Circulating science, incompletely regulating commodities: governing from a distance in transnational agro-food regulation

Ryan E. Galt

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Whereas exposure to pesticides through occupation or accident is basically a local problem, capable of being countered by national legislation or education, the contamination of food must inevitably become a matter of worldwide concern because of the extensive international trade in this commodity.

— Hough 1998: 88.

Hence the major effect of the Panopticon: to induce in the inmate a state of conscious and permanent visibility that assures the automatic functioning of power. So to arrange things that the surveillance is permanent in its effects, even if it is discontinuous in its action; that the perfection of power should tend to render its actual exercise unnecessary; … in short, that the inmates should be caught up in a power situation of which they are themselves the bearers.

— Foucault 1977: 201.

In this chapter I show that national agro-food regulations in the global North strongly shape international agro-food networks down to specific production practices in specific locales. Importantly, this shaping occurs in ways that only partially correspond with the intent of the regulation. Using the case of the regulation of pesticide residues on food, I detail how scientific understandings of pesticide risk, and especially the way these are operationalized in pesticide residue monitoring, significantly shape the transnational agro-food system and production at the local level. Regulatory agencies employ risk assessments and specific techniques of analytical chemistry to enforce agro-food regulation, but these techniques are limited in their coverage because of the massive resources required to detect all residues. These risk assessments and their always-partial application in agro-food regulation govern from afar and create local policing regimes that ultimately shape economic and ecological activities at the farm level in places tied into global North markets through the production of exported food commodities. The shaping is highly uneven due to local circumstances and because of the necessarily partial nature of enforcement. Below I use the case of two specific pesticides and their use in Costa Rican export vegetable production demonstrate how agro-food government at a distance shapes local practice.

Pesticide residue regulation

Of all the negative consequences of pesticide use, pesticide residues[1] in food have generated, and continue to generate, the most concern in the general population (Baker et al. 2002; Whorton 1974). Pesticides degrade over time at different rates depending upon the compound, exposure to sun and other weathering forces, and the ability of organisms to metabolize them. They often will degrade to a level below the detection limit of modern equipment,[2] but they remain on food. "One of the fundamental principles of pesticide residue chemistry is that if a compound is used on a food crop there will be a residue in the food—whether or not it is detectable by the chosen analytical method or even by state-of-the-art techniques" (Wargo 1998: 152). Whether detected or not, we do not see pesticide residues and most of us do not think about them, yet we ingest them with almost every meal (Baker et al. 2002).

The health effects of pesticide residues in food remain vigorously debated. Showing that chronic, low-dose pesticide exposure is safe or harmful is currently beyond the limits of toxicology and epidemiology (Shrader-Frechette 1985). As Beck (1992, 64) notes, "[a] central term for 'I don't know either' is 'acceptable level.'" Many citizens consider pesticides a dreaded risk because the mechanisms by which pesticides affect health are unfamiliar, the potential effects are serious but delayed, and the risk is imposed rather than voluntary (Slovic 1987). Thus, great citizen concern persists over pesticide residues (Knight and Warland 2004).

Nation-states use some of their resources to employ risk assessments that establish legal limits concerning which pesticides are allowed at what levels on certain foods. In the US, the Environmental Protection Agency (EPA) sets these limits, called "tolerances" or, outside the US, maximum residue levels (MRLs). Current US regulation involves MRLs for 371 different active ingredients of synthetic pesticides (Environmental Protection Agency 2007). The state also uses its resources to monitor residues on food based on these MRLs, a role the Food and Drug Administration (FDA) performs in the US. This residue regulation creates a double-edged sword. On the one hand, its existence helps assure citizens that their food will not poison them, at least not immediately. On the other, this regulation serves as a state-sanctioned legitimation of pesticide residues in food, which many consider an intolerable risk. As Rachel Carson noted, "[i]n the end the

[1] Pesticide residues are traces of pesticide that remain on a product after it has been sprayed or treated in post-harvest.

[2] Pesticide detection in analytical chemistry has advanced greatly in the last century to the point where parts per quadrillion of some chemical substances can be detected.

luckless consumer pays his taxes but gets his poison regardless" ([1962] 1994: 183).

Carson hints at another important point: the pesticide residue regulation system, and especially its extension across national borders where many other pesticides might be allowed and used on export produce, assumes constant and vigilant enforcement. The possibilities that (1) pesticide residues on foods may exceed MRLs and (2) foods may contain residues not allowed on that food, *necessitate* constant monitoring for *all* potential residue combinations if the government were to actually assure consumers that their food complies entirely with US law. In other words, MRLs require and assume a panoptic style of enforcement that is ever active.[3]

Tracing two pesticide with different risk profiles

Many pesticide "families" exist. Two of the most commonly used families are organophosphate (OP) insecticides and ethylenebis-dithiocarbamate (EBDC) fungicides. I choose a representative of each of these two families as the major non-human actors, or actants (cf. Callon 1986), in this chapter because of their very different risk profiles, and the large difference in the way their residues interact with monitoring and enforcement meant to find and regulate them. These actants are methamidophos, a systemic OP, and mancozeb, a non-systemic EBDC.[4] Tracing methamidophos and mancozeb and their regulation is not meant to provide an overall view of pesticide regulation, but instead I purposefully select them as two endpoints of enforcement for risky pesticides: those that are highly monitored, and those least monitored. In their specific characteristics they cannot adequately represent their chemical families, but in the way they are regulated and perceived by farmers they can adequately stand in without creating large distortions.

The German chemist Gerhard Schrader first developed the potent organophosphate insecticides (OPs) in the late 1930s (Carson 1994: 28). Chemists then modified them for use in World War II as potent nerve gases (Russell 2001), testing their toxicity on prisoners at Auschwitz (Du Bois 1952). OPs became available to farmers in the US in 1946 (Shepard 1951: 6), one year after the (in)famous DDT made its debut. This history reveals that, in addition to acting as powerful, broad-spectrum insecticides, the OPs are clearly neurotoxins and very acutely toxic to humans and other mammals.

