The Plant Cell, Vol. 2, 275–277, April 1990

Debating the Responsibilities of Plant Scientists in the Decade of the Environment

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COMMENTARY

This month marks the 20-year anniversary of Earth Day and a new commitment to make the 1990s the Decade of the Environment.

Maybe the flurry of media attention surrounding this event will shake us out of our sleep. In the last few years, I have become very frustrated by the feeling that we, as a civilization, are in the midst of a global crisis and are not responding appropriately to the scale of the events. Most of us seem numb to the claims of global climate change, ozone depletion, rainforest destruction, species extinctions, and so on. The changes being wrought by our way of life are so extensive, and the solutions so unimaginable, that the response is usually denial. I, for example, go on with life as usual or make minor concessions such as recycling or walking to work. But the really basic changes necessary to reverse the "inevitable" seem impossible. It is my opinion that the appropriate scale of my response should be to use a tenth of the resources I now use, rather than simply recycling, and to change the kind of work I walk to.

To respond to what I perceive as a crisis, I have been examining my own actions and, in particular, my profession of basic plant scientist. From my reading and thinking, I have come to share the conclusion that using science and technology to solve problems in the world has gotten us into our current situation and is, thus, not the approach for getting us out (Devall and Sessions, 1984; Plant, 1989). If you will bear with me, I would like to outline my rationale and then discuss its implications for my career.

Starting with first principles, it seems to me that the crisis of our current age originates in our relationship with nature (e.g., Merchant, 1980). We are exploiters and manipulators; humans form the pinnacle of a hierarchy and attempt to control all other parts of the earth: animal, vegetable, and mineral (Ehrenfeld, 1978). Within this view of the world, the logical way to solve our problems is to manipulate nature in different directions, using new technology to counteract the old technologies. For example, if we have a problem with river flooding, a dam is built. Several years later, it is discovered that the dam creates a whole new suite of problems: for example, declining soil fertility in the flood plains. Solution: use fertilizers on the plains. New problem: fertilizer runoff. In this scheme, each solution causes a new problem. Problems are all addressed using the "humans as managers" paradigm. That this approach seems only to dig us deeper into a hole is explained by us just not knowing enough. If we had more information, we would successfully solve the problem. The role of scientists is, thus, central to problem solving because the more we know, the better we will be able to manage our environment.

Now imagine a different view of the world, one in which humans are part of an interacting web and every action tweaks a thread, causing a complex set of reactions. This view causes us to be humble about our actions. Floods are not viewed as a problem because we regulate human activities with the natural cycles of floods. It is assumed that the system around rivers has evolved in a complicated way with the flooding cycle and that to disturb it would upset all parts of the web. Human beings act with humility and respect, adapting ourselves to what exists rather than the other way around. In this world, the role of the scientist is more equal with artists and musicians: scientific understanding enriches our lives but is not any more or less valuable than other forms of knowledge.

I believe that it is this second view of our place in the world as mere equal participants that must be fostered if any change is to take hold. This has been called an ecocentric rather than anthropocentric world view. Our civilization is based on the anthropocentric view, and it obviously is not taking us in the direction we want to go.

In this context, I have examined my research career of the last decade and, not surprisingly, have found it to be firmly planted in the anthropocentric view in the following way. Basic plant science in the United States is inextricably linked to technology. By definition, in our society technology is developed by industry to profit from domination of nature. This is a strong statement, but I can think of few exceptions. There is no way to uncouple basic science from development of technology, and, in fact, the system is designed to foster the interaction. That is one of the jobs we get paid for. Therefore, basic scientists are an important part of the process of technology development, whether we think about it or not. In agriculture, new technologies are used to enhance the power of the developers of the technology, which results in further control by industry of all levels of agricultural production (Carroll et al., 1990, pp. 583–628). Witness the vertical integration of plant breeding, seed production, agrichemical syntheses, and product marketing. This system increases dependence of the poor on the rich and drives true cultural and biological diversity out in the name of development and efficiency (Berry, 1977). This assessment of the role of science in an industrial society has led me to the conclusion that I, as a plant scientist, am fostering a system of agriculture whose goals and endproducts are at odds with an ecocentric world view.

Let me give a more concrete example of how seemingly innocent basic research facilitates the spread of large-scale agriculture at the expense of poor farmers, indigenous peoples, and the environment. People in my lab have made progress in understanding the role of maternal factors in plant embryo maturation. We found that abscisic acid and high osmoticum could allow embryos to mature more normally in culture. This information, added to the work of other plant embryologists, has been helpful in producing clonal plants with "superior" characteristics. This is because many plants can only be propagated asexually by somatic embryogenesis and, if these somatic embryos are cultured under conditions that allow them to mature, they are then able to produce healthier plants. Oil palm is a good example of a product for which classical vegetative propagation is not possible. Now that healthy somatic embryos can be produced, it is possible to plant plantations of identical trees.

