PRESIDENTIAL ADDRESS

Can we live with our paradigms?

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I will confess to you this morning that I am a weed scientist. Right now, if your the average person, one of two things just popped into your head. The first is "I should ask her how to control _____ (you fill in the blank) in my garden, (lawn, field)". What you really want is a prescription for a herbicide, and if I respond with a mechanical method (hoeing, mowing, pulling), you may be disappointed. The other response to my confession is something like "She sprays chemicals (maybe too many damn chemicals), and is ruining the environment. I should discuss that with her".

Either way (giving herbicide recommendations or spraying lots of chemicals) is not what I really do. What you just did was fall into the Pesticide Paradigm when thinking about weed scientists. I'm not saying that there are not weed scientists who do just the sorts of things you thought of, I'm just saying that not all weed scientists are alike. But let's examine the Pesticide Paradigm further.

A paradigm is defined as a pattern, standard, or example. Kuhn defined a scientific paradigm as "a universally recognized scientific achievment that for a time provides model problems and solutions to a community of practitioners". Well, the community of practioners are the weed scientists. The scientific achievement? What is the time frame? From about 1946 to the present and into the foreseeable future. What is the scientific achievement? Herbicides, herbicides, and more herbicides. Which is why, if I answer your control question with a mechanical method, you are disappointed. You have bought into the herbicide example for controlling weeds.

Starting with 2,4-D, moving on to dicamba, striding towards the sulfonyl ureas and immidiazaliones and now, the crowning achievement, having herbicide-resistant crops, so that no longer do we have to spend a lot of time thinking about carryover, crop safety, or timing. Herbicides have served us well. Very well. Today, we have less people in farming, farming more acreage, and feeding more people than ever before. Changes in crop varieties, fertilizer practices, and other changes have helped in this revolution. But herbicides and the control they provide for weeds are a large part of the equation. In some cases, crop rotation, cover crops, and mechanical techniques have been scraped. If you pick up weed science journals from the 1950's through about the early 1980's, 80% or more of the articles are devoted to herbicides, rates of

application, dates, combinations, mode of action, or efficacy. We learned the pesticide model for weed control very well.

In 1991, Dr. R. Zimdahl wrote an essay entitled "Weed Science: A Plea for Thought". In this essay, Dr. Zimdahl asked weed scientists to examine the pesticide paradigm, to see where it has led us, and to examine where it will take the practioners in the future. There has been excellent research that can be traced back to herbicides. For example, plant physiology and biochemistry have been advanced in the areas of the shikimate acid cycle for aromatic amino acid synthesis, the branched chain amino acid synthesis reactions, lipid synthesis, and photosynthesis including the structure of the D1 protein and binding site for PQ. We have also gained understanding in the areas of water flow through soils, particle transport, and microbiology. That is where we have been.

Where will the herbicide paradigm lead us in the future? Herbicides will continue to have an important and major role in agriculture. There is nothing at the present to replace the efficiency, cost, and labor savings that herbicides bring to agriculture. But weed scientists should not be blinded by the herbicide light and as Zimdahl puts it the "controlling knowledge" of the tool. We are just beginning to think about weed ecology, biological control, site-specific management, and using long-term (4 to 6 yr) rotations for the primary purpose of weed management (not control).

When the herbicide paradigm works so well, why change to something else? There are several reasons. The first is that plants are showing resistance to herbicides. The first plant that was documented to be resistant to triazine herbicides was *Senecio vulgaris* in Idaho in 1968. Today, hundreds of plants in several species have shown resistance to many different types of chemicals. Today's most promising herbicides for reduction of offsite contamination are used at very low rates (ounces per acre) and only affect a single enzyme in the plant. However, some weeds are selected for resistance after as little as two continuous applications and because of their dispersal mechanism can be transported for miles from the original site of application. In the case of kochia, single mutations confer resistance up to 75 times normal field rate. In order to reduce the chances of selecting for resistant weeds, the label directions indicate that these chemicals should be used only once every 48 months and then in combination with some other herbicide that can control the resistant population. So, resistant weeds may shift the herbicide paradigm.

The second reason to examine a new paradigm is societal pressure. In the 1950's, scientists had instrumentation that could detect herbicides in the ppm range. Today's instrumentation can detect ppb, ppt, and in some cases ppq. Society is concerned about herbicides in the environment even at very low levels. Herbicides can be found in surface and ground waters, in rain, and in soils in areas far from cropland.

Zimdahl presents three dilemas that may be unresolvable but are nevertheless important. The first is that pesticides, as with other unknowns, makes people nervous. There is a basic lack of scientific understanding concerning basic environmental and health implications of pesticide use. What level really causes birth defects? cancer? How does long low rate exposure affect us?

