# IPM IS A STRATEGY THAT WILL SUSTAIN PESTICIDE TECHNOLOGY AS A VIABLE TOOL FOR MANAGING RISK

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IPM is dead!

I thought that phrase might turn your head. It emphasizes what I am witnessing as the two minds about IPM. First, insect ecologists have been arguing for well over a decade that we're not really practicing IPM (Integrated Pest Management) anymore. Rather, we are practicing Integrated Pesticide Management, and somehow we've lost our way. To this point of view, all systems seem to rely too heavily on therapeutic techniques, with pesticides as therapy number one. Surely, if we just understood the ecology of the cropping system, we would be much more successful at deploying preventative tools. Second, some crop protection specialists are purportedly arguing that the new bevy of reduced risk pesticides, having incredibly low toxicity to non-target organisms and high specificity for pests, are tools in the arsenal to satisfy environmental concerns while gaining maximum control of all of our pest problems in lieu of IPM. I am hopeful for the bloom of a third perspective. I view IPM as a decision-making methodology that must be dynamic to achieve what is the logical goal of the business of farming: reduce costs, increase quality and quantity of output, and make a profit. Surely, the latter must be considered sustainable, especially among farmers who understand that environmental quality is akin to state-of-the-art, well maintained infrastructure.

For good or for bad, all farming systems use pesticides because they are effective against a diversity of pests, fast acting, useful in emergencies, and have a very low cost to benefit ratio. The difference between farming practices considered sustainable, such as certified organic production, and conventional practices is more about the kinds of pesticides allowed than use or non-use of pesticides. However, whether any particular pesticide remains a viable, effective tool long into the future depends on overcoming limitations observed even before the advent of DDT. These limitations include destruction of insect pests' natural enemies, rapid evolution of pest resistance, prolonged presence of residues beyond a growing season, and uncertainties over health effects. Many of these limitations are being overcome with the introduction of reduced risk pesticides. However, these new pesticides will only remain effective when used as part of a comprehensive IPM program that serves as decision support strategy. Following the principles of IPM, growers can use the new pesticides to achieve better integration of biological and chemical control techniques, thereby assuring long-term capabilities for adequately controlling pests.

In this paper, I explore why I think we've become a little too complacent about IPM, and address somewhat the concerns of those desiring an ecologically based IPM rather than Integrated Pesticide Management. Given that IPM is a systematic methodology for "doing the right thing" to protect crop yield and quality, I'm more concerned about rumors of the irrelevancy of IPM with the advent of our new and improved crop protection chemistries. Therefore, I offer several hypotheses to explain the troubling perspective that somehow crop protection practices don't need IPM any more. First, so many groups with varied agendas have bastardized the definition of IPM that we forgot that it is a dynamic ecologically based risk management system rather than a panoply of off-the-shelf products (Zalom, 2001). Second, the ingenuity of chemistry has lulled us into complacency about the costs of the technology and the problems of sustaining new products. Third, the amazing effectiveness of pesticides in concert with the greater dependence on international markets and standards has displaced the focus from making an annual profit to "counting dead pest bodies".

**Will the Real IPM Please Stand Up?**

I'm sure my faculty colleagues have become aware, perhaps painfully, of the tendency of policy makers and administrators to focus increasingly on outcomes (while still focusing on how many publications and grants are produced each year). How many people did you reach, affect, or change? Or, how much money will this save for them or us? etc. Of course, as scientists trained in experimentation and hopefully still exercising the practice of science, we're interested (hopefully) in understanding how and why the world works as it does. So in our reductionist tendencies to understand life's great mysteries, we are reduced to fitting our academic interests into a preconceived notion of what the outcome should be. Applying this concept to IPM funding, I've noted a comparatively new partnership between the EPA and the American Farmland Trust (AFT) to fund IPM programs that are outcome based ("FQPA/Strategic Agricultural Initiative Program Grants" at URL: http://www.aftresearch.org/grant/ ). The program has adopted the Rensselaerville Institute outcome funding framework to force longtime practitioners of IPM research and educators into concocting estimates of outcomes such as how many growers will be changed, the reduction in use of EPA-targeted pesticides (a euphemistic phrase for OP insecticides), and progress toward implementation of ecologically based pest management or biointensive IPM. To quote from a recent request for applications in EPA Region 10 of the United States (which includes the Pacific Northwest), "Proposals are ranked on potential for success and potential to achieve the two desired outcomes of reducing pesticide use and/or risk and increasing the adoption of biointensive IPM."

Such outcomes may be the epitome of the problem regarding the incessant discussions of the future of IPM. First, it essentially gives weight to the myth that IPM's objective is to reduce pesticide use. The stated outcome goal presumes the existence of a technology called biointensive IPM as an off-the-shelf remedy rather than a virtual reality concept made up to re-create the definition of IPM for sale to a new batch of legislators and their staff who are assigned to read the plethora of reports about how bad (or good) things are.

