UNITED STATES BEET SUGAR INDUSTRY

Comments on the Request for Information for the

United States Department of Agriculture's Agriculture Innovation Agenda

Submitted via regulations.gov

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These comments are submitted on behalf of the United States Beet Sugar Industry as represented by both the American Sugarbeet Growers Association and the Beet Sugar Development Foundation. The American Sugarbeet Growers Association represents all of the 10,000 progressive family farmers of sugarbeets in 11 states who own all nine farmer cooperatives which have 22 beet sugar processing factories. The membership of the Beet Sugar Development Foundation (BSDF) is comprised of the Vice Presidents of Agriculture for the beet sugar processing companies and representatives of sugarbeet seed related companies. The BSDF is active in research and development, education and technical programs of common interest to its members. The sugarbeet is a root crop which is harvested for the production of sugar. Our industry produces 56% of the sugar grown in the U.S. We raise sugarbeets on 1.2 million acres, support 100,000 jobs and generate $10.6 billion for the U.S. economy. We proudly provide a sustainably-produced and reliable source of this essential ingredient which is vital to our nation's food security.

We have had near universal adoption of bioengineered plants since 2009. Our adoption rate was the fastest of any biotech commodity in the world. Adoption of this innovative technology has allowed us to make huge gains in productivity and sustainability. Through the adoption of Roundup Ready ® sugarbeets we were able to identify more than 25 environmental benefits which have allowed us to reduce the use of herbicides, improve plant health, improve soil health, reduce water use and improve water quality, and reduce greenhouse gases emissions.[1] Our industry is the most sustainable beet sugar industry in the world but we could also benefit from further advancements in technology. With improved research and technology, we can contribute more toward USDA's overarching goal of the Agriculture Innovation Agenda as described in the Request for Information (RFP) to enable American agriculture to increase production by 40 percent by 2050 while cutting the environmental footprint of U.S. agriculture by 50 percent.

We, like the rest of agriculture, have serious production challenges that limit our output. Our challenges can be broken into several categories which include: a) pathology, b) weed control and management of weed resistance, c) static growth in sugar content as a percentage of the sugarbeet by weight, and d) post-harvest storage issues.

TOP PRODUCTION CHALLENGES FOR SUGARBEETS

1. *Cercospora beticola* resistance to fungicides (pathology-fungus)
    - Cercospora leaf spot is ranked as the number one production threat by our industry at this time. The fungus attacks the sugarbeet leaves which cause the leaves to die. The sugarbeet

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[1] U.S. Beet Sugar Submission to the National Academy of Sciences National Research Council Committee on Genetically Engineered Crops, Submitted on September 9, 2015, https://americansugarbeet.org/wp-content/uploads/2017/04/U.S.-Beet-Sugar-Submission.pdf.

then uses sugar stored in its root to regrow leaves, greatly reducing the overall level of recoverable sugar from the crop. This microcyclic fungus has the shortest reproductive cycle of any sugarbeet pathogen (10-14 days). Therefore, mutations arise swiftly within the fungal population rendering the limited number of fungicides ineffective. Over sixty percent of the acres in sugarbeet production in the U.S. are subject to moderate to high levels of *Cercospora* pressure against which the incomplete, quantitative tolerance bred into commercial sugarbeet hybrids alone is ineffective.