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[3] The panopticism discussed here is analogous to Foucault's (1977) discussion of Bentham's Panopticon. Similarly, if a panoptic style of governance is successful, export farmers in faraway places will self-regulate to avoid being disciplined and punished for being out of compliance with US regulation .

[4] Systemic refers to pesticides that enter plant tissues and move throughout them, while non-systemic pesticides work on the plant's surface where they come into contact with pests.

The OPs rose to particular prominence in agriculture once governments in the 1970s began banning the organochlorine insecticides like DDT, which persist and bioaccumulate in the environment, thereby causing harm to both wildlife and human health (Carson 1994). Relative to the organochlorines, OPs generally persist for a shorter time in the environment, although they present a *much* higher risk of acute poisoning and death to farm workers (Wright 1986, 1990). They affect the central and peripheral nervous system by binding to and deactivating the vital enzyme acetylcholinesterase, resulting in uncontrolled, repeated firing at nerve junctions. Poisoning symptoms include excessive sweating, salivation, nausea, vomiting, diarrhea, abdominal cramps, general weakness, headache, poor concentration and tremors. Serious cases involve respiratory failure and death. Long-term effects of poisoning events involve lower dexterity, attention, and visual motor skills (Rosenstock et al. 1991), and studies of long-term exposures to low doses have generated mixed conclusions, with some showing exposed populations with lowered cognition and motor skills (Vergara 1993), and others showing no difference (Ray 1998). Poisoning by OPs account for around 80 percent of pesticide-related hospital admissions in the US (Taylor 2001, cited in Casida and Quistad 2004), similar to the pattern of OPs and their cousins the carbamates causing 72 percent of pesticide-poisoning deaths where documented in developing countries (Roberts et al. 2003).

Methamidophos is a very acutely toxic, systemic OP. Its systemic nature means it translocates throughout the plant, working for weeks to kill insects that feed on the plant. This characteristic makes it popular with farmers, but potentially problematic for consumers. Cases of farm worker and farmer poisonings often involve methamidophos. In Nicaragua, 77 percent of cases were caused by methamidophos and carbofuran, an acutely toxic carbamate insecticide (McConnell and Hruska 1993: 1559). Similarly, in Sri Lanka, before it was banned, methamidophos and monocrotophos, another OP, caused the majority of poisonings (Roberts et al. 2003). With figures such as these, methamidophos has been identified as one of the 12 most dangerous pesticides which the health ministers of Central American countries have agreed to ban (Nieto Z. 2001).

Methamidophos residues have also been responsible for a large number of poisonings of consumers due to high levels of residues (Chan 2001; Wu et al. 2001), including the recent (contested) poisonings in Japan from Chinese dumplings (channelnewsasia.com 2008). Work measuring OP metabolites in the US population shows that OP metabolite concentrations are significantly higher in children ages six to 11 than adults, and that most of the population is exposed to OPs (Barr et al. 2004). This result makes sense when we take into account the human ecology of

residues: children often eat fruits in much greater proportion to body weight than adults, and much conventional fruit and vegetable production relies heavily on OP insecticides (Wargo 1998).

The ethylenebis-dithiocarbamates (EBDCs) — originally developed as accelerators in the rubber vulcanization process (Russell 2005) — became subject to a concerted effort to employ laboratory techniques to discover new fungicides. Through his laboratory experiments, McCallan (1930) at Cornell University first described EBDCs as having fungicidal action. The EBDCs were first patented in 1934 by Tilsdale and Williams at DuPont, but the first, thiram, did not appear on the market until 1942 (Russell 2005). By the 1950s, the EBDCs were in use globally (Dich et al. 1997). These were the first organic[5] fungicides, classified as such because their new chemical configurations included carbon from compounds in fossil fuels.

In contrast to the OPs, the EBDCs are not acutely toxic to humans, yet concern focuses on cancer (Dich et al. 1997) and birth defects caused by the compounds and their carcinogenic breakdown product, ethylenethiourea (ETU) (Holland et al. 1994). Epidemiological studies show a variety of negative effects of chronic exposure to EBDC fungicides, including thyroid toxicity and tumor generation (Houeto et al. 1995). A rarely cited study from the 1970s showed increases in thyroid and liver cancers in regions with higher EBDC exposure as estimated by sales and crop production data (von Meyer 1977, cited in Houeto et al. 1995). A more recent study showed an increase in relatively rare cancers (thyroid, bone, testis, thymus, and other endocrine glands) in the region in Minnesota where EBDCs are most heavily used, where potato, wheat, and sugar beet are grown (Schreinemachers et al. 1999). Clinical studies of fifty workers with chronic exposure to maneb had "significantly increased incidences of various neurologic effects (including cogwheel rigidity, fatigue, and complaints of memory loss) and increases in a variety of other Parkinson-like symptoms (including tremor, ataxia, and bradykinesia)" relative to a non-exposed control group (Ferraz et al. 1988, paraphrased in Houeto et al. 1995). Toxicological studies on rats have shown EBDCs to be teratogenic, damaging the reproductive organs of males and females, which results in malformations in offspring and decreased fertility (Houeto et al. 1995).

Mancozeb, an EBDC based on manganese and zinc, was introduced in 1961, and is likely the most commonly used of its chemical class (Russell 2005). EPA classifies mancozeb and ETU, its breakdown product, as "probable human carcinogens." One review of mancozeb residues on

[5] Far predating the application of the term "organic" to an agriculture that does not depend on synthetic fertilizer and pesticide inputs, chemists use the term to refer to compounds containing carbon of biological origin.

apples suggested that according to "supervised trials, including harvest at the recommended PHIs, the most likely resulting dithiocarbamate residue is in the vicinity of 0.90 mg/kg [ppm] for mancozeb" (Hamilton et al. 1997: 1405). An assessment by the National Academy of Science that it and many other fungicides pose relatively high risks of cancer if allowed to persist on food at their MRLs,[6] with an estimated risk of 3.4 per 10,000 individuals, much higher than EPA's rule of thumb of one in one million (NAS 1987, cited in Wargo 1998: 119). Under high heat (cooking), EBDCs convert to ETU at rates up to 50 percent. In contrast to some knowledge on mancozeb residues, the literature lacks information on home-cooked foods with EBDC residues and their conversion to ETU (Holland et al. 1994).

