PESTICIDE USE ON GENETICALLY ENGINEERED CROPS

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Much has been written by scientific and mainstream media about the advantages of using genetically engineered (GE) crops because, according to popular belief, these crops require significantly less pesticide to control weed and insect pests. Or in slightly more sophisticated but equally misleading coverage, cursory acknowledgement is given to increasing herbicide use, but such increase is qualified in terms of the lower toxicity profile of glyphosate relative to more toxic herbicides that are also increasingly used. (See e.g. "Labels for GMO Foods Are a Bad Idea", *Scientific American,* 8/20/13: "Because conventional crops often require more water and pesticides than GMOs do, the former are usually more expensive."; see also Seeds of Doubt, *The New Yorker,* 8/25/14; "The Promise of GMOs", *Biology Fortified*, 2/14/14 and "Environmental Benefits of Genetically Modified Crops", Fig. 7 *CropLife*, 11/02.) These accounts are inaccurate and rely on annual pesticide application rates and volumes reported prior to 2010, when widespread resistance began to emerge in "superweeds" and "superinsects." (See "What Happens When Weed Killers Stop Killing?", *Science,* 9/20/13 and "Field-evolved resistance by western corn rootworm to multiple Bacillus thuringiensis toxins in transgenic maize", *Proceedings of the National Academy of Sciences*, 9/12/13.) These reports also ignore the now widespread practice of coating seeds in systemic pesticides, which has emerged in the past 10 years. This lack of journalistic and scientific integrity distorts the facts on the ground.

In the United States, GE corn is planted on some 90 million acres, so the overuse of undesirable pesticides on this crop can have profound effects on the natural ecosystem, including beneficial organisms. GE corn makes up over 90 percent of US corn acreage as of 2014, with 76 percent "stacked" with both insecticide producing (Bt) and herbicide tolerant (Roundup Ready) traits. The latter enables heavy use of the herbicide glyphosate on food crops. (See "Recent Trends in GE Adoption", *USDA*.)

Many of us are unaware that in addition to the ever-increasing spraying of glyphosate and the presence of genetically engineered insecticidal Bt toxin in every cell of every GE crop plant, massive amounts of other pesticides (herbicides, insecticides, fungicides) are applied to genetically engineered food crops. The continuing massive overuse of pesticides – along with the failure to use refuge set-asides, the failure of GE corn to produce desired levels of Bt toxin and financial incentives for corn-on-corn planting cycles – have collectively resulted in the

selection of pesticide-resistant weeds and insects, leading to ever more pesticide applications. (See "Bt Corn Farmer Compliance with Insect Resistance", *AgBioForum,* and "Biofuels Incentives: A Summary of Federal Programs", *Congressional Research Service*, 1/11/12) This is now termed "the chemical treadmill."

Chemical companies that historically have produced DDT, PCBs, bovine growth hormone, Agent Orange, glyphosate products and, more recently, neonicotinoids have inserted themselves squarely into the seed crop production component of the world's food supplies. These corporations have a clear conflict of interest when it comes to reducing the numbers and concentrations of chemicals on crops, because any such reduction has an immediate impact on their financial bottom line. There is also a clear conflict of interest when it comes to altering farm management to avoid insect and weed resistance if it results in using fewer chemicals. As University of Nebraska entomologist Lance Meinke says, "economics are driving everything." (See "As Biotech Seed Falters, Insecticide Use Surges In Corn Belt", *NPR Morning Edition*, 6/9/13.)

The USDA has shown that since 1996, glyphosate use has increased some 12-fold during the GE crop era, with overall herbicide usage increasing by more than 500 million pounds. Meanwhile the agency has now documented weed resistance on some 60 million American farm acres. (See "USDA Report: Genetically Engineered Crops Don't Measure Up", *Examiner*, 3/5/14; "'Superweeds' Resulting from Monsanto's Products Overrun U.S. Farm Landscape", *Union of Concerned Scientists*, 12/11/13 and "Invader Batters Rural America, Shrugging Off Herbicides", *New York Times*, 8/11/14.)

The media still points to USDA charts showing that insecticide used on Bt corn had decreased substantially prior to 2010 (See "Are GE Crops Good or Bad for the Environment?" *Vox.com* 8/14, which is the last data point USDA published, but widespread reporting in subsequent literature has documented that insecticide use has dramatically *increased* since 2010.) Insecticide companies are reporting huge increases in insecticide sales applied to Bt corn. (See "Pesticides Make a Comeback: Many Corn Farmers Go Back to Using Chemicals as Mother Nature Outwits Genetically Modified Seeds", *Wall Street Journal*, 5/21/13 and "War on Cornfield Pest Sparks Clash Over Insecticide", *Bloomberg*, 1/11/14.)

