Next Up: 2,4-D

Weed and insect resistance caused by genetically engineered crop failure treadmill

By Nichelle Harriott

2,4-D Corn and Soybeans: Bad for Agriculture, Bad for the Environment, Bad for Health

The U.S. Department of Agriculture (USDA) is on the verge of allowing into cultivation the latest round of genetically engineered (GE) crops –corn and soybeans engineered to be resistant to the highly toxic herbicide 2,4-D. The agency released its draft Environmental Impact Statement (DEIS) last December for public comment, announcing its plan to deregulate these crops. This is a devastating decision for farmers, the environment, and public health. 2,4-D, one ingredient in the deadly Agent Orange that was used to defoliate forests during the Vietnam war and the cause of severe illness in exposed veterans, will now enter the environment at elevated rates as integral to a cropping system that uses 2,4-D-tolerant engineered crops. This, despite decades of science showing that this chemical is highly toxic, linked to numerous short- and long-term health and environmental impacts.

Behind this development is a story that has been unfolding in the science literature and on farmland across the country. Genetically engineered, herbicide-tolerant, Roundup Ready crops (created by Monsanto) are failing. The GE crops, originally designed to be cultivated with and tolerant of the use of the herbicide Roundup (glyphosate), have spawned a new generation of resistant "superweeds." These superweeds are no longer being killed by Roundup, whose use on these crops has increased dramatically since their introduction in 1996. In fact, one 2012 report shows that GE crops have been responsible for an increase of 404 million pounds of pesticide, or about 7%, in the U.S. over the first 16 years of commercial use of GE crops (1996-2011). The prolific presence of Roundup in the environment means that wild plant/weed species gradually developed an immunity to the chemical. Not surprisingly, industry's solution to the growing GE-induced weed resistance, given that its business model requires increasing pesticide sales, is to develop new engineered crops tolerant to more toxic pesticides. Those following the history of chemical-intensive agriculture, which developed with World War II chemicals and an orientation to killing unwanted organisms rather than preventing them with management practices, are watching history repeat itself –from the pesticide treadmill to the herbicide and insecticide-tolerant GE crop treadmill. What makes this point in history different, however, is the burgeoning organic agriculture and food industry that has proven the commercial and economic value of soil-building practices and systems respectful of beneficial organisms.

A Solution for Weed Resistance?

2,4-D tolerant corn and soybeans, and their accompanying use of 2,4-D (a new choline salt of 2,4-D, Enlist™), are being marketed by the petitioner Dow AgroSciences as a solution to combat the surge in Roundup-resistant weeds brought on by Roundup Ready GE crops and the accompanying increase in herbicide use. In theory, 2,4-D, with its different mode of action, would now control these resistant weeds.

However, experts say these new 2,4-D-tolerant crops and the associated increased 2,4-D use will not provide the solution to escalating weed resistance. Instead, they threaten to introduce more damage to plants through the selection of yet another strain of resistant weeds –2,4-D resistance. It is therefore counterintuitive and futile to treat the impacts of GE use with more GE crops and increased herbicide use.

USDA estimates 2,4-D use to increase 1.75-3 times current use,[1] with the new GE corn and soybean crops. Independent estimates are much higher. Additionally, USDA notes in its DEIS that, given the prevalence of Roundup-resistant weeds, it is "very likely" that 2,4-D resistant weeds will occur, and that the adoption of 2,4-D corn and soybean can have a "potentially significant environmental impact" on the proliferation of resistant weeds, due to an increased reliance on 2,4-D for weed control. Further, the agency acknowledges that possible onset of 2,4-D resistant weeds will mean that farmers relying on 2,4-D will likely experience "increased socioeconomic impacts from more costly and restrictive weed control alternatives" to combat these weeds. Already, 28 species across 16 plant families have evolved resistance to the synthetic auxin herbicides, of which 2,4-D is one. They mimic plant growth hormones (also known as plant growth regulators). Sixteen species of plants are known to be resistant specifically to 2,4-D.[2] As 2,4-D resistance grows, chemical-intensive farmers will look to even more toxic chemicals to control these weeds at great economic and environmental costs.

Given that USDA is aware of the problems associated with GE crops, herbicide use, and the onset of resistant weeds, it is remarkable to those tracking the technology that the agency is effectively encouraging successive generations of GE crops. Critics say that the agency should be encouraging farmers to move to sustainable farming practices that protect the economic and environmental future of U.S. agriculture.