Specific mechanisms of toxicity are important to the effects of these two pesticides on farmworker and consumer health. As Dich et al. (1997: 421) note,

> Pesticides with an extremely high acute toxicity may be easily metabolized and eliminated from the body; following long-term low exposure, they may be less toxic and without carcinogenic or mutagenic properties. On the other hand, pesticides with low acute toxicity … can accumulate in the body and cause chronic toxicity after long-term exposure even in comparatively low doses.

The first category includes the OP insecticides, as they can be metabolized if the person survives the exposure (although, as noted above, long-term effects often result from these exposures). The second category includes those low acute toxicity pesticides that are carcinogenic, like the EBDCs, but it is important to note that the EBDCs are not known to bioaccumulate.

Government at a distance

How do these actants perform on the world stage? The United Nations Food and Agriculture Organization (FAO) Codex Alimentarius has worked to "harmonize" pesticide residue regulations internationally by setting specific MRLs for crop-pesticide combinations. These are non-binding standards meant to harmonize residue regulations internationally, though many nations continue to use their own risk assessments and regulatory systems (Hough 1998). Table 1 shows EPA's and FAO's MRLs for methamidophos, and Table 2 shows the same for mancozeb. While Hough (1998) notes that EPA standards are usually more restrictive than FAO standards, the opposite appears to

[6] Not all foods on which mancozeb is permitted have mancozeb at its MRL, so risks here are likely overestimated if we assume exposure to only mancozeb (but for a critique of the single exposure idea, see Carson 1994; Wargo 1998).

be the case for these two pesticides: EPA MRLs are generally higher than FAO's, thereby allowing for more exposure to consumers. These MRLs and their national differences become important to the global food regime when produce crosses national boundaries.

INSERT TABLE 1 HERE [data source is (Environmental Protection Agency 2007; Food and Agriculture Organization 2008)]

INSERT TABLE 2 HERE [data source is (Environmental Protection Agency 2007; Food and Agriculture Organization 2008)]

Not only do MRLs differ between countries, but so do regulations that register the agricultural use of certain pesticides and ban others. Figures 1 and 2 reveal the global regulatory status in terms of use regulations for methamidophos and mancozeb. Both of these maps demonstrate the highly uneven regulations between nation states. Methamidophos, while registered for a number of crops in the US, is banned or never registered in a large number of countries, including large numbers of African and Southeast Asian countries. Regulation in Europe, Latin America, and South and East Asia is highly heterogeneous. Indeed, no consensus exists within most world regions, with the exception of North America, in which both the US and Canada allow methamidophos use (Figure 1). Mancozeb remains a commonly used fungicide in the US and is also registered in Australia, Canada, India, and many African and European countries. In contrast, Sweden has strongly restricted mancozeb because it causes cancer and genotoxic effects, and many African nations have never registered it (Figure 2).

INSERT FIGURE 1 HERE [data source is (Orme and Kegley 2008)]

INSERT FIGURE 2 HERE [data source is (Orme and Kegley 2008)]

The heterogeneous regulatory status shown by the global maps of pesticide registrations hint at the enormous complexity of international pesticide regulation and the difficulties faced by various actors in global agro-food systems. More then 651 pesticide active ingredients exist in the world, and most have highly heterogeneous regulation across the globe. For farmers and export firms, there is potentially a bewildering array of difference in complying with pesticide residue regulations in trade between nations. For national governments, imposing their own regulations on the global flows of food poses a considerable challenge, as the specific production practices in other countries remain hidden from government regulators. If nations are successful in their regulation attempts, these efforts expand the governing of agro-food systems along octopus-like tentacles that are extensions of power from the nation state to the specific locales — down to the land user and even specific agricultural fields — where pesticide regulations intersect with farmers' production

practices. The more powerful and wealthy the nation state and its pesticide residue monitoring, the stronger the tentacles. Latour calls this type of control "action at a distance" (Latour 1987), and others have drawn on that concept to discuss "government at a distance" (Agrawal 2005: 123; Miller and Rose 1990) or "regulation from afar" (Galt 2007).

In the case of pesticide residues, government at a distance specifically involves (1) risk assessments that set MRLs, (2) sampling of produce to test for residues, and (3) residue testing using the laboratory methods of analytical chemistry to enforce MRLs. These risk assessments and their enforcement ultimately have important effects on the actions of farmers who are not directly controlled within the territory of the regulatory body. As Agrawal (2005: 194) notes, "[a]ction at a distance thus overcomes the effects of physical separation by creating regulations known to those located at a distance." Although Agrawal (2005) refers to the devolution of some control to community forestry councils in Kumaon, India, in agro-food systems as well this "government at a distance" becomes supplemented and enforced by "intimate government" in each locality tied to the global market through its export production system. In export production systems, this intimate government often rests on export firms that construct specific understandings of regulations of various export markets and enforce these among the farmers with whom they contract.

FDA's uneven enforcement of tolerances

Critiques of FDA's residue testing often focus on the low percentages of total imported food that is tested (General Accounting Office 1986a, 1986b; Wargo 1998; Wright 1990). *The New York Times* recently posted an online computer game that readers can play to reveal how FDA can only test a minute percentage of imported produce (Persuasive Games 2007). Less than one percent of produce is tested (General Accounting Office 1986a: 3), and this seems inadequate to many. While I agree that the level of observation is indeed suboptimal, my research suggests that the testing has important but partial effects, as exporters and export farmers have attempted to rationalize pesticide use based on previous residue violations (Galt 2007). In other words, the specific residues tests employed — with their ability to detect some pesticides but not others — have important effects.

I argue that we need to explore the specific manifestations of government from a distance, i.e., the exact ways in which FDA testing occurs, and how this manifests itself in land users' decisions, one of political ecology's historic foci (Blaikie and Brookfield 1987). The specificities of the field of analytical chemistry impact export farmers. The field—its advances, the limitations of its methods, and the resources needed to employ them—all matter greatly in the way that government at a

distance manifests itself in specific locales of agro-food production tied into export channels.