Furthermore, the use of seeds coated with systemic neonicotinoid insecticides has skyrocketed in the past 10 years, but this is generally ignored. Recently, U.S.

government scientists found that the use of clothianidin on corn in Iowa alone almost doubled between 2011 and 2013, with widespread contamination of waterways and harmful effects on non-target wildlife. (See "Insecticides Similar to Nicotine Widespread in Midwest", *U.S. Geological Survey*, 7/24/14.)

Throughout the Midwest, farmers are discovering rootworms that resist genetically modified corn. Failure of the genetically engineered Bt toxin to control insect corn pests has also been recently reported in Brazil. (See "Brazil farmers say GMO corn no longer resistant to pests", *Reuters*, 7/28/14.) In Illinois, Minnesota, Nebraska and Iowa, where the rootworm has made a comeback, farmers have increasingly used toxic systemic pesticides such as clothianidin as a seed coating product or as a pre-emergent insecticide injected directly into the soil. (See "Voracious Worm Evolves to Eat Biotech Corn Engineered to Kill It", *Wired Magazine*, 3/14/14.)

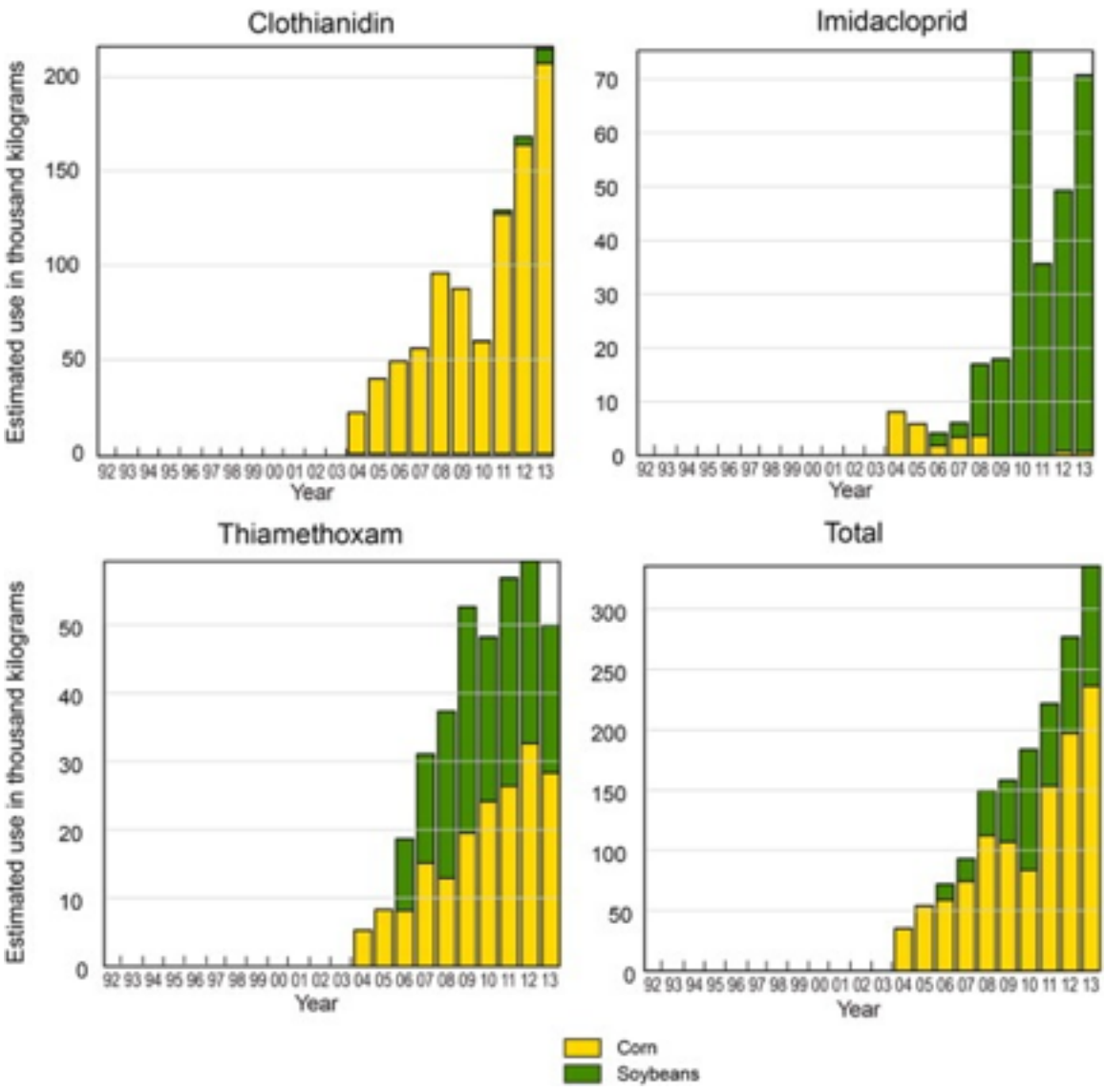
Probably for financial reasons, chemical companies have historically refused to admit that weed and insect resistance to their GE traits is an emerging – and in some locations, a serious – pest control problem. Resistance among insects and weed populations provides golden opportunities for additional corporate profits when chemical corporations offer new chemicals and engineer more genetic traits into their seed offerings. More gene traits and greater chemical use mean more profits. Through enforcement of intellectual patent rights, industry has also prohibited independent scientists from investigating emerging insect resistance problems (See "Do Seed Companies Control GM Research", *Scientific American*, 7/20/09 and "Crop Scientists Say Biotechnology Seed Companies Are Thwarting Research", *New York Times*, 2/19/09.) Without access to patent-protected genetically engineered seeds, scientists are severely limited in their attempts to identify and reduce farm crop failures. (See "Voracious Worm Evolves to Eat Biotech Corn Engineered to Kill It", *Wired Magazine*, 3/14/14.)

