**Weed Science For A Sustainable Agriculture and Environment - An Ethical Perspective**

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 In my younger years I tried to develop some expertise as a weed scientist. I studied the kinetics of herbicide degradation in soil and weed control in agronomic crops.

 It was interesting and enjoyable work but because of the Vietnam War, the environmental movement, and the development of organic agriculture, I was guided toward the more intellectually challenging study of moral philosophy.

 Philosophy attempts to achieve a wide perspective of life and reality

 We study history and philosophy to find out what man is. We can't find that out through science.

 Philosophers study Ethics

 They don’t tell us what is right and wrong

 They show us how to think about what is right and wrong

 Today the family has been weakened,

 Religion has been weakened,

 Our educational system is discouraged by class and race war

Public opinion loses force through division, fear, apathy and universal worship of wealth

 Even sex seems to be in chaos

 Today — whether one lives in a developed or developing country and whether one is rich or poor, male or female, formally educated or not, we all live in a post-industrial, information-age society. We live in an era of scientific achievement and technological progress, unequaled in human history, which has created the good life many of us, but not all, enjoy and some of the problems from which we suffer.

 The achievements include:

 Waking up this morning to music from your cell phone.

 Preparing breakfast in your microwave as you review the news on your tablet computer, which gives you nearly instant access to information that is orders of magnitude greater than the resources of most of the world’s libraries.

 Medical advances that cure what used to kill or cripple.

 Immunization to prevent childhood diseases.

 Elimination of smallpox and possibly polio in the near future,

 Travel at speeds and convenience unknown to our grandparents

 Finally, for many, but sadly not for all - abundant food.

The problems include: global climate change

 which affects mean temperature, rainfall amounts and seasonal distribution

 pollution of all forms,

 social inequality,

 environmental degradation,

 Agriculture, has additional problems: maintaining production, pesticide resistance, loss of biodiversity, Invasive species, biotech/GMO’s, and concern about sustainability. Many know and benefit from the achievements of agricultural science but are concerned about the problems science and technology has created

 We live in a world where progress is frequently equated with growth, which is generally regarded as good.

 Many want more of the good things of life

 We expect the future to be bigger, better, easier, and faster.

 So many aspects of our life change faster than we are able to keep up.

 We may not always know our destination, but we are going there in a hurry. We

believe in the efficacy of science and technology, which promises to solve the problems of society, agriculture, and industry. Many involved in agriculture believe that development and use of more and more energy dependent technology is always good and more will be better. The problems caused by the unintended consequences of technology will, many are certain, be solved by improved technology.

 I do not mean to imply that we should abandon science and technology. We humans, the earth’s dominant species, are not just figures in the landscape — we are shapers of the landscape (Bronowski 1973, p.19). Having achieved this power we should think carefully about whether our shaping of the landscape is desirable and sustainable. Although we may often know what we are doing, we should consider what we may be undoing. We must develop in ourselves and our students critical thinking about the moral dimension of what we do and undo.

 With that brief introduction I ask two questions (Zimdahl 2012) that I frequently ask myself:

 How do you know what to do in agriculture and in life?

 How do you know what you choose to do is the right thing to do?

 How do we decide what to do?

 Norman Borlaug (2000 winner of the World Food Prize and Nobel Peace prize - 1970) cautioned “that agricultural scientists have a moral obligation to warn the political, educational, and religious leaders about the magnitude and seriousness of the arable land, food, population, and environmental problems that lie ahead”. Unless these problems “are addressed in a forthright manner future solutions will be more difficult to achieve” (Soby 2013). Agricultural scientists pride themselves on the achievements of the green revolution, but they have not addressed the existing moral problems.

 The reason for ignoring them was that the costs associated with pollution, environmental damage, and harm to human health were justified by the production benefits. The problems caused by pesticides were unintentional developmental problems (Atreya et al. (2011) . If these costs are counted, the benefits from the use of pesticides could be outweighed by the cost of pollution and human health effects. Since the mid-20th century the quality of science in the US has been evaluated almost exclusively in terms of its ability to deliver technological innovations. This is particularly true in agriculture. Agricultural scientists have made great strides to improve crop production. However, when we claim credit for improving production and keeping the cost of food low, we must also accept society’s right to hold us responsible for problems we have regarded as externalities.

