. Additionally, many export farmers use fewer doses of insecticides and fungicides overall, another part of the rationalization of pesticide use in response to regulatory risk. These differences in regulatory risk and their effects on farmers' pesticide choice influence, but do not by themselves determine, between-market variation.

Table 4 illustrates the influence of crop value and pest susceptibility in pesticide intensity. Agricultural economists compare pesticide intensities in different crops by looking at the productivity of a pesticide input, which is the value of the crop that is being protected compared to the amount spent on a pesticide (Fernandez-Cornejo et al., 1998). Instead of using this measurement, I rely on a similar one — the value of the crop protected compared to the application of a kilogram of pesticide — or, in economic terms, what can be called the average productivity of a kilogram of pesticide.[11] The top row of Table 4 expresses kg ai/ha, while the bottom row of Table 4 shows productivity (or value/ha)/kg ai. Despite order of magnitude differences in kg ai/ha/cycle, there is similarity in productivity/kg ai even between very different crops like banana ($176), corn ($177), and tomato ($178). From Table 4 it is evident that differences in crop value influence pesticide intensity. Field corn and potato illustrate the argument. The value received from a hectare of national market field corn is very low ($239/ha), so it makes little sense to protect it with pesticides, and, as we would expect, it is not pesticide intensive (1.4 kg ai/ha/cycle). In contrast, the value of one hectare of potato is very high ($7,747/ha), so it makes economic sense for farmers to apply pesticides to protect or increase that value. Consequently, potato is much more heavily sprayed (57.3 kg ai/ha/cycle) than corn in part because it is worth far more.

Pest susceptibility also influences differences in vegetable crop pesticide intensity within and between markets. Table 4 shows some variability in the productivity of pesticide use on different

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[11] I used productivity per kilogram of pesticide used instead of the productivity of amount spent on pesticide inputs because adequate data on the value of the pesticides are unavailable in Costa Rica.

crops, ranging from $124/kg ai in onion and $350/kg ai in sugar cane. High productivity/kg ai for sugar cane and chayote suggest that pesticide use is fairly low per unit of value protected, whereas low numbers like onion suggest a relatively high use per unit of value that is being protected (the average for the crops in the table is $210.52). This variability in productivity/kg ai between crops suggests that a crop's pest susceptibility also influences differences in pesticide intensity. The open national market category in Figure 2 shows that chayote is sprayed considerably less than potato, but this would contradict agricultural economists' predictions based on crop value since chayote is worth more than potato on average ($14,551/ha versus $7,747/ha, respectively, in Table 4). Farmers and researchers report that chayote, as a crop native to the region, faces relatively low pest problems (Pineda Cabrales, 1973), while potato faces extreme pressure from potato late blight, *Phytophthora infestans*, in the area (Hijmans et al., 2000; Molina Umaña, 1961).

Thus, in place of the political economic literature's binary conceptualization of pesticide intensity that results from market orientation, I propose that it is strongly influenced by the interactions between (1) regulatory risk that varies by market orientation, (2) farmers' crop protection decisions that are based on crop value (*ceteris paribus*, more valuable crops are more heavily sprayed), and (3) material, "second nature" processes influencing crops' pest susceptibility. The interactions of these three factors in specific crops are explored below.

5.2 Crop specific comparisons

Table 5 focuses on the same crops grown for the national and export markets, and also controls for differences in varieties' growing cycle lengths by comparing kg ai/ha/week. The general pattern for these crops as seen in Table 3 remains, but differences in the carrot and squash comparisons become non-significant. Chayote remains significantly less pesticide intensive for export than for the open national market, and corn remains significantly more pesticide intensive for export than for the open national market, but the sample sizes are very small for corn.[12]

I argue below that these comparisons illustrate the interaction of market orientation, crop value, and pest susceptibility in influencing pesticide intensity. By themselves, statistics comparisons of pesticide intensities on these crops for the different markets cannot illuminate the difference influences of these factors because the differences are bundled together by market, i.e., different varieties are grown for markets that have different levels of regulatory risk and receive different prices. The ideal comparative situation — the same variety grown for both markets that receives the same price — does not exist. In an attempt to understand these bundled relationships, below I examine logical relationships between regulatory risk, crop value, pest susceptibility, and pesticide intensity within and between markets. For example, if there is no significant difference between pesticide intensities of a specific export and national market crop, but the export market crop receives a higher price and is more susceptible to pests (both of which mean that, *ceteris paribus*, it would be sprayed more), it suggests that regulatory risk in the export market is influencing export farmers to use less pesticide. As a common condition for the discussion below, it is important to note that farmers report that export crops typically receive a higher price than national market crops, so this difference in crop value would influence export farmers to spray more in all cases, everything else being equal.