Company websites reflect the real story of the insect resistance problem and give farmers recommendations for controlling insect resistance outbreaks. The recommendations naturally include the use of many chemical insecticides plus multiple Bt toxin-stacked gene traits. In addition to the EPA requirement that up to 20 percent of the farmed land mass be set aside as a refuge to deter the appearance of resistant insects, farmers are strongly encouraged to develop and employ a so-called integrated resistance management scenario. This might include deployment of stacked genetically engineered Bt traits of up to eight genes (See the University of Georgia's "2012 Guide to Bt Corn"); application of pre-emergent soil-applied insecticides (insecticides injected into soil prior to crop germination); use of seeds

coated with a talcum-like powder containing up to four systemic insecticides plus a fungicide; and an annual crop rotation guide recommending the planting of other GE crops to avoid "corn after corn" cycles. There are, of course, promises of improved genetic traits in the product pipeline.

In light of the documented increased use of neonicotinoids (neonics) and insect resistance issues, one hopes the popular press will stop reporting that pesticide use in the U.S. farm belt has declined since the advent of GE crops. (See "Widespread Occurrence of Neonicotinoid Insecticides in Streams in a High Corn and Soybean Producing Region, USA", Figure 1, *Environmental Pollution*, 6/2014, which shows that 350 tons or 770,000 lbs. were used in 2014, and "Insecticides Similar to Nicotine Widespread in Midwest", *U.S. Geological Survey*, 7/24/14.) Reporting on the number of pounds of insecticide use alone does not reflect the increased toxicity and broad non-target effects that even a small amount of the now widely used neonicotinoid neurotoxins have on the ecosystem. The amounts reported in Figure 1 by the USGS are estimates only for the state of Iowa. At least seven other corn and soybean growing states in the Midwest also use neonicotinoids (See "Bee-death Insecticides Common in Midwest Rivers", *The Courier Journal*, 7/24/14). Scientists report that only 5-40 parts per billion (ppb) of these neurotoxins are lethal to pollinators. (See "Ecotoxicity of Neonicinitoid Insecticides to Bees", Table 1, and "Chronic Exposure of Imidacloprid and Clothianidin Reduce Queen Survival, Foraging, and Nectar Storing in Colonies of Bombus Impatiens", 3/18/14.) An amount of neonicotinoid powder the size of a standard pencil eraser may contain 50-100,000 lethal bee doses. The killing power of the 350 tons (770,000 pounds) of neonicotinoids used on Iowa farms last year is incalculable.