 An externality is a cost that is not reflected in price, or more technically, a cost or benefit for which no market mechanism exists. It is a loss or gain in the welfare of one party resulting from an activity of another party, without there being any compensation for the loss. From a self-interested view, an externality is a secondary cost or benefit that does not affect the decision-maker.

 We need to ask and be prepared to respond to what we have not asked often enough—what could go wrong?

 Agriculture, the essential human activity, is our most widespread interaction with the environment. We live in a post–industrial, information age society. No one will ever live in a post-agricultural society. Continuing to justify all of agriculture’s activities and technology by the necessity of achieving the moral obligation and the production challenge of feeding a growing population has not been and will not be a sufficient defense for agriculture’s negative environmental and human effects (Mann 2018).

 Humans, the world’s dominant species, are no longer just a part of nature; we are a force of nature—“that is disturbing and changing the climate and our planet’s ecosystems at a pace and scope never seen before in human history” (Friedman 2016, p. 87). “We cannot rebuild the Greenland ice sheet, the Amazon rain forest, or the Great Barrier reef or the Koalas. When the macaws, the rhinos, and the orangutans are gone, no 3D printer will bring them back to life (Friedman 2016, p. 183).

**Concerns About Agriculture**

 **1. Sustainability** Everyone is in favor of sustainability. Within the agricultural community to sustain usually means protecting the productive resource (soil, water, gene pools). It is not clear why that legitimate goal always outranks sustaining environmental quality. Agriculture has a major responsibility because it is so widespread and has the potential to care for or harm so much land. This is a different view from protecting only the productive ability of land. Because of increasing urbanization, there will be less land to feed the 9+ billion. We create places for people to live and simultaneously destroy agricultural land. Concrete is the land’s last use.

 Without the land there will be no agriculture. Therefore, land must be regarded as something more than other productive resources (fertilizer, machines, irrigation water, pesticides, or seed). To harm or destroy the land is to destroy something essential to life, and that certainly raises a moral question.

 The pursuit of agricultural sustainability is commonly viewed as mainly or wholly a technical problem that simply requires changing farming methods and adopting new, alternative technologies (Morgan and Peters 2006). But achieving agricultural system sustainability will not be accomplished by tinkering at the fringes with new technology. It will require re-thinking how we practice agriculture and emphasizing more than production.

 Some believe that current agricultural practices may threaten future global food security and will have negative effects on global food production (Liu et al. 2015). The total agricultural area has decreased since 2000, pesticide consumption has increased, water use efficiency has increased. Available water sources are already being used for irrigation.

 In the US, 60% of irrigated crop production depends on groundwater (Siebert et al. 2010). It is forecast that agriculture’s demand for water could rise to 10 to 13 trillion cubic meters by 2050. That is 2½ to 3½ times greater than the total human use of freshwater today (Fox and Fimeche 2013).

Water use for agriculture peaked in 1980 and has decreased every year since due to improved irrigation system efficiency, in spite of an increasing number of acres irrigated (Donnelly and Cooley 2015).

 Economic growth has acquired the power and scope of a new religion and it drives agricultural expansion (Worster 2016, p. 147). Should there be limits to agricultural expansion?

 I am compelled to add at this point that cultural diversity challenges the Western and particularly American belief in the universal relevance of Western culture (Huntington 1996, p. 310)]. This belief holds that people in all societies want to adopt Western values, institutions, and practices. It suggests that people throughout the world should embrace Western values and culture because they embody the highest, most enlightened, most liberal, most rational, most modern, and most civilized thinking of humankind. It is my view that

 Western belief in the universality of Western culture suffers three problems: it is false, it is immoral, and it is dangerous.