As an initial caveat, in addition to the three-factor framework I use here, there are other

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[12] The small sample sizes of some crops deserve explanation. Only a handful of farmers in the area grow carrot and corn for export, and I surveyed all of them that were identified by exporters and other export farmers. Similarly, only a handful of farmers still plant corn for the national market, and I sought out corn farmers for the survey when I found it planted. Since sample size of these farmers is close to the population, the carrot and corn comparisons remain valid illustrations.

possible explanations for the differences in pesticide intensity in the crop comparisons below. These include differences in socioeconomic characteristics (e.g., risk aversion) and agroecological characteristics (e.g., pest populations in specific locales) between farmers oriented to different markets. These are excluded from the discussion because I argue that higher regulatory risk from stricter export market requirements acts as a structural driver behind pesticide use decisions. For example, farmers in the area who spray more heavily have dropped out of the export market because of disagreement with restrictions on their pesticide use (Breslin 1996), and export squash farmers seek out fields in climates that allow them to reduce their pesticide use (Galt, 2006, p. 335-378). Nevertheless, these are potentially important considerations if they are exogenous to market influences, and are explored elsewhere (Galt 2006, p. 379-406).

5.2.1. Carrot, green bean, and chayote

Using the above logic with data from Table 2 and Table 5 allows for a discussion of the importance of regulatory risk, crop value, and pest susceptibility. The comparisons of carrot, chayote, and green bean pesticide intensities for export and national markets (Table 5) suggest that regulatory risk in the export market pressures farmers to reduce pesticide use in the study site.

The Mokum variety of carrot for export and Bersky for the national market face similar pathogen pressures as shown in Table 2 and observed by a farmer who has grown these varieties and said he noticed no difference in susceptibility to pests or pathogens. Since (1) export carrots are worth more, (2) the different varieties face similar pest pressures, and (3) export production is slightly less pesticide intensive, this suggests the importance of regulatory risk.[13]

The analysis is similar for Masai green beans for export and Provider green beans for the

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[13] Another contributing factor could be that export carrots have a shorter growing cycle, so it is possible that they do not have to be protected for as long against nematodes and soil insects like *joboto*, allowing for reductions in the use of granulated insecticides.

national market. Two farmers who had grown Provider before adopting Masai disagreed as to which was more susceptible to pests and pathogens. One said Masai was more susceptible to all pests, while the other said Provider was the more susceptible variety. My plantings suggested that whitefly — the vector for viruses — congregate more on Provider than Masai (Table 2). Since export and national market farmers spray one or two applications of the very low dose systemic insecticide imidacloprid to control whitefly, this difference would not affect pesticide intensity much. Since (1) export green beans are worth more, (2) pest susceptibilities seem roughly similar and differences likely impact pesticide intensity minimally, and (3) exported green beans are slightly less pesticide intensive, higher regulatory risk in the export market is likely an important influence.

Findings are similar for chayote, and stronger conclusions about regulatory risk are possible since sample sizes are adequate. The differences arise mostly from higher regulatory risk in export markets, a conclusion derived from the following logic: (1) export chayote is worth more, (2) the varieties likely have the same pest susceptibility since chayote farmers reported no major differences,[14] and (3) export production is significantly less pesticide intensive. Export chayote farmers' response to regulatory risk is illustrated with the following examples. The three largest chayote farmers I surveyed, which are the farming operations of the three large chayote exporters in the area, have almost completely stopped using fungicides recently.[15] While I would hypothesize based on the technology adoption literature that they were probably the early adopters of fungicides

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[14] It is possible that export variety, *quelite*, is actually more susceptible to pests than the other varieties because of strong selection pressure to conform to the perfect type defined by the export market. This has not yet been investigated.

[15] For these surveys I first made contact with the packing plant manager to find the farm manager. The surveys were conducted with the export firms' farm managers.

