AG OUTLOOK 1999

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Good morning ladies and gentlemen. First of all, I would like to thank John Love for asking me to be here with you today. I hope that my presentation will give you some insight into the advancing technologies in sugar crop production. Although I will be speaking on both sugar beet and sugar cane, I must preface my remarks by telling you that I an no expert in sugar cane production. Even though, sugar beet and sugar cane are very different crops, as you will see, through my presentation, the advancing technologies are similar, as are they in most agronomic crops.

To begin with a bit of background. In 1998, Sugar Beets were grown in 14 states, on 1, 430,000 acres and will produce about 4.4 million tons of sugar. Sugar Cane was grown in 4 states plus Puerto Rico on 877,000 acres for an estimated production of 3.3 million tons. Sugar Cane was introduced to the Americas by Columbus, and Sugar Beet production came much later, around 1836.

When we look at the technology of sugar beet and sugar cane production, it can most easily be broken down by what I will refer to as Agronomic Factors, I have them listed here. Biology and Physiology, in essence the basics. Genetics and Breeding, as it relates to and interacts with crop growth. Soil Management and Crop Establishment, the interaction of the crop with the environment. Nutrition, primarily the fertilization of the crop. Diseases, Insects, in which I include Nematodes and Weeds, as these are the major pests of the crop, and finally, Harvest and Quality factors, which ultimately effect the processability of both cane and beet. I would like to discuss each of these separately, however, you will see that they all interact.

Biology and Physiology

The biology and physiology of the crop is the basis for all the other sciences names. It is what forms the relationships between the various components of crop growth and production. This is long term/high risk research, but is essential knowledge to be able to proceed in advancing the more applied technologies. There have been rapid advancements in instrumentation and availability of tools used in physiological research. An example is automated measurements of physiological properties in the field, such as photosynthesis or leaf area index. Chemical instrumentation has advanced also, especially in the areas of Chromatography and Spectroscopy, making it possible to determine many physiological characteristics more rapidly and precisely.

Genetics and Breeding

Traditional breeding programs in both sugar beet and sugar cane have been very successful. Major milestones that can be cited include the discovery of monogerm seed in sugar beet, major advancements in disease resistance in both sugar beet and sugar cane, and a steady

increase in yield and sucrose content. However, it is felt, given the limited gene pool within these species, that we may be near the upper limits of what can be obtained with only traditional breeding programs. Genetic engineering, through biotechnology, is our next major stepping stone. The technology in this area is, as you know, advancing more rapidly than can be reported on. There are three major areas in this program. Isolation of the needed gene, insertion of that gene, and regeneration of the plant material. As I speak later of the various pest problems and yield and quality parameters, the isolation of the needed genes will be addressed. The techniques for the insertion of a desired gene include such things as bombardment guns, which use DNA-coated gold particles and the use of biological vectors, such as Agrobacterium. Sugar beet is more difficult to transform and to regenerate than many other crops. However, advances are being made in tissue culture techniques that are speeding up this part of the process. This whole process is not as simplistic as I have outlined. Even after the desired gene is located, inserted, and the material regenerated, the genetic engineer and the traditional breeder must work together to incorporate this into existing breeding lines, while maintaining the original traits and the new trait or traits which came from the genetic engineering process. In line with this, significant efforts are being made in gene mapping to identify important genes. Areas of most promise in the near future are herbicide resistance, disease resistance, and yield and sucrose content.

Soil Management and Crop Establishment

As with most agricultural crops, the traditional practices of deep plowing and heavy disking are going away. We are also moving away from flat planting in sugar beets, a practice which lent itself to severe erosion by both water and wind. New equipment is being developed for incorporation of minimum or reduced tillage operations. Along with this, planters are being developed, which do an excellent job of planting into this type of field preparation, while still allowing for good germination and crop establishment. The practice of planting on formed beds has also aided in reducing the erosion problems.

