USDA, Agricultural Research Service, Northern Plains Area

Sugarbeet Research Unit – Fort Collins, CO
Strategic Research Plan – Developed February 2004

Background:

Sugar beet is the source of more than half the domestic sugar (sucrose) produced in the United States. U.S. sugar beet growers are efficient and competitive in the world market, but constant improvement in production and processing efficiency is required to maintain that position. Importantly, sugar beet is the most valuable crop in rotations in many growing areas, and is often grown on small to medium sized farms. Sugar beet helps provide the United States with a viable domestic sweetener industry that produces an estimated $262.2 billion in economic activity.

Fort Collins, Colorado, is situated at the foothills of the Rocky Mountains, just east of the Continental Divide and about 35 miles south of the Wyoming border. At an elevation of 5,000 feet and in the rain shadow of the Rocky Mountains, the environment is characterized by low relative humidity and an average annual precipitation of about 15 inches. This environment has proven highly conducive to the sugar beet breeding efforts at Fort Collins, which now concentrate on the development and release of germplasm with enhanced resistance to Rhizoctonia root rot, Cercospora leaf spot, beet curly top virus, and other diseases.

Many advances have been made in sugar beet genetics to provide improved sugar yields through incorporation of disease resistance and better growth characteristics. Similarly, growers have gained increased knowledge of many sugar beet diseases, pests, and weeds; and chemical control methods for these problems have been introduced when genetic resistance is insufficient. Nonetheless, diseases and storage problems remain important sources of crop and sugar losses. In addition, there is growing awareness that serious environmental costs and problems can result from the use of chemical pesticides to control pests and diseases. Thus, it is essential to continue to develop and improve disease resistant germplasm, biocontrol agents, and other means to help maintain a healthy environment and sustainable production system while reducing the grower's cost. As an integral part of a national sugar beet research program since 1926, the Sugarbeet Research Unit at Fort Collins, Colorado, develops germplasm with disease resistance, provides fundamental knowledge about important diseases and their control methods, and the genetics responsible for disease resistance. This research information helps U.S. growers keep the cost of production low and maintain their position in an increasingly competitive world sugar market.

Vision:

Working together to produce the highest quality and most useful research to meet the changing needs of the beet sugar industry.

Mission:

- Discover new information and techniques to identify and produce sugar beet germplasm exhibiting superior disease and stress tolerance and agronomic qualities;

- Develop new knowledge and biotechnologies to better understand and modify host-pathogen relations that affect sugar beet disease resistance, pathogenesis, and epidemiology in sugar beet and other plant species pertinent to sugar beet cultivation;

➢ Utilize traditional and molecular methods to evaluate, characterize and utilize available genetic resources; determine genetic diversity within sugar beet and pathogen populations, to better manage important pathogens of sugar beet, and to produce enhanced germplasm more rapidly and more efficiently.

Research Thrust: Develop and distribute enhanced germplasm with high agronomic performance and strong resistance to sugar beet disease, primarily focusing on resistance to *Rhizoctonia solani* and *Cercospora beticola,* but with effort on resistance to other important sugar beet pathogens.

Resistant germplasm is the most effective and environmentally safe way to control plant disease. Most of the disease resistances for which sugar beet is bred are quantitative (polygenic, i.e., controlled by more than one gene); therefore, much more experimental effort is needed to identify differences among plants than would be required with a qualitative resistance (monogenic). This is especially true of resistance to Cercospora leaf spot. Other cultivar-groups of beet (Garden Beet Group, Fodder Beet Group, and Leaf Beet Group) (*Beta vulgaris* ssp. *vulgaris*), wild sea beet (*Beta vulgaris* ssp. *maritima*), and other *Beta* species all are potential sources of resistance to sugar beet diseases. The disease resistance must be in a genetic background of sufficient agronomic quality that it can be used by commercial seed companies. Through the development of public germplasm, there also is the possibility for the breeder to examine basic questions regarding plant breeding techniques.