 **2. Pesticides**.

 The world uses a vast array of synthetic organic chemicals to manage insects, weeds, fungi, and other organisms that sometimes just bother and other times may cause significant yield losses and harm to humans. Pesticides and other agricultural technology have made it possible to feed a growing human population and protect millions of people from malaria and other insect- borne diseases. Of the pesticides used in the world, 80% are used in agriculture: approximately 40% are herbicides — (Kraehmer et al. 2014), 33% insecticides, and 10% fungicides. Sales and use have been expanding rapidly throughout the world, although the development of new modes of actions has become rare (Lamberth et al. 2013).

 There is no question that pesticides increase crop yields and may harm the environment, people, and other creatures. For example, there are 42% fewer species of invertebrates in streams with severe pesticide contamination and 85% fewer new queens in bee hives exposed to pesticides[[1]](#footnote-1)4. Pesticides have been aggressively promoted and are generally accepted within the agricultural community, as essential to maintaining yields and feeding a growing world population. There are also legitimate global human rights concerns because of their detrimental effects. The UN General Assembly (2017) report denies the claim that pesticides are necessary to feed the world and regards them as a short-term, unsustainable solution.

 A common view among the general public is that synthetic, organic chemical pesticides are dangerous, overused, are should not be present in food, soil, and water. It is also widely acknowledged within the agricultural community that they have made our lives easier and more enjoyable by reducing mosquito, ant, and cockroach populations. (Enserink et al. 2013).

Modern pest management is highly dependent on pesticide science. Weed science has been slow to “catch up” with progress toward precision agriculture that has been made in irrigation and fertilizer management (Reddy and James 2018) . It is clear from any current issue of Weed Science and Weed Technology that herbicides continue to dominate weed science research and lead to one of agriculture’s moral dilemmas. True integrated weed management requires a high level of plant ecological and biological knowledge, technological machinery, and decision-making algorithms that can respond rapidly to changes in weeds and the environment Young (2018).

 **3. Antibiotics.** There is great concern about the increasing incidence of poor performance of antibiotics for treatment of human diseases due to bacterial resistance because of their use in livestock enterprises. It is estimated that approximately 80% (a disputed number) of all antibiotics used in the US are fed to farm animals. There is disagreement about the quantity and patterns of antibiotic use in food animals. These very effective, necessary medicinal products originally developed to protect human health, have become less and less useful as resistance to them has become more common due to widespread use in animal/poultry production for disease prevention and growth promotion and over-prescribing them for human problems. It is estimated that global antimicrobial use in food animals would increase 67% by 2030 (Van Boeckel et al. 2015) One can argue that antibiotics created modern agriculture and changed the way we eat (McKenna 2017) **.**

 **4. Loss of biodiversity.** There is a well-documented, continuing loss of ecological biodiversity, species, and genetic diversity. Between 0.01 and 0.1% of all known species become extinct every year. If the low estimate is correct, we are losing between 200 and 2,000 species every year. If the high estimate is correct, the earth is losing between 10,000 and 100,000. The earth is undergoing a sixth extinction (Kolbert 2014). Between 1.4 and 1.8 million species have been identified. We don’t know how many more there may be. The low estimate is around 2 million different species on our planet. The high estimate is 100 million. It is important to know that we don’t know how many species the earth has. Therefore, it is hard to know how many are being lost. Scientists estimate that we are losing species at a rate 1,000 to 10,000 times higher than the natural extinction rate, the rate that would occur if humans were not involved.

 **5. Biotechnology and GMOs.** The first genetically modified crop planted in the United States was canola in 1996. The world acreage of GMO crops has increased dramatically since then. Agricultural scientists have been using conventional plant breeding techniques to improve food crops for hundreds of years to create plants that have higher yield and are more responsive to fertilizer. However, an intense debate continues between two sides, both of whom, are convinced they are right and the others are wrong, at least partially misinformed, and don’t understand. Many argue that misinformation and over-regulation are stopping or slowing GM foods with the potential to save lives. They claim that the technology is proven, rigorous safety studies have been done.

 Partisans on both sides are convinced they are in an all-or-nothing battle (Heldke 2015).