(cf. Feder et al., 1985), now the largest export farmers have essentially disadopted fungicides and one's long-term plan is to become certified organic. I was skeptical since fungicide use in the area is ubiquitous, so I pressed them on it. One exporter's farm manager swore that the firm had stopped using fungicides and took me to the agrochemical shed. He showed me that there were no fungicides (but there were insecticides) and that they use Zinvert, a foliar nutrient[16] that contains zinc and 22.6 percent sulfur. Chayote farmers commonly use elemental sulfur as a fungicide, but in an 80 percent formulation. He explained that the small amount of sulfur in the foliar nutrient he uses is sufficient to control chayote's fungal pathogens. Another exporter's farming operation stopped using fungicides in 2002, preferring to rotate different foliar nutrients and rely on repellents and biopesticides made on the farm (Figure 3). The farm manager for the other major exporter reported using many foliar nutrients and applying one fungicide two to three times per crop cycle.

The significant difference in chayote pesticide intensity between markets remains even when the large export firms are excluded. Thus, there are considerable differences in pesticide intensity even between smaller-scale chayote farmers orienting production to the different markets, with export farmers using significantly lower amounts of pesticide. I argue this difference results from export farmers' responses to regulatory risk in export markets.

5.2.2. Corn

The difference in pesticide intensity for corn grown for the different markets suggests the potentially strong influences of crop value and pest susceptibility. *Criollo* varieties of corn in Costa Rica are a field corn variety and are resistant to corn pests and pathogens (Risch, 1983). These are produced exclusively for the national market and household consumption. As argued above, since corn prices are low, it makes little sense for farmers to invest in crop protection through frequent

[16] Foliar nutrients are crop nutrients prepared in a spraying mixture and applied directly to crop foliage.

pesticide applications. Like in highland Guatemala (Morales and Perfecto, 2000), in Northern Cartago herbivorous insects in the *milpa* are not generally treated as pests because they do not cause economic losses. Only cutworm (*Agrotis* spp.) threatens large losses since it can kill young corn seedlings, so insecticides are used only at the beginning of the cycle to control it. Thus, the native *criollo* varieties of corn are one of the least pesticide intensive crops in the study site, with a pesticide intensity about one-tenth of the Costa Rican national average (Figure 2).

In contrast, export farmers grow the Primetime variety of sweet corn, which was released in 1994 and bred for North American conditions (Tracy, 2005). In the study site, farmers noted that this variety, like sweet corn generally, is very susceptible to damage by insect pests, especially corn earworm (*Heliothis zea*), which can make the valuable ear unmarketable. Since export corn is (1) much more valuable, (2) more susceptible to pests, and (3) more heavily sprayed, the factors of crop value and pest susceptibility appear to be strongly prevailing over export market pressures to rationalize pesticide use. Export corn is not necessarily more heavily sprayed because it is exported, but rather because it is much more valuable and more susceptible to pests than the national market variety.

5.2.3. Squash

For squash comparisons it is important to note that different squash species are grown for the national market and export. Only one farmer in the survey grows both regularly. He reported that export squash, mini-scallop squash and mini-zucchini (*Cucurbita pepo*), are more susceptible to pathogens than zapallo (*C. maxima*). He sprays his zapallo for national market 34.4 percent less than his export mini-squash (the difference is 12.2 versus 18.6 kg ai/ha/cycle, respectively). In my plantings of zapallo and mini-scallop squash at the INA, I found that mini-scallop squash was more susceptible to powdery mildew (Table 2). If export regulatory risk had no effect, we would expect export farmers to spray mini-squash more intensively based on (1) its greater susceptibility to pathogens and (2) the higher value of the crop. Despite this expectation, Table 5 shows that export squash is slightly less pesticide intensive than national market squash, but the difference is not significant. This suggests that regulatory risk has an influence on export squash farmers' pesticide use in the study site even though the immediate comparison of squash pesticide intensities does not appear to show this until one considers differences in pest susceptibility and crop value.