2. Weed control and management of weed resistance
    - We have no viable and immediate fallback to glyphosate for glyphosate-resistant weed populations.
3. Rhizomania (pathology-virus)
    - This is caused by the *Beet Necrotic Yellow Vein Virus*, vectored by *Polymyxa beta*, a fungal-like *plasmiodiophorid.* The effects on the sugarbeets are characterized by taproot constriction and a proliferation of lateral roots that give the root a bearded, wine glass appearance. This can result in small sugarbeets, with low sugar content and total field loss. Resistance bred into the commercial sugarbeet hybrids completely controls symptom expression, but does not fully inhibit viral replication. Therefore, in certain environments the pathogen is able to break down resistance. Some novel resistance genes have been identified and stacked into commercial hybrids, but are proving ineffective in certain production regions in the US and globally.
4. *Rhizoctonia solani* (pathology-fungus)
    - This causes the sugarbeet roots to rot and also affects the crown and leaves. All of this greatly reduces or eliminates yield. Rotting beets cannot be stored and their viability for immediate processing is greatly reduced.   As with *Cercospora,* tolerance to *Rhizoctonia* bred into commercial sugarbeet hybrids is incomplete and quantitative. Under moderate to high pressure, synthetic pesticides are necessary to augment disease suppression. Recently developed seed treatments are highly efficacious during emergence and early growth, but cannot provide season-long control. Although highly efficacious *in vitro*, the foliar product for late stage infection is largely ineffective at field scale since it is limited to xylem mobility and therefore cannot move toward the root being infected by this fungus.
5. *Aphanomyces cochlioides* (pathology-oomycete)
    - *Aphanomyces* is also a root-rotting pathogen that early in the season expresses itself as seedling damping off and later in the season as root lesions, root deformation and foliar death. Rotting beets cannot be stored in storage piles and their viability for immediate processing is also reduced. Highly efficacious seed treatments are available for the control of damping off, but there are no pesticides available to control the chronic stage of infection. Sugarbeet growers must rely on incomplete, quantitative tolerance to manage late season infection and under high pressure and wet conditions, these genetics lack durability.
6. *Beet Curly Top Virus* (pathology: virus)
    - This virus is spread by the leaf hopper and results in stunted and distorted plant growth, both foliar and root morphology. Yield and sugar content are greatly affected. Commercial hybrids contain incomplete, quantitative tolerance against late stage infection. This trait works well in low pressure regions, but completely breaks down under higher pressure. Inclusion of the trait also vastly limits sugar yield potential. Alternative control measures, like seed treatment and control of the vector via insecticides is costly and moderately effective.
7. Static sugar content

- Our sugar content has averaged around 17% since 1987. The land use efficiency of the industry has been driven through increased yields while the sugar contents have largely remained unchanged for the past 40 years.

8. Post-harvest crop loss (food waste)
   - Twenty-one of the twenty-two beet factories in the U.S. use large beet piles to store sugarbeets because they are harvested at a much faster rate than they can be processed. The cold fall and winter ambient temperatures act as a natural refrigerator, allowing beets to be stored throughout the winter. High temperatures in California prohibits storage, so the factory is supplied daily with fresh beets. During this storage period, the sugar (sucrose) is used as an energy source in plant respiration, which is the primary driver of sucrose loss in storage. Other losses are attributed to plant decay and fermentation when oxygen content is low because of poor ventilation, freezing and thawing cycles, disease in the pile and root desiccation.

OPPORTUNITIES

We have identified opportunities to address some challenges and help USDA reach its overarching goal of increased productivity while reducing the environmental footprint. Below we list various opportunities within a few clusters that could provide the potential transformative innovation necessary for our industry to overcome our various production challenges. We, as an industry, place paramount importance on genome design. That is the area that has provided our industry the most innovation to date and we believe it will continue to do so in the future.

Genome Design: As we highlighted in our list of industry challenges, many are the result of incomplete tolerance and lack of genomic understanding. Gaining better knowledge of the genetic underpinnings of phenotype and physiology will allow for more targeted and effective plant breeding, whether for disease and pest tolerance or improved quality and storability. Improved genetics will make the farmer more profitable with fewer agricultural inputs and greater predictability in performance. Additionally, we will see improved environmental outcomes with improved breeding through 1) increased land use efficiency, 2) reduced food waste with better storability, 3) reduced fuel consumption leading to fewer GHG emissions and 4) reduced reliance on synthetic pesticides.