Figure 1. USGS Estimates Of Neonicotinoid Use By Year In Iowa



Source: US Geological Survey's "Widespread occurrence of neonicotinoid insecticides in streams in a high corn and soybean producing region, USA." http://www.sciencedirect.com/science/article/pii/S0269749114002802; October, 2014 (See also "Mid-western waters are full of bee-killing pesticides," Tom Philpott, Mother Jones, Jul. 29, 2014. http://www.motherjones.com/tom-philpott/2014/07/federal-agency-finds-neonic-pesticides-midwestern-water)

In the last several years, numerous scientists have shown that neonicotinoids such as clothianidin are lethal for pollinators at agricultural field concentrations and are the most likely cause of colony collapse disorder in bees. (See "Sub-lethal exposure to neonicotinoids impaired honey bees winterization before proceeding to colony

collapse disorder", Bulletin of Insectology, 2014.) Other studies show correlations between environmental neonics and the loss of birds, especially species that consume aquatic invertebrates. (See "Declines in insectivorous birds are associated with high neonicotinoid concentrations", Nature, 7/17/2014.) This study in the Netherlands was consistent with the recent study by the U.S. Geological Survey (noted above) that showed that neonics can persist from one season to the next and flush out into wetland habitats frequented by various avian species. Sadly, we have much to learn about additional non-target effects of excessive neonics use including persistence in the human food chain via contaminated food crops.

European regulators have placed a temporary halt on the use of certain neonics on agricultural crops and admitted publicly that their earlier decisions were based on faulty and incomplete data and knowledge on the fate and effects of neonicotinoids. (See "Conclusions of the Worldwide Integrated Assessment on the risks of neonicotinoids and fipronil to biodiversity and ecosystem functioning", Environmental Science and Pollution Research, 6/17/14; "EFSA identifies risks to bees from neonicotinoids"; "Conclusion on the peer review of the pesticide risk assessment for bees for the active substance clothianidin", European Food Safety Journal, 2013; and "Bees & Pesticides: Commission goes ahead with plan to better protect bees".) The European Commission has adopted a proposal [Regulation (EU) No 485/2013 PDF] to restrict the use of three pesticides belonging to the neonicotinoid family (clothianidin, imidacloprid and thiametoxam) for a period of two years.

Presumably the same information was presented to industry-friendly U.S. regulatory bodies that recently decided not to change the use status of neonics in the United States. (See "EPA Denies Emergency Petition to Suspend Clothianidin"). However, in a key development, the U.S. Fish and Wildlife Service (FWS) plans to phase out the use of genetically engineered (GE) crops to feed wildlife and will ban neonicotinoid insecticides from all wildlife refuges nationwide by January 2016. (See "Use of Agricultural Practices in Wildlife Managnement in the National Wildlife Refuge System", FWS Memorandum, 6/17/14.)

Pesticide overuse in agriculture is analogous to the overuse of antibiotics in intensive commercial livestock production systems, which has given rise to new germs that can withstand multiple antibiotics, requiring even more antibiotics at higher concentrations. These "supergerms" are like the "superweeds" and now "superinsects" that resist standard treatment options. Scientists warn that without

non-chemical management procedures, weed and insect resistances will grow and require still higher concentrations of more toxic chemicals in our food production system. The Bt insecticidal trait has not only led to resistant "superinsects," but also is directly linked to the rapid adoption and widespread use of seeds coated with systemic pesticides, which are wreaking havoc on bees and other non-target wildlife. In order to combat just glyphosate-resistant weeds, the following herbicide-resistant food crops are awaiting federal approval or are in the process of entering the commercial pipeline:

- **2,4-D tolerant crops** from Dow AgroSciences, including resistance to glyphosate, glufosinate, and ACCase-inhibitor. EPA and USDA approval expected in fall 2014; ("EPA Set to Approve Increased Use of Toxic 2,4-D on Dow's "Agent Orange" Crops")
- **ALS-tolerant crops** from Pioneer Hi-Bred, including resistance to glyphosate;
- **bromoxynil-tolerant crops** from Calgene;
- **dicamba tolerant crops** from Monsanto;
- **imidazolinone-tolerant crop**s from BASF;
- **isoxaflutole-tolerant crops** from Bayer, including resistance to glyphosate; and
- **sulfonylurea-tolerant crops** from DuPont.

A recent international report by some 60 scientists warned that current agricultural practices in developed nations cannot be maintained. (See "Wake up before it is too late: Make agriculture truly sustainable now for food security in a changing climate", Trade and Environment Review, United Nations Conference on Trade and Development.) The energy inputs, environmental destruction, habitat loss and loss of natural biodiversity are all too severe. Rapid and significant changes in the management of agricultural production systems are essential. What is recommended are agricultural practices (aka "sustainable, agroecological, or biological practices") that replace the resources consumed by intense commercial agriculture through the use of various cover-cropping strategies, ecosystem-friendly crop rotations and less use of toxic chemicals. (A good example envisioned on a large scale is described in "The Healthy Farm: A Vision for U.S. Agriculture", Union of Concerned Scientists.)