In summary, comparisons of these five crops illustrate the important interactions of regulatory risk, crop value, and pest susceptibility in influencing pesticide intensity. The cases of carrot, green bean, and especially chayote suggest that with even with higher crop values, the export market's stricter pesticide residue enforcement can lead to less pesticide intensive production for export between crops that are roughly the same in pest susceptibility. The case of corn demonstrates that much higher pest susceptibility and market value can strongly override regulatory risk that pressures for reduced pesticide use and lead to much higher pesticide use in the export variety. Lastly, the case of squash suggests that the interaction of stricter residue requirements, higher crop susceptibility, and greater value for export market crops can lead to a similar level of pesticide use on export squash compared to national market squash. Quite simply, market orientation, while important, cannot by itself predict the outcomes of these comparisons.

6. Conclusion and conceptual implications

The conventional wisdom in the critical literature about pesticide use and markets — that exports are pesticide intensive while national market crops are not — is too simplistic. While political economic influences are clearly important, pesticide intensity on crops for the same market is highly variable. I have proposed that this variability is strongly influenced by the interactions of regulatory risk, crop value, and pest susceptibility, and likely other factors not discussed here. This study is not meant to refute all previous political economic literature on export crops that argues that they are pesticide intensive. Indeed, Figure 2 shows clearly that vegetable exports from

Northern Cartago and the Ujarrás Valley are more pesticide intensive than the average agricultural pesticide intensity in Costa Rica. Instead, this study addresses a blind spot in this literature that arises from the common comparison of high-commodity value, pest susceptible export crops to low-commodity value and typically pest resistant staple crops.

I wish to conclude on three interrelated points. First, the conventional wisdom on pesticide use and markets is another example of the "scalar trap" (Brown and Purcell, 2005). While Brown and Purcell (2005) note that political ecologists and others in allied fields assume that local political control of resources results in more sustainable human-environment relations than organization at other scales, this paper reveals that the local trap is also evident in the literature on the environmental effects of economic globalization and export market integration. Implied in the literature is that integration into local and national markets is less harmful to local environments than integration into the export market. Marx, in using the case of England to inform his ideas of the tendencies of capitalism, did not differentiate between market scale and socio-environmental impact:

> all progress in capitalist agriculture is a progress in the art, not only of robbing the worker, but of robbing the soil. .... Capitalist production, therefore, only develops the techniques and degree of combination of the social process of production by simultaneously undermining the origin sources of all wealth — the soil and the worker (1990, p. 638).

My point is that before society reigns in capitalist agriculture's most egregious problems (cf. Polanyi, 1957), capitalist agriculture, regardless of how distant its markets are, generally has detrimental environmental and social effects locally, especially when compared to non-capitalist modes of production based mostly on use value. Thus, Marx's observations on the spread of capitalist relations in English agriculture serve to remind us that we should not forget that environmental degradation is created through the penetration of national markets as well as international markets. National market expansion and regulation are important but severely understudied processes in most developing countries, though this is being remedied somewhat through more attention to the expansion of supermarkets in developing countries (e.g., Berdegué et al., 2005). Many other topics of interest to political ecologists and environmental historians could be addressed through symmetrical comparisons of the environmental effects of export and national markets. These comparisons are likely to become more interesting with social movements' continued demand for increasingly regulated agri-food markets in industrialized countries and the often incipient expressions of these pressures in developing countries.

Second, the geographical applicability of the narrative that national market farmers increased their pesticide use by producing for export markets is highly variable and depends strongly on the agricultural systems that existed before the spread of export market relationships. While the narrative fits staple crop producing areas, it is likely that farmers in national market vegetable systems in Latin America did not substantially change their pesticide use intensity since they swapped one high-commodity value horticultural crop for another. Alternatively, in these national market horticultural areas, a process similar to that in Northern Cartago and the Ujarrás Valley may have occurred in which they decreased their pesticide use as a way to conform to export market pesticide residue requirements. Thus, considerable opportunities exist in documenting location-specific cropping patterns, agro-environmental history, and social mediation of market requirements in order to understand the local environmental impacts of changes in agro-export production and market orientation.

Lastly, these findings highlight the importance of ecological processes in the differential environmental outcomes of capitalist production, thereby resonating with a political ecology that pays considerable attention to these material processes and resists a merger with environmental politics that is based in the social sciences and humanities (Walker, 2005). While the social science-based field of political economy of agriculture has shown the limits that natural processes place on the development of a capitalist agriculture in the industrial world (Mann and Dickinson, 1978), we still lack a wider socio-environmental theorization of what geographers and political ecologists call "social nature" (FitzSimmons, 1989) or "second nature" (Biersack, 2006) in industrialized and industrializing agriculture in developing countries. Diagnosing pesticide problems and creating agroecologically-based solutions demand an integrated understanding of political economy and second nature ecology, a task to which political ecologists can greatly contribute.