 The proponents have faith that limitless technological progress will finally solve the problem of feeding a growing population. Science will solve the problems. Others deny this and claim that “it is likely that there will be a permanent difference in .... opinion that cannot be solved with more data or new facts (Mampuys and Brom 2015). Others remind us that many of those who see only the benefits of biotechnology do not remember or refuse to acknowledge, that nature “requires respect, a kind of reverence, and deference before Nature’s ultimately mysterious forms and processes ” (Berry 2017, p. 211) .

 I suggest this is correct and reflects the past optimism about human and environmental safety, which was proclaimed by the agro-chemical industry and, which was ultimately proven to be wrong. The current strategy is unlikely to solve the problems and the focus should shift to “managing permanent different viewpoints and providing a platform for a broader conversation on agriculture and food production Mampuys and Brom .” Proponents claim that it is not unjust to use GMO’s to alleviate hunger and malnutrition and achieve the goal of feeding an expanding population (Toft 2012), a reasonable argument that is weakened because more than half of the US general public (57%) say that GM foods are generally unsafe to eat. It is an enduring gap between the public and scientists and depicts a moral challenge for the agricultural community.

 It is not an argument to determine who is right and wrong. It should be seen as a discussion that seeks understanding between right and right points of view.

 The comment of James Davidson (Emeritus VP for Agriculture and Natural Resources, University of Florida) illustrates the agricultural communities optimism and difficulty of responding to past errors (Kirschenmann 2010). Davidson’s comments lends support to those who believe that GMO’s portend other problems which agriculture’s practitioners will have to recognize and eventually apologize for:

 With the publication of Rachel Carson’s book entitled Silent

 Spring, we, in the agricultural community, loudly and in

 unison stated that pesticides did not contaminate the

 environment—we now admit they do. When confronted

 with the presence of nitrates in groundwater, we responded

 that it was not possible for nitrates from commercial fertilizer

 to reach groundwater in excess of 10 parts per million under

 normal productive agricultural systems— we now admit they

 do. When questioned about the presence of pesticides in food

 and food quality, we reassured the public that if the pesticide

 was applied in compliance with the label, agricultural products

 would be free of pesticides— we now admit th ey are not.

 The claim that GM crops will feed growing numbers of people in the third world has great moral appeal. It is responsible, even altruistic. But the claim is deeply misleading because it is based on the incorrect but popular assumption that we don’t produce enough food to feed starving people. People are hungry because they do not have enough money to buy food, do not have access to land to grow food, or do not live in a country where the government provides adequate help. Agricultural scientists have essentially said, “Trust us, we know what we’re doing.” There is a prevailing illiteracy about science among the general population

 **6. The environment.** Some claim that agriculture encroaches on and harms the natural environment (Berry 1977, Brei 2013, Gebhard et al. 2015). Over the last 200 years an estimated 30% of US farmland has been abandoned because of erosion, salinization, and waterlogging. Since the 1960s one third of the world’s arable land has been lost to erosion. Some US crop land loses soil, the essential agricultural resource, at an average rate of 5 tons/acre/year from water and wind erosion (Jackson 2000).

 Are these just concerns a radical fringe of society-a few wackos?

 If they are general societal concerns about agriculture that justifies everything because it increases production.

 Then we - agriculture’s practitioners - have a responsibility to ourselves and to society to confront discuss and debate our ethical dilemmas.

 Is production a sufficient criterion?

 Does it justify all agricultural practices?

**Concluding comments.**

 Within the agricultural community, feeding the 9+ billion is the primary, if not the only, value that justifies technological innovation. The social, environmental, and economic costs of a developed country’s capital, energy, and chemically dependent agricultural system, and the challenge of sustaining the environment and other species are recognized as important, but the necessity of increasing production dominates.

 The world now produces enough food to feed everyone a minimally adequate daily diet1[[2]](#footnote-2)1.

 Feeding the 9+ billion is undeniably a good thing. Is it a production problem?

 Of course it is.

 BUT

 It is also a distribution, waste and poverty problem.