Ignoring the Science: 2,4-D Drift, Dioxin Contamination, Threats to Human and Environmental Health

Compounding the costs of weed resistance is the inherently toxic nature of 2,4-D and the environmental damage that can occur. 2,4-D drift has long been a known problem to off-site locations, endangered species, and non-target crops. Many forms of 2,4-D volatilize above 85°F[3] and 2,4-D drift has been known to damage specialty crops, like tomatoes and grapes, half a mile or more from the application site, even at concentrations 100 times below the recommended label rate.[4] In addition to non-target plants, 2,4-D can impact species listed under the jurisdiction of the *Endangered Species Act* (ESA). In fact, in 2011, the National Marine Fisheries Service (NMFS) identified 2,4-D as likely to jeopardize all listed salmonid, based on current registration and label directions.[5] No surprise that 2,4-D is also commonly detected in surface and ground water in regions of heavy use.[6,7]

Dow AgroSciences maintains that the new 2,4-D choline salt formulation (Enlist™), which will be exclusively used with the new 2,4-D-tolerant corn and soybeans, is anticipated to have lower volatility (50 times lower) and, as a result, decreased drift compared to other forms of 2,4-D.[8] However, the technical information supporting this has not been made available for public or peer review. Moreover, the surfactants and adjuvents added to commercial mixtures that can substantially alter volatility are, at present, unknown. There is no publicly available data to verify Dow's claims. The U.S. Environmental Protection Agency (EPA) is currently reviewing the registration of 2,4-D, including this new choline salt, but will not have a decision before 2017.

2,4-D ChemWatch Profile

CAS Registry Number: 94-75-7

Use: B2,4-Dichlorophenoxyacetic acid, commonly known as 2,4-D, is a widely used herbicide in the phenoxy class of chemicals. 2,4-D is a selective herbicide used to kill broadleaf weeds, and is the most commonly used pesticide in the non-agricultural sector, and in the top 10 most common in the agricultural sector, with 25-29 million pounds being used in the U.S. annually.

Mode of Action: 2,4-D is a plant growth regulator, and mimics the natural plant growth hormone, auxin. It causes rapid cell growth leading to plant death. While 2,4-D is normally applied to a plant's leaves, it can be absorbed through the roots and stems. 2,4-D is produced in several forms, including acids, salts, amines and esters, and its toxicity varies between the different forms.

Environmental Fate & Toxicity: 2,4-D is said to have low persistence in both soil and water. However, 2,4-D has a high potential to leach from soils, and therefore a potential for contaminating groundwater. 2,4-D has been shown to have negative impacts on a number of animals. 2,4-D is slightly toxic to wildfowl and slightly to moderately toxic to birds. In frogs, 2,4-D interferes with a sex hormone and stops frog eggs from maturing. 2,4-D is linked with both cancer and testicular problems in dogs. Exposure of certain dogs to lawns treated with phenoxy herbicides is associated with an increased risk of bladder cancer. The herbicide also has negative effects on a range of beneficial insects. It reduces offspring numbers in honey bees, kills predatory beetles and ladybug larvae.

In addition to the environmental consequences 2,4-D use brings, the pesticide's contamination with dioxins remains a part of 2,4-D's chemistry. While recent manufacturing advancements have reduced dioxin levels in 2,4-D, the threat of dioxin contamination is still very much a consequence of 2,4-D use. The science is very clear that dioxins are a class of chemicals that cause cancer, reproductive and developmental problems, damage the immune system, and interfere with hormones. They have left a toxic legacy for human and environmental health across the U.S. due to their persistence and toxicity. The issue of 2,4-D contaminants, such as dioxins that are present in formulations, has been ignored and is probably much more serious in terms of degradation issues than the "active ingredient." Dioxins have notoriously long half-lives, are bioaccumulative, and present broadly significant health risks developmentally and postnatally, including increased risk of heart disease and diabetes.[9]

In regard to human toxicity, the scientific literature demonstrates that 2,4-D as an active ingredient is neurotoxic, mutagenic and genotoxic, and poses serious risks to human health. 2,4-D is also an endocrine disruptor and is known to interfere with the thyroid hormone. According to EPA, current data "demonstrate effects on the thyroid and gonads following exposure to 2,4-D, [and] there is concern regarding its endocrine disruption potential."[10] EPA researchers found that persons with urinary 2,4-D presence have low levels of thyroid hormone. Their results also indicate that exposure to 2,4-D is associated with changes in biomarkers that have been linked to risk factors for acute myocardial infarction and type-2 diabetes.[11] Other studies find that those exposed to 2,4-D have poor semen quality.[12,13] Higher rates of birth defects are also observed in farmers with long-term exposure to 2,4-D.[14]

Occupational exposure to 2,4-D has also been observed to increase the risk of Parkinson's disease. Studies have reported that 2,4-D has effects on dopaminergic neurons in experimental settings and is associated with more than a three-fold increased risk of the disease.[16] 2,4-D is also associated with non-Hodgkin lymphoma (NHL) and a high incidence of NHL has been reported among farmers and other

Right to Know How Food Is Produced

People nationwide want the right to know whether or not their food is grown with or contains GE ingredients. A recent *New York Times* poll shows national support for GE labeling reaching 93%,[20] a number consistent with past polls showing broad support that cuts across race, gender, socio-economic class, and political party affiliation. Consumers are concerned with the environmental and human health impacts that are associated with the cultivation of GE crops. They care about the food they eat.