Nutrition

Crop fertilization is very important in sugar beet production. As in most crops, the primary fertilizer applied is some form of nitrogen. For many years, fertilization was done on a broadcast basis, utilizing recommended rates for the crop and the yield expected. Often this led to over-fertilization. Not only is over-fertilization costly, but it can create environmental problems. The use of soil analysis and petiole analysis have taken us a long way toward the more accurate and discriminate use of chemical fertilizers. Now we are entering a new era, using satellite imaging and global positioning to determine the needed fertilizer, and to apply that fertilizer more accurately.

Diseases

Diseases account for the greatest losses in both sugar beets and sugar cane. The traditional methods of disease control, namely varietal resistance, crop rotation, cultural practices, and fungicides, have been utilized for a number of years. However, due to agronomic and economic restriction, and resistance to some fungicides, in recent years, the diseases seem to have been winning the war. As an example, the states of North Dakota and Minnesota alone estimate they lost 70 million dollars in 1998 to one disease, caused by the fungus Cercospora. We are confident that the future advances in the area of disease control will lie in Genetic Engineering, as I mentioned earlier in my talk.

Insects

There are several major insect pest of sugarbeets. These can cause damage either directly or indirectly, by transmitting diseases. The traditional means for control of insects are similar to those mentioned for control of diseases: chemical insecticides, cultural practices and crop rotation. These have worked well in the past, but again similar to the disease situation, there are environmental concerns and an increase in resistance. Biological control of insects has been a growing science for years, however, it has not been effective in controlling sugar beet insects. Recent developments in technology have taken us one step further than that. Examples include the use of trap crops for the control of the sugar beet cyst nematode. This technology incorporates the use of either a special type of radish or mustard crop, preceding the sugar beet crop, which in essence disrupts the life cycle of the nematode, causing a dramatic reduction in population. This practice does not work in all places where nematodes are a problem, but it is effective in many areas. Another good example is the recent discovery of a fungal pathogen, that is very effective in attacking and controlling the sugar beet root maggot. The areas of biological control, natural predators and ultimately genetic engineering will be the future of developments in insect control.

Weeds

For many years, the only means of weed control were hand labor and cultivation. Then came the era of herbicides, both pre- and post-emergence, where we were able to virtually eliminate hand labor. This has been effective, but again has been expensive and has raised environmental questions. The two up and coming areas of advancement in weed control still utilize herbicides, however in very different ways. The first lies in the development of equipment to apply very low volumes and low rates of herbicides, referred to as micro rates. This is certainly a more environmentally friendly means of herbicide application and has been shown to be very effective. The second is the one which I am sure most of you are familiar with. This is the use of genetic herbicide resistance or tolerance. This advancement through bioengineering and transgenics is now a reality. In sugar beet, we have varieties ready to go to the commercial fields which are resistant to two of the broad spectrum herbicides, Roundup and Liberty. We are currently awaiting EPA approval for the use of these herbicides on sugarbeets. Due to this fact, I would expect to see the first commercial production of transgenic herbicide resistant sugar beet in the 2000 growing season. Development of herbicide resistant sugar cane is also very near and should be commercial in the next few years.

Harvests and Quality

Definitely the goal in harvesting is to deliver the best possible raw material to the sugar beet factory or sugar cane mill. This not only means a high yielding crop, which is also high in sucrose content, but one which is low in impurities and in good physical condition. Through traditional breeding programs and fertilizer management, we have continued to make advances in yield, both tonnage and sucrose content, and a reduction in impurities, especially nitrogen containing compounds, which can cause difficulties in processing. The industry continues to develop new harvest equipment which is gentler on the crop, therefore allowing us to deliver a better quality raw material to the factories and mills. However, again, as I mentioned when I was speaking on Genetics and Breeding, we feel that we may be reaching a plateau with our existing gene pool and traditional method. Again, steps in biotechnology will be combined with the basic science of physiology. If through genetic engineering we are able to express the desired genes, it may be possible to go beyond our current yield plateaus in tonnage and sucrose content, and possibly to alter the levels of non-sucrose components in the sugar crop. Even further than that,

we may be able to change the form of sugar that the plant produces and stores. Two examples of this include the recent discovery and description of a super active form of the sucrose transporter and the discovery of a non sugar beet gene, which when inserted into a sugar beet causes the sugar beet to store fructans, rather than sucrose.

