Challenges and Opportunities for Plant Propagation in a Changing World

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The environment in which we do our research or propagate plants has changed dramatically in the past 25 years. It is critical that we appreciate the nature of those changes and how they are influencing our research agenda and our businesses.

At one point in our history we were pretty much left alone to pursue scientific inquiry or conduct our business as we wished. But now many people and groups have an interest in setting our agenda. Let me give some examples based on the 2½ years I spent in Washington, D.C. as Assistant Secretary for Science and Education. As we establish the challenges, I will suggest plans of action, so we can anticipate and plan ahead.

The U.S. agricultural system is viewed by the world as one of the outstanding products of American ingenuity. In 1950, one American farmer produced food and fiber for 27 people; in 1990, the production was for 128 people. This increased efficiency has been passed on to the consumer in the form of lower food costs. In 1950, the average consumer spent 21% of his/her disposable income on food. In 1990, the figure was one of the world's lowest—11.8%. In addition, agricultural efficiency has made the United States a strong competitor in international trade. Agricultural exports represent one of the few segments of our economy in which there is a favorable balance of payments.

How were these achievements made possible? In the period of U.S. history following World War II, the power of science was harnessed to give agriculture a dramatic boost in productivity. Through a combination of genetic improvement, the application of fertilizers, and the use of chemicals to control insects, diseases, and weeds, agriculture achieved striking increases in yields. In the field of plant propagation new technologies were introduced. Plant growth regulators were discovered and used to speed and extend the range of plant material propagated from cuttings. Mist propagation extended the range of plants propagated from cuttings even more and reduced cost of production. Tissue culture facilitated clonal propagation of plants, and now molecular biology or biotechnology is providing new tools to understand plant growth and development, such as juvenility and the process of root initiation as well as to exchange genetic material in a way and with a precision that was not previously possible.

But that was in simpler days, when the goal was merely to produce enough food, fiber, and plant material and to deliver them to the consumer. Today's agriculture is being required to fill many roles and meet many obligations. In the 1990s, agriculture is being asked to play a major role in preserving our environment, increase food safety through the use of fewer chemicals, provide jobs in rural areas, maintain international competitiveness in the presence of free trade agreements, and feed a growing population on an ever-decreasing area of cultivated land. For example, the USDA's Economic Research Service states that by 2010 world

population will reach 7.5 billion people, and just to maintain current caloric intake on a world average food production will have to increase by 40%.

EXTERNALITIES

Over the years, I have concluded that if we truly want to understand the forces at work in motivating agricultural policy, we need to go beyond a simple preoccupation with the technology and science involved or with our day to day business operations. There are powerful forces—what economists call "externalities"—which supersede the control of individuals and even of institutions. These externalities affect not only the way in which we do our work, but what work we decide to do. For example, our agricultural research policies are not formulated in any pure and solitary test tube. They spring from the messy and often disorderly real world of conflicting demands and unclear choices.

Agriculture can no longer operate—in fact, we probably never really did—in isolation from an increasingly concerned public. Our course is continually influenced by the changing winds of public opinion and national policy.

Some 40 years ago, when a national farm bill was formulated, there were fewer players, only three or four major groups were involved. Now, someone counted over 215 groups with active interests that are making their voices heard and are shaping policy. To give you an idea of the complexity of the issues involved, the 1990 Farm Bill is the largest piece of legislation ever passed by Congress—719 pages long! When the President signed the bill, he said to Clayton Yeutter, then Secretary of Agriculture, "It's all yours....if you can carry it!"

Maybe we don't necessarily need to learn any more about agriculture per se, but we may need to learn more about the world outside of agriculture and how it affects us as reflected in the attitudes and opinions of the public—and by extension, Congress. My point is that we in agriculture must keep many different public and congressional priorities, needs, desires, and concerns in mind—<u>and</u> work to make <u>them</u> more aware of <u>ours</u>. We need to make clear that we benefit society—even beyond providing the basic necessities of food, fiber, and environmental enhancement—and that we can help it meet many of the crucial challenges of our times.

COMPETITIVENESS

And what exactly are some of those challenges? Just look at the headlines in the newspapers. For example, the current focus in the public and in Congress on the importance of international competitiveness and the U.S. trade deficit. These concerns are pushing agriculture to reduce production costs and enhance product quality, and are driving agricultural research to find the best ways to do that. In order to maintain our competitiveness in a tough global marketplace, and at the same time have environmentally sensitive agriculture, we need every ounce of careful management and efficient technology we can muster.

We also need to adjust to shifting consumer trends and demands. Through research, we can develop agricultural products which are less expensive, more appealing to consumers, and more nutritious. Demands change constantly. Look at the grocery store shelf space now devoted to oat and rice bran, dietary fiber products, and lowfat milk. You have to hunt for the whole milk these days!

Agricultural researchers need to join with nutritionists and physicians to study the questions of diet and health. Do cole crops prevent cancer? If so, is it because

of Vitamin E? Or something else? With some hard data, we might even be able to convince President Bush to eat broccoli. Closer to home is the ovarian anti-cancer drug, taxol, extracted from the bark of *Taxus* trees.

ENVIRONMENT

The environment is another major area in which the overall national agenda is influencing agriculture. Environmental concerns were strongly reflected in the sodbuster and swampbuster provisions of the 1985 Farm Bill—and they are even more strongly present in the 1990 Farm Bill. The swampbuster, or wetlands, provisions are among the most controversial, particularly when there has been a lack of agreement on the definition of "wetlands."

As I mentioned earlier, through technology, the United States has developed the most efficient food, fiber, and forest system in the world. But we now recognize that the technology which helped bring that about has had some costs which were not fully anticipated at the time of its introduction.

As science has fine-tuned its instrumentation and its abilities to track and detect smaller concentrations of contaminants in our food, our ground water, and our environment, the public is becoming more and more sensitive to the social, environmental, and health implications of agriculture—and more and more vocal about them. Research must now help agriculture respond to these legitimate concerns.

It is time for those of us in agriculture to be proactive rather than defensive. Not only does our future ability to produce food and fiber depend on it, but to do otherwise is to invite restrictive legislation and regulation which may remove our decision-making power and constrain our flexibility to adopt management practices which best fit each farming situation. There is the feeling among some that agriculture must be regulated into environmental concern. This is not the case—nor would it be in the best interest of our nation.

GLOBAL CLIMATE CHANGE

But there are other concerns about agriculture and the environment. Soil erosion is an old problem that is still with us, while newer issues include greenhouse gases which may contribute to global climate change. Although there is continuing debate about whether the accumulation of greenhouse gases will actually lead to global warming, there is general agreement that we should explore ways to reduce emissions and to sequester the carbon dioxide already in the environment. Agriculture has three major roles to play in global change.

First, it generates greenhouse gases, albeit a relatively small percentage in relation to carbon dioxide released in the production of electrical energy. Agriculture's contributions to greenhouse gases are methane and nitrous oxide which trap 20 and 290 times more radiant energy respectively than carbon dioxide. When expressed in carbon dioxide equivalents, rice cultivation contributes 2,300 metric tons per year or 7% of the greenhouse gases; ruminant animals, 1,500 metric tons per year or 5%; and nitrous oxide from nitrogen fertilizer, 440 metric tons per year or 1%. Thus, all the greenhouse gases from agriculture represent 13% of those emitted each year. By comparison, globally, commercial energy production is 18,800 metric tons per year, or 57% of the total greenhouse gas emissions.

A second role for agriculture in global change research is to genetically modify

plants and animals so that they may adapt if there is climate change. Conventional plant and animal breeding has been used for years to extend the range in which crops and animals can be raised. When red wheat was first introduced into the midwest, its range was limited. Plant breeding to adapt the wheat to other climates dramatically extended the area in which it is grown. In fact, the geographical range is now so large that the average temperature variation is over two degrees Fahrenheit, equivalent to the temperature increase predicted in some global climate change models.

The new tools of molecular biology are enabling us to explore the mechanisms by which plants survive temperature stress, drought, and salty conditions. This ability may become even more important as we get a better understanding of the potential impacts of global climate change — it is already relevant in areas of this country, and in nations that experience droughts and other climate extremes.

The third and very beneficial role for agriculture and forestry is in sequestering and recycling carbon dioxide through the process of photosynthesis. This was the basis of the President's "America the Beautiful" program, designed to plant a billion trees a year. In addition, there is renewed emphasis on the production of energy from biomass.

Although interest in this area of research peaked in the 1970s at the time of the first energy crisis, there are three good reasons to believe that a more sustained effort is developing:

1) The experience in the Persian Gulf has reemphasized the need to reduce our dependence on foreign energy sources and, in the long term, to find alternatives to fossil fuels.

2) The President's Clean Air Act requires the use of more oxygenated fuels in cities that have failed to meet EPA clean air standards. Ten percent ethanol in gasoline can reduce carbon monoxide output by 20% to 25%.

3) Finally, producing energy from biomass rather than from fossil fuels recycles carbon dioxide rather than adding it to the atmosphere.

Today, the U.S. average for carbon dioxide emissions is the equivalent of 19.4 metric tons of carbon dioxide per person per year. The average for Great Britain is 9.9 and for China 2.1. Clearly, if we are to at least maintain current standards and at the same time help developing nations achieve similar living standards without overwhelming the atmosphere with carbon dioxide, we must conserve energy and develop alternative energy sources, including biomass.

Researchable areas include crops developed specifically for energy production, increased photosynthetic efficiency, better conversion of biomass into energy, and improved methods of separating ethanol from water. Successful research in this area includes a recent report that a genetically modified microorganism can hydrolyse cellulose into sugars and then ferment the sugar into ethanol. But this is also an area of great potential for the nursery industry. Trees used in the urban and suburban landscape not only fix carbon dioxide, but they provide shade and cooling through transpiration. Since conservation of energy can be one of the most cost effective ways of reducing carbon dioxide emission, we as an industry can help achieve the country's goals by providing the trees used for shading of buildings and other facilities such as parking lots which act as heat sumps.

SUSTAINABLE AGRICULTURE

The goal is for agriculture to operate in an environmentally responsible fashion, while continuing to produce both economically and profitably. Sustainable agriculture is the use of the very best of technology in a balanced, well-managed, and environmentally responsible system. This includes using our newest scientific tool, biotechnology, to move genes precisely and quickly to create plants that are genetically resistant to disease and pests and therefore require fewer chemicals in their production.

As we learn more and more about the processes and materials involved in animal and plant life, we can ask—and answer—questions that weren't even possible before. Everywhere you look, there are exciting things going on. This is not pie-in-the-sky science; we are very close to application, e.g., BT gene in tomatoes and cotton and the use of antisense gene technology to modify the ripening process in fruits and vegetables.

WATER QUALITY

One of the reasons that sustainable agriculture is coming to the fore is a very real public concern over reports of contamination of the nation's ground and surface water resources by agricultural chemicals and nutrients.

In response, the USDA has identified protection of the nation's water resources as a high priority. It has made it clear that farmers need to be involved in a vigorous effort to protect both ground water and surface water from contamination as a result of their land management practices.

Our incredibly low food costs are very dependent on the use of technology—including important pesticides and fertilizers. Technology also includes increased emphasis on Integrated Pest Management (IPM)—getting the best use out of all the control strategies available: genetic resistance, biological control, cultural practices, and precision application of pesticides. We want to develop new systems of control and speed the adoption of existing programs.

These are often under the umbrella of Integrated Resource Management (IRM)—a systems management approach which looks at the farm as a whole. We can increase efficiency by cutting production costs and protect the environment by optimizing chemical usage.

Not only our economic welfare, but also the quality of our lives depends on our ability to develop agricultural systems which produce efficiently while sustaining our natural water resources. A proactive program to address real and perceived impacts of agricultural technology on the environment is a far better alternative than a regulatory program which could reduce competitiveness and unnecessarily increase the cost of agricultural commodities. For example, in the nursery industry we have to be sure that the public is aware that we are addressing issues such as run-off from container operations by exploring the possibilities and problems of recycling irrigation water.

FOOD SAFETY

In addition to water quality, many Americans are tremendously concerned about the safety of the food they eat. According to a recent national survey of over 900 households by the Environmental Protection Agency (EPA) and the Michigan Agricultural Experiment Station, 28% of the respondents ranked pesticide resi-

dues as the "most serious" food safety issue. And 25% thought that the risk of health problems from pesticides was as high as one in a hundred! This is so far from reality!

While every reasonable care should be taken to protect consumers, the balance between risk and safety unfortunately has sometimes tipped too far in one direction, leading to the belief held by some that any risk, no matter how small, is totally unacceptable. Look at the outcry that arose when the EPA invoked a "negligible risk standard" for agricultural chemicals in food—and we're talking about a one in a million chance over an entire lifetime.

The perception of chemical residues on food items, especially fresh fruit and vegetables, has caused widespread public alarm and major disruptions of markets. Remember how the outcry over Alar caused some supermarket chains to refuse to sell an otherwise desirable crop?

Agriculture must communicate to the public that we do not live in a totally risk-free environment—that you are infinitely safer eating fruit and vegetables than riding in a car. Again, we need to stress the fact that our incredibly low food costs are very dependent on the use of technology—including pesticides and fertilizers.

We also need to emphasize the positive effects of agriculture, especially fruits and vegetables—so well-produced here in California—on human health. Vitamins from fruits and vegetables reduce cataracts; anti-oxidants prevent cancer; and dietary fiber helps control cholesterol. In a recent article in the International Herald Tribune there was a discussion of the role of vitamins such as beta carotene and E in reducing cholesterol accumulation and thus reducing the potential for heart attacks and strokes, even though the blood cholesterol level is high.

PUBLIC PERCEPTION OF TECHNOLOGY

There is one further challenge I want to share with you before I close: my personal—and professional—concern over the growing anti-science, anti-technology attitude of much of the general public. The scientific freedom of inquiry is under the threat of becoming an endangered species!

It is ironic that some of the best new tools we have in agriculture to help address the challenge of feeding and clothing a growing world population on a finite amount of land in an environmentally sensitive manner are being attacked under the banner of environmental, economic, ethical, and social concerns.

For example, with all the possible benefits of biotechnology, anxiety on the part of a worried public still exists. And unfortunately, that anxiety is often based upon the perception of risk rather than the reality.

To my mind, this is one of the single most critical issues confronting us today. Let me quote a January (1/7/91) editorial in the Wall Street Journal: "No modern advance is more vulnerable to damaging public assault today than agricultural biotechnology. It promises to produce a more bountiful, cheaper food supply. But for years the promise has had to confront demagogic scaremongering about the science itself, which in turn frightens consumers, which in turn causes not-very-courageous supermarket executives to repudiate the new technology." Last August a group of New York chefs announced they would not prepare or serve genetically engineered vegetables.

Another example is herbicide "safened" plants. There was an attempt during the debates on the 1990 Farm Bill to ban publicly funded research on herbicide

resistance. The rationale was that such research could lead to an increased use of herbicides. This approach is wrong for two reasons. First, the presumption is wrong. Herbicide-resistant plants will not lead to the use of more herbicides, but rather to the use of environmentally safer herbicides. Actually, less of the herbicide may be used because the herbicide can be applied directly on the "safened" plants after weed competition becomes a problem rather than using them as a prophylactic control. Second, restricting research will diminish the possibility of discovering better ways to control weeds which are both effective and environmentally safe.

Social, ethical, environmental, and economic impacts of new technology are valid issues, but they should be approached by science-based research, not emotion-based regulation.

Some people seem to forget that the ultimate beneficiary of research and technology which increases food production efficiency is the consumer—in other words, all of us—who enjoy inexpensive, wholesome, and safe food which can be produced in a way that is environmentally sound. As the Wall Street Journal concludes, "Better achievements are still to come—if the public and policy makers are willing to stand up to the scaremongers."

My own experience has been that the more people understand about science and agriculture the more they are interested in pursuing it and feel positive about the work it is doing. If agriculture is to be able to continue to use technology to improve itself and our overall quality of life, we must increase general scientific literacy, and make our case in the court of public opinion. This challenge is becoming more critical as society becomes more urbanized. People lose touch with the knowledge of the source of their food and fiber and the important role agriculture plays in the economy.

CONCLUSIONS

As change breeds challenge, agriculture must not only respond, but must anticipate and lead the way. The agricultural sciences and agribusiness will play a central role in meeting the challenges I have mentioned today.

Clearly, from ancient civilizations to our current technologically advanced society, national leaders have understood that new scientific knowledge can be a tremendous instrument of national strength and public good. The great British leader Winston Churchill said, "If the human race wishes to have...prolonged... prosperity,...science will do for them all they wish and more than they can dream." However, we can no longer take that support for granted. In addition to research and teaching, we must continue to communicate with the public and the policy makers about how our research benefits them and the quality of their life. This is an essential responsibility if we are to compete effectively for public funds to support research.

Thank you for the opportunity to share these thoughts with you. I see a very challenging, but nevertheless very rewarding, future ahead for all of us in agricultural research.