Five of our identified challenges relate to disease management. Targeted genome design will help improve native tolerance and resistance within the sugarbeet. As highlighted in the challenges, most sugarbeet tolerance is incomplete therefore it lacks long-term durability and requires supplemental external controls (*e.g.* exogenously applied synthetic pesticides) under high disease or pest pressure. Although many public genetic releases have been made by the USDA, little has been done to characterize underlying genes contributing to the tolerance. Therefore, commercial breeders don't know which factors are most important to integrate into elite commercial lines, which genes may provide more robust resistance upon introgression and which releases are truly genetically unique. Conducting robust genomic characterization and/or developing molecular markers for public release will speed the progress in increasing tolerance and introducing novel traits as well as identifying key gaps that may need to be addressed through introgression from wild relatives, gene editing or genetic engineering. This effort will ultimately lead to cost savings within USDA-ARS where curators are maintaining thousands of releases only subject to phenotypic characterization. Complimentary genetic characterization will allow for streamlined management of the germplasm collection.

Our challenge with static sugar content and losses during storage can also be addressed through focused research around genome design. Genomic characterization will provide greater insight to breeders to select for quality without sacrificing yield. This will allow for improved land use efficiency and vastly reduced emissions as more sugar per truckload is delivered to factories for processing. One cannot address sustainability without including food waste. Losses occur in the time between root digging and processing. Understanding genetic activators and repressors of respiration would allow for targeted development of sugarbeets with improved storability and reduced sugar losses.

Improved genetic understanding needs to be coupled with rapid breeding technologies. Newly discovered traits need to be easily integrated into elite germplasm and fixed for predictable expression. Sugarbeets lack the degree of inbreeding found within other crop groups and therefore exploitation of heterotic effects within our crop is currently impossible. Focus should be placed upon developing a publicly available protocol for double haploid development within sugarbeet such that novel traits are easily introduced, fixed and released to farmers in high-performing hybrids. Furthermore, our ability to confront production risks mandates all tools for rapid introduction of novel traits be freely accessible to seed producers without burdensome and unnecessary regulation that imparts downstream costs to the farmer using the seed technology. With the advent of CRISPR-Cas9, the industry will embrace the introduction of novel traits that are perhaps unavailable within wild germplasm or difficult to integrate without the introduction of other deleterious effects. Climate change is causing increasingly unpredictable environmental conditions with greater extremes in terms of excess moisture, drought, temperature swings and violent storms. Understanding the genetic potential and developing novel traits to improve crop response to extreme environmental conditions will introduce much needed resiliency on the farm. Although some genomic sequence exists for sugarbeets, it is in absentia of annotation making those limited sequences of little utility. Searching for analogous alleles of beneficial traits from other more well-defined crops is a good starting point.

Digital/Automation/Prescriptive Intervention: Genetics play a role in sugar content and in nutrient use efficiency, but farm management practices can also have an impact on genetic potential. Finding ways to reduce reliance on synthetic fertilizers by improving precision agriculture, soil analyses and crop nutrient use efficiency would be extremely helpful for our industry. The manufacturing and application of synthetic nitrogenous fertilizers are the cause of nearly 50% of the carbon footprint associated with crop production, in general. Developing methods to better determine accurate crop nutrient requirements, improving delivery methods and boosting the plant's natural nutrient use efficiency will drastically reduce GHG emissions on the farm. Improved nutrient stewardship will require: 1) developing cost effective high throughput means of soil testing, 2) creating computer models to manage data generated from micro-satellite imagery/ prescription development, and 3) calibrating novel methods for predicting nutrient availability, specifically mineralization. Sugarbeets are uniquely sensitive to nitrogen, too little inhibits yield potential and too much reduces sugar content and extractability. Therefore, in addition to improving environmental outcomes, gaining a better understanding of true nutrient use efficiency, including the genetics that influence it, will benefit the farmer at the front and back end of his or her operation. In addition, we need to continue development of novel active ingredients to complement existing control measures and address emerging pests and disease. As the climate becomes more unpredictable, all farmers will need to supplement or replace current products with those that : 1) have more pest specificity, 2) can be applied in a more targeted fashion, 3) introduce novel modes of action and 4) come with better pest prediction modeling to ensure the pesticides impart the least impact possible on beneficials in the environment.