If policymakers are really interested in fundamental change among growers, they better first agree on what IPM is really about. Without a coherent, logical, and reality-based definition, how is progress toward implementing rational pest management programs to be measured (Kogan, 1998)? A compendium of IPM definitions that covers the years 1959-1999 (http://www.ippc.orst.edu/IPMdefinitions/) suggests two basic types of definitions are circulating. One perspective is IPM as an integration of many tools for controlling pests, and an avoidance of pesticides, to be used only as a last resort. Such a definition is definitively outcome based — you can measure the reduction in pesticide use, for example, and it fits well with the EPA/AFT granting program. The other perspective is strategy focused — how do you know what to do and when to do it, or do you need to do anything? The specific tools used once a decision is made necessarily can affect successful implementation of your whole strategy, but the use or non-use of any one tool is not the measurement point for success.

So what is IPM? The definition you gravitate to will depend on your agenda. After reviewing tens of definitions, Kogan (1998) described IPM as "a decision support system for the selection and use of pest control tactics, singly or harmoniously coordinated into a management strategy, based on cost/benefit analyses that take into account the interests of and impacts on producers, society, and the environment." This definition suggests the ecological and economic concepts that gird IPM and includes some perspective that risk assessment and management are integrated. Everyone should be happy with his definition because it includes all stakeholders. Surely diehard pesticide users still relying on the old saw of prophylactic treatments can certainly support the concept of "decision support system". After all, if not for the fundamental knowledge of an agroecosystem as dependent on the functional mechanics of ecological relationships (i.e., the foundation of IPM), how would you know what week to start spraying?

As further explication of the role of IPM in correctly applying control tactics, especially pesticides, let's presume that an ancient method putatively capable of controlling moth larvae has been resurrected. According to Pliny the Elder (23-79 AD), "Apples were said to be preserved from the attack of caterpillars as well as from rot by touching the top of the tree with the gall of a green lizard" (Shepherd, 1939)." Use of IPM as a decision support system would ask certain questions and guide appropriate use of this "reduced risk," biointensive technology. For example, we need to know how long the lizard gall works. We need to answer if its application should be timed as close as possible to when the earliest instars are about to hatch. After all, it is a reasonably well-known principle from insect toxicology that the earlier instars are more susceptible on a biomass basis than the later instars. Someone has to scout for the eggs so the gall is used correctly. Otherwise to use it at the wrong time risks an ineffective waste of time as well as money that went into capturing the lizards. Wouldn't it be just as egregious if we sprayed a pesticide when there was no pest problem or at the wrong time in a pest's life cycle? Perhaps you might call the practice an application of unmitigated gall.

**Aren't Chemicals Grand … and Ephemeral?**

If all a grower cares about are outcomes in one season, then there is no reason to sit through another lecture about IPM, because there is a pesticide out there for everyone. And those tools work damn well. However, pesticides in use today provide a false sense of security because they are so much better (i.e., more selective, more toxicologically benign, less disruptive to nontarget organisms and communities) than yesterday's pesticides. Thus, they may have lulled us into thinking that the process of IPM is passé.

Perhaps a trip down memory lane to wake us from our stupor is in order. Pesticides have been a technological option for millennia, but pesticides that work well were inventions of the mid 20$^{th}$ century. DDT was the silver bullet that saved millions of lives as louse borne epidemic typhus was on the verge of taking off in 1940s Europe. Malaria was the scourge of tropical climates everywhere, as our soldiers in the Pacific Theater learned during the war. Again, DDT was the simple, magical elixir to defeat the nonhuman foe. But those fantasy pictures of the neatly coiffed housewife in dress and high heels blissfully pumping sprays of DDT around her kitchen to control flies turned dark as the silver bullet was transferred to the agricultural sector.

Not too long after DDT jumped from public health savior to the over used method of controlling all types of agricultural pests, problems began to multiply (Stern et al., 1959). Entomologists quickly observed insects of non-economic importance cross the threshold from secondary pests to primary pests. Resurgence of pest populations despite DDT application signaled something was going awry. The need for increasing DDT application rates to achieve acceptable control after just a few years of use came so swiftly as to make creationists begin to believe in the process of evolution. One by one, insect species succumbed to resistance development as if they had read Darwin's *The Origin of Species*.

Lest my friends in the weed control world think they are not victims of lack of implementation of fundamental principles of IPM, let them count the number of weed species that developed resistance to new herbicides like imidazolinones and sulfonylureas as rapidly as wildfire could scorch rangelands infected with cheatgrass. Is glyphosate next, or just a low level infection as its specific monogenic mode of biochemical action has become applicable over huge acreages of weeds that never before could experience its wrath in the midst of growing crops. How certain are we that in the absence of an ecological perspective on population dynamics and economic injury levels the new biotechnology-derived host plant resistance engineered with single, or even stacked, genes will stave the evolutionary imperative of differential reproduction?