Palm oil is a major export commodity from many tropical countries and, with the advent of chemical inputs and various incentives, is increasingly grown on large plantations. With or without the use of cloned plants, the establishment of oil-palm estates is capital intensive, costing more than $75 million to set up a 10,000-hectare estate. With clonal palms, the expense is greater, and access to material may be limited by patents. However, potential benefits include a promise of greatly increased yields, control of fatty acid composition, pest resistance, and changes in plant structure to facilitate reduction in labor costs. Poor farmers cannot afford to buy into this system, nor can they compete with the outcome. Thus, new clonally propagated oil palms will be controlled primarily by large corporations and government estates, with little or no opportunity for small-scale producers (Fowler et al., 1988, pp. 116–123).

There are also negative environmental impacts of large-scale oil-palm plantations: water pollution from pesticides and processing plants, destruction of native tropical rain forests to plant them, and loss of traditional livelihood for local indigenous people. In 1986, the Federation of Indigenous Peoples of the Ecuadorian Amazon claimed that cultivation of oil palm in the region threatens the lives of 115,000 indigenous people living in the area. According to the indigenous leaders, ". . . we also have to face threats of investors, national and international companies that are planning, with the help of the government, to plow the jungle under. They see us only as opposing progress, or as cheap labor for their plantations and agroindustry" (Fowler et al., 1988, pp. 119–120).

In other words, what on face value should provide a source of vegetable oil and increased agricultural income for the people of tropical countries is more likely to end up putting small farmers out of business, displacing indigenous people, degrading the environment, and causing unpredictable economic effects on the edible-oil market. The real benefit accrues mainly to the diversified, vertically integrated multinational companies and governments involved in establishing the large plantations.

My own research has potentially played a real, if small, part in making this possible.

This oil-palm story illustrates the complexity of the effects of introduction of new technology. In particular, changes in who controls land, credit, seeds, and processes in agriculture can devastate poor farmers. Although average per-capita income and total agricultural production may increase, the number of people living in absolute poverty is also likely to increase unless measures are taken to redistribute resources (Carroll et al., 1990, pp. 20, 143–145). The link between poverty and environmental degradation is strongly forged (Gupta, 1988). Similar scenarios have been meticulously documented for cotton and beef in Central America (Williams, 1986; Karliner, 1989) and various green revolution crops in Asia and Africa (Juma, 1989, pp. 76–107).

Other obvious examples of how basic science can immediately advance agritechnology are the use of meristem-specific promoters to increase glyphosate tolerance in rapeseed and the use of tapetum-specific promoters to make male steriles that facilitate hybrid-seed production. Who will benefit from these technologies, and at whose expense?

When I ask myself these kinds of questions, I keep coming back to the idea that, within the context of our society, almost all new technologies will serve to strengthen the dominant system. Bill Mollison states it clearly:

"We know how to solve every food, clean energy, and sensible shelter problem in every climate; we have already invented and tested every necessary technique and technical device, and have access to all the biological material we could ever use. The tragic reality is that very few sustainable systems are designed or applied by those who hold power, for to let people arrange their own food, energy, and shelter is to lose economic and political control over them" (Mollison, 1988, p. 506).

So, that is the rationale for my quitting experimental science. I can't think of any way to do plant molecular biology without contributing to a system that, in my view, is not working. In the long term, only a change in our approach to nature will be sustainable, and science as currently practiced is part of the problem.

What would plant science be like in an ecocentric world? This is the big question, and I'm going to spend the next several years developing answers. I am going to try to synthesize information from rural economics and sociology, anthropology, history, political science, ecology, and molecular biology into a different vision of plant science. Many talented people have been writing on this topic lately, so there are sources of inspiration and colleagues for discussion. If alternatives can be formulated, I will most likely then work toward putting a different form of science into practice.

My challenge to you is to examine the fruits of your own research. Who picks them up and disperses them? What sprouts from their seeds? Make your analyses deep and broad. Perhaps the greatest environmental impact of biotechnology is not the direct biological effect of new genotypes but the ramifications of the social and economic upheaval created when existing imbalances are tipped even further. The positive feedback loop between poverty and environmental degradation is well established. I urge you to read about the role of export agriculture in the environmental crisis in Central America to learn how agricultural changes can tear apart a society (Williams, 1986; Karliner, 1989). Make analogies. For example, see if you can anticipate the consequences of introducing increased drought tolerance into a major crop by comparing it with the spread of the beef industry onto marginal lands in Central America. Maybe you will be more imaginative than I am at coming up with alternative visions.

Agriculture is one of the most powerful technologies on earth. It has the proven potential to cause more environmental havoc than any other human activity. We should take our responsibility as shapers of that technology as seriously as physicists who debate their role in nuclear war.

The floor is open for discussion.

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