Methods of analytical chemistry have improved dramatically over the course of the last half-century both in terms of the number of compounds that can be detected in a single test, and also in the limits of detection (usually expressed in parts per million, or ppm). For most residue tests, FDA relies mostly on multiresidue methods (MRMs), which can determine the presence and level of a number of different pesticide residues simultaneously. FDA's Pesticide Analytical Manual instructs its chemists: "[w]henever a sample of unknown pesticide treatment history is analyzed, and no residue(s) is targeted, a multiclass MRM should be used to provide the broadest coverage of potential residues" (FDA 1999a: 301-1). The number of residues detected with one MRM has expanded as chemists refine and improve the specific screening modules used (see Figure 3). The commonly used MRMs, e.g., the Luke method (Luke et al. 1988) and its subsequent modifications (Food and Drug Administration 2000a), can determine residues of close to half of the approximately 400 pesticides for which EPA has set tolerances (FDA 2004: 3). The MRMs commonly used by FDA can also determine residues of many pesticides for which EPA has revoked tolerances, such as DDT and many other organochlorine pesticides.

INSERT FIGURE 3 HERE [source is (Food and Drug Administration 1999a)]

It is important to note that the "ultimate" MRM analyses developed by academic chemists can detect over 400 pesticides (Stan 2000), but these are complex, and thus expensive, for use in the regulatory setting. Employing these "ultimate," almost panoptic methods is thus out of the question for the state. About the use of various screening modules of MRMs to expand the detection potential, the FDA manual blithely notes that "[t]he user may choose as many or as few of these modules as time and resources permit" (FDA 1999a: 301-1). Time and resources are clearly limited, so coverage does not include the "ultimate" MRMs from the labs of academic chemists.

Single residue methods (SRMs) determine the residue level of a single pesticide or highly related group of pesticides, while selective MRMs determine a small group of chemicals. Both of these are considerably more expensive than MRMs on a per-residue-determined basis and are therefore used much less frequently (FDA Pesticide Program 2004). FDA gives very little external indications as to the circumstances under which its chemists choose to use SRMS. In its manual, FDA notes that "[t]hese methods are most often used when the likely residue is known to the chemist and/or when the residue of interest cannot be determined by common MRMs" (FDA 1999a: v).

These seemingly tedious specificities about residue testing impact our two dangerous protagonists, methamidophos and mancozeb, and the way they are used and perceived. As an OP,

methamidophos belongs to the 200 pesticides that can be detected by most MRMs FDA uses. On the other hand, the EBDCs, including mancozeb, belong to the 200 that cannot be detected using common MRMs. Instead, SRMs must be used to detect them (Chang et al. 2005).[7] As noted above, EPA considers mancozeb and other EBDCs to be high-risk pesticides (Hettenbach and Wile 2000) and has set MRLs that in theory should be enforced. Additionally, many agricultural sectors rely on mancozeb in many countries — for example, it accounts for 30 percent of all fungicides used in Costa Rica (Humbert et al. 2007) — and it appears very regularly on produce in developing and industrialized countries when it is specifically tested for (Chang et al. 2005; Hamilton et al. 1997; Vargas and Rodríguez 1996). Costa Rican tests have shown that mancozeb exceeds FAO's MRLs on fresh[8] sweet peppers and tomatoes at rates of 50 percent and 19 percent, respectively (Vargas and Rodríguez 1996: 58).

Table 3 shows FDA tests for the two actants methamidophos and mancozeb. While FDA conducted a handful of tests for mancozeb on imported produce each year in the late 1990s, FDA no longer tests for mancozeb on imported produce, presumably because of a lack of resources for SRMs. Mancozeb, despite being in heavy use for more almost 50 years, remains a kind of fugitive actant that has eluded analytical chemists' attempts to fold it into their overall project of panoptic but affordable MRMs. The state must expend considerable resources to find mancozeb, and clearly chooses not to do so. In contrast, methamidophos remains a pesticide that will be detected by many MRMs that FDA labs use. It remains within the view of US pesticide residue regulation on imported food.

INSERT TABLE 3 HERE [data source is (Food and Drug Administration 1999b, 2000b, 2002, 2003, 2004, 2005)]

The characteristics of the various pesticide actants — mancozeb presents a risk of cancer and birth defects, and methamidophos presents a risk of acute poisoning and neurological impairment — has caused EPA to regulate pesticide use on food through the creation of MRLs on specific

[7] The FDA manual notes that "[a]nalyses for residues of ethylenebisdithiocarbamates (EBDCs) require special handling of the laboratory sample. EBDCs decompose rapidly as soon as the crop surface is broken and residues contact water, enzymes, and sugars" (FDA 1999a: 102-6), which happens when lab personnel prepare samples for residue testing.

[8] It appears as though cooking does cause the breakdown of EBDCs (Chavarri et al. 2005), but as noted above cooking also causes EBDCs to convert to the carcinogen ETU. Problematically, only once EBDC residues are detected — a rare situation since they are not detected by MRMs that FDA commonly uses (Table 3) — does FDA test for the carcinogenic breakdown product ETU (Food and Drug Administration 2000c).

foods. Both their relationship to analytical chemistry — mancozeb remains a fugitive to common MRM tests, while analytical chemists can relatively easily find methamidophos — and the lack of material resources — labor and time to fulfill the panoptic requirements of thousands of specific MRLs — shape the actual regulatory structure that governs agro-food systems from a distance. What effects does a regulatory structure that can only find some pesticides create? How does it shape intimate government created by the control structures of exporters and, ultimately, farmer behavior?

Effects of uneven enforcement on the intimate governing of Costa Rican vegetable production

For the purpose of understanding the influence of pesticide residue regulation on export farmers it is essential to consider contract farming because it "presupposes some form of regulation and control, a sort of direct fashioning, of the labor process by the contractor, and a web of social relations, which are practically and ideologically central to the production system" (Watts 1992: 70). Exporters with imperfect understandings of US pesticide residue regulation employ this "direct fashioning" or intimate governing of the production process. A handful of export firms contract with Costa Rican farmers for export vegetables in Northern Cartago and the Ujarrás Valley, Costa Rica. These firms export squash, green beans, chayote (a native cucurbit), and other vegetables to the US, Canada, and the European Union (Figure 4).

