Endocrine Disruption and Turfgrass Pesticides

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Most people don't know who Philippus Aureolus Theophrastus Bombastus von Hohenheim is, but his work and theories in the early 16th century has had a profound effect on how pesticides are regulated around the world today. Better known as Paracelsus, this Swiss biologist is often referred to as the father of toxicology. In general terms he is probably most famous for naming the metal zinc, but in the world of toxicology he is most famous for developing the phrase "the dose makes the poison." In other words, Paracelsus realized from his experiments that basically anything could be toxic when presented in large doses. On the other hand, basically anything could be non-toxic if exposure was sufficiently small.

There was no doubt that some substances were more toxic than others and needed to be contained to prevent toxicity, but the underlying theory that anything can be toxic in the proper dose was a critical thought process and still holds today. The Environmental Protection Agency (EPA), and similar agencies around the world, still regulate pesticides based on this theory today. The Food Quality Protection Act (FQPA) of 1996 mandated that chemicals be regulated based on their total exposure in the environment, the so-called "risk cup." This meant that even highly toxic chemicals still could be present in the environment and in food if kept below levels established generally through animal testing. But those "acute" toxicity levels are generally developed by how much of the pesticide causes 50% of the animal population to die. As both the knowledge of and the concern over pesticides in the environment has increased, it's clear that much more than the death of an organism is important in determining pesticide toxicity.

One non-acute effect of pesticides and other toxins in the environment that has been garnering increased attention in recent years is the activity of endocrine disruptors. Much of this increased attention can be attributed to the ongoing regulatory battle of bisphenol A (BPA), a common compound used in many plastics. BPA, like other endocrine disruptors, has been implicated as a factor in breast cancer, prostate cancer, and other reproductive disorders. Endocrine disruption is a general term for any substance that may interfere with the endocrine system, which includes many hormones secreted by the hypothalamus, pituitary gland, thryroid gland, and gonads. The key difference between endocrine disruptors and other forms of pesticide toxicity is the extraordinarily low concentrations at which the endocrine system can be disrupted. This has altered long-held beliefs about the dangers of environmental compounds present in very low concentrations, and shows that Paracelsus' theory may not be relevant when it comes to endocrine disrupting chemicals.

Endocrine disruption (ED) is difficult to determine in nature or humans for two main reasons. One, as previously discussed, ED can be initiated at very low toxin concentration. Two, because some ED agents act during reproduction it can take years or generations to see the effects (Mendes, 2002). In fact, much of the early endocrine disruption observations occurred in amphibious organisms that had altered sex characteristics and reproductive disorders. It wasn't until decades later, and the book Our Stolen Future by Theo Colburn in 1996, that the potential effects of EDs were recognized on a large scale. The widespread nature of ED agents in the environment coupled with the increasing rates of breast cancer, prostate cancer, testicular cancer, and decreasing sperm counts present in the male population led many to look for a potential connection (Mendes, 2002).

How does endocrine disruption affect the current array of turfgrass pesticides? The current answer is not at all, but that will likely change. In 1994 the National Academy of Science formed the Endocrine Modulators Panel. A little-known provision in the 1996 FQPA required that pesticides be screened for estrogenic effects that may alter the endocrine system, BUT that appropriate tests be used in the analysis. The use of appropriate tests is where the system has really bogged down. In 1996 the Endocrine Disruptors Screening and Testing Advisory Committee (EDSTAC) was formed, and released its final report for testing in 1998. In 2001, an Endocrine Disruptor Methods Validation Subcommittee (EDMVS) was formed to further develop quality screening assays that could determine the endocrine disrupting effects of environmental chemicals. These committees formed two "tiers" of screening assay designed to determine the endocrine disrupting effects of chemicals accurately and efficiently. Tier I assays are a series of assays that are meant to test short-term effects quickly and cheaply. Examples include how tightly the pesticide molecules bind to different endocrine molecules in the lab, and how they affect the organ development in certain animals. Critics of the Tier I assays say they are prohibitively expensive, and that binding to endocrine molecules in the lab may mean nothing in nature. Tier II assays are meant to test reproductive effects and are generally done in rat, fish, or frog experiments. Critics of these assays cite the even higher costs of the Tier II assays and the wide range of effects that alter reproduction in these animal systems.

Despite these criticisms and delays, routine screening by the EPA for endocrine disruption appears to be progressing. Ten years following the formation of the committee to develop the endocrine disruption screening, an initial list of chemicals for endocrine screening was released on April 15th, 2009. Nineteen months later, in November of 2010, an additional list of chemicals to be tested was released by the EPA. A number of turfgrass pesticides are present on these two lists and will be tested for their ED effects in the coming weeks, months, and years (Table 1). It is important to note, though, that inclusion on this list is simply by means of potential exposure to the public and other at-risk groups and is not meant to suggest any endocrine disruption activity. Chlrothalonil, for example, is on this list but has shown little to no signs of ED activity in university assays (Andersen et al., 2002). Iprodione and vinclozolin, on the other hand, are also on this list and have been implicated in several university studies as ED agents (Blystone et al., 2007; Ferraris et al., 2005).

More information on the endocrine disrupting effects become available it is likely that as an applicator of pesticides you may be asked by members of your club or members of the public to provide more information about the products you apply. An in depth knowledge of the subject is unnecessary and likely impossible unless your employer has the money to send you to medical school. Recognition of the term endocrine disruptor, a basic knowledge of the effects that ED agents may cause, and a listing of any products in your chemical shed that have been implicated as ED agents will go a long way towards the perception of turfgrass managers as responsible stewards of the environment. For more information on the EPA's endocrine disruptor screening program, including the full list of chemicals to be screened, visit www.epa.gov/endo.

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Initial List on April 15, 2009	Additional List on Nov 17, 2010
2,4-d	Fosetyl-AI
Captan	Fenarimol
Carbaryl	Paclobutrazol
Chlorothalonil	Thiophanate-methyl
Flutolonil	Trinexapac-ethyl
Iprodione	Vinclozolin
Metalaxyl	
Myclobutanil	
Propiconazole	
Tebuconazole	
Triadimefon	

Table 1. A list of the chemicals of potential interest to the turfgrass industry that are included in the final list to be screened for Tier I endocrine disrupting activity. Inclusion on this list is based solely on potential exposure to the public and at-risk populations and does not imply endocrine disrupting activity.

References:

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Ferraris, M., Flora, A., Chiesara, E., Fornasari, D., Luccetti, H., Marabini, L., Frigerio, S., Radice, S. 2005. Molecular mechanism of the aryl hydrocarbon receptor activation by the fungicide iprodione in rainbow trout (Oncorhynchus mykiss) hepatocytes. Aquatic Toxicology 72: 209-220.

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