The second dilema is that the full cost of use (on health, environmental quality, and non-target organisms) is impossible to derive. The third is if even if we did identify all the problems, there would still be risk involved and not everone would agree on what is a "safe" risk.

Individuals feel helpless because it is not their choice to be exposed to pesticides. When 97% of the corn acres are treated with herbicide, you have very little choice in exposure.

I am not advocating tossing out herbicides. That would be akin to throwing out the baby with the bath. However, we must rethink our models in weed science. Herbicides are so great a tool and allowed for large farms to be the norm that growers have little time for tillage, crop rotation, and cover crops. We are so used to seeing immediate reults that give 90%+ control that we have no time for establishment of bioagents. Zimdahl argues that we need to stress preventative technology rather than control. We need to think in terms of weed management. Weed scientists need to become better ecologists, weed specialists, and managers not just control specialists.

Moving away from a successful paradigm will be difficult. Asking the right questions may be even more difficult. But where will progress be made? Someone said that the world is an ocean of ideas and one just bobs to the surface. But we must have some background knowledge of the subject to be able to understand if the idea is good or bad and we must be able to see beyond the present paradigms to come up with inovative ideas. Often progress is made by people on the fringes of the field of research. This may be because they have few preconcieved ideas of what cannot be done. They don't have a lot of energy, money, or emotional baggage invested in the paradigm and therefore, have less to lose if their hypothesis is proven wrong. Collaboration and interdisciplinary research (ie bringing new ideas from "outsiders" of the science) may help to solve old problems. For example, I work with soil scientists, entomologists, genetists, microbiologists, and remote sensing specialists in integrated research projects to work on weed science problems.

What are your paradigms that you are confronted with? Do we need to change other paradigms? One of the paradigms that Dr. Nels Granholm discussed in his SDAS presidental address in 1992 was the "Think Small" Syndrome for South Dakota. It goes like this "South Dakota is a poor state lacking in many of the resources of our surrounding states. We're at the low end of teachers' salaries, per capita income, industrial output, and gross state product." As a result we come to the conclusion that "… we cannot compete with people at the national level … It has always been like this and we might as well get used to it." He also stated "Let's not be intimidated by the granting process or any other facet of this business of doing science." I totally agree with him. There are researchers in the state that are being awarded substantial amounts of money. However, in 1997, there are a lot of us that are still wrapped in the think small syndrome.

We also cannot ignore what is happening in South Dakota. As Dr. Sword stated in an interview about his retirement as SDSU graduate dean and director of research "Never have I seen morale so low among faculty … It will take many years to rebuild (SDSU) back to where it was a few years ago …" The

frustration is also seen in students as a recent editorial in the Collegian states … SDSU is a sinking ship in an unfriendly ocean of efficiency …" Between increasing out-of-state tuition, cancelling small class sizes, implimenting the sophomore proficiency exam, and the downsizing of other curriculm, students have become just as frustrated as the faculty. This frustartion appears also to be evident in the number of papers submitted here. In the early 1990's there were about 100 papers submitted, today there are 45. Perhaps it was this long, cold winter that has also contributed to this.

Or perhaps it is the think small paradigm. I have had the opportunity to sit on several granting panels this year from the regional to national level. If we just play the numbers game (ie a certain percentage of the propsals will get funded) South Dakota gets blown out of the water. In North Central IPM funding project, MN had 12 proposals, 5 each from NE and IN, 7 from WI, and 8 from OH. SD submitted one. Is that all the expertise we have in IPM in the state? I don't think so. Of the 120 grant proposals submitted to NRI, one came from SD. Yes, grants are a pain to apply for. Yes, you do need to have good ideas and develop them. But part of this reflects back on the think small syndrome. We are only one deep in certain disciplines in the state. This makes it hard, but perhaps this is a real opportunity to create truly multidisiplinary teams to begin working in systems research. We don't have to step across too many departments to work together on a problem. But even this means rethinking our own paradigms. Arguing and discussing problems and their possible solutions and perhaps using new methods may give us the "competitive edge" over larger more disciplined-orientated institutions.

As a scientific society, I hope that we can use each others diverse experience to help resolve problems of today and challenges of tomorrow. Part of the solution is examing the paradigms we have grown to know and love. We must keep the beneficial parts of the model but rethink faulty examples to make real progress toward the goals of our respective disciplines. I hope that today, as you sit through the scientific presentations, you gain new insight into your paradigms and begin to expand to ask new questions for progress in our everchanging world of science.