Now that I have outlined where our traditional technology is going, the question is where are these advances coming from. The answer is many places. The research and advancements I have mentioned are coming both from the Public and the Private sectors. In the Public Sector, both the United States Department of Agriculture/Agricultural Research Service and the State Land Grant Colleges are very active. In both sugar beet and sugar cane, the USDA/ARS is involved in the more basic research and the Land Grant Colleges are working to develop the more applied research. In the Private Sector, the research and developments are spread across Research Institutes, Seed Companies, Agro-chemical Companies and yes, the Sugar Companies themselves.

The structure of the sugar industry in changing rapidly. Not too may years ago, in the US, our sugar companies were totally domestic, and either cane or beet. Now we have more companies which are involved in both beet and cane sugar operations, some of these companies being multinational. The seed industry has moved from smaller domestic companies, to larger international companies, as has the agro-chemical companies. This movement has certainly had a positive effect on the development of new technologies in the area of sugar crops.

Another area which has stimulated the advancements in technology of sugar crop production is the global interaction of the people involved. On a national basis, we have such organizations as the American Society of Sugar Beet Technologists (ASSBT) and the American Society of Sugar Cane Technologists (ASSCT). Both of these groups promote the interaction of technologists and the exchange of information in their respective fields. Internationally, we have the International Society of Sugar Cane Technologists (ISSCT) and the International Institute for Beet Research (IIRB). Here also, the interaction and exchange of information has aided in the development of new technologies.

In conclusion, over the long history of sugar crop production in the US, we have come along way in the area of production technology. However, we feel that we still have along way to go. Especially with the increased development of biotechnology, advancements in the near and long term are plentiful. The sugar industry, through its partnerships with public and private institutions, will continue to strive to develop the needed technologies to advance our industry in the years ahead.

Advancing From Traditional Technologies in Sugar Crop Production

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The Crops

- Sugar Beets
  - 1,430,000 A
  - 14 States
  - 4.4 M Tons
- Sugar Cane
  - 877,000A
  - 4 States and Puerto Rico
  - 3.3 M Tons

Agronomic Factors

- Biology and Physiology
- Genetics and Breeding
- Soil Management and Crop Establishment
- Nutrition
- Diseases
- Insects
- Weeds
- Harvest & Quality

Biology and Physiology

- Basis for all other sciences
- Relationship between the various components
- Long Term/High Risk

Genetics and Breeding

- Traditional Breeding
  - Monogerm seed
  - Disease Resistance
  - Yield/Sucrose Content
- Genetic Engineering
  - Herbicide Resistance
  - Disease Resistance
  - Yield Parameters

Soil Management and Crop Establishment

- Deep Plowing
- Heavy Disking
- Flat Planting
- Reduced Tillage
- Seed Bed Formation

Nutrition

- Chemical Fertilization
  - Broadcast
- Soil Testing
- Petiole Testing
- GPS

Diseases

- Varietal Resistance
- Crop Rotation
- Cultural Practices
- Fungicides
- Genetic Engineering

Insects

- Insecticides
- Cultural Practices
- Crop Rotation
- Trap Crops
- Natural Predators

Weeds

- Hand Labor
- Cultivation
- Herbicides
  - Pre and Post Emergence
- Micro Rates
- Herbicide Resistance

Harvest and Quality

- Yield
- Sucrose Content
- Impurities
- Traditional Breeding
- Fertility Management
- Biotechnology

Organizations

- Public
  - USDA/ARS
  - Land Grant Universities
- Private
  - Research Institutes
  - Seed Companies
  - Agro-chemical Companies
  - Sugar Companies

Sugar Industry Structure

- Combination Beet and Cane Sugar Companies
- Multinational Companies
- International Seed Companies
- International Agro-chemical Companies

Global Interaction

- American Society of Sugar Beet Technologists
- American Society of Sugar Cane Technologists
- International Society of Sugar Cane Technologists
- International Institute for Beet Research

Conclusions

- Advancements
- Biotechnology
- Partnerships