INSERT <u>FIGURE 4</u> HERE [source is author's collection]

Exporters do not have a complete understanding of US or FAO pesticide residue regulations, and they intentionally simplify the message about pesticides to export farmers. To paraphrase, most emphasize that farmers cannot use OPs or the older organochlorines. The Costa Rican state through its Ministerio de Agricultura y Ganadería (MAG) has also been involved in communicating with farmers and monitoring produce for prohibited pesticides — particularly methamidophos — in the chayote sector. Because methamidophos and other OP residues on chayote and squash have caused violations of US tolerances in the past — resulting in the loss of entire shipments and the income those bring — exporters and MAG attempt to exert control over farmers' use of OP insecticides through various policing mechanisms. This intimate governance focuses on insecticides, but largely ignores fungicides like mancozeb, as these have never caused violations in the past. As we have seen, they have never caused violations of US residue law in part because MRMs will not detect them. If, for example, they were detected on green beans and other vegetables for which they

do not have a US tolerance (see Table 2), they would be in violation of US law.

Data from a survey of 148 Costa Rican vegetable farmers supports the idea that farmers treat fungicides like mancozeb quite differently from OP insecticides like methamidophos. Figures 5 shows pesticide use as it relates to the residue question for squash produced for the open national market and the export market. The pesticide details section on the left includes pesticide active ingredients, their "pesticide group," and check boxes showing whether they are classified as Bad Actors according to the Pesticide Action Network classification.[9] The open national market section and the export market sections present similarly ordered data: number of farmers using it, regulatory information, the waiting period between spray and harvest (also known as "pre-harvest interval" or PHI), and dose used. The dose section on the right side of each market section shows doses used by each farmer relative to the maximum recommended dose on the label, which is set at 100 percent. The average dose sits to the left of the dose plot. A gray fill signifies that the dose exceeds the label's requirements. The PHI section in Figure 5 shows the result of subtracting the minimum required PHI on the label from minimum PHIs reported by farmers. Thus, a zero means that the farmer waited just long enough between spray and harvest, while a negative number means that the farmer did not wait long enough. The average is to the left of the PHI plot. The gray background shows that a use violates the PHI required by the Costa Rican label.

INSERT FIGURE 5 HERE [source is (Galt in review)]

Export squash farmers' OP use generally complies with requirements for dose and the PHI. Their use of organophosphates generally, and methamidophos specifically, reflect the exporters' and MAG's concern over causing more violations and losing income from rejections. In this sense, they have become partial, Foucauldian "environmental subjects" created by government from afar (cf. Agrawal 2005). In contrast, export farmers generally violate the PHI for mancozeb, as well as most other fungicides. Many farmers in the area see fungicides as essentially harmless agrochemicals (Galt 2007). Exporters and MAG have done little to change this perception, as they have never experienced direct economic losses, or even a hint of a problem, due to fungicide residues.

Implicit in farmers' and exporters' understandings of US pesticide residue regulation is that it is

[9] Bad Actor pesticides are those that meet any of the following criteria: highly acute toxic according to the World Health Organization (WHO), EPA, or the US National Toxicology Program; a known or probable carcinogen according to EPA; a reproductive or developmental toxin listed in California's Proposition 65; a cholinesterase inhibitor according to the Material Safety Data Sheet (MSDS), the California Department of Pesticide Regulation, or the PAN staff's evaluation of chemical structure; or a known groundwater contaminant (Orme and Kegley 2008).

truly panoptic like as Bentham's Panopticon: if fungicides caused health problems, they would be regulated by the US government, and strict and complete enforcement would guarantee that those fungicides most threatening to human health would be detected and the offender disciplined. This kind of discipline has been the case for OP insecticides, but this lack of negative feedback for fungicide residues serves to reinforce a view of them as safe products.

Conclusions

This examination of pesticide residue regulation and enforcement, traced through the actants of methamidophos and mancozeb and their use in a specific locale, allows for a number of conclusions. First, pesticide residue regulations and enforcement act as de facto agro-environmental regulations from afar that create partial environmental subjects out of export farmers. This government from a distance is, in the case of Costa Rica, more often powerful than its own "government from nearby" as farmers pay considerably more attention to the residue issues of pesticides for export than they do when producing for the national market (Galt in review). This results from large differences in the enforcement budgets between the countries, and also from the subordinate position of Costa Rica in the world economy vis-à-vis the global north, manifested in the need of Costa Rica to continue agricultural exports to generate foreign exchange to service its international debt accrued from previous decades of development. By opting into the world system, Costa Rica must maintain exports, and therefore must play by the rules of the more powerful.

Second, in this era of market-based solutions to environmental problems, this research shows that regulation *works*, but, from the perspective of protecting human health, the current manner in which it works is flawed. The understanding of pesticide residue testing as truly panoptic does indeed instill self-regulation by partial environmental subjects through intimate governance at the point of production. However, a contradiction arises: although EPA, exporters, and export farmers perceive US pesticide residue regulation as panoptic, it clearly is not (Table 3 and Figure 5). This leads to a serious disconnect where farmers view fungicides like mancozeb as not harmful to human health and exercise considerably less caution with them. Equally problematic is that EPA continues to assume the existence of an adequate regulatory apparatus, one that is essentially all seeing when it comes to residues, when it approves pesticides. Rather than being panoptic, it is clearly demi-optic (half-seeing), with considerable problems — especially lack of local concern about pesticides that can cause cancer and birth defects — resulting from misunderstanding that this creates.

Third, the decline in the amount of FDA residue testing between the late 1990s and the early

2000s is disturbing both from the point of view of US consumers and for those concerned with the potential positive impact of US residue regulations on export sectors (as de facto agri-environmental regulation from afar). While the US in its neoliberal zeal has not revoked MRLs, in terms of pesticide residue enforcement the US has become a "weak" state. As McCarthy (2002: 1288-9) notes, "the United States, often portrayed as the gold standard of sovereign state capacity, actually experiences many of the problems and limitations supposedly diagnostic of 'weak' states in controlling its own territory and population." These decisions are political decisions pushed by the Bush Administration, which makes it no secret that consumer and environmental protections are low priority areas relative to war and control over dissidents. Significant pushback against neoliberalism is needed on many fronts, including the realm of agro-food regulation.

