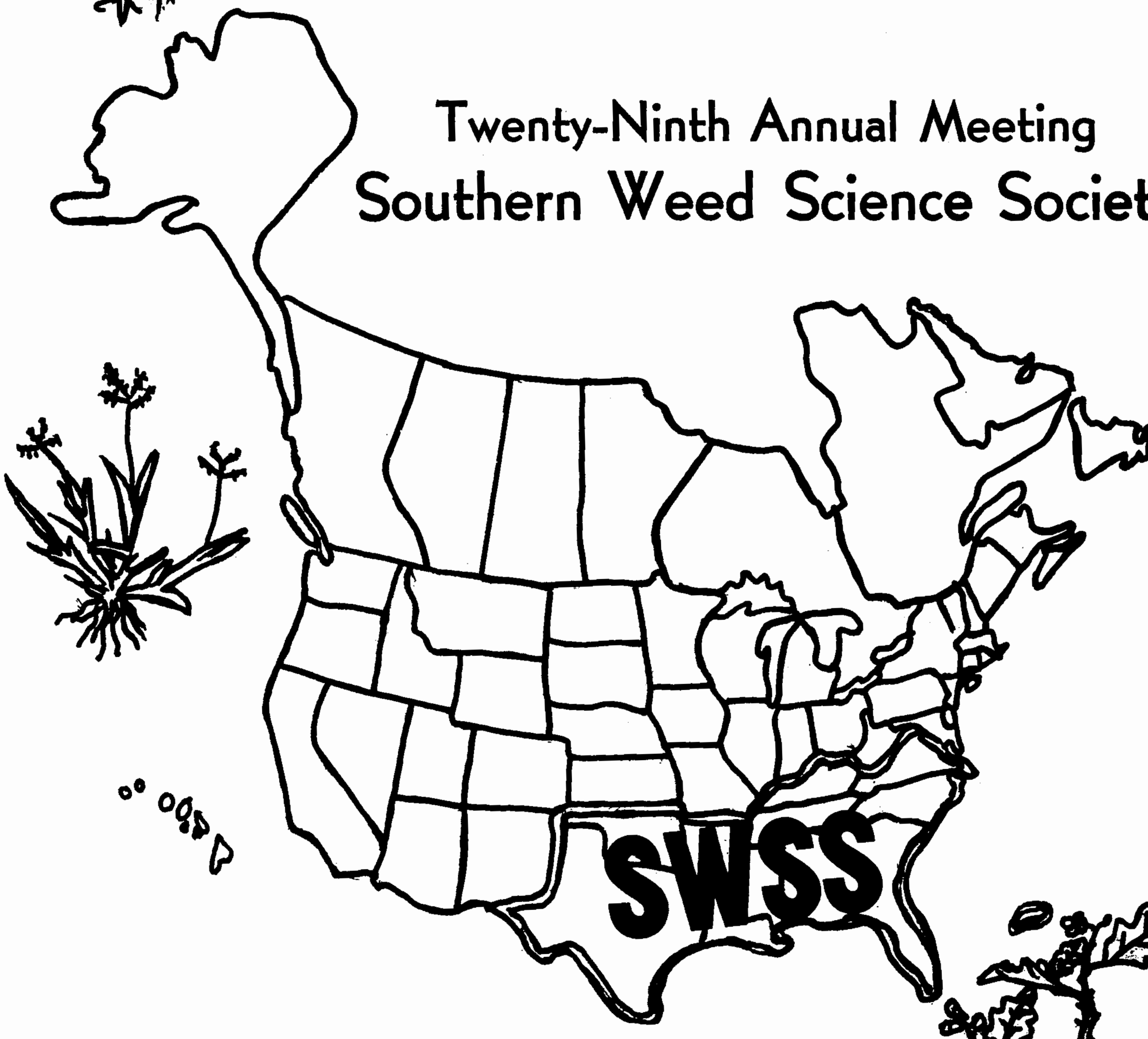
PROCEEDINGS

SWSPBE 29:1-576. (1976)

Twenty-Ninth Annual Meeting
Southern Weed Science Society



JANUARY 27, 28 AND 29, 1976
DALLAS, TEXAS
U.S.A.

As chairman, I would strongly suggest the Committee begin work a little earlier and that a special effort be made to develop leadership among industry people, although I visualize this situation might be a lesser problem two years hence.

Respectfully submit .d,

J. A. Keaton
M. G. Merkle
C. W. Swann
W. G. Westmoreland, Chairman

PLACEMENT COMMITTEE REPORT - Presented by K. E. Savage

The Placement Committee operated the Placement Service at the Statler Hilton. It currently has 32 individuals who are looking for a position, and 19 jobs listed. These jobs are divided between universities and industries. The room was in operation until 11:00 a.m., Thursday.

Respectfully submitted,

Ford Baldwin
Lloyd Hill
James Palmer
K. E. Savage, Chairman

PROGRAM COMMITTEE REPORT - Presented by Don Murray

"The Next Two Hundred Years" was chosen, during the Program Committee meeting held in Memphis in January, 1975, as the theme for the 1976 SWSS meeting. There was general agreement to organize the general session program around this theme. Contact with possible participants for the general session was made in late February.

Section chairmen initiated efforts to develop their respective programs in late summer. The 1976 program included 67 papers in Section I, 23 in Section II, 17 in Section III, 11 in Section IV, 7 in Section V, 27 in Section VI, 7 in Section VII, 8 in Section VIII, 12 in Section IX and 6 in the general session and luncheon. There were a total of 179 papers in nine technical sessions. The program was delivered to the printer and received by the program chairman. Immediately, copies were sent to those persons attending one of the last three SWSS meetings. These include copies sent to 1632 individuals in 31 states. Copies were sent to a number of individuals in foreign countries. The breakdown by states in the Southern region is as follows:

Texas	226	Arkansas	108
Mississippi	204	North Carolina	84
Georgia	156	Missouri	55
Tennessee	150	Alabama	43
Louisiana	125	South Carolina	40
Florida	111	Oklahoma	36

8. Whereas, the EPA and Federal Extension Service are misusing the term pest management, and

   Whereas, the term pest management should be an all inclusive term including the management of all pests such as weeds, diseases, and insects, and

   Whereas, the term pest management has frequently been used to mean insect management, thus ignoring the other pest sciences, and

   Be it therefore resolved, that the Southern Weed Science Society object to the misleading use of the term pest management.

9. Be it resolved that the Southern Weed Science Society commend Secretary-Treasurer Howard A. L. Greer, and Editor, Jerome B. Weber, for their services and excellent way in which their financial records have been maintained.

Each resolution was passed by vote of the membership.

Respectfully submitted,

Gene Pearson
Bill Blackmon
Dick Oliver, Chairman

STUDENT INTEREST COMMITTEE REPORT - Presented by J. R. Abernathy

Thirty-two graduate student papers were entered in the 1976 contest. Twenty-nine actual papers were presented at the 1976 SWSS meeting in Dallas.

The papers were divided into three sections with five judges per section. Judges were selected from the industry, research, extension, and teaching segments of our Society.

A $50 award was presented to each sectional first place winner and $30 to each sectional second place winner of the graduate student contest at the annual noon banquet.

Winners of each section were:

Weed Control in Agronomic Crops

1st - Early Postemergence Susceptibility of Gramineae Species to HOE 23408 - W.D. Mathis, L.R. Oliver, D. Bell, Univ. of Arkansas
2nd - Effects of Rate and Incorporation Depth of Three Dinitroaniline Herbicides in Cotton - E.C. Gordon and R. E. Frans, Univ. of Ark.
Honorable Mention - Plant Activity and Soil Movement of HOE 23408 - Chu-huang Wu and P.W. Santelmann, Oklahoma State University

Control of Weeds in Agronomic, Horticultural Crops, Rangelands, and Forests

1st - Control of Spiny Aster - H.S. Mayeux, Jr. and C.J. Scifres, Texas A&M University

2nd - Weed Control in a Pine Seedling Nursery - G. Barr and M. G. Merkle, Texas A&M University

Honorable Mention - Root Inhibition of Cotton and Soybeans by Profluralin, Trifluralin, and Dinitramine - G.C. Weed, D.S. Murray, and G. A. Buchanan, Auburn University

Ecological, Physiological & Edaphic Aspects of Weed Control

1st - Influence of Glyphosate on Bermudagrass - T. Whitwell and P.W. Santelmann, Oklahoma State University

2nd - Uptake and Comparative Phytotoxicity of Tebuthiuron, W. Steinert and J.F. Stritzke, Oklahoma State University

Honorable Mention - Movement and Persistence of RH 2915 in Soil - C.M. French and P.W. Santelmann, Oklahoma State University

Respectfully submitted,

R. M. Hayes
Ron Brenchley
W. S. Hough
J. R. Abernathy, Chairman

SUSTAINING MEMBERSHIP COMMITTEE REPORT - Presented by Roland Cargill

During June 1975, a mailing was made to all 126 sustaining members listed in the 1974 proceedings requesting their continued support; for their convenience an application for sustaining membership and invoice were included. Response to the June mailing was good, but a number of second notice letters had to be sent out in August.