 It is becoming obvious to anyone who listens to, reads, or watches the news that citizens of democratic societies are becoming reluctant to entrust their water, their diets, and their natural resources blindly into the hands of farmers, agribusiness firms, and agricultural scientists.

 Ethicists and agricultural practitioners must participate in the dialog that leads to social consensus about risks. In the past most of the risk was borne by users of the technology. Now there is widespread concern that the risks and short- and long-term consequences of agricultural technology are borne by others. Agriculturalists must begin to contribute the time and resources needed to understand their positions and those of their fellow citizens. For most non-agricultural segments of society, these are not new demands. For agriculture they are.

 Because agriculture is the essential human activity

 it is essential that it rest on a firm ethical foundation.

 Agriculture is not just about results.

 The prevailing assumption is that technological solutions will continue to reduce and eventually eliminate hunger because the productive progress of the green revolution was proof that the key to agricultural success was faith in scientific knowledge and technological know-how.

 The dominant focus of those involved in agriculture is how to achieve the moral obligation and challenge of feeding the human population projected to be 10-12 billion by 2100. However, many people throughout the world, in both developed and developing countries, have concerns about agriculture and our food system that have ethical dimensions going beyond the central need to feed humanity. As mentioned, agriculture's responsibilities include: Sustainability, Pollution of water, soil, and humans, Harm to other species, Habitat destruction, Future availability of surface and ground water, Exploitation and inhumane treatment of farm labor, Loss of small farms and rural communities, Corporate farming and the power and lack of transparency of agri-businesses and corporate food processors, Cruelty to animals, Effects of biotechnology/GMO's, Loss of crop genetic diversity, and nutritional value of foods provided to consumers by the food system.

 All of agriculture is involved in ethical questions. What should be done? How should it be done? Who should be considered? The way agriculture is practiced, development projects are chosen and conducted, and the kind of research and teaching done involves scientific and ethical values and a view of a future we expect, desire, or fear. Because agriculture is the essential human activity, it must rest on a firm ethical foundation.

 What is the right thing to do?

 From an ethical perspective, feeding the growing world population is clearly a very good thing, but it does not absolve the agricultural community from critical, ethical examination of the totality of agriculture’s effects.

 What can our universities do? A place (Zimdahl 2000, Zimdahl and Holtzer 2018) to begin is the classroom. The agricultural curriculum lacks courses in agricultural ethics that focus on general ethical principles, their application to agricultural issues, and ethical expectations of agricultural professionals. Such courses are available at only a small minority (9) US universities with agricultural colleges. It was 15 in 1999.

 I suggest this is because those who determine curricula and advise undergraduates do not regard studying ethics and the ethical values of agriculture as important preparation for a agricultural professionals

 Offering classes on agricultural ethics and encouraging students to enroll will not by themselves quickly increase the overall emphasis on ethical considerations within the agricultural community. It will be an important recognition of the need for agriculture to recognize and discuss it's ethical dimensions.

 Agriculture has been troubled by economic problems, which have affected our performance. They have focused our attention on production and our education and practice have ignored human dimensions of our discipline (Damasio, A. 1994).

 I leave you with my two questions.

 How do you know what to do in agriculture and in life?

 How do you know what you choose to do is the right thing to do?

 AND - A story. Paul Gauguin (1848-1903 ) a French, post-Impressionist artist painted what is regarded as his masterpiece in Tahiti in 1897. He was in despair, mourning the death of his favorite daughter, in debt, and contemplating suicide. The 5 x 12' picture is the culmination of his thought. It is in the Boston Museum of fine arts. It consists of three major groups, right to left

 Right - Three women and a child represent the beginning of life.

 Middle - The daily existence of young adult life.

 Left - An old woman approaching death appears reconciled to her thoughts. At her feet a strange white bird represents the futility/uselessness of words. The blue idol in the background symbolizes the beyond.

 He inscribed the original title in the upper left corner:

 D’où Venons Nous / Que Sommes Nous / Ou Allons Nous.

 OR - Where do we come from? What are we? Were are we going?

 What should we do? I leave the questions for you to contemplate.

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