Figures captions

Figure 1: A global view of national registration statuses of mancozeb

Figure 2: A global view of national registration statuses of methamidophos

Figure 3: The residue testing procedures from FDA's Pesticide Analytical Manual. The various modules (e.g., DG2) will detect different groups of pesticides.

Figure 4: A box of chayote ready for export to the United States.

Figure 5: Pesticide use on open national market and export squash in relation to regulation, Northern Cartago and the Ujarrás Valley, 2003

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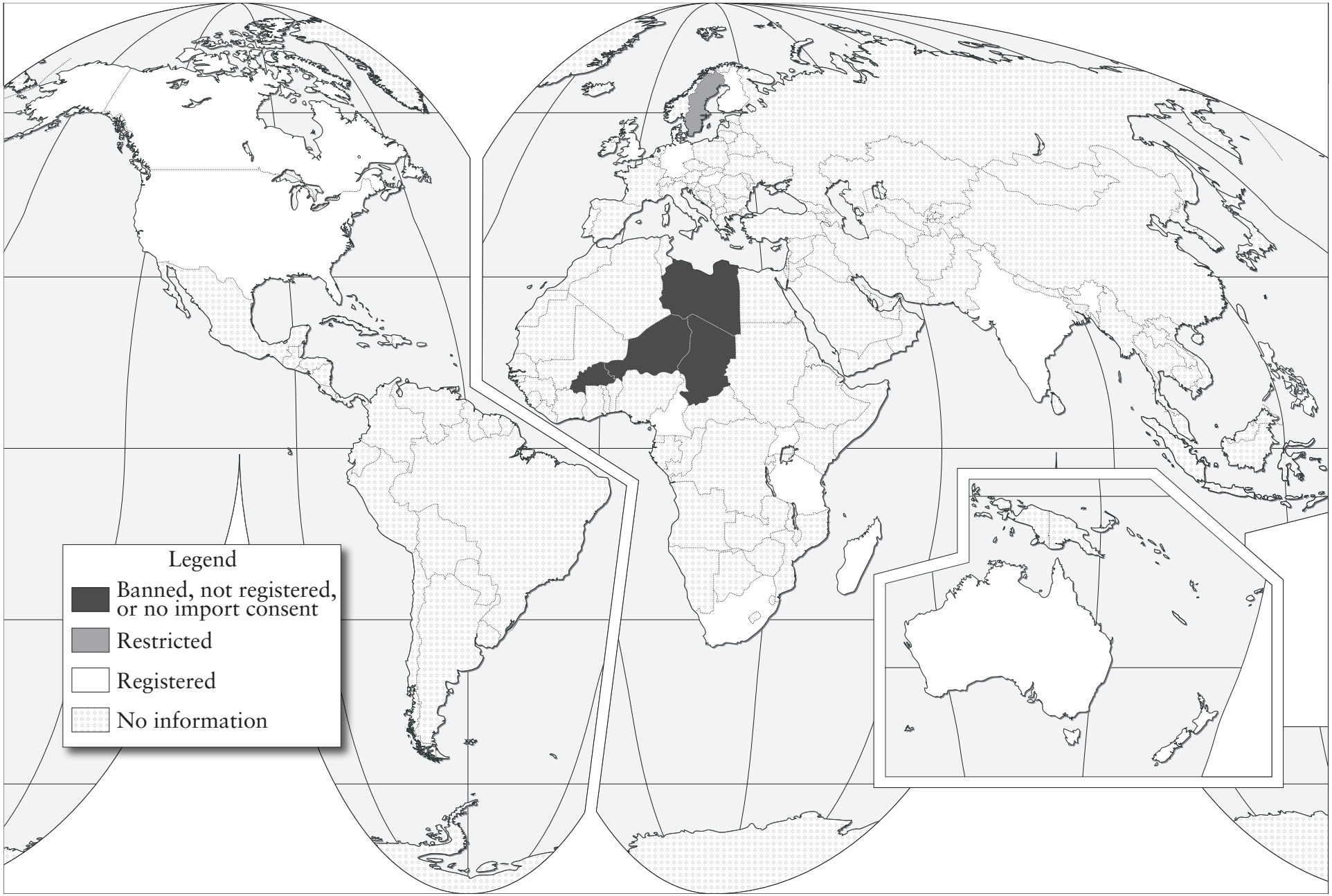
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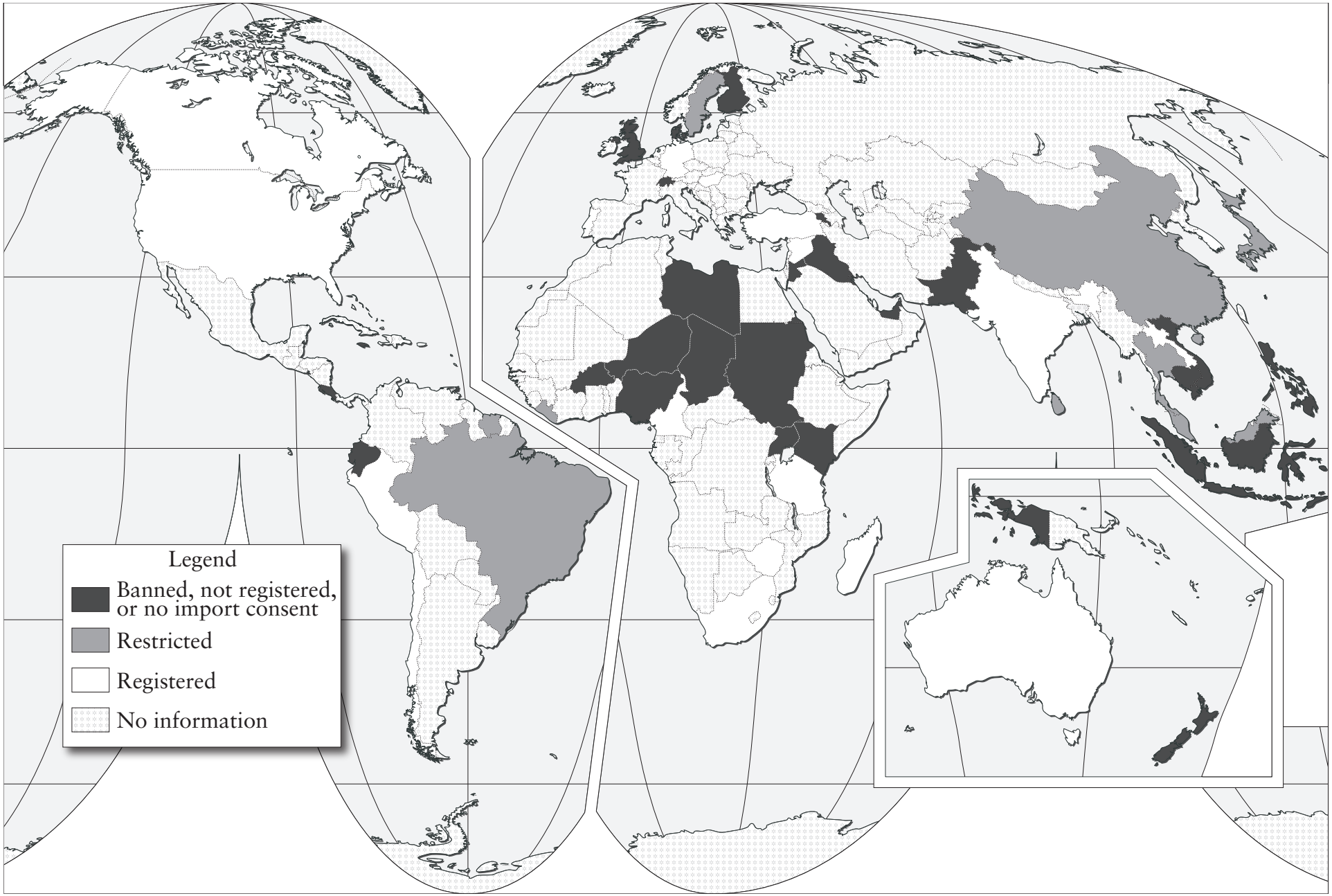
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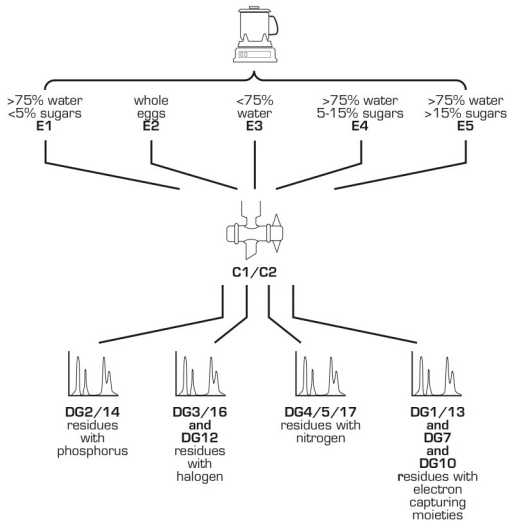
Figure 303-a
Recommended Approach: Nonfatty Foods