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Figure Captions

Figure 1: Northern Cartago and the Ujarrás Valley, Costa Rica

Figure 2: Vegetable Pesticide Intensities (kg ai/ha/week) by Market Compared to the Costa Rican National Average and Common Crops, Northern Cartago and the Ujarrás Valley

Figure 3: An insect repellent made of garlic and hot peppers for use on a chayote export farm, Ujarrás Valley

Table Captions

Table 1: Descriptive Statistics of Farmers and Farm Operations, Northern Cartago and the Ujarrás Valley, 2003-04

Table 2: Relative Susceptibilities to Selected Pests and Pathogens for Varieties Grown for Different Markets

Table 3: Crop Cycle Pesticide Intensity (kg ai/ha/crop cycle) by Market Type, Northern Cartago and the Ujarrás Valley, 2003-04

Table 4: Productivity of a Kilogram of Pesticide Used on Various Crops, Costa Rica, Various Years

Table 5: Weekly Pesticide Intensity (kg ai/ha/week) of Open National and Export Vegetables, Northern Cartago and the Ujarrás Valley, 2003-04

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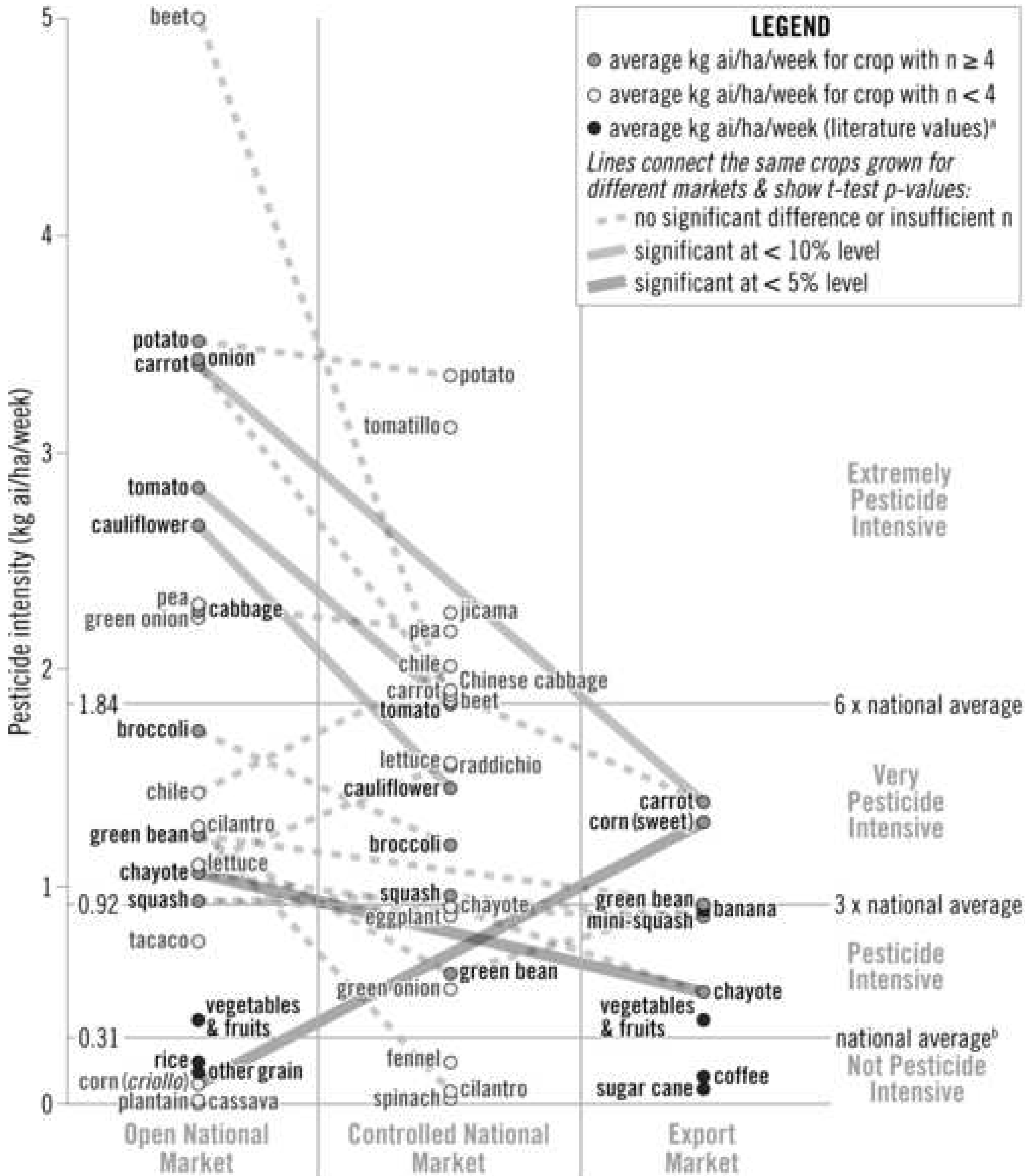
NORTHERN CARTAGO
EL GUARCO VALLEY
UJARRÁS VALLEY
Cartago
Tres Ríos
Tierra Blanca
Cot
Pacayas
Capellades
Cervantes
Paraíso
Guadalupe
San Rafael
El Tejar
COSTA RICA
NICARAGUA
PANAMA
Source: IGN 1981a, 1981b