Objectives:

1. Locate new sources of disease and pest resistance, esp. for resistance to *Rhizoctonia solani*, *Cercospora beticola*, and, as methods become available, to *Fusarium oxysporum* (and other *Fusarium* spp.), in the USDA-ARS NPGS *Beta* germplasm collection; concentrating, first on other cultivar-groups of beet (Garden Beet Group, Fodder Beet Group, and Leaf Beet Group) (*B. v.* ssp. *vulgaris*) and wild sea beet (*B. v.* ssp. *maritima*), with less emphasis on the less easily hybridized *Beta* species.

2. Develop additional sources of host plant resistance, increased levels of resistance, and early season resistance (or biocontrol using seed treatments) in the case of resistance to *Rhizoctonia solani*.

3. Elucidate the genetics of host plant resistance, identifying responsible pathways common and unique in response to different pathogens.

4. Develop germplasm populations with high agronomic quality to use as parents for crossing with exotic germplasm.

5. Develop methodologies and biotechnology to elucidate selection methodology and accelerate the breeding process.

Research Thrust: Characterize the biology and interaction of major sugar beet pathogens (esp. *Cercospora beticola, Rhizoctonia solani,* and *Fusarium oxysporum*) and potential biocontrol agents with sugar beet to provide new information that will facilitate development of sugar beet with greater disease resistance and assist in the development of improved and innovative management principles.

Diseases are recognized as the major cause of sugar beet losses world-wide. The Fort Collins ARS Research Unit has focused on two important fungal diseases, Cercospora leaf spot and Rhizoctonia root rot, and produced germplasm with good resistance to these diseases. Further advances will require better understanding of the way in which the disease-causing organism actually affects the plant, so that we can modify the genetic mechanism underlying the plant's resistance to each disease. We also seek to understand the mechanisms of other important diseases (e.g., Fusarium yellows and the sugar beet cyst nematode), and to develop ways to manage diseases by biological rather than chemical methods. For example, the potential to use fungi and bacteria as biological disease control agents, and the modes of action of such agents can be an area of investigation. In addition, an understanding of the potential interactions of sugar beet pathogens with other crops in rotation is necessary for effective disease management.

Goals:

1. Develop a better understanding of the interaction of the fungal pathogen *Cercospora beticola* with sugar beet, elucidate the host plant resistance mechanism(s), and provide new information that will facilitate development of sugar beet with greater resistance to Cercospora leaf spot. Investigate the possibility of facilitating a collaboration of CSU, ARS, and Western Sugar to validate the Leaf Spot predication model in the Central High Plains.

2. Investigate the potential to use biological control agents to manage important sugar beet diseases; develop a better understanding of the interactions between biological control agents, pathogens, and the host plant.

3. Investigate the biology of *Rhizoctonia solani*, *Fusarium oxysporum,* and other fungal pathogens of sugar beet, esp., responses to stress and a better understanding of the biochemistry of infection, and interactions with other diseases and potential hosts throughout cropping systems.

Research Thrust: Using traditional and molecular methods, evaluate, characterize and utilize available genetic resources (esp. in the USDA-ARS NPGS *Beta* PI germplasm collection) and determine the genetic diversity within sugar beet and pathogen populations, to better understand and manage important pathogens of sugar beet, and to produce enhanced germplasm more rapidly and more efficiently to meet the changing needs of seed companies and the growers they serve.

The USDA-ARS National Plant Germplasm System's (NPGS) beet germplasm collection is one of the largest in the world. Traditional and molecular genetic analysis techniques can be used to understand, characterize, and move these novel sources of resistance into sugar beet germplasm with suitable agronomic quality for use by the sugar beet seed industry. The use of biotechnology and information generated by it will allow the managers of our USDA-ARS *Beta* collection to make

intelligent decisions on the collection of new materials, the utilization of the current collection, the management of regeneration of the active collection, and the removal of unwanted duplications within the collection. The same traditional and molecular genetic analysis techniques can be used to better understand and control pathogens of sugar beet. A better understanding of pathogen genetics is critical in understanding the diversity of the pathogen population, and can determine the appropriate pathogen isolate for use in resistance screening and other research.