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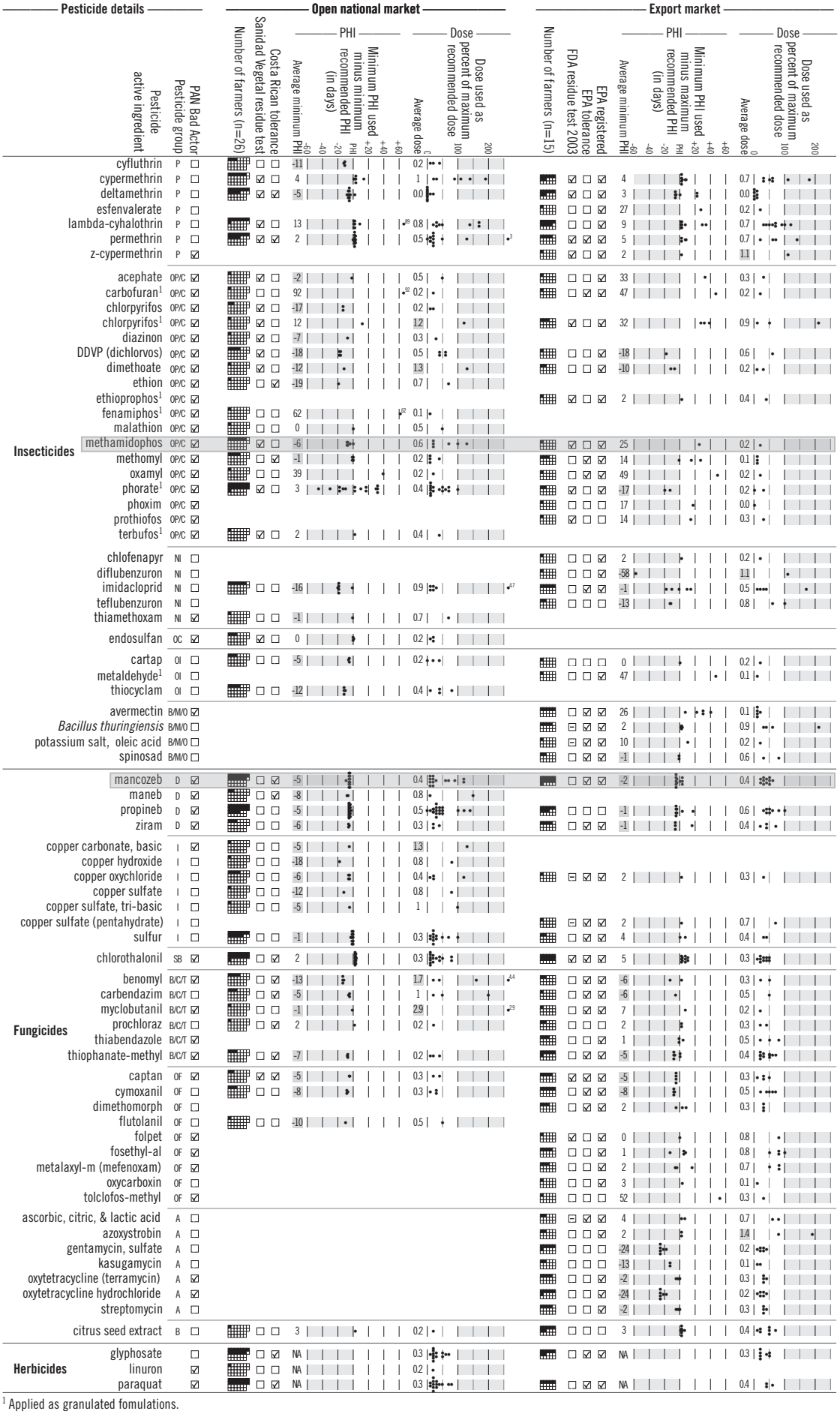