Sources: Author's farmer surveys 2003-04; [a] from Castillo et al., 1997, p. 42; [b] from Chaverri 1999, p. 6.

	median	mean	st dev	n
Farmer Characteristics				
Age	40	42.1	11.1	148
Years of formal schooling	6	6.5	2.9	148
Years in farming	23.5	23.7	12.3	148
Member of a farmer group	—	36%	0.5	148
Household & Labor Characteristics				
Number of minors in household	2	2.14	1.6	148
Number of adults in household	2	3.12	1.5	148
Number of permanent workers	1	4.2	13.6	148
Greatest number of temporary workers at one time	3	5.0	9.2	148
Land Ownership & Land Use Characteristics				
Hectares of land owned	2.1	8.4	27.8	147
Current number of hectares planted	2.8	7.0	22.6	148
Number of parcels planted	2	2.1	1.7	148
Number of crops planted	3	3.9	2.3	148
Produces NTAEs	—	26%	0.4	148
Farm Equipment				
Owns a pickup truck or car	—	75%	0.4	148
Owns a tractor	—	16%	0.4	148
Economic Characteristics				
Home ownership	—	89%	0.3	143
Value of house(s) owned[a]	$15,050	$20,926	$21,762	133
Received credit in the past 12 months	—	52%	0.5	148
Total reported agricultural profits in 2002[b]	$2,779	$8,540	$40,778	123

[a] Using the 2003 exchange rate of 398.66 colones/US$.

[b] Using the 2002 exchange rate of 359.82 colones/US$.

Source: Author's farmer survey 2003-04.

Common name	Latin name	Relative Susceptibility, National Market Variety
Carrot		Bersky
Leaf blight	*Alternaria dauci* & *Cercospora carotae*	same
Green bean		Provider
Whitefly	*Bemisia tabaci*	more
Squash		zapallo *criollo*
Powdery mildew	*Sphaerotheca fuliginea* & *Erysiphe cichoracearum*	less

Relative Susceptibility, Export Market Variety
Mokum
same
Masai
less
Nova, Jaguar
more