Some may profess that IPM has nothing to do with pesticide resistance management strategies, but in short, they couldn't be more wrong. Monitoring populations whether for density or for resistant alleles is most definitively part and parcel of IPM. While chemical class rotation and transgenic crop-free refuges have been touted as slowing or even reversing resistance development, adhering to use of a pesticide only when necessary is still the best way to relieve resistance pressure. The idea is to have available pesticides (and resistant crop varieties) that work in an outbreak, when you really need it.

Agricultural chemical manufacturers are dwindling in number, having consolidated so rapidly as to create proverbial soup lines of agricultural scientists looking for gainful employment. New instrumentation to automate the organic synthesis laboratory with combinatorial chemistry has made it even harder for chemists to stay off the streets. The result has been good for the proverbial bottom line, but the grower is not on that line. Stockholders come before growers. It is up to the agricultural community to sustain its technological tools. And the only way to do that is to understand that they are best used in response to decision-making that is informed by knowledge of functional principles of applied ecology and statistically based population measurement systems and economics. To apply pesticides without the adequate use of decision systems is to not act in one's self interest but to give yourself up to manufacturers who focus on the quarter, not the decade. Should we abandon IPM now will the current tools used as a result of crop protection decisions be just as ephemeral as the utility of the great miracle insecticide DDT in previous generations?

I have three caveats about being enamored with the newly registered, reduced-risk pesticides and any thought they might save us in the absence of an IPM program. First, many problems still exist without solutions amenable to chemical technology. For example, plant viruses and some other insect transmitted disease microorganisms have no chemical solution. Exotic species are found often in today's highly mobile world, and new pest problems arise continuously. Thus, the trend in pesticides for more selectivity and safety will not solve new problems until we understand population ecology.

My second caution about the new pesticides is that their cost of development and registration is becoming so high, and the return on investment so laggardly relative to the length of patent protection, that minor crops supportive of the farm economies outside of the Corn Belt do not have the products they need, especially when exotic pests become established. Third, the so-called reduced-risk pesticides are not just about being less hazardous to humans and terrestrial and aquatic wildlife. Successful crop protection with the new pesticides must rely on their potential for conservation of natural enemies and beneficial arthropods like bees. The neonicotinoid insecticide imidacloprid is an example of a compound with a nearly innocuous toxicological profile that has come under suspicion because of evidence of effects on increasing fecundity of phytophagous mites (James and Price 2002), high toxicity to some Coccinellid (ladybird beetle) predators (James, 2003), and potential cause of bee toxicity when used as a seed treatment in sunflower production (Suchail, 2001; Decourtye, 2004). In a word, there is no free lunch.

**Are International Markets Pushing Us Away from Profitability?**

Let me share my perspective as a Corn Belt boy who went west to the great Pacific Northwest, land of salmon worship and Microsoft. In Washington State a source of pride is our number one position in pome fruit production. But viable growers know that our exports keep the industry alive because the domestic market is too small. Adding insult to injury is the displacement of U.S. apple culls to the juice processors because China has about six times more apple acreage than in the whole of the United States and China knows where to send its fruit. The U.S. consumers' attitude about blemishes is the least of worries at the moment. Rather, our international markets have become our customers, and we bow to their wishes. And what do they demand? Like victims of multiple personality, they simultaneously demand, for all practical purposes, zero pesticide residues (even though their domestic farmers use them as liberally as any in the West) and zero evidence of pesticide damage! The paradox came home to roost over the last two years with warnings from our Taiwan trading partners that they will not tolerate seeing any more codling moths in fruit shipments. They were worried essentially about two previous detections. That's not two whole shipments contaminated, but two apples. Pertinently, all farmers, whether described as conventional or certified organic, use pesticides, just different kinds. But the pesticides themselves are not sufficient to control every last codling moth, they will never be, and we never expected them to be. In keeping international markets open, growers must realize that they have little control over rational standards of pest control, so the focus must be on profitability, not dead insect bodies. Thus, if pesticides are not the prefect solution to the paradoxical Asian demands for fruit perfection and no pesticide residues, then growers must rely on a decision support system that reduces technological inputs as much as possible. My view is that pesticides will be here to stay, but less will be used as we realize that overkill does not prevent irrational market forces from robbing us of potential profit.

## Conclusions

Pesticide technology is far safer than ever before. It is toxicologically more innocuous. The efficacious per acre application rates are much lower than even two decades ago because of toxicokinetic and toxicodynamic selectivity combined with a comparatively higher potency against pests than against nontarget natural enemies. But we shouldn't be lulled that these advances have come independently of the widespread implementation of the principles of IPM. To the contrary, chemicals only seem to be the main solution because IPM has engendered a perspective of successful crop protection that, fortunately, has changed manufacturers' response in the choice of products developed. By adhering to the correct functional definition of IPM as a decision support system, or perhaps even more descriptively as applied population and systems ecology in concert with risk management, we will sustain the newer, safer, and more selective pesticides as a very useful technology far better than our predecessors of the last century. To turn our back on the foundational principles of IPM is to cut off our nose to spite our face.

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