Given our unique cooperative structure, each cooperative has a vast amount of data on the production practices of its grower-owners. However, more data collection by USDA on the collective practices of our industry would be helpful. Collection and publication of statistics on cultural practices and outcomes is necessary for us to measure our progress in helping USDA meet the goals of the Agriculture Innovation Agenda. USDA does not conduct all surveys every year because of the time and expense involved to both USDA and farmers. In addition, sugarbeets have seemingly been dropped from some recent USDA surveys which results in a data gap at USDA and a corresponding data gap by private market data aggregators. When the data is available, third-party data aggregators use information gathered from various USDA surveys including the Census of Agriculture, Irrigation and Water Management Survey (IWMS), the Agricultural Resource Management Survey (ARMS) and annual National Agricultural Statistics Service Information (NASS) Surveys to provide a detailed view to farmers on the outcomes from their practices and whether their goals are being achieved. Even though our cooperatives often collect this important data, it would be helpful for USDA to collect it for sugarbeets as well, when it is collected for other commodities, so we could use this data directly and can also benefit from the information that is obtained when it is analyzed by third-parties.

Systems-based farm management: Healthy soil leads to higher crop productivity and more carbon sequestration. However, tracking soil health in real-time is currently very challenging, if not impossible. Developing tools for farmers to understand, in real-time, how their changes to cultural practices will impact long-term soil health is becoming increasingly important. Our growers are committed to best practices and continual improvements in productivity and sustainability outcomes but must be able to see the data to prove that practice changes will not result in lost productivity. Without the corresponding real-time data, growers are unlikely to change cultural practices beyond what has already been achieved. Unless the data can show that growers will incur measurable benefits from a practice, there is little incentive for them to adopt it.

BARRIERS TO OPPORTUNITIES

Genome Design: The biggest research gap for sugarbeets today is the lack of genome annotation. Focused development of tools for characterizing key genes for pest and disease tolerance and abiotic stress will be key to achieving plant breeding goals of the future. Our industry devotes considerable amounts of money each year to help fund research grants and supplement research being done by USDA Agricultural Research Service, but we need as much federal help as we can get. The incredible cost and time associated with deregulating novel transgenic traits inhibits commercial release of helpful traits on farm. And those that are released often come with hefty increases in seed costs passed along to the farmer. Transgenic technology is faster and more precise than traditional breeding methods however it is sometimes viewed with suspicion by the general public. More consumer education about the many environmental and productivity benefits of transgenic biotechnology would be helpful to improve consumer acceptance. We believe that the publication by USDA of the Sustainable, Ecological, Consistent, Uniform, Responsible, Efficient (or "SECURE") Rule was a very positive step for transgenic technology and that it will prove to be for gene editing as well. We hope the Environmental Protection Agency (EPA) and the Food and Drug Administration (FDA) will follow similarly positive rulemaking procedures that will continue to foster the development and acceptance of biotechnology and allow the United States to continue to be the world leader in the development of biotechnology.

Digital/Automation, Prescriptive Intervention, Systems-based farm management: For these other important clusters, our industry is often dependent on the private market to develop the tools for us to advance. Any federal research goals that could be prioritized toward incentivizing private development of technology that would help with automation, prescriptive intervention and systems-based farm management would be incredibly helpful to a small industry, such as ours.

CONCLUSION

Our industry takes great pride in the achievements we have made around productivity and environmental outcomes. We also greatly appreciate this effort by USDA to help us and the rest of American agriculture achieve even greater successes. As detailed in this document, we believe that there is incredible potential around genome design but also for automation, prescriptive intervention, and systems-based farm management. We are confident that with the right research funding, we and American agriculture, will continue to set the global standard for sustainable and efficient production.

Sincerely,

The American Sugarbeet Growers Association

The Beet Sugar Development Foundation