	Open National			Controlled National			Export (NAm or EU)			All Markets			Open National vs. (p-value)[a]
	mean	sd	n	mean	sd	n	mean	sd	n	mean	sd	n	
Beet	83.5	71.3	3	20.3	10.8	2				58.2	61.4	5	
Broccoli	20.8	13.8	11	15.2	5.7	7				18.6	11.5	18	
Cabbage	32.3	24.3	22	25.0	10.0	2				31.7	23.4	24	
Cabbage, Chinese				20.7	—	1				20.7	—	1	
Carrot	**64.4**	**45.5**	**28**	38.3	28.5	2	**17.0**	**10.7**	**4**	57.3	44.6	34	**0.05***
Cassava	0	—	1							0	—	1	
Cauliflower	36.9	23.8	16	20.3	3.6	4				33.6	22.2	20	
Chayote	**71.5**	**39.4**	**15**	62.1	42.4	2	**33.4**	**26.4**	**29**	47.0	35.8	46	**0.00****
Chile, hot & sweet	65.9	57.3	3	72.4	102.3	2				68.5	65.4	5	
Cilantro	12.0	5.4	3	0.3	—	1				9.0	7.3	4	
Corn	**1.4**	**2.0**	**3**				**17.3**	**10.6**	**6**	12.0	11.6	9	**0.04***
Eggplant				45.8	13.8	2				45.8	13.8	2	
Fennel				2.0	—	1				2.0	—	1	
Green bean	**14.5**	**16.4**	**22**	5.5	2.9	6	**10.2**	**6.8**	**13**	12.1	13.0	41	**0.37**
Jicama				58.8	—	1				58.8	—	1	
Lettuce	14.1	19.8	2	19.4	7.6	2				16.8	12.6	4	
Onion	57.1	32.3	5							57.1	32.3	5	
Onion, green	38.3	53.7	2	5.8	—	1				27.4	42.3	3	
Pea	20.7	—	1	30.5	—	1				25.6	7.0	2	
Plantain	0	—	1							0	—	1	
Potato	57.3	57.3	98	59.8	9.9	2				57.3	29.8	100	
Radicchio				24.8	—	1				24.8	—	1	
Spinach				0.6	—	1				0.6	—	1	
Squash	**23.2**	**29.0**	**32**	14.3	6.1	7	**11.3**	**6.8**	**34**	16.8	20.5	73	**0.02***
Tacaco	57.8	—	1							57.8	—	1	
Tomatillo				53.0	—	1				53.0	—	1	
Tomato	73.4	47.9	14	39.5	18.9	6				61.5	43.8	20	
All combined	46.1	37.0	283	26.2	25.8	55	19.3	19.3	86	38.1	34.7	424	
Costa Rican average[b]										15.9	—	—	

[a] Two-tailed t-tests with unequal variance assumed. Differences significant at the 5% level are designated with * and at the 1% level with **.

[b] Figure is from 1994-1996 (Chaverri 1999, p. 6) and originates from total imports of pesticide active ingredient divided by total cultivated hectares.

Source: Author's farmer surveys 2003-04.

	Corn[d]	Sugar Cane	Coffee	Banana	Chayote	Onion	Potato	Tomato
Pesticide intensity[a]	1.4	3.5	6.5	45	47	57.1	57.3	63.3
Area (Hectares)[b]	11,638	46,800	107,783	47,065	541	824	3,324	1,190
Value (US$)[c]/Ha	$239	$1,226	$1,522	$7,899	$14,551	$7,089	$7,747	$11,288
Productivity/kg ai	$177	$350	$234	$176	$309	$124	$135	$178

[a] In kg ai/ha/cycle. Banana, coffee, & sugar cane pesticide data from Castillo et al., 1997, p. 42; other data from author's farmer surveys 2003-04.

[b] Average of the years 1998-2001 from SEPSA, 2004, p. 51.

[c] Average of the years 1998-2001 from SEPSA, 2004, p. 10, converted to 2004 US dollars at the rate of 1 US$/437.91 colones.

[d] Pesticide use data for exported sweet corn is excluded since SEPSA national data refer to field corn.

Sources: Author's farmer surveys 2003-04; Castillo et al., 1997; SEPSA, 2004.

	Open National			Export (NAm or			Export > Open National	p-value[a]
	mean	sd	n	mean	sd	n		
Carrot	3.41	2.46	28	1.39	0.93	4	no	0.12
Chayote	1.07	0.49	15	0.51	0.41	29	no	0.00**
Corn, *criollo* & sweet	0.09	0.13	3	1.29	0.71	6	yes	0.03*
Green bean	1.24	1.24	22	0.91	0.54	13	no	0.37
Squash	0.93	0.73	32	0.86	0.51	34	no	0.66
All combined	1.69	1.84	100	0.80	0.57	86	1 of 5	0.00**

[a] Two-tailed t-tests with unequal variance assumed. Differences significant at the 5% level are designated with * and at the 1% level with **.

Source: Author's farmer surveys 2003-04.