[1] Applied as granulated fomulations.

Sources: Author's farmer surveys 2003-04 & Costa Rican pesticide labels; La Gaceta (1997) & Rodríguez Solano (1994); EPA (2004) & FDA (2005).

Table 1: Methamidophos MRLs (tolerances) set by EPA and FAO

EPA tolerances		FAO MRLs	
commodity	ppm	commodity	ppm
Broccoli	1	Artichoke, globe	0.2
Brussels sprouts	1	Beans[a]	1
Cabbage	1	**Cauliflower[b]**	0.5
Cauliflower	1	**Cotton seed**	0.2
Cotton, undelinted seed	0.1	Fodder beet	0.02
Cucumber	1	**Peppers, chili**	2
Eggplant	1	**Peppers, sweet**	1
Lettuce	1	**Potato**	0.05
Melon	0.5	Soybean (dry)	0.1
Pepper	1	Sugar beet	0.02
Potato	0.1	Edible offal, mammalian	0.01
Tomato	1	Edible offal, poultry	0.01
		Eggs	0.01
		Meat[c]	0.01
		Milks	0.02
		Poultry meat	1

[a] Except broad bean and soybean.

[b] Based on treatment with methamidophos or acephate.

[c] From mammals other than marine mammals.

Sources: EPA 2007, 40 CFR 180.315 and FAO 2008.

Table 2: Mancozeb MRLs (tolerances) set by EPA and FAO

EPA tolerances	
commodity	ppm
Apple	7
Asparagus (negligible residue)	0.1
Banana	4
Banana, pulp (no peel)	0.5
Barley, grain	5
Barley, milled feed fractions	20
Barley, straw	25
Beet, sugar	2
Beet, sugar, tops	65
Carrot, roots	2
Celery	5
Corn, forage	5
Corn grain (except popcorn grain)	0.1
Corn, stover	5
Cotton, undelinted seed	0.5
Crabapple	10
Cranberry	7
Cucumber	4
Fennel	10
Fresh corn[a]	0.5
Grape	7
Melon	4
Oat, bran	20
Oat, grain	5
Oat, milled feed fractions	20
Oat, straw	25
Onion, dry bulb	0.5
Papaya[b]	10
Peanut	0.5
Peanut vine hay	65
Pear	10
Popcorn grain	0.5
Quince	10
Rye, grain	5
Rye, milled feed fractions	20
Rye, straw	25
Squash, summer	4
Tomato	4
Wheat, grain	5
Wheat, milled feed fractions	20
Wheat, straw	25
Kidney	0.5
Liver	0.5

Source: EPA 2007, 40 CFR 180.176 and FAO 2008.

FAO MRLs[c]	
commodity	ppm
Asparagus	0.1
Banana	2
Barley	1
Barley straw and fodder, dry	25
Beet, sugar	0.5
Cabbages, head	5
Carrot	1
Cherries	0.2
Cranberry	5
Cucumber	2
Currants (black, red, & white)	10
Garlic	0.5
Kale	15
Leek	0.5
Lettuce, head	10
Maize fodder	2
Mandarins	10
Mango	2
Melons, except watermelon	0.5
Onion, bulb	0.5
Oranges (sweet & sour)	2
Papaya	5
Peanut	0.1
Peanut fodder	5
Peppers, chili (dry)	10
Peppers, sweet	1
Pome fruits	5
Potato	0.2
Pumpkins	0.2
Squash, summer	1
Squash, winter	0.1
Sweet corn (corn-on-the-cob)	0.1
Watermelon	1
Wheat	1
Wheat straw and fodder, dry	25
Edible offal, poultry	0.1
Milks	0.05
Poultry meat	0.1

[a] Including sweet corn, kernels plus cob with husk removed.

[b] Whole fruit with no residue present in the edible pulp after the peel is removed and discarded.

[c] From MRLs of dithiocarbamates specifying mancozeb as the source, or no specific source.

Table 3: Number of tests that would detect mancozeb & methamidophos on fresh vegetables imported into the U.S., as tested by FDA, 1998-2003

	1998	1999	2000	2001	2002	2003
mancozeb, reported as EBDC (identity unknown)[a]						
all imported vegetables	4 (0)[b]	13 (0)	0	0	0	0
Costa Rican vegetables	0	0	0	0	0	0
methamidophos						
all imported vegetables	476 (17)	376 (19)	0	46 (16)	66 (12)	39 (15)
Costa Rican vegetables	11 (0)	10 (1)	0	3 (2)	2 (0)	1 (1)

[a] FDA laboratories generally report all EBDC fungicide residues as "EBDC (identity unknown)" because all are converted to carbon disulfide for detection (FDA 1994: 104-3).

[b] Numbers refer to number of commodity-country combinations tested, e.g., garlic from Thailand; numbers in parentheses refer to number of commodity-country violations (either in excess of MRL or without an MRL).

Source: FDA 1999-2005, databases IMVE1998 through IMVE2003.