Goals:

1. Determine the basis of fungicide resistance of *Cercospora beticola*, major pathogen of sugar beet, i.e., is resistance to benzimidazole fungicides due to mutation(s) in the β-tubulin gene?

2. Use of microsatellite and morphological markers within a subsample of the *Beta vulgaris* ssp. *maritima* accessions from France in the NPGS *Beta* collection to examine how selection and drift act on quantitative traits and if neutral marker data can be used to predict differentiation in quantitative traits; and how much of the total neutral variation is captured if one optimizes quantitative trait diversity in the collection versus how much quantitative trait diversity is captured in a collection maximized for neutral trait variation.

3. Investigate the genetic variability in sugar beet pathogens and test for genetic markers, factors, or genes important in the plant-pathogen interaction.

4. Elucidate the genetic relationships among strains of *Fusarium oxysporum* pathogenic on sugar beet; develop a better understanding of the interaction of strains and the genetic resistance of sugar beet to them, including potential stress factors influencing disease severity – chemical, pathogens, and environment; examine other species of *Fusarium* that may cause disease on sugar beet.

5. Understand *Fusarium* strains (genetic diversity of strains) and examine screening tests so we can better understand the resistance.

6. Develop the transgenic sugar beet models necessary to study the disease resistance pathways in sugar beet.

Essential Core Service Provided

- **Each year, controlled disease epidemics of Cercospora leaf spot and Rhizoctonia root rot will be produced to determine the disease resistance of sugar beet commercial varieties, experimental breeding materials, and Plant Introductions from the USDA-ARS National Plant Germplasm *Beta* (beet) collection.**

    - Early researchers depended on natural epiphytotics to provide the disease pressure necessary to make selections for leaf spot and root rot resistant germplasm, and it was quickly realized that it was necessary to manage the screening nurseries in such a way as to promote the

development of the disease. Evaluations are most effective when there is a uniform, moderately severe epiphytotic. At Fort Collins, artificial inoculation and management of the nursery micro-environment have been employed successfully since 1956 to create the development of such epiphytotics. The arid climate and low relative humidity, combined with a careful crop rotation (sugar beet-barley-barley-barley-sugar beet), have allowed this to be done in such a manner that there is rarely any other major disease pressure present in the nurseries to confound the results.

- We will begin to develop methods to screen for genetic resistance to disease caused by *Fusarium oxysporum*, with the goal of developing a field nursery, in which the results are highly correlated with greenhouse methods and field performance. Then we will be able to evaluate breeding lines and germplasm for their tolerance in either field or greenhouse studies.

Communication and Technology Transfer: Communication among researchers and transfer of research results to end users is critical.

When we undertake research to solve important agricultural problems, that research project is not complete until its results been communicated to those end users who confront the problem. Sugar beet scientists must strive to make their research complementary to that of others, not redundant. If this is to happen, scientists world-wide must communicate among one another about their research projects and techniques. Federal scientists must continue and expand upon collaboration with university scientists to develop the synergy necessary to make the most of research funding and help assure technology transfer.

A number of suggestions to help improve communication to end users and among researchers were put forward at the last strategic planning session that are still valid:

1. Put the Annual BSDF 'Executive Summary' of ARS Sugar Beet Research on the BSDF website and link to that from the Sugarbeet Research Unit website.

2. Continue close collaboration with the universities, especially with Cooperative Extension Service personnel who can help disseminate research results.

3. Work with BSDF and grower magazines to better publicize ARS research results.

4. Continue personal outreach of ARS scientists and technical staff with growers, processors, and seed producers.

5. Maintain close contacts with European sugar beet researchers (private and public) to avoid duplication of effort and exchange research results and experimental organisms, e.g., fungal cultures, seed, DNA, etc. when necessary to enhance research efforts.