In the absence of a federal labeling requirement, it is up to the states to give consumers the information they need to make informed choices for their families. States passing legislation are putting consumers first and give them the power of choice. People want to be able to make choices in the marketplace that they believe are protective of their family's health and the larger environment in which food is grown. Because we have a regulatory system at the federal level that has deregulated major GE crops in agriculture without complete health and safety reviews associated with their cropping systems, consumers want the ability to make independent judgments. This is especially true in light of increased pesticide use in GE crops, elevated pesticide exposure, and residues of modified toxins found in human blood samples.

Politico reported early in 2014 that, "The Grocery Manufacturers Association, on behalf of the food industry, is pitching to Capitol Hill lawmakers a bill that would preempt any state mandatory GMO labeling requirement by creating a voluntary labeling standard…" The discussion draft of the legislation would prohibit states from requiring GE food labeling legislation.

occupational groups working with 2,4-D. According to the National Cancer Institute, frequent use of 2,4-D, has been associated with two- to eight-fold increases of NHL in studies conducted in Sweden, Kansas, Nebraska, Canada, and elsewhere. Farmers using 2,4-D are associated with an increased risk of NHL in 131 lymphohematopoietic cancers (LHC) in a case-control study embedded in a cohort of 139,000 members of United Farm Workers of America (UFW) diagnosed in California between 1988 and 2001.[17]

Advocates have argued that the science has shown for decades that 2,4-D is a chemical whose use should be decreasing, not increasing with new chemical-reliant crops. With environmental damage to non-target plants, possible dioxin contamination and human health concerns, 2,4-D has proven that it is harmful for the environment and human health.

Non-GE and Organic Farmers Left to Fend for Themselves

It is inevitable that genetic drift from GE fields can contaminate non-GE and organic crops. For instance, corn, a wind pollinated crop, has the potential to have its genetic material (pollen) transfer across neighboring plants and crops. Evidence suggests that GE corn plants can cross-pollinate non-GE corn plants up to and beyond a distance of 200 meters.[18] Unfortunately, many farmers have been sued by Monsanto after GE genetic material was detected on their farms. Industry giants like Monsanto claim that farmers are responsible and liable for its genetic property being found on land farmed by farmers who did not pay to cultivate the company's genetically engineered crop. Organic farmers have continued to fight for their rights against GE contamination, but it has been an uphill battle. A 2011 lawsuit, *Organic Seed Growers and Trade Association (OSGATA) et al., v. Monsanto*, sought to protect farmers from GE trespass. A District Court dismissal (2012), followed by a U.S. Court of Appeals decision (2013) upholding the lower court, entered under the rules of evidence an assurance from Monsanto that it would not sue farmers with "trace amounts" (less than 1%) of GE crop contamination for patent infringement. According to Reuters, between 1997 and 2010 the agrichemical giant filed 144 patent-infringement lawsuits against farmers that it said made use of its seed without paying royalties. The U.S. Supreme Court refused to hear the case. Organic and non-GE farmers remain seriously concerned that their farms and livelihoods will be adversely affected by GE contamination.

USDA, in deregulating GE crops, continues to put non-GE and organic farmers at risk from economic losses and legal retaliation from industry. The agency believes that these farmers should take steps to defend themselves by erecting barriers and buffer zones, or delaying planting to minimize contamination. With this scenario, the burden lies solely on the farmer, who is afforded little to no redress for lost value of the contaminated crop and still unprotected from GE drift. Even though Dow claims that the new formulation of 2,4-D is less volatile than other forms, 2,4-D drift remains a serious concern.

Failed Promises, New Way Forward

The proposed deregulation of GE crops is being met with criticism from farmers, environmentalists, and other concerned groups. A decision to deregulate 2,4-D-tolerant crops and allow its unrestrained marketing will exacerbate the treadmill of U.S. chemical-intensive farmers becoming more dependent on toxic inputs to grow food. Thus far, after billions of dollars in research and public relations campaigns, the promises made by the biotechnology sector have not come to pass. GE crops have ushered in increased pesticide use, increased weed resistance, and a regression to more toxic chemicals. Additionally, GE yields are not significantly higher than non-GE.[19]

Similar to previous decisions to deregulate other varieties of GE soybeans, alfalfa, and sugar beets, safety advocates charge that USDA continues to fail at taking into account several scientifically-validated environmental and human health concerns, especially in light of documented problems created by these herbicide-tolerant GE crops.

2,4-D and its resistant crops, as well as other herbicide-tolerant strains, are not the solution for weed resistance created by increased herbicide use on GE crops deregulated by USDA. Had proper precaution and thorough environmental assessment been conducted for previous GE decisions, the economic and environmental fallout of resistant weeds could have been avoided. It is time for the agency to focus on organic practices and other sustainable, integrated methods for long-term weed management, which allow the nation's farmers to get off the toxic GE treadmill.

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Insecticide Incorporated GE Crops

Genetically engineered crops are often broken down into two categories, herbicide-tolerant and plant-incorporated protectants (PIPs), a euphemism for pesticide-incorporated plants. In addition, crops are also engineered or "stacked" to express multiple traits, such as crops that are resistant to multiple herbicides or are resistant to herbicides and incorporate insecticides.

PIPs are created when scientists take the gene for a specific pesticidal protein and introduce it into the plant's genetic material. Then the plant continuously expresses the pesticidal protein that kills the target insect when it feeds on the plant. Both the protein and its genetic material are regulated by the Environmental Protection Agency (EPA). The plant itself is not regulated.

In 1995, EPA registered the first *Bacillus thuringiensis (Bt)* plant-incorporated protectant for use in the U.S. Since then, EPA has registered 11 *Bt* plant-incorporated protectants, although five are no longer active. Corn and cotton *Bt* incorporated varieties were introduced in 1995 and a *Bt* variety of soy was registered in 2010.

Insect resistance to the engineered crops has raised concerns about the efficacy of natural *Bt* used in organic food production and the loss of an important tool.

Resistance

Target insect or plant resistance is a predictable consequence of prophylactic and repeated pesticide use, as has been seen with the use of antibiotics. How quickly pesticide resistance develops depends on the frequency of use, the mechanisms of resistance, the size of the gene pool, and the rapidity of the organism's reproductive cycle.

Reports of resistance to certain varieties of *Bt*-incorporated plants have been widely reported. A study, "Severe Corn Rootworm Injury to *Bt* Hybrids in First-Year Corn Confirmed" (Spencer and Gray, 2013), identified significant damage from western corn rootworm in farm fields that were planted with GE corn incorporated with a *Bt* protein referred to as "Cry3Bb1," which has been inserted into nearly one-third of the corn planted in the U.S.

"Field-Evolved Resistance to *Bt* Maize by Western Corn Rootworm" (Gassman et al. 2011) verifies the first field-evolved resistance of corn rootworm to a *Bt* toxin.

EPA has concluded that, "Corn rootworm may not be completely controlled by Cry3Bb1 in certain parts of the corn belt." (2013)

"Potential shortfall of pyramided transgenic cotton for insect resistance management" (Brévaul et al 2013) found that stacking several *Bt*-incorporated traits does not stop resistance.

Older Insecticides Brought Back

According to the *Wall Street Journal* (2013), insecticide sales soared in 2013 as target insects have developed resistance to GE crops that incorporate an insecticide. Pesticide manufacturers American Vanguard, FMC Corp, and Syngenta have all reported higher sales in 2012 and 2013 than in previous years. Syngenta alone reported doubling sales in 2012. Similarly, American Vanguard reported soil insecticide revenues rose by 50% in 2012.

Environmental and Food Contamination

In a 2011 study, "Evidence of reduced arbuscular mycorrhizal fungal colonization in multiple lines of *Bt* maize" (Cheeke et al. 2011) found that the cultivation of GE corn, which expresses *Bt*, has negative impacts on beneficial soil life. Their findings show a decreased presence of beneficial arbuscular mycorrhizal fungi (AMF) colonization in multiple *Bt* maize.

"Occurrence of maize detritus and a transgenic insecticidal protein (Cry1Ab) within the stream network of an agricultural landscape" (Tank et al. 2010) finds that streams throughout the Midwest are contaminated with transgenic materials from corn crop byproducts, with BT toxin at 23 percent of the sites.

StarLink™ GE corn, only registered for domestic animal feed, was detected in taco shells, indicating that it had entered the human food supply.

Human Health Risks

"Maternal and fetal exposure to pesticides associated to genetically modified foods in Eastern Townships of Quebec, Canada" (Arisa et al. 2011) found that the Cry1Ab toxin was detected in 93% of maternal blood samples, 80% of fetal blood samples and 69% of the nonpregnant women's blood.

"A Comparison of the Effects of Three GM Corn Varieties on Mammalian Health" (Spiroux de Vendômois et al. 2010) found that three varieties of *Bt*-incorporated corn crops show varying levels of adverse health effects, primarily in the liver and kidneys, in addition to the heart, adrenal, spleen and blood cells.

Risks to Organic

Use of natural *Bt* in organic crops production is part of a systems approach and only used when needed. However, resistance caused by GE *Bt* will undermine the effectiveness of this tool.

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