In August 1975, a mailing to approximate 100 perspective new members gathered from past registration lists as well as suggestions from committee members and other members of the SWSS was made. Each perspective member was sent a letter outlining SWSS objectives and activities in which an invitation for membership was extended. Also included was an application for membership and an invoice.

All applications and checks were received by the chairman of this committee; a letter of acknowledgement and thanks was sent to each member following receipt. All checks were transmitted by certified mail to the Secretary-Treasurer. The sustaining membership card file was up-dated and expanded based on information from completed applications for membership received by the committee chairman.

The proceedings for 1974-1975 show 126 sustaining members. Of these, 12 chose not to renew their membership, there were two mergers of membership, and while we were not as successful as past committees in recruiting new members--6 were added. At present we have 118 sustaining members who

Proc. So. Weed Sci. Soc. 29:4-12.1976

COMMENTS ON THE NEAR FUTURE IN WEED SCIENCE

Paul W. Santelmann
Agronomy Department, Oklahoma State University
Stillwater, Oklahoma

It has been a privilege to serve as president of the Southern Weed Science Society this past year. It has been a very interesting year, and I hope that I have been able to accomplish something for the benefit of the Society and the science. However, as you gentlemen well know, the various committee chairmen do all the work. For instance, Gale Buchanan put this excellent program together. Minch Hillis has been working all year arranging the physical setups. President-elect Jim Becton has been worrying with the research and finance phases of our Society. Thus, I would like to sincerely express my appreciation to the many committee members for all the help and support they have given me in this past year. We will continue to have an active and effective Society so long as the chairmen and members of the committees function as they have this past year. It is only by each individual's contributing his time, efforts, and knowledge that will enable our organization to meet the challenges of the future.

One new activity undertaken by our Society in 1975 has been to participate and support the Council for Agricultural Science and Technology, better known as CAST. I would like to comment that I feel our investment in CAST has been an excellent one. In 1975 the organization has been quite active in many areas of particular concern to us - regarding herbicides, agriculture, and regulation. For example, they have published reports on chlordane and heptachlor, on the use of herbicides in Viet Nam and the United States, and on evaluation of an EPA report on the economic impact of guidelines for registering pesticides; they have issued a report on the phenoxy herbicides which had very wide distribution; they held a student-scientist food production dial-ogue answering questions from students all over the U.S. pertaining to fo production; they published an analysis of EPA's regulations on experimental use permits; and they have supplied expert testimony in hearings in various states about the phenoxy herbicides. I strongly feel that CAST is beginning to gain the credibility it needs with our national policy makers in Washington. Such credibility is going to be absolutely essential for CAST to make any significant contribution. Quite a few congressmen now know about CAST and recognize it as an unbiased source of information relating to agricultural and environmental problems. I note that one thing CAST is looking for is areas in which they can be of service in writing impartial reports. If any of you know of agricultural problems on which an unbiased analysis could be effectively written, we would appreciate knowing of it.

I would like to spend the remainder of my time discussing two things - weed science research, and public opinion and our work. I don't claim to be particularly original in my ideas - I have heard most of them expounded upon at one time or another over the years. However, these are some that particularly concern me. The challenge to weed science and weed scientists is the greatest right now that it has ever been. Agriculture is getting more intensive .d costs are increasing. This means that weeds are going to be a greater ; blem and that the means of controlling them are going to cost more. Thus, growers are going to need more effective control methods than we have provided in the past. In addition, more and more regulations, combined with reduced research funding, are going to require greater ingenuity on the part of the research weed scientist.

As a teacher of graduate students, over these past few years I have been amazed at the hiring by industry of a large number of students and weed scientists. I can remember six or seven years ago some of my university colleagues telling me that I should stop having seven or eight graduate students annually because there would be no jobs available for them. As we know, to date this has not occurred. Industry needs the trained manpower and it is part of the university function to provide such men as long as there is a need. However, it would appear that we are undergoing a re-defining of the traditional roles of industry and governmental agencies in the development of herbicides, and that this re-definition may have some far-reaching effects in the future for all of us. I have heard some industry personnel indicate that industry doesn't really need the universities in chemical development, particularly at the early stages of development. We are finding that industry is conducting more and more of its own herbicide research and development work. Industry men that visit us now frequently provide us with information they used to ask about. This increased level of industrial research has probably led to the flush of requests for university graduates, but must ultimately lead to a decline in the need for graduate students. University research programs are going to have to change as industry's activities in herbicide development change. Thus, I think the future will bring a noticeable change in the weed science research being done by the universities.

During the 50's and 60's, industry synthesized, screened, and selected candidate compounds. University men tested these compounds, advised about their utility, worked out mechanisms of action and metabolic pathways and environmental effects, and provided other useful data. The universities also tested widely within the state to evaluate or establish recommendations in specific areas, and also provided many residue samples. Extension weed workers spread the information throughout the state. Industry then sold the products - which have been used with considerable success. Thus, there has been an intermeshing of work throughout the whole process of the development and sale of a product. Now we find that industry is developing and in some instances carrying through almost all phases of product development from initial synthesis in the laboratory to placing it on the dealer's shelf. I cannot say this is a bad trend. However, I do feel that both the universities and industry need to recognize the changes that are taking place and try to insure that they work out in such a way that it is to the advantage of both interests. For instance, once industry staffing has been essentially completed, there will probably be a reduced role for the universities in the development of pesticides. The reduced role will not necessarily be of any less importance, but it certainly may require fewer people and will probably result in less funding from industry.

Since funding is involved with everything we do, I'd like to comment briefly on that. A major part of the funding of my research program at Oklahoma State University has been through industry. Many of the graduate students that are being hired by industry today have had their training funded through grant-in-aid programs with universities. Of the eight graduate students that I currently advise, only two are on regular departmental assistantships. Industry also has financial problems. Industrial administrators have to decide on priorities for their limited funds, and these may or may not include funding outside research. However, I would like to remind industry leaders of the cost of training graduate students. I know of university weed scientists who have had to cut back in their training programs due to changes in their financial support from industry. As universities are having more and more financial problems, we find that they are choosing their funding priorities in trying to keep faculty salaries competitive and in keeping up with drastically increasing maintenance and equipment costs. Thus, the number of assistantships available for faculty use is decreasing. If industry is also cutting back on their funding of university work, this cannot help but reduce the number of quality research personnel that we turn out in the future.

It is important that those of us in university research recognize the changes that are taking place and think through our rôle of the future. We are going to have to be more active in developing new concepts and new approaches to weed control and the use of herbicides. This could be of advantage to the entire field of weed science as the universities have probably spent too much time on herbicide screening and not enough time on the development of principles. Perhaps USDA weed scientists have been ahead of us in this. We are seeing that many crop cultural practices can be completely changed by the advent of effective herbicides. However, much more research is needed in this area and it probably can be done most effectively by governmental agencies.

Another research concern I have relates to breeding for new plant varieties. I hear entomologists and pathologists say that one of the outstanding procedures which may be followed in integrated pest management is to develop resistant varieties. Of course, they usually mean integrated insect management. However, they are ignoring some of the practicalities of weed control - as it will take a little longer to develop crop varieties that are resistant to weeds than to diseases and insects. However, my concern relates to whether or not plant breeders are inadvertently breeding for herbicide susceptibility or resistance in their breeding programs. How many of the plant breeders you know habitually treat their breeding fields with a dinitroaniline, urea, or triazine herbicide to cut down on their weed control costs while they carry on their research programs? If this goes on over the years, I can see where we may get new varieties that are at least partially developed and selected on the basis of the fact they look better in herbicide-treated fields - without the plant breeder realizing the varietal differences that may occur. As but one of many examples, Lloyd Wax at Urbana has said that some varieties and breeding lines of soybeans are severely injured or killed by bentazon, metribuzin and 2,4-DB when applied at rates that cause little or no injury to other soybean varieties. If soybean breeders or other crop breeders are not careful, they could very readily be selecting new varieties on the basis of herbicide tolerance. Most of us in weed science know the herbicides used in a field will change as time passes and I hope we can work with breeders to see to it new varieties are not being selected on the basis of herbicide susceptibility.

I recognize in talking about future research needs in weed science, it is equivalent to saluting the flag and admiring motherhood to say we need more basic research on weed species themselves. However, this is going to become more and more important as time passes, and it must therefore, be mentioned continually. Certainly some of the most fundamental apsects of weed biology have received scant attention, and yet they have over-riding influence on our technical problems. The concept of weed evolution, spread and adaptation is fundamental in nature. It should be one of the bases for establishing the activities of weed science research programs. We are still in the dark ages in understanding the biology of weeds. We need to develop better predictive systems with respect to what weed species or varieties are evolving as greater problems. With advanced warnings, research lead time can be gained in dealing with this problem.

We have made considerable progress in developing weed control programs - and any crop grower who is not sure of that can easily find out by leaving a few rows of cotton or soybeans untreated when they apply their herbicides. However, the common weed control system we have seen become so widely used - a preplant, a preemergence, and a postemergence herbicide - has been utilized very widely, with minor variations, for 10 to 20 years in the South. We are beginning to see signs of the potential lack of adequacy of this system in the future. If we can learn anything from the past, it is that future changes will come quicker than we anticipate. The challenge is now to find new alternatives to the present system. Maybe we need to spend more time in training farmers how to carry out other weed control practices, as well as on ways to utilize less chemical per acre and still get effective weed control. Perhaps herbicides in a more concentrated form could be used to save on freight and handling costs. Maybe we need to come up with more imaginative methods of reducing total herbicide volume. Perhaps farmers need to be thinking in terms of decades rather than years when they plan their weed control program. Farmers could minimize the buildup of herbicide resistant weed populations in their fields by keeping records of weeds found infesting their fields and adopting cropping sequences or herbicide sequences in which these weeds could be more easily controlled. Better knowledge of the level and types of weed infestations would also give the grower some insight as to new weed species that may be becoming prominent in his fields - before they reach the stage where they overrun the whole area. Only with a system of vegetation management utilizing proper field selection, good cropping sequences, knowledge of the weed infestation, intelligent herbicide selection, good sanitation, adequate fertilization, and other pesticide practices can the grower progress in controlling weeds. As the grower learns to think by the decade rather than by the year, a little extra effort in controlling a new particularly troublesome weed may save considerable time and money in the future. With the government constantly demanding more extensive and expensive information, we all need to recognize that industry is going to have to take a much harder look at its expenditures in herbicide development. This will have to result in fewer new herbicides reaching the market in the future. This means we are going to have to use more imagination in developing uses for herbicides already on hand. We have been set on the path of the most expedient weed control method - which ultimately is the one that will provide more niches for more problem weed species. Development of more effective weed control systems is one possible answer to this.

We also need to consider energy. The cost of energy is going to increase. Operating machinery will become more and more expensive - which will lead to greater herbicide use and increased problems of carryover, runoff, species shift, etc. As the price of gas goes higher, the relative price of herbicides will decrease. This is something we need to be ready for and that I suspect many of the companies have already figured out. We are going to see increases in herbicide problems as herbicide use increases. This means research programs are going to have to be modified to learn more about injury to non-target species, pesticide interactions, and excessive persistence problems that we are going to run into.

As indicated earlier, it is difficult to talk about weed science and near future without being concerned about funding. All of us know the way costs are rising. The increasing cost of government at all levels is having a significant influence on education and research - and one that we must consider. We've heard of the miracle of American agriculture and how well it is able to produce with limited land and water resources. I think that most of us who are actually involved with agriculture recognize that this is not really a miracle. It is an interaction of many things - including a lot of hard work by many research and extension men as well as the growers. This miracle is now being hurt by restrictions on research due to the fewer and fewer dollars that are available. The percentage of the total research dollar going into agricultural research by most agencies is decreasing at a fairly rapid rate. At the same time, the costs of research continue to increase. One survey indicated that while sales of all agricultural pesticides were increasing by 13 percent, research and development expenditures were increasing by 33 percent. The cost of supporting a scientist man year in the university has doubled in the last 10 years. In order to continue doing effective work, we are going to have to do a better job of setting priorities in our weed science research programs. I can assure you that administrators - university, federal, and industrial - are having to set more definable priorities for their money. Unfortunately, some of the governmental (federal) priorities are being placed where there is too much emphasis on resolving the negative side of responses of pesticides to environmental and biological factors, much to the detriment of basic research which needs to be supported. We seem to be reaching the stage where much of the financing has to go into applied research to answer immediate questions asked by government agencies and thus, we find basic research is not being financed - even though this will be the only basis for future advances in weed science and agriculture. If we are going to do an acceptable job of planning for research needs in the years ahead, each of us is going to have to evaluate our priorities and adjust our programs accordingly.

Another area in our research programs that concerns me is long-range planning. Many organizations have long-range planning boards. Perhaps we need to be operating in such a manner. This might enable us to do a better job of expecting the unexpected. We all occasionally have to fill out 5- or 10-year plans - but do we really pay much attention to them? Do we ever really think in detail about what may be happening in the next 5 or 10 years? I haven't heard of anyone in the pesticide industry that hasn't been surprised by many events over the past few years. For instance, there was the tremendous increase in public concern about ecology and the environment during the 1960's. This caught us by surprise. Perhaps we should ask, "should this have been a surprise?" Another happening has been the energy crisis. Why did this hit us so hard and come so unexpectedly? Again, perhaps we should ask, "Was this really a surprise?" I suspect we should have been able to foresee this type of problem. There have been many other things occurring in the past few years which caught us by surprise. I suspect we should have been able to do a better job of anticipating the unexpected. As with most people, my hindsight is 20 - 20. It's the seeing into the future that is hard. However, some industries develop continuous strategies for unexpected happening. Perhaps we all need to start doing better planning for the unexpected in weed science and crop production. We need to make realistic appraisals of events, both real and imaginative. We need to step back and look at our operations from a distance. We need to develop a flexibility in developing innovative strategies so that more of these surprises will not really be surprises. The unexpected is going to happen. It may come in the area of prices, of ideas the public may develop, of weather modification, of public pressures, of new plants, of new pests. I suspect one of the reasons for the initial development of the EPA was because we didn't handle the unexpected as well as we thought we were. There are some who feel every challenge and every surprise is an opportunity. Perhaps more of us need to think this way. How will true population control (which will come someday) affect our businesses and our research programs? What if we find other crops for human consumption - alfalfa, perhaps? What if the yield of soybeans should be doubled through a research breakthrough? Or, what will happen if we run out of fertilizers or the energy to make herbicides? How will all these things have an effect on our activities? How will it affect herbicide use? How will it affect weed problems? There are many questions of these types which we must start thinking about in relation to our own programs and which are going to need industrial and governmental cooperation to solve. We had better start planning.

During this past year I had the very interesting experience of working on a CAST "Dial-ogue" in St. Louis. Advertisements in school papers all over the U.S. encouraged high school students to call a toll-free number with questions about agricultural production, including the use of pesticides. It was very interesting to note the many different types of questions that flowed in - over 2,000 of them - and a very great concern to see how many questions were based on fals information the students had received somewhere in their educational process. This seemed to be true whether the students were calling from New Jersey, Montana, Texas, California, or any point in between. There is a tremendous lack of knowledge among young people about what is really meant by agricultural production, the balance of nature, the quality of the environment, and so forth. The other day I saw a quotation by Bacon that it is only for God and the angels to be spectators in human affairs. We are at a stage where all of us must become a part of the action, and the action today is more in the hands of politicians, regulatory agencies, and the general public than it is in our halls of academia or our company. Our basic challenge is to become a meaningful part of the action mechanism. Scientists complain because many decisions seem to be based on emotion. Yet we must recognize that emotions play a strong role in what we do, and that this emotional input often distorts the facts available. Emotions are real and we might as well accept it. In our educational systems, our children are learning about nature and wild things as something good to be cherished and that man and his environmental activities are evil and must be condemned. They are learning that agriculture disturbs the natural ecosystem, and associated with this the fact that pesticides are evil. There is essentially no concern or understanding of man's basic need for food which makes survival possible, and certainly no understanding at all of the fact that if American farmers were not such effective producers most of these students would be out on the farm trying to help support their families. These students are not taught to think of human beings as a natural part of the ecosystem at all. It seems to me that the agricultural and pesticide industry is going to have to launch some sort of a public relations offensive much greater than anything we have seen in the past. Many of the so-called consumer and environmental organizations are doing this. All this is pointing to the fact that we need to better justify both our research and our production practices - not just to our administrators and funders, but to the public in general. We like to think we are working for the betterment of mankind, and that our research is done so that we can produce better crops more economically at greater savings to the consumer. We have put very little effort into justifying our research to the public. I've discovered that one of my own administrators thinks all we have to do to get a new herbicide cleared is to apply it to a few plots around the state, take a couple of residue samples, send them in, and then get approval - and he supposedly knows more about it than the average laymen.

There are two groups that are really going to decide our research funding in the future - the consumers and the government. We need to keep in mind that so far as the consumers are concerned, they don't know or care about the financial situation in agriculture. What they do care about is what they have to spend at the supermarket to buy food. Consumers are organizing and they are going to have more and more influence on the activities of congressmen in Washington. As an example, several of the new members of the House Agricultural Committee are city men from such areas as Queens, Boston, and Rye, New York. All are consumer advocates. Thus, we might as well face the fact that agricultural funding by Congress is going to be decided by those who don't know much about our research. For both of these groups, consumers and government regulators, a tremendous educational effort is going to be necessary both by the industry, by producers, and by the universities. I am not enough of a public relations man to know how this is going to be done but even I can see how badly it is going to be needed. I have noticed that magazines such as Time and Newsweek sometimes carry full page advertisements by some of the big companies like IBM and Continental Can showing how their companies are helping to improve the environment. Perhaps more of the agricultural industries need to start placing full page advertisements about the importance of agriculture (and pesticides) for feeding our population. Another aspect involves communication with congressmen. Maybe it's time we stop griping about problems with the Congress and the financing of agriculture and research and start doing something about it. How many of you have communicated with your congressman within the past year? We are repeatedly told that our congressmen want our input and yet most of us just don't seem to have the time to do anything about it. I'm beginning to think that communication with the congressmen could be one of the most important acts we could perform in the years to come.

We've all heard many times that weed scientists need to make their stories better known to the general public. I attended a conference this past summer on research to meet world food needs, and it turns out other professional science organizations are saying the same thing. We've talked about this for many years, but I can't think of any significant way in which we have actually changed the activities of this organization in such a way to achieve this oft-repeated objective. Perhaps it's time we try some different method of attaining visibility, both for us and for our science. For a world that is extremely media conscious, I suspect we are making too few concessions to that increasingly anxious public. Just what has our Society done to further the process of understanding or appreciation of the work we do? Have we changed our meetings or publications to make it easier for the media to get information - or do we just continue to descend on a location and impress each other with what we have done since the last time we got together? Perhaps we have at times had too much visibility in some areas - such as in the case of 2,4,5-T. However, it is time that some weed scientists begin to get their names known to the public the way that some so-called "ecologists" or "environmentologists" are able to do. The only weed scientist that I can think of who seems to be able to do this is one of our speakers this morning, Dr. Boysie Day from California. The other day I saw about a recent university thesis on what it takes for scientists to communicate effectively with the general public. One of the main findings was that some scientists are visible because of their public involvement, their "activities in the messy world of politics and controversy." We've all avoided this. Certainly more is needed than public involvement. You have to be able to talk and you have to be able to translate your scientific papers into the kind of English that most Americans use. It helps if you have a colorful image, one place that I'm afraid I'm sadly lacking. Certainly such visibility is not all glory. It may have a negative effect on a scientist's research career. It takes a lot of time which could be devoted to research. However, there are certainly weed scientists who have the necessary qualifications for visibility and who have established a name for themselves and can talk in terms the public understands. Perhaps we need a few more publicity seekers who feel it is in the greater overall interest of their science to become involved in public issues. We need to have more responsible scientists who have memberships and activity in some of the so-called environmental societies. It's hard to complain about their activities if we have no part in them and ignore them as much as we can.

I note recently some of the members of our Society have found another way to gain some visibility and hopefully have some influence on public opinion as related to weed science. Within this past year an Alabama Society of Weed Science was organized to bring together a wide variety of persons interested in weed science and weed control - including farmers, homeowners, company representatives, teachers, and university personnel. The overall purpose is to advance weed science in Alabama, and I think there is no question but such an activity can only help to gain support for proper use of herbicides. Since Gale Buchanan is the first president of this society, I have to assume that he had a major part in forming it; but certainly farmers and industry representatives also played an important part in the organization. I note one of their objectives deals with informing the public about the magnitude of weed problems and the need of better control techniques to benefit the entire nation. Efforts such as this will do a better job of informing the public of just what really is going on and can work only for the overall advantage of weed science. Perhaps some of us older fellows need to spend more time involved with the problems of the environment and of science while the younger scientists work with the challenge of research. I recognize this sounds like heresy to some of us who don't like to admit we are getting a little older, but there have been too many instances of trained scientists holding back while those who don't really know much about the matter charge ahead and make the decisions affecting our work. Certainly we have some outstanding examples of publicly active scientists in the men who are on the remainder of the program this morning - men like Charlie Black, Glenn Burton, and Boysie Day. More of us need to get involved - I hope we will.

Proc. So. Weed Sci. Soc. 29:28-41.1976

PLANTS AND PLANT USES IN 2176

Glenn W. Burton
USDA, ARS
Georgia Coastal Plain Experiment Station
Tifton, Georgia 31794

Forecasting the future is not new. Man was reading the signs to predict the future when the first pages of history were written. He continues to do so. If he guesses right often enough, he makes the headlines. Otherwise his credibility as a forecaster quietly slips away.

You have been kind to allow me to look into the future 200 years. By that time none of us will be around to check my credibility. And if the volume of printed material continues to increase at its present rate, wading through to get to my forecast would be too much for anyone to undertake.

Lee and DeVore (9) tell us that man has been a hunter-gatherer for more than 99% of the time that he has been on the earth. He took what nature provided and made no attempt to alter it. "Only in the last 10,000 years has man begun to domesticate plants and animals, to use metals and to harness energy sources other than the human body." Generally the hunter-gatherer ate well of a great variety of foods and worked less than 20 hours a week to do so. Harlan (7) calls it the Golden Age.

Mangelsdorf (10) states that, "During his history, man has used at least 3,000 species of plants for food and has cultivated at least 150 of these to the extent that they have entered into the world's commerce. The tendency through the centuries has been to use fewer and fewer species and to concentrate on the more efficient ones, those that give man the greatest return for his land and labor." As man concentrated on the more efficient plants, he began to modify them to better suit his needs. His efforts left some crops (the sunflower, *Helianthus annus* L. and oats, *Avena sativa* L.) enough like their wild progenitors that their evolutionary pathway can be easily traced. Others like maize, *Zea mays* L., differ so much from existing wild relatives that their origin is still a matter for dispute (7).

Modern plant science, particularly genetics and plant breeding, has made it possible for man to acelerate the rate at which plants can be altered to meet his needs. I expect this acceleration to continue.

Plant uses will be determined by man's needs. What will man need from the plant kingdom in 2176? If we could answer this question, we would be better able to describe the plants that man will use.

Let me begin my forecast by making some very important assumptions. First, I'm going to hope that the world's climate pattern will not change. If the world continues to cool as some has suggested, there could be much less land on which to grow plants useful to man. If the climate pattern does not change, agriculture, currently based on irrigation from ground water not being recharged, will be dry-land farming. Yields will be down. Plants with greater drought resistance and water-use efficiency will be needed.

Lack of energy may alter man's life style by 2176 more than any other feature of his environment. Man's use of energy from fossil fuels has made possible the sophisticated life he enjoys in the U.S. today. In 1969 the average U.S. worker had 37,494 kwh of energy to help him do his work. This is the equivalent of 240 slaves per worker. The average U.S. home in 1969 used 6,570 kwh of energy - the equivalent of 42 servants. When reminded of this fact, my wife replied, "I'd like to swap a few of those 42 for one with a pair of hands."

By 2176 much of the world's fossil fuel that can be harvested economically will be gone. Unless we learn to utilize the energy from atomic fusion or find some other inexpensive source of energy, the world could be forced to demechanize agriculture. Chinese rice (Oryza sativa L.) culture, based largely on human labor, required much less fossil energy to produce a pound of rice than the most highly mechanized methods used to grow the crop in the U.S. But nothing short of real hunger and threat of famine would make most of us grow rice the Chinese way.

To replace 1974 U.S. mechanized chemical agriculture with 1918 horse - organic methods would require 61 million horses and mules and 26 million more farm workers (6). It is biologically impossible to breed 61 million horses from the 3 million we now have before 1992, and it might be even more difficult to find the additional farm workers. It would take 180 million acres of prime farm land to grow feed (fuel) for the horses. Most important, 1974 agriculture production was 2-1/4 times that of 1918. With demechanized agriculture, we would have less to eat (food would be rationed) and we would pay a lot more for it.

Agriculture uses only 2.5% of the energy consumed in the U.S. today (13). The U.S. farmer produces about 3 calories of food for every calorie invested (6). It takes an additional 14 calories to transport, process, package and put those 3 calories in your grocery bag. Much of your food bill is for built-in maid service. By 2176 consumers should know this; and, if they do, mechanized chemical agriculture will have a high enough priority to get the energy it needs. Energy will cost more and farmers will search diligently for plants that will produce the most per unit of energy invested.

I believe there will be more people to feed in 2176 than today. Food production will continue to set the population ceiling. Before 2176, the world will have learned from experience that if population is not limited before it is conceived, famine will do it afterwards.

Limited supplies and increased costs of fertilizer and other inputs will put greater pressure on geneticists and plant breeders to increase the efficiency with which plants use growth factors.

I believe by 2176 people, particularly in nations like our own, will have a greater appreciation of the importance of agriculture. I like to think that agriculture's needs for machinery, fuel, credit, and incentives will receive top priority.

I must assume that agricultural research will be continued and will be supported with a higher percentage of the world's gross national product than today. I sincerely hope that by 2176 a higher percentage of the research dollar will be spent on interdisciplinary basic and applied research and that more of the people paid by research will be actively involved in doing it.

Green plants have fed the world for more than 500 million years as they have converted solar energy into food for themselves and other organisms on earth. Supplying the basic food stuffs for man will continue to be the main use of plants for the next 200 years.

Plant taxonomists have described and named over 350,000 plant species. These exhibit tremendous diversity and range from microscopic single-celled algae that live only a few hours to giant redwood trees towering 340 feet into the sky and boasting an age of more than 3,000 years. These have been grouped into four major divisions with subdivisions and classes (Table 1).

Table 1. Numbers of plant species by subdivisions and classes.

	No. of species
Division I <u>Thallophyta</u>	
Subdivision I Fungi (Lack chlorophyll)	100,000
Subdivision II Algae (Chlorophyll)	24,500
Division II <u>Bryophyta</u>	
Subdivision I Mosses	14,000
Subdivision II Liverworts	9,000
Division III <u>Pteridophyta</u>	10,000
Division IV <u>Spermatophyta</u>	
Subdivision I Gymnosperms	650
Subdivision II Angiosperms	
Class I Monocotyledons	50,000
Class II Dicotyledons	150,000
Total	358,150

The largest subdivision in the Thallophyta is the fungi that lack chlorophyll and cannot fix solar energy. Here are the yeasts and mushrooms that supply small amounts of food for man but only at the expense of another energy source. Here also are grouped the plant diseases that reduce food supplies. The fungi will not solve the world's food problems.

The algae, some 24,500 strong, are the most important of all plants in biological communities of fresh and salt water. Although some of these, the red and brown algae, are used as human food, their greater contribution to man's food supply is indirect. They furnish the initial food for water animals that man in turn may eat. In laboratory experiments, algae have been shown to fix solar energy efficiently and produce high yields of protein. I believe, however, that the energy investment required to grow, dehydrate,and process algae will be too high to make them competitive with our best food plants in 2176.

Schrimshaw (14) summarized his assessment of the Thallophyta as a direct source of food for man as follows:"Even torula yeast, produced on very cheap molasses in tropical countries, has thus far proved too expensive to be an economically competitive source of protein for either animal or human feeding."

The 23,000 mosses and liverworts, that make up the Bryophyta, supply food for some animals. But they are of much lesser economic importance than the Thallophyta and will continue to be.

The Pteridophyta contain 10,000 species commonly called "ferns", "club mosses" and "horsetails." Beautifying the environment is and will continue to be the main contribution of these plants.

The Gymnosperms with some 650 species supply wood and paper of great economic importance to modern man. By 2176 most of the natural woodlands now growing these trees will be planted to F_1 hybrids of the most efficient species. They will have been modified genetically to produce a higher yield of better quality wood, fiber, gum, or other components that man will need. They will not be free of pests,but they will carry resistance that will enable them to better meet man's needs. The beauty of those species used as ornamentals will have been enhanced.

The angiosperms,containing 200,000 species grouped into 300 families, will still be supplying most of man's food in 2176. But which ones will be used and how will man change them?

In his Economic Botany, Hill (8) lists about 100 species of plants currently used for human food. Out of more than 250,000 green plant species in the plant kingdom, why are only 100 important enough to list in such a text? Are there others yet to be discovered that can play a significant role in feeding man?

One of the plants listed by Hill is breadfruit, Artocarpus altilis, a stranger to most North Americans. Hill states that "Few plants furnish a more wholesome food for man and beast or have a greater yield" (8). I have enjoyed eating the fruit of this tall tropical tree in Puerto Rico, but it is hard to harvest and transport and has a short shelf life. By 2176 geneticists may have dwarfed the tree to facilitate harvest, but I doubt that it will enjoy much wider use than today.

Many plants used as food in remote parts of the world fail to yield enough to contribute much toward solving the world's food problems. Digitaria exlis, grown on the plateau near Vos, Nigeria, produces only about 200 kg/ha of grain.

One of the favorite, always available fruits in much of the world is the banana, Musa sapientum L. With the best varieties and good culture, it is possible to produce 23 tons of fruit/acre/year. This amounts to 17.4 tons of edible fruit with a dry weight of 8,700 pounds. The banana is an easily digested, sugary food, deficient in both fat and protein. Although bananas can convert more solar energy into edible food than most plants, man's taste and the extra energy required to grow, ship, and store them will not allow them to replace the top cereals as human food.

Mangelsdorf tells us that "Today the world's people are actually fed by about 15 species of plants - rice, wheat Triticum aestivum L., corn, sorghum Sorghum bicolor (L.) Moench, barley Hordeum vulgare L., sugar cane Saccharum officinarum L., sugar beet Beta vulgaris L., potato Solanum tuberosum L., cassava Monihot esculenta Crantz, common bean Phaseolus vulgaris L., soybean Glycine max (L.) Merrill, peanut Arachis hypogaea L., coconut Cocos nucifera L., and banana"(10). What are our chances of discovering exotic food crops that can replace these that are currently feeding the world?

From 1949 through 1974, the USDA, ARS introduced 219,373 different plants into the U.S. (15). Most of these moved through the hands of Dr. Howard Hyland, Principal Plant Introduction Officer for the U.S. Many of them were varieties or relatives of our major food crops and have made invaluable sources of germplasm for our plant breeders. During this period, hundreds of plant explorers have collected plants thought to have food potential. To my knowledge, none of the new species have been as good as our standard food crops. We must continue to look, but I believe man's diet in 2176 will consist largely of the same plant species he eats today.

New food crops will not be easy to find. To succeed they must be adapted and capable of giving high yields of a desired product. Because 2176 will still find most of the world's people living in urban centers far from the fields where crops are grown, new crops must be easy and cheap to store and transport. They must require a minimum of energy to process and must satisfy man's taste. Finally they must be better than the food crops generally used.

Can exotic food crops gain acceptance in nations such as the United States, with its complex and sophisticated agriculture? The soybean, an exotic crop in the Western Hemisphere at the turn of the century, answers with a loud, "Yes, if that crop meets the above requirements."

In 1898, USDA Agronomist W. J. Morse collected more than 7,000 samples of soybeans from the Orient and grew them in test plots at various locations in the United States. For a time, the new crop seemed to have more potential for forage than human food. By the mid-30's, thanks to the special efforts of J. C. Hackleman, University of Illinois Agronomist, his state was producing around 20 million bushels, two-thirds of the nation's total soybean crop.

Not even the soybean's most ardent supporters would have dreamed in 1936 that 30 years later, it would be the No. 1 cash crop in the United States, with a farm-sale value of $2.4 billion. Agricultural, chemical, engineering, and food research, that taught us how to grow and process a bushel of soybeans into 10.8 lbs. of edible oil and 47.5 lbs. of high protein meal, deserves credit for this remarkable success story.

In 1956, Simon and Schuster, Inc., (3) published a fascinating novel by John Christopher entitled <u>No Blade of Grass</u>. The book described a new virus disease so devastating as to destroy all grasses it attacked. Starting first with rice in the Orient, the virus rapidly spread around the world, leaving in its wake no blade of grass and only a few people, who had survived starvation. The story, dealing mainly with the response of man to starvation, dramatizes most effectively man's dependence on grass for food.

Today the cereal grasses are man's most important source of food. One species alone - rice - furnishes 60% of the energy for at least half of the people in the world. Thus, 30% of the human energy of the globe comes from one grass, rice. Wheat ranks second and maize third as human foods. To these, add barley, rye, oats, sorghum, and millet, and you have listed the plant species that directly or indirectly supply over three-fourths of our food.

I believe the cereal grasses will still be man's most important food source in 2176. Here are some of the reasons behind that statement. The cereal grasses are adapted to a wide range of soil and climatic conditions. They have the high yield potential necessary to feed the world's hungry billions. Cereal culture is well suited to mechanization. A few can feed many when the food is from the cereal grasses. The seeds of cereal grasses are high in food content and are easy to handle, store, and transport. Finally they require less energy per calorie of food delivered to urban people than most other food sources.

I believe in 2176 man will still be using the major food crops he grows today to round out his cereal diet. He will grow sugarcane and sugar beets for sugar; the potato, sweet potato, and cassava for starch; and cereal legumes (soybeans, peanuts, and coconuts) for oil and protein as well as the other nutrients supplied by these crops. The characteristics that make these plants man's staple food crops today will keep them there 200 years from now. I also believe that man will add variety and healthfulness to his diet by continuing to consume most of the other crops, vegetables and fruits that he eats today.

The varieties that feed man 200 years from now will be different. Some may be so different that old men may find it difficult to recognize crops they knew as boys. Corn, for example, may produce its grain in the tassel on top of a plant only half as tall as the shortest hybrids grown today. Most of the genes necessary to make this transformation have been isolated. The change could facilitate mechanical harvest, but would leave the grain more subject to bird and insect damage. Such transformations will not be made unless they will increase the efficiency and usefulness of the plant.

Greater tolerance of drought, flooding, heat, and cold will be features of 2176 food crop varieties. These characteristics will increase their dependability and extend their areas of adaptation. More extensive, more efficient root systems, thicker cuticles, and fewer stomata or stomata that open at night and close in the daytime (as in the pineapple plant) will help 2176 varieties use water more efficiently.

Some of the changes in grass morphology to be expected will be shorter, stiffer stalks to overcome or reduce food losses due to lodging. Where grain is the food product sought, a higher proportion of grain to plant is indicated. The success of the semi-dwarf varieties of rice, wheat, and sorghum proves that solar energy diverted into long stems and extra leaves may be a liability rather than an asset. Leaf placement to maximize the absorption of solar energy in densely planted fields will have been determined by plant physiologists and added to 2176 varieties by plant breeders. Better grain placement and increased shatter resistance will reduce today's harvesting losses in soybeans and similar crops.

Genes to hasten field drying once a grain crop is mature will reduce the energy required to produce these crops in 2176. Today it takes two to three times as much energy to dry field-shelled corn as it takes for all other cultural practices on corn.

Most grain varieties grown in 2176 will carry no photoperiod sensitivity, so they can be grown at any season of the year if temperatures are right. Days from planting to maturity will be altered in these varieties to permit two or three crops per year where temperature and water will permit. Varieties of crops like corn will carry increased tolerance to low temperatures in the seedling stage so they may be planted earlier. Increased shade tolerance in the seedling stage will be added to varieties to be planted in existing crops where relay cropping is practiced.

Varieties planted in 2176 will be able to recover more of the fertilizer elements applied and will use these materials more efficiently. According to the Fertilizer Institute (16), production of the 3 most commonly used fertilizer elements, N, P, and K, in fertilizer form required 25,000; 7,000; and 2,300 BTU/lb., respectively. The energy required to produce the 150 lb/A of N frequently applied to corn is over 5 times the energy required to grow and harvest the crop. I believe varieties of many of the grasses grown in 2176 will satisfy a part of their N requirements by biological fixation of atmospheric N (4). The cereal legumes will be able to meet their N needs through symbiotic nitrogen fixation. If N is very costly in 2176 due to high energy costs, special legume varieties will be grown in association with nonlegume crops to supply a part of their nitrogen requirements. In Pennsylvania, corn planted by no-till methods in perennial crown vetch weakened with Paraquat or Atrazine and fertilized with 50 lb/A of N yielded as well as that grown by conventional methods and fertilized with 150 lb/A of N. If the legume can continue to recover and perenniate with continuous corn culture, such a cropping system could save energy equivalent to 19 gallons of gasoline per acre per year.

Part of the superiority of 2176 crop varieties will be due to genes from wild relatives introduced by introgression. Frey (5) and his associates have set the pattern in their recent genetic improvement of oats. From wild oats (Avena sterilis L.) they have transferred genes to cultivated oats that have given resistance to 5 diseases, improved protein content in the grain and straw, raised grain oil content to 12%, and increased grain yields 25 to 30%, twice the yield increase from 55 years of conventional oat breeding.

I believe by 2176 geneticists will have learned how to transfer purified DNA from one species to another too unrelated to hybridize. With this capability, they will be able to develop varieties carrying much greater resistance to diseases and insects than the best varieties available today.

Farmers will still be fighting weeds in 2176. Varieties better able to compete with weeds will be available, and improved cultural practices will help them do it. Herbicides capable of controlling a broader spectrum of weeds will be applied without risk of injury to varieties bred for adequate tolerance.

Triticale, a man-made species from a wheat x rye cross will be a commonly grown cereal in 2176. Will man have created other new, useful species by that time? Certainly the potential is there. Bread wheat, the world's No. 2 staple food, is a hybrid between three unimportant grass species: Triticum monococum L., Aegilops speltoides Tausch and Aegilops tauschii Coss. Brought together before the dawn of history to form an allopolyploid hybrid, the genes in these species produced one of man's most useful cereals. To create new species in this way will not be easy. After examining all reports of intergeneric hybridizations in legumes, McComb (12) concluded, "There is little evidence for intergeneric crosses amongst legumes and consequently scant possibility of breeders increasing genetic diversity of agriculturally important species in this way."

Protein and some of its essential amino acids are the components frequently deficient in food today. Lack of adequate amounts of the essential amino acids retards physical development and causes permanent brain damage in young children. In older people, protein deficiency reduces their ability to resist disease and cuts their capacity for work. It has been estimated that half the people in the world suffer from protein deficiency (7).

Well over half of man's protein comes from cereals. Unfortunately cereals are low in protein and are frequently deficient in one or more of the essential amino acids. Lysine, methionine, tryptophan, and threonine are the amino acids that may occur at inadequate levels in cereal grains. Of these, lysine is usually most deficient.

All essential amino acids have been synthesized in the laboratory, and lysine and methionine are produced commercially. It is possible today to prepare for people the same kind of pelleted food, completely balanced with synthetic vitamins, amino acids, minerals, etc., that we feed our chickens. The demand for such a colorless diet would be low even if it were inexpensive, and I doubt that the demand will be much greater in 2176 than it is today.

Seeds of legumes such as beans, peanuts, and soybeans contain more protein than the cereals and higher percentages of amino acids that supplement the amino acid deficiencies of the cereals.

It has been suggested that large urban populations could not form in America as long as maize was man's staple food, because it did not supply sufficient protein to meet his needs. Wild animal sources could not be concentrated to supplement this deficiency. It was not until early Americans started to cultivate beans and balance their maize diet with them that the large concentration of people necessary to sustain a high culture was possible.

Legume seeds supply over 9 million tons of man's protein today. In India over 10 million tons of non-oilseed legumes are consumed annually. Some oilseed legumes, particularly the soybean, are usually processed before they are eaten by man. Orientals have long supplemented their cereal diet with soybean protein by producing soybean curds, or "tofu". Modern processing includes removing the oil, heating the residue to drive off undesirable substances, and developing meals, flours, finely pulverized milk substitutes, and texturized products that closely resemble meats. I believe legume seeds will still be an important source of protein and oil in man's diet in 2176.

As the demand for food protein increases, man may be forced to turn to certain forage crops to meet his needs. Akeson and Stahmann (1) used the Amino Acid Handbook and United States yields reported for 1953 to 1962 in Agricultural Statistics to calculate the yield of essential amino acids in various crops harvested as forage or seed. Some of their data, reproduced in Table 2 show that an acre planted to alfalfa can produce 67% more essential amino acids than soybeans harvested as seed.

Akeson and Stahmann also estimated the yield of protein and essential amino acids from an acre of corn, harvested as leaf protein, seed protein, and animal protein (Table 3). With 75% extraction, harvesting corn as leaf protein would increase the yields of essential amino acids 60% over seed protein, 245% over milk protein, and more than 12 fold over beef protein.

Yields reported by Akeson and Stahmann are relative for the various crops but are far below the potential that might be realized. In Georgia, 'Coastal' bermudagrass, fertilized with 600 lbs/acre/year of nitrogen has produced over 7 tons/acre of dry forage containing over 2,400 lbs of protein and 130 lbs of lysine, the amino acid most deficient in world diets (2).

Table 2. Yield of essential amino acids for various crops harvested as forage or as seed.*

Plant parts	Pounds/acre of lysine, methionine tryptophan, phenylalanine, threonine, valine, leucine, and isoleucine
Alfalfa forage	300
Soybean seed	180
Corn forage	170
Soybean forage	155
Clover forage	150
Cowpea forage	130
Lespedeza forage	110
Field pea seed	105
Sorghum forage	105
Field bean seed	100
Rice seed	90
Peanut seed	90
Corn seed	80
Sorghum seed	70
Wheat seed	55
Rye seed	35

* Adapted from graph by Akeson and Stahmann (1).

Table 3. Yield of edible protein and essential amino acids per acre from corn grain, leaf protein concentrate extracted from fresh corn forage, and animal products obtained by feeding corn grain to various classes of livestock.*

Protein foodstuff	Lbs. of protein per A	Lbs. of essential amino acids per acre
Leaf protein concentrate from corn		
50% extraction	199	85
75% extraction	298	128
Corn Seed protein	234	80
Animal proteins		
Milk	87	37
Broilers	82	28
Eggs	60	27
Turkey	62	21
Hog	56	22
Chicken	49	17
Beef	26	10
Sheep	14	5

* Adapted from Akeson and Stahmann (1).

Under the current price structure, leaf proteins as presently extracted cannot compete with those from oilseed meals. As the demand for food protein increases, oilseed meal prices will also increase. By 2176 man may be forced to produce essential amino acids from the crops that produce the highest yields regardless of cost.

All food constituents (amino acids, protein, oil, starch, sugar, etc.) in cereals are under genetic control and can be modified by plant breeding. The opaque-2 (O_2) recessive gene doubles the lysine and tryptophan content in corn. The recessive floury-2 (fl_2) gene in corn doubles lysine and increases methionine content of the grain by more than 50%. In 'Hyproly' barley, a single gene confers both high protein and high lysine content. Breeding programs are underway to improve the protein content and amino acid spectrums of all major cereals. By 2176, I believe the quantity and quality of protein in the major cereals will be high enough to provide a balanced diet without supplement. I can think of no cheaper or better way to solve the world's protein problem. Other foods, vegetables, fruits, and animal products can then be added to this basic cereal diet to supply variety and zest. But those unable to afford little more than the basic cereal diet can still enjoy good health.

To maximize yield and efficiency of production, most 2176 food crops will be F_1 hybrids. Apomixis will be used to reduce seed costs for some of these crops. Fruit and nut crops, sugar cane, potatoes, and others will be propagated vegetatively as they are today. Hopefully, basic research will be able to remove more of the mystery associated with heterosis than it has done in the past. To utilize this phenomenon most effectively, we must understand it. But how can we understand it until we know more about the organisms that exhibit it?

Man will still be eating meat and animal products in 2176. The proportion of his diet made up of these products will be determined by the number of people that must be fed at that time. Much of the earth's land is too cold, too dry, or too rough to grow food crops. These lands can feed man only as he consumes the animals that feed on the plants that grow there. Crop wastes can feed animals that in turn can help to feed man. I doubt that animals will be fed grain in 2176. But I do believe that animals, largely ruminants, will produce substantial amounts of food for man as they consume crop wastes and the superior, high-quality forage varieties bred to grow on land too rough for crop production. These plants, largely grasses and legumes, as they produce food for man through animals, will also control soil erosion, conserve water, greatly reduce the sedimentation of rivers, lakes and irrigation reservoirs and help to beautify the environment.

Man will still be growing plants for recreational purposes in 2176. Whether he has a potted plant in his house or a spacious garden will be determined by the population pressure and the supply and cost of energy. He may not have enough spare land for golf but I can't imagine a world without football, and by 2176 more of it will be played on natural turf than today, particularly if energy is short and costly. Turfgrass varieties better than the best we know today will cover man's lawns, parks, athletic fields, and recreation centers. They will be dense dwarfs requiring little fertilizer and little if any mowing. They will have greater resistance to insects, diseases, and weeds and greater tolerance of the herbicides that may be required occasionally to control them. Flowers and plants used for landscaping will be similar to those grown today. But they will be more pest-resistant, more dependable, easier to grow, and more beautiful.

The fossil fuels that supply the energy for the sophisticated life style in nations like the U.S. trace their origin to solar energy fixed by green plants millions of years ago. If man fails to learn how to harness the fusion power in the atom or is prohibited from using it because of possible risks involved, he may be forced to obtain more energy directly from plants. Fast-growing hybrid trees such as the American sycamore, sweet gum, and yellow poplar will probably be used. Because it takes twice as much wood as coal to produce the same amount of heat, yields must be high. The average forest today yields 5 to 7 T/A/yr of dry wood, about half the best experimental yields obtained in Georgia (10). But annual yields of 15 to 20 T/A/yr will be required to make wood competitive with coal today. An estimated 50-square-mile energy plantation could supply enough fuel for a 150-megawatt plant capable of furnishing electricity for a city of 30,000. The yield of energy per unit of energy invested will not be high, and the cost will exceed the cost of fossil fuels today.

The realization of my predictions rests on one final assumption. The next 200 years must find many outstanding innovative plant scientists teamed up with scientists from every discipline, who can help alter plants to better serve man. They must be honest, enthusiastic, and dedicated, and they must be motivated by an insatiable curiosity and a conviction that no other work on earth is more important. Such scientists, working long hours for a lifetime, will, I believe, create all the plants I have described and more.

REFERENCES

1. Akeson, Walter R. and Mark A. Stahmann. 1966. Leaf protein concentration: a comparison of protein production per acre of forage with that from seed and animal crops. Ec. Bot. 20:244-250.

2. Burton, Glenn W., J. E. Jackson, and R. H. Hart. 1963. Effects of cutting frequency and nitrogen on yield, in vitro digestibility, and protein, fiber and carotene content of Coastal bermudagrass. Agron. J. 55:500-502.

3. Christopher, John. 1956. No Blade of Grass. Simon and Schuster, Inc. New York.

4. Day, J. M., M. C. P. Neves, and J. Dobereiner. 1975. Nitrogenase activity on the roots of tropical forage grasses (Pennisetum purpureum, Digitaria decumbens). J. Soil Biol. Biochem. 7(2):107-112.

5. Frey, K. J. 1975. Plant breeding in the seventies: useful genes from wild plant species. Jour. paper No. J-8136. Ia. Agr. and Home Ec. Exp. Sta. Ames, Ia.

6. Gavett, Earle E. 1975. Can 1918 farming feed 1975 people? Farm Index Aug. pp. 10-13.

7. Harlan, Jack R. 1975. Crops and Man. Am. Soc. of Agron. Madison, Wis.

8. Hill, A. F. 1952. Economic Botany. McGraw Hill Book Co., Inc. New York.

9. Lee, R. B., and I. DeVore (ed.) 1968. Man the Hunter. Aldine, Chi.

10. Mangelsdorf, Paul C. 1966. Genetic potentials for increasing yields of food crops and animals. Prospects of the World Food Supply, a symposium, National Acad. of Sci. Washington, DC, pp. 66-71.

11. McClelland, Maggie. 1975. Way down south on the energy plantation. Un. of Ga. Res. Reporter. Vol. 9, No. 1/Fall. pp. 5,6.

12. McComb, J. A. 1975. Is intergeneric hybridization in the leguminosae possible? Euphytica 24(2):497-502.

13. Nelson, L. F., W. C. Burrows, and F. C. Stickler. 1975. Recognizing productive energy-efficient agriculture in the complex U.S. food system. Paper No. 75-7505. Presented at the meeting of the Amer. Soc. of Ag. Eng. Dec. 15-18.

14. Scrimshaw, Nevin S. 1966. Applications of nutritional and food science to meeting world food needs. Prospects of the World Food Supply, a symposium, National Acad. of Sci. Washington, DC, pp. 48-55.

15. White, Geo R. 1975. He keeps germplasm coming. Crops and Soils. Nov. pp. 5-7.

16. White, W. C. 1973. Fertilizer, food energy relationships. Amer. Chem. Soc. Aug. 1973.

Proc. So. Weed Sci. Soc. 29:42-48.1976

THE FUTURE OF THE REGULATION OF HERBICIDES

Boysie E. Day
Professor of Plant Physiology
University of California
Berkeley

One of the challenges of advancing age is to deal with the common notion that a few gray whiskers and a mite of stiffness in the joints signify wisdom and qualifies one to forecast the future. Strangely, some of us accept the challenge despite the near certainty that events will prove us wrong. The options are to be the coward and say nothing or speak out and be revealed a fool. There is, however, another way. It is a middle ground, so to speak, although admittedly an unsporting one. When confronted, one assumes a reflective pose, gropes for words, mumbles about complex relationships and then profoundly forecasts a sure thing; that is, something that everyone agrees is sure to happen. This will be recognized instantly as high wisdom and will solidly establish one as a person to be listened to. Furthermore, finding sure things to foretell is not as difficult as it might first appear. With a little practice one can soon get the hang of it. For example, one can say that the weather will be highly variable over the next century, that there will be inflation, or that there will be an overwhelming and paralyzing increase in government regulation of all aspects of weed control, not only in the use of herbicides but in alternate methods as well. Which, incidentally brings me around to my subject.

You may ask how I can be so certain that we face greatly increased controls over weed control technology. The answer is that the momentum is overwhelmingly in that direction and that all present and foreseeable trends point toward the extension and intensification of control over research, development and practice in weed control. One reason is that herbicides are classed as pesticides and whatever happens to pesticides generally will happen also to herbicides.

Let us begin by looking into the history of pesticides regulation in the United States and see what lessons can be extracted. The first law was the "Federal Insecticide Act" of 1910. This law was aimed at protecting the purchaser from misbranded, adulterated, and fraululent products in interstate commerce. The 1910 Act was a truth-in-labeling law, requiring that the purchaser be properly informed of the nature of the product, however without restricting his use of it after purchase. Since this beginning two-thirds of a century ago regulation has extended to all kinds of chemicals and devices used in any way against pests. Also the definition of a pesticide has been extended beyond all logic to include such non-pesticides as harvest aids, plant regulators, implements, and biological agents.

The "grandfather" law is the Federal Insecticide, Fungicide, and Rodenticide Act of 1947 (FIFRA) as amended to the present time. FIFRA introduced the concept of placing the burden of proof of safety on the seller prior to marketing. FIFRA initially maintained the format of a truth-in-labeling law and retained the legal restriction that it applied only to interstate commerce. Registration was made a more complex and exacting procedure with the label the key document. Nevertheless, intrastate handling of pesticides remained outside most aspects of FIFRA and the user was allowed to deviate from the label at his own risk.

The next major step in regulation was the enactment of the Federal Environmental Pest Control Act of 1972 (FEPCA). This is technically an amendment of FIFRA; however, it greatly alters the parent law. FEPCA largely abandons the figment of regulating interstate commerce and of truth-in-labeling and grants sweeping powers to EPA for control of virtually all aspects of the discovery, development, manufacture, possession, use, and disposal of pesticides, biological agents and devices used in pest control and allied fields.

FEPCA provides for the certification of applicators and their supervision. Handlers (manufacturers) must be registered and report on their business in detail. Pesticides are classified for either restricted use or general use. States can continue to register pesticides for local use, however, under EPA supervision. Research on pesticides is restricted in complex ways that may be intelligible to lawyers but not readily understood by research workers. The setting of tolerances for residues of pesticides in agricultural products is moved by FEPCA from FDA to EPA and so on.

In addition to EPA there are possibly several hundred other federal, state, and local agencies regulating one aspect or another of pest control. FDA enforces pesticide tolerances in food generally and USDA in meat and poultry. FAA among others controls the aerial applicator. The Department of Transportation governs shipment and the Department of Labor regulates working conditions throughout the chain of activities from laboratory to factory, to shipper, to dealer, to applicator, to farm worker, to producer handler, to finally the consumer.

FDA originally administered aspects of the Federal Food, Drug and Cosmetics Act governing the occurrence of pesticide residues in food. In 1948, FDA began setting tolerances for pesticides in food. In 1954, the Miller amendment to the act formalized procedures for USDA and FDA cooperatively to register pesticides and set tolerances for residues. In 1958 the Delaney clause was passed specifying that no food additive should be permitted if it could be shown to cause cancer in man or animals. This provision technically does not apply to pesticides since they are not legally food additives, however, the Delaney amendment nevertheless seems to apply in practice to pesticides.

Each state has its complex of agencies with one or another regulatory control over pesticides. Some of these agencies are large and sophisticated while others are rudimentary and technologically naive. Some have effective programs and others only nominal control over their regulatory territories. State agencies commonly include departments of agriculture, forestry, water resources, fish and game, environment, public health, transportation, parks and recreation, public utilities, consumer affairs and the like. Few such agencies have technical staffs adequate to their tasks and few accomplish anything beyond making life a little more difficult.

State agencies are frustrated by having most of their powers preempted in recent times by the federal government. There is constant clamor by state agencies for more authority over pest control and much bureaucratic in-fighting to capture for particular agencies the small amount of authority still retained by states.

Regulatory decision making also extends to county and municipal levels. In my home state of California the county agricultural commissioners have active day to day regulatory control over many aspects of private and public pest abatement programs. City health departments, fire departments and others also supervise and regulate pest control activities. To further complicate matters, state legislatures and city and county legislative bodies occasionally pass laws banning this or that pesticide or pest control procedure.

Now the important question, What does this history tell us? What simplifying conclusion can be drawn from this seemingly aimless welter of laws, regulations, conflicting agencies, bureaucratic squabbles, and contradictory actions? There is one and only one conclusion possible and it is simple and obvious. This is that each law is followed by a more comprehensive one, that each set of regulations leads to other more complex and restrictive ones, that each delegation of authority to regulatory agencies leads to pressure for even more authority, and in due course this authority is granted. These trends began gradually, have increased to the present time and will expand in the future at an accelerating pace. As regulation grows in power and complexity the pressure is to become even more powerful and complex. I consider this to be the national policy on pesticides for this century, that is, to progressively accumulate all significant decisions about pesticides into government hands. Such a policy is not overtly advocated, however real policy is best judged on the basis of the progression of events rather than the political claims and disclaimers of the moment. The record of events tells us to expect a tightening of controls over all aspects of weed control including herbicides and alternate technology.

Now you can see how easy it is to predict a sure thing. Are any of you prepared to argue the contrary: that regulation will become less, that government will make fewer decisions about weed control and farmers more, that regulatory bureaucracies will be dismantled and their regulations revoked? The answer, of course, is that these things will not happen, and that the contrary trend of events can be expected.

With this in mind, let us consider the potential consequences on weed science and technology in a world of greater government control.

1. Will there be enhanced human safety?

I doubt it. Intensified regulation is focused largely on herbicides which rarely cause death or injury. Safety has never been a valid issue in the use of herbicides. More people are killed annually by avalanches in the U. S. than by herbicides. The hazard in weed control is associated almost entirely with machines. Tractors turn over and kill people, mowing machines throw rocks or fly apart and maim or kill the operator or bystander. These are the hazardous operations in weed control, although even here the hazard is not great. Regulatory activities are not aimed at alleviating these hazards. I can find no credible evidence that past regulation of herbicides has been geared to safety nor has enhanced safety.

2. Will future regulation lead to the more intelligent use of herbicides?

The response here is also negative. The trend is to specify on a national scale more rigid and less flexible uses of herbicides. For greater effectiveness procedures must be adapted to local conditions and this cannot be done on a national scale. There is ample evidence that centralized decision making is less effective than decisions made by the farmer on the spot. This applies to the use of herbicides as well as to other farm practices.

3. Will intensified regulation lead to a reduction in the use of pesticides?

There is no indication in the record that this has been the case in the past or will likely be so in the future. The effect of restricting herbicide use is most often to lead to switching from one chemical to another and less efficient one. This, in the end leads to larger doses, more frequent use and greater total use.

4. Will intensified regulation lead to cheaper agricultural products?

The answer is a resounding "NO!" The cost of regulatory compliance becomes part of the cost of the commodities and this cost passes on to the consumer. On top of this is the further cost of supporting the regulatory bureaucracies. I note that congress appropriated 71.5 million dollars recently to support the EPA pesticide program through March 1977. To my mind most of this money could far better be spent on research programs to discover better and safer pest control measures that would competitively replace existing procedures.

5. Will intensified regulation stimulate research for alternate methods of weed control?

The answer is "Yes and no." If a chemical is banned or a procedure is no longer allowed, research will be stimulated to find new technology to replace the one that is lost. On the other hand, an increasing burden of regulatory busy-work necessary to get a new product registered is a deterrent to the development of new procedures. The greatest effect of regulation on research is to channel scarce research resources away from the solution of problems of high scientific and technological merit into the solution of regulatory non-problems. An example of this is regulations that require expensive research on the detection of minute quantities of essentially non-toxic herbicides in food and feed. There are scores of herbicides that present no conceivable toxicological hazard to consumers and research should move on to other problems.

6. Will intensified regulation stimulate research by the scientific community generally?

The answer to this is unfortunately also "NO!" Over the long run intensified regulation can be expected to virtually eliminate all pesticide research except that conducted by the chemical industry and approved on a case by case basis by the regulatory body. University and other public agency scientists do not have the attorneys, administrative personnel and the patience, or perhaps kind of mentality to cope with regulation of research. For example, I see by the Federal Register of August 4, 1975, that Michigan State University was given a permit to test 200 grams of ethephon on cherries. This use is restricted to 0.4 acres and was authorized to be applied only in the State of Michigan and had to be carried out between July 16, 1975 and December 31, 1975. I remind you that Michigan State

University is one of the world's most distinguished research institutions and that ethephon is not a significantly hazardous material and is shortlived in the environment. The authorized operation involved no greater human or environmental hazard than adding a quart of engine oil. Indeed, for EPA to issue such a permit reminds me ever so much of the Board of Chiropractors issuing permission to the Mayo Clinic to apply a band-aid. University scientists will not put up with this kind of meaningless harassment, and having freedom of choice will move into other work.

7. Will restriction of pesticides lead to greater research and exploitation of biological controls?

The answer here is emphatically "NO!" Intensive regulation will lead to the virtual elimination of research on biological control. Of all kinds of research biological control is most vulnerable to discouragement by regulatory control. Biological control methods are rarely subject to patent protection and for this reason corporations generally do not enter this work. This is why biological control research is limited to the universities and public agencies. It has already become clear that biological methods will be subject to the same strict controls as chemical methods. Universities being less able than industry to cope with restrictions on its activities will allow this work to languish if not disappear.

8. What will be the effect on the structure of industries involved in herbicides and other regulated methods?

The effect will be to squeeze out the small operator. Large companies can afford to set up specialized bureaucracies of their own to meet regulatory complexity with equal complexity. Large companies can ammortize these costs over a larger sales volume. Small business will continue to move out of the picture including ultimately nationwide companies of intermediate size. With less competition the remaining large companies can exercise sufficient market control to readily recover regulatory costs whatever they may be.

Let me give you in closing my view of the general outlook for this kind of regulation. The political science of regulation tells us that ultimately the regulatory agency become the handmaiden of the industry being regulated. This we see in public utility commissions, power commissions, and related regulatory bodies here and in other nations. It is a universal truth of human relations and we can expect it to occur in this case as in others. Regulatory bodies are started as militant agencies aimed at correcting unwanted practices. As abuses are corrected and times change, the regulators and the regulated accommodate their interests and begin to get along with one another, neither side rocking the boat. EPA is now the militant agency and yet to forecast that this will happen to it also is, within the context of my original thesis, another case of foretelling a sure thing.

EPA can now freely rock the boat in its new responsibilities over pesticides because it is overturning decisions originally made by USDA, FDA and others. It will be a different matter when over the years the main body of decisions will have been made by themselves. They will be defending their own past decisions instead of overturning the work of others. In the future the regulators will be joining with the regulated to defend procedures they have established and gained a vested interest in. By that time industry will have been pruned down to a comfortable half-dozen international companies, and the academic community and other agencies successfully isolated from the decision making processes. Pesticides will then have become in effect public utilities moving with glacial slowness without a harsh word spoken. All decisions will be made with a minimum of publicity by quiet negotiations between government and corporate bureaucracies on the basis of unpublished industry research.

In summary, my view of the future of regulation of herbicides is for a further turbulent intensification of regulations. This will isolate the academic and scientific communities and dqueeze out small business. The government will then quietly regulate the remaining several companies on a reasonable and cordial basis without public controversy or fanfare. After the bureaucratic war will come bureaucratic peace. Meanwhile, to quiet our nerves over the turbulent years in anticipation of some future nirvana, I have written a poem to commemorate the travails of EPA. After all we must be charitable about our friends in EPA. They are the expandable shock troops of the regulatory war. If the EPA man is on your back, remember that many others are on his back and there is nothing personal to it.

THEY ALSO SERVE WHO SIT AND PRIORITIZE ENVIRONMENTAL PARAMETERS

EPA regulates our external conditions.
Whatever we do requires its permission.
Its staff is composed of lawyers organic,
Whose method of work is creation of panic.
The ice caps are melting! The oceans will flood!
Monoxide is increasing and ruining our blood!
The air will be toxic and smother our breath,
Which everyone knows is a horrible death!
We're destroying the ozone with aerosol cans,
Which greatly distresses deodorant fans.
Through a gullible press they create alarm.
Over chemical hazards from factory and farm.
Pesticides are a threat more fearful indeed
Than nematode, fungus, insect, and weed.
They worry we'll eat astronomical doses.
If you eat fifty tons! It will give you cirrhosis!
They doubt all research, but believe every rumor,
Apprehensive do-gooders, with no sense of humor
When it comes to decisions, they do as they please,
All